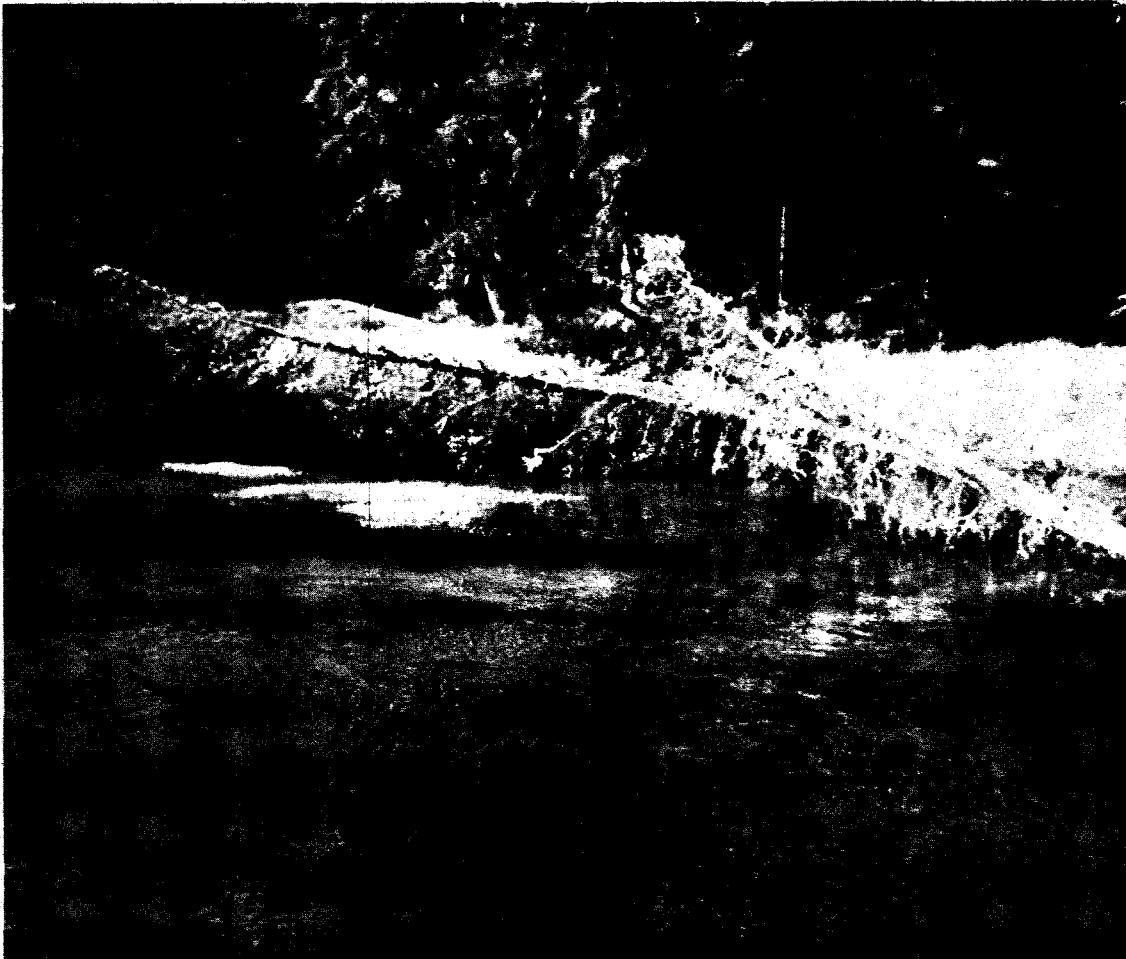


UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Fishery Resources



FISHERY AND AQUATIC MANAGEMENT PROGRAM
in
YELLOWSTONE NATIONAL PARK
Technical Report for Calendar Year 1984
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ANNUAL PROJECT TECHNICAL REPORT FOR 1984

Fishery and Aquatic Management Program

Yellowstone National Park

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INTRODUCTION

In 1872, the United States Congress established Yellowstone National Park "... for the benefit and enjoyment of the people and for the preservation, from injury and spoilation of all timber, mineral deposits, natural curiosities or wonders..., and their retention in their natural condition." From this beginning, federal legislation and policies have evolved to prohibit hunting of all birds and mammals and to regulate fishing. The Park is currently managed for the perpetuation of natural processes within the Yellowstone ecosystem, including interactions between and among native fauna, flora, geology, and scenic landscape (Houston 1971).

Angling has always been a major visitor activity in Yellowstone Park. Although initial regulations were extremely liberal and associated with frontier subsistence, present restrictions have been developed over the past fifty years to more closely reflect the Park's management mandate. Basic objectives of the fishing program are to:

1. Manage the fishery as an integral part of the Park's ecosystem.
2. Preserve and restore native species and aquatic habitats.
3. Provide anglers with a high quality angling experience for wild trout in a natural setting.

Attainment of these objectives requires that angler harvests do not alter natural replenishment rates or age structure, or significantly reduce numbers, biomass, or sizes from those occurring in unfished populations. This management policy necessitates both a philosophical and literal distinction between recreational angling and removing fish for consumption. Protective policies of the National Park Service that have prevented significant degradation of the aquatic habitat have also restricted the use of maintenance stocking in Park waters. Given these constraints, special angling regulations have become the primary means to accomplish Park fishery objectives.

Regulations used to protect fishes and maintain angling quality have included manipulating season dates, bait and terminal gear restrictions, and the use of creel and size limits (including catch and release). Additionally, some waters have been closed to angling in order to protect threatened species, nesting birds, or provide scenic vistas with undisturbed wildlife and fish.

Yellowstone has one fish species (Montana grayling) and over a dozen waters restricted to catch and release fishing. Several other waters, including Yellowstone Lake, require the release of some fish as a result of maximum or minimum size limits. The implementation of these regulations has improved angling quality despite substantial fishing pressure, and population structure more closely resembles historic levels.

The 1980 National Survey of Fishing, Hunting, and Wildlife Associated Recreation (USDI 1982a) indicated that Yellowstone Park supports approximately 1.3% of the nation's trout anglers. According to recent figures, eight states have fewer licensed anglers than the Park, and in 1981, the number of Park license-holders was greater than 63% of the total licenses issued by Wyoming, over 51% of the total issued by Montana, and 39% of the total issued by Idaho (USDI 1982b). An estimated 4 million dollars is spent annually in and around Yellowstone Park by Park anglers.

In 1984, approximately 176,800 non-fee permits were issued to potential Park anglers. Permittees came from all 50 states, all Canadian provinces, and several other foreign countries (Table 1). The largest single group resided in the west coast states (California, Oregon, and Washington); however, an almost equal number were from local states of Montana, Wyoming, Idaho, and Utah. On an individual state basis, the number of permittees from each of the local states was exceeded only by California and Colorado.

Of 120 lakes and streams which are annually utilized by Park anglers, 30 support most of the fishing pressure. The quality of at least six of these fisheries has gained national recognition, and several articles, usually complimentary, are published about Yellowstone fishing each year.

The only regulation changes during 1984 involved opening and closing dates of the fishing season. The season now opens on the Saturday of Memorial Day weekend. Most Park waters will close on 1 November; however, the Madison River, Firehole River, Gibbon River, Lewis River below Lewis Falls, Snake River, Lamar River, Gardner River, and Soda Butte Creek will close when the Grand Loop Road closes. Several other proposed regulations designed to simplify current statutes and provide additional protection to vulnerable populations have not been implemented. We believe these changes are necessary to both protect native fishes and maintain quality angling; we urge that these regulations be initiated as soon as possible.

Table 1. Residency of anglers¹⁾ interviewed when leaving Yellowstone Park, 1976 and 1978-1984.

States by geographical groups	Number interviewed at Entrance Station								Percentage of total interviewed							
	1976	1978	1979	1980	1981	1982	1983	1984	1976	1978	1979	1980	1981	1982	1983	1984
"Local states"																
Idaho	37	47	61	23	71	55	86	52	2.79	3.91	4.96	3.38	4.64	4.42	5.09	3.64
Montana	68	46	62	49	79	79	78	70	5.14	3.83	5.04	7.20	5.17	5.35	4.62	4.90
Utah	71	97	112	50	141	103	128	131	5.36	8.07	9.10	7.34	9.23	8.28	7.58	9.17
Wyoming	67	58	58	23	89	62	100	63	5.06	4.82	4.71	3.38	5.32	4.98	5.92	4.41
Total	243	248	293	145	380	299	392	316	18.35	25.48	23.80	21.29	24.87	24.04	23.22	22.11
West coast states																
California	225	158	222	102	228	198	270	225	6.99	13.15	18.03	14.98	14.92	15.92	16.00	15.75
Oregon	24	34	24	23	40	36	56	50	1.81	2.83	1.95	3.38	2.62	2.89	3.32	3.50
Washington	56	49	48	21	54	64	69	73	4.23	4.07	3.90	3.08	3.53	5.14	4.09	5.11
Total	305	241	294	146	322	298	395	348	23.03	20.05	23.88	21.44	21.07	23.95	23.40	24.35
Southwest states																
Arizona	18	28	26	22	41	23	42	28	1.36	2.33	2.11	3.23	2.68	1.85	2.49	1.96
Colorado	65	65	80	47	118	111	163	130	4.91	5.41	6.50	6.90	7.72	8.92	9.66	9.10
Nevada	7	4	10	4	12	7	14	15	0.53	0.33	0.81	0.59	0.79	0.56	0.83	1.05
New Mexico	9	8	9	6	16	18	15	21	0.68	0.67	0.73	0.88	1.05	1.45	0.89	1.47
Total	99	105	125	79	187	159	234	194	7.48	8.74	10.15	11.60	12.23	12.78	13.86	13.58
Central plains states																
Iowa	15	25	17	13	28	21	33	21	1.13	2.08	1.38	1.90	1.83	1.69	1.95	1.47
Kansas	14	12	8	7	26	14	21	21	1.06	1.00	0.65	1.03	1.70	1.13	1.24	1.47
Nebraska	18	15	21	10	22	19	19	10	1.36	1.24	1.71	1.47	1.44	1.53	1.13	0.70
North Dakota	10	12	2	8	10	8	20	7	0.76	1.00	0.16	1.17	0.65	0.64	1.18	0.49
Oklahoma	14	7	10	11	28	18	20	23	1.06	0.58	0.81	1.62	1.83	1.45	1.18	1.61
South Dakota	9	14	8	5	5	11	12	4	0.68	1.16	0.65	0.73	0.32	0.88	0.71	0.28
Texas	42	52	43	30	57	46	68	59	3.17	4.32	3.49	4.41	3.73	3.70	4.03	4.13
Total	122	137	109	84	176	137	193	145	9.22	11.38	8.89	12.33	11.52	11.01	11.43	10.15
North central states																
Illinois	70	48	40	26	56	32	47	53	5.29	4.00	3.25	3.82	3.66	2.57	2.78	3.71
Indiana	20	23	11	3	10	7	15	20	1.51	1.91	0.89	0.44	0.65	0.56	0.89	1.40
Michigan	58	61	47	13	42	27	39	33	4.38	5.07	3.82	1.91	2.75	2.17	2.31	2.31
Minnesota	64	44	31	17	44	39	63	32	4.83	3.66	2.52	2.50	2.88	3.14	3.73	2.24
Ohio	49	40	22	19	32	32	33	32	3.70	3.33	1.79	2.79	2.09	2.57	1.95	2.24
Wisconsin	40	37	31	23	44	25	35	35	3.02	3.08	2.52	3.38	2.88	2.00	2.07	2.45
Total	301	253	182	101	228	162	232	205	22.73	21.05	14.78	14.83	14.92	13.02	13.74	14.35
Southern states																
Alabama	3	3	1	2	2	6	3	4	0.23	0.24	0.08	0.29	0.13	0.48	0.18	0.28
Arkansas	1	4	6	3	5	4	5	7	0.08	0.33	0.49	0.44	0.33	0.32	0.30	0.45
Florida	22	14	20	12	23	13	42	32	1.66	1.16	1.62	1.76	1.50	1.05	2.49	2.24
Georgia	7	10	7	5	7	7	10	9	0.53	0.83	0.57	0.73	0.46	0.56	0.59	0.61
Kentucky	7	2	4	3	7	4	6	4	0.53	0.16	0.32	0.44	0.46	0.32	0.36	0.28
Louisiana	5	4	5	1	6	4	4	5	0.38	0.33	0.41	0.15	0.39	0.32	0.24	0.31
Mississippi	5	8	3	3	5	7	5	3	0.38	0.66	0.24	0.44	0.33	0.56	0.30	0.21
Missouri	19	19	23	12	11	13	24	26	1.44	1.58	1.87	1.76	0.72	1.05	1.42	1.82
North Carolina	9	9	6	2	3	9	3	3	0.68	0.79	0.49	0.29	0.20	0.72	0.18	0.21
South Carolina	5	4	3	1	3	2	2	2	0.38	0.33	0.24	0.15	0.20	0.16	0.12	0.11
Tennessee	7	1	4	0	4	2	11	4	0.53	0.08	0.32	0.00	0.26	0.32	0.55	0.2
Virginia	11	4	7	6	10	9	12	10	0.83	0.33	0.57	0.88	0.65	0.72	0.71	0.7
Washington, D.C.	1	0	0	0	0	0	0	0	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.0
West Virginia	4	4	1	2	3	3	1	4	0.30	0.33	0.08	0.29	0.20	0.24	0.06	0.2
Total	106	86	90	52	89	85	128	113	8.03	7.15	7.31	7.64	5.82	6.83	7.58	7.9
Northeast states																
Connecticut	10	11	13	7	3	7	8	10	0.76	0.95	1.06	1.03	0.20	0.56	0.47	0.7
Delaware	1	0	0	1	1	3	0	0	0.08	0.00	0.00	0.15	0.07	0.24	0.00	0.0
Maine	2	1	0	1	4	2	1	1	0.15	0.08	0.00	0.15	0.26	0.16	0.06	0.0
Maryland	14	9	9	7	8	7	4	5	1.06	0.74	0.73	1.03	0.52	0.56	0.24	0.3
Massachusetts	10	6	9	7	8	4	6	9	0.76	0.49	0.73	1.03	0.52	0.32	0.36	0.6
New Hampshire	3	2	2	2	2	2	0	2	0.23	0.16	0.16	0.29	0.13	0.16	0.00	0.1
New Jersey	14	12	17	10	17	12	18	12	1.06	1.00	1.38	1.47	1.11	0.95	1.07	0.8
New York	28	27	31	12	27	11	17	15	2.11	2.24	2.51	1.76	1.77	0.88	1.01	1.0
Pennsylvania	26	41	25	10	34	29	33	29	1.96	3.41	2.03	1.47	2.23	2.33	1.95	2.0
Rhode Island	1	0	1	0	3	1	1	0	0.08	0.00	0.09	0.00	0.20	0.08	0.06	0.0
Vermont	1	1	3	0	1	2	2	3	0.08	0.08	0.24	0.00	0.07	0.16	0.12	0.2
Total	110	110	110	57	108	80	91	86	8.33	9.15	8.94	8.37	7.07	6.43	5.39	6.0
Isolated states																
Alaska	3	1	1	1	2	1	0	2	0.23	0.08	0.08	0.15	0.13	0.08	0.00	0.1
Hawaii	2	1	1	2	0	2	0	2	0.15	0.08	0.08	0.29	0.00	0.16	0.00	0.1
Total	5	2	2	3	2	3	0	4	0.38	0.16	0.16	0.44	0.13	0.24	0.00	0.2
Canada	33	19	12	11	31	16	22	17	2.49	1.58	0.97	1.62	2.03	1.28	1.30	1.1
Foreign countries	0	0	14	3	5	5	1	1	0.00	0.00	1.14	0.44	0.33	0.40	0.06	0.0
GRAND TOTAL w/o Canada	1291	1182	1205	667	1492	1223	1685	1411								
GRAND TOTAL w/ Canada	1324	1201	1217	678	1523	1239	1687	1428								
GRAND TOTAL w/ Canada and foreign countries	1324	1201	1231	681	1528	1244	1688	1429								

1) Persons who obtained fishing permits.

This introduction is presented not only to demonstrate the significance of Park fisheries but also to illustrate the complexities involved in managing those fisheries. This project conducts annual investigations which provide information necessary to evaluate the fishery management program and check its adherence to Park objectives. The following report details results of our efforts during 1984.

PARKWIDE ANGLING

Although Park recreational visitation (2.2 million visitors) declined slightly (5.3% less than 1983) in 1984, issuance of non-fee fishing permits increased 5.6% (Table 2). Approximately 176,800 permits were issued; however, gate survey data indicated that 25.1% of the permit holders did not fish. After adjustments were made for nonanglers, the number of Park anglers was estimated at 135,000. This represents a 10.7% increase in the number of anglers since 1983.

The exit gate survey indicated that anglers spent an average of 1.93 days fishing in the Park and fished approximately 1.24 different waters/day. Computations utilizing these data (Jones et al 1977) yielded estimates of total use (329,200 angler days) and effort (790,100 angler hours). Both figures are among the highest estimates since 1973 (Table 2).

The Volunteer Angler Report (VAR) system estimated that 732,700 fish were landed and 92,100 creeled at a rate of 0.93 and 0.12 fish/hour, respectively (Table 3). Of the fish landed, 90% were released and 10% creeled. The number of fish landed per average angler trip (2.40 hours) was 2.2, and the number creeled was 0.29 (Table 4).

Species composition was indicated by anglers for 49,324 landed fish; 66.5% were reported as cutthroat trout, followed by rainbow trout (12.4%), brown trout (8.8%), brook trout (6.4%), and lake trout (2.8%). Small numbers of grayling, mountain whitefish, cutthroat x rainbow hybrid, and nongame species were also caught.

Average size of landed fish (344 mm or 13.5 in) decreased slightly from 1983. Of 47,450 fish, about 66% were greater than 305 mm (12 in), and 49% exceeded 356 mm (14 in). Average length of creeled fish was 322 mm (12.5 in). Lake trout were the largest fish landed (446 mm or 17.6 in) followed by cutthroat trout (367 mm or 14.4 in), whitefish (331 mm or 13.0 in), cutthroat x rainbow hybrids (329 mm or 12.9 in), brown trout (304 mm or 12.0 in), and rainbow trout (290 mm or 11.4 in). Some positive bias in mean length may occur in VAR parkwide estimates because 229 mm (9 in) represents the minimum size which can be reported with this system. Since 80% of the anglers measured fish are longer than 254 mm (10 in), bias is probably not excessive.

Table 2. Estimates of Park recreational visitation, fishing permits issued, total parkwide anglers and total parkwide angler days, Yellowstone National Park, 1972-1984.

Year	Total Park Recreational Visitation	Park Fishing Permits Issued	Total Parkwide Anglers	Total Parkwide Angler Days	95% Confidence Limits
1972	2,246,827 --	----- --	----- --	----- --	----- --
1973	2,061,537 -8.2% ²⁾	169,103 --	121,888 --	230,100 --	225,500- 234,700
1974	1,928,915 -6.4%	164,600 -2.7%	116,518 -4.4%	220,000 -4.4%	215,500- 224,300
1975	2,239,483 +13.9%	191,550 +16.4%	136,322 +17.0%	257,300 +17.0%	248,400- 266,300
1976	2,519,224 +12.5%	213,200 +11.3%	151,730 +9.7%	284,200 +10.5%	278,500- 289,900
1977	2,481,933 -1.5%	217,000 +1.8%	154,581 +1.9%	311,300 +9.5%	304,000- 318,500
1978	2,618,380 +5.5%	218,000 +0.5%	155,700 +0.7%	333,800 +7.2%	326,200- 341,300
1979	1,892,908 -27.7%	195,100 -10.5%	139,100 -10.7%	291,300 -12.7%	274,500- 308,200
1980	2,000,273 +5.7%	184,200 ¹⁾ -5.6%	130,800 -6.0%	311,300 +6.9%	287,000 334,600
1981	2,521,831 +26.1%	172,300 -6.5%	160,000 +22.3%	383,400 +23.2%	363,400- 403,300
1982	2,368,897 -5.9%	205,000 +19.0%	152,000 -5.0%	332,500 -13.3%	314,700- 350,300
1983	2,347,242 -0.9%	166,800 -18.6%	120,500 -20.7%	275,900 -17.0%	261,800- 289,900
1984	2,222,027 -5.6%	176,800 +5.7%	135,000 +10.7%	329,200 +16.2%	341,000- 305,400

1) Actual number unknown, figure given is an estimate.

2) Percent change from previous year.

Table 3. Fisherman use, effort, success and harvest for Yellowstone National Park, 1973-1984

Year	Angler days	$\bar{x}$ length angler day	Total hours fished	Landing rate	Total fish landed	Creel rate	Total fish creeled	% of anglers satisfied with Overall experience	Numbers caught	Sizes caught	Average length of landed fish (in.)	Mean expertise level (95% C.I.) ²⁾
1973	230,100	2.45	564,400	0.86	485,400	0.16	90,300	--	--	--	--	--
1974	220,000	2.42	531,300	0.86	456,900	0.19	101,000	--	--	--	--	--
1975	257,300	2.31	594,400	1.09	647,900	0.23	136,700	77	74	75	13.3	--
1976	284,200	2.36	670,700	1.02	684,100	0.20	134,100	74	69	69	13.2	1.90
1977	311,300	2.33	725,300	0.98	710,800	0.20	145,100	75	68	70	13.4	1.83
1978	333,800	2.23	744,400	0.99	736,900	0.17	126,500	73	66	68	13.4	1.86
1979 ¹⁾	291,300	2.49	725,300	1.01	731,100	0.15	107,300	73	67	68	13.6	1.88 (1.87-1.90)
1980	311,300	2.44	758,000	0.96	725,300	0.13	101,000	73	66	68	13.4	1.87 (1.86-1.88)
1981	383,400	2.41	923,000	0.93	844,700	0.12	110,800	73	65	66	13.4	1.88 (1.87-1.89)
1982	332,500	2.34	777,600	0.95	740,200	0.14	107,500	74	67	68	13.5	1.88 (1.86-1.89)
1983	275,900	2.36	652,100	0.95	622,400	0.11	71,600	76	69	68	13.6	1.89 (1.87-1.89)
1984	329,200	2.40	790,100	0.93	732,700	0.12	92,100	76	68	69	13.5	1.91 (1.89-1.92)

1) Revised from that reported in Jones et al 1980.

2) Based on: 1.0 = inexperienced angler, 2.0 = experienced, 3.0 = expert. 95% confidence interval in parenthesis.

Table 4. Characteristics of satisfied and unsatisfied anglers, and the influence of the relative expertise of anglers to sportfishing success in Yellowstone National Park, 1984.

	Mean number days fishing	Mean number hours fished per day	Landing rate	Creel rate	Fish landed per angler day	Fish creeled per angler day	Average length fish landed (in)	Average expertise ¹⁾	Sample anglers (n)
Satisfied anglers		2.54	1.06	0.14	2.69	0.36	13.73	1.02	4,070
Unsatisfied anglers		2.19	0.52	0.06	1.14	0.13	12.09	1.87	1,647
sum or x	1.78	2.40	0.93	0.12	2.23	0.29	13.53	1.91	6,721 ²⁾
Inexperienced anglers	1.61	2.05	0.70	0.12	1.44	0.25	13.01	1.00	1,416
Experienced anglers	1.82	2.44	0.90	0.12	2.20	0.29	13.52	2.00	4,389
Expert anglers	1.93	2.73	1.33	0.11	3.63	0.30	13.86	3.00	812
sum or x	1.78	2.40	0.93	0.12	2.23	0.29	13.53	1.91	6,721 ²⁾

Satisfaction Matrix

	Satisfied Anglers			Unsatisfied Anglers		
	Overall satisfaction	Satisfaction with numbers landed	Satisfaction with sizes landed	Overall satisfaction	Satisfaction with numbers landed	Satisfaction with sizes landed
Landing Rate (Fish/hr)						
Inexperienced anglers	0.83	0.90	0.81	0.30	0.29	0.41
Experienced anglers	1.01	1.05	0.97	0.42	0.43	0.66
Expert anglers	1.49	1.56	1.40	0.67	0.57	1.14
Creel Rate (Fish/hr)						
Inexperienced anglers	0.14	0.15	0.14	0.04	0.05	0.06
Experienced anglers	0.14	0.14	0.14	0.05	0.06	0.07
Expert anglers	0.12	0.11	0.11	0.07	0.09	0.09
Fish Size (Inches)						
Inexperienced anglers	12.97	13.01	13.19	13.72	13.00	11.72
Experienced anglers	13.61	13.60	13.93	12.32	12.76	11.39
Expert anglers	13.99	13.88	14.44	12.40	13.67	11.59

1) Based on 1.0 = inexperienced angler; 2.0 experienced; 3.0 expert.

2) The averages are based on all anglers in the sample. Not all anglers marked satisfaction or expertise boxes therefore the sums of the columns do not add up to the total given.

The percentage of anglers that reported satisfaction with their overall fishing experience was 76% in 1984. Satisfaction rates with numbers and sizes of fish landed were 68% and 69%, respectively (Table 4). Anglers indicating satisfaction with their fishing trip landed 2.7 fish, but unsatisfied anglers landed only 1.1 fish. Average length of fish landed was also higher for satisfied anglers (349 mm or 13.7 in) than for unsatisfied anglers (307 mm or 12.1 in).

On the VAR card, anglers are asked to judge their own angling expertise level, and expertise is then estimated for each water by a mean index value as follows: 1.0 is an inexperienced angler, 2.0 is experienced, and 3.0 is an expert. In 1984, mean expertise for 7,071 Park anglers was 1.96, indicating that most fishermen fall into the inexperienced to experienced category (Table 4).

Comprehensive analyses of several fisheries including Yellowstone Lake, the catch and release section of the Yellowstone River, Riddle Lake, Sylvan Lake, Lamar River, Lewis River, Madison River, Snake River, and Soda Butte Creek were completed in 1984. Although it was not possible to expand these analyses to additional waters, data for 34 lakes and streams that made up over 95% of the total Park angler use are given in tabular form (Tables 5 and 6).

Table 5. Fishery statistics from Yellowstone Park waters with over 40 angler days in the sample and which comprise over 97% of the parkwide angler day use in 1984.

	% of total parkwide angler days	Total reported angler days (VFR)	Estimates for the season						Total fish landed	Total fish creel	Y length fish landed (inches)	Y length fish creel (inches)	% anglers landing 1 or more fish	Average expertise	% anglers satisfied with:		
			Anglers	Y length angler day (hours)	Angler days (trips)	Angler hours (effort)	Landing rate	Creel rate							Overall experience	Numbers caught	Fish sizes caught
Parkwide fishery	100.00	11,994	135,047	2.40	239,194	790,067	0.93	0.12	732,661	92,138	13.5	12.7	67	1.91	76	68	69
Yellowstone Lake	40.00	4,906	49,429	2.38	134,645	321,117	0.92	0.18	296,877	59,467	14.5	12.3	68	1.78	79	71	77
Yellowstone River	15.90	1,907	21,279	2.52	52,330	131,956	0.97	0.04	127,610	5,619	15.4	12.7	68	1.98	83	78	87
Madison River	7.19	862	9,444	2.39	23,647	56,457	0.54	0.03	30,179	1,672	13.1	16.3	46	2.00	58	44	49
Firehole River	6.40	768	9,685	2.32	21,067	48,937	0.75	0.02	36,645	833	10.9	13.8	64	2.04	70	62	48
Gibbon River	5.44	652	9,544	1.88	17,883	33,643	0.95	0.08	31,939	2,730	9.9	10.8	61	1.94	60	53	38
Slough Creek	3.81	457	5,646	2.80	12,531	35,080	1.09	0.01	38,142	429	14.0	13.0	86	2.05	84	78	87
Lewis Lake	3.62	434	4,119	2.80	11,900	33,328	0.49	0.16	16,271	5,258	14.2	14.2	49	1.92	69	59	67
Shoshone Lake	3.04	365	2,471	3.86	10,006	30,659	0.55	0.16	21,115	6,082	18.2	18.8	52	1.98	83	73	84
Gardner River	1.33	160	2,532	1.91	4,379	8,369	1.61	0.24	13,506	1,976	10.6	10.4	75	1.94	75	70	50
Lewis River	1.27	152	2,070	1.99	4,160	8,285	1.05	0.05	8,693	434	10.1	15.2	71	2.04	69	59	42
Soda Butte Creek	1.13	135	1,105	1.87	3,693	6,908	2.54	0.28	17,549	1,932	10.6	11.6	93	1.94	79	75	72
Gallatin River	0.81	97	1,145	2.57	2,630	6,807	0.80	0.17	5,473	1,134	12.2	13.2	65	2.09	72	59	74
Lease River	0.77	92	1,507	2.10	2,513	5,278	1.74	0.06	9,164	290	12.0	12.2	82	2.00	77	69	68
Nes Perce Creek	0.66	79	1,326	1.40	2,156	3,015	0.66	0.16	2,004	472	9.8	10.9	49	1.86	52	43	41
Indian Creek	0.64	77	1,065	1.63	2,101	3,419	0.94	0.21	3,205	732	9.2	9.6	61	1.84	68	70	43
Bechler River	0.58	70	824	2.63	1,909	5,012	1.32	0.10	6,591	503	11.5	13.2	96	2.20	85	79	69
Heart Lake	0.42	51	442	2.86	1,387	3,973	1.17	0.12	4,650	456	16.1	17.8	88	2.14	86	86	77
Grebe Lake	0.41	49	904	1.99	1,332	2,654	0.86	0.16	2,272	427	10.8	12.5	83	2.05	73	56	59
Snake River	0.38	46	563	1.86	1,250	2,319	0.69	0.16	1,598	365	11.3	12.4	79	1.89	72	72	68
Falls River	0.35	42	723	2.40	1,140	2,733	1.28	0.13	3,506	359	10.1	11.7	78	2.03	90	76	45
Pebble Creek	0.35	42	603	1.74	1,140	1,979	2.39	0.28	4,724	550	9.5	10.4	86	1.79	90	87	81
Pelican Creek	0.35	42	603	2.76	1,140	3,148	1.94	0.03	6,100	81	15.8	17.0	91	2.25	92	92	92
Trout Lake	0.33	40	623	1.98	1,085	2,155	0.34	0.07	727	147	14.4	14.5	36	1.83	42	35	58
Lewis Channel	0.33	40	502	2.12	1,085	2,305	0.44	0.11	1,005	253	14.5	15.7	47	1.83	48	57	61

Table 6. Fishery statistics from Yellowstone Park waters with less than 40 angler days per year represented in the sample^a, 1984.

	% of total parkwide angler days	Total reported angler days (VFR)	Estimates for the season						Total fish landed	Total fish creeled	Y length fish landed (inches)	Y length fish creeled (inches)	% anglers landing 1 or more fish	Average expertise	% anglers satisfied with:		
			Anglers	Y length angler day (hours)	Angler days (trips)	Angler hours (effort)	Landing rate	Creel rate							Overall experience	Numbers caught	Fish sizes caught
Tower Creek	0.18	22	382	1.67	591	988	1.64	0.34	1623	335	10.0	10.9	94	1.78	94	89	83
Grayling Creek	0.21	25	362	2.39	674	1609	1.20	0.15	1935	240	11.2	12.7	85	2.17	63	50	75
Obsidian Creek	0.22	27	402	1.64	729	1198	1.81	0.02	2172	30	9.4	9.0	80	1.63	84	84	16
Sylvan Lake	0.28	33	583	1.60	893	1425	0.90	0.03	1289	48	9.4	9.0	65	1.90	83	78	57
Hellroaring Creek*	--	141	239	2.24	482	1080	1.58	0.28	1708	297	10.0	10.9	91	2.00	80	76	63
Clear Creek*	--	141	299	2.18	482	1051	2.87	0.17	3018	177	15.0	12.6	97	1.92	91	92	81
Cascade Lake*	--	161	359	1.51	551	831	1.40	0.14	1161	120	10.9	11.1	75	1.80	84	79	74

* Figures represented for these fisheries are an average value for 1977-1984 except for reported use which is the sum of those years.

YELLOWSTONE LAKE

Throughout the past century, Yellowstone Lake has remained the most popular fishery in the Park, and the lake supports the largest inland cutthroat trout population in the world. Despite a great surface area (35,400 ha or 87,450 acres) and once seemingly inexhaustable trout population, large scale spawn taking operations, commercial fishing, and a 100 year history of almost unabated increases in sport fishery harvests altered historical trout stocks from the original state. Managers have attempted to enhance and protect this unique resource, and regulations restricting anglers date back to the 1880's. From this early date until 1968, periodic reductions in the creel limit failed to have lasting positive effects and angling success and the condition of the trout stocks declined (Gresswell 1981).

A 356 mm (14 in) minimum size (3 fish creel) restriction imposed in 1970 helped curb the intense overfishing which occurred during the 1950's and 1960's. Despite initial benefits, it soon became evident that rising effort and harvests and a rapid decrease of older and larger trout negated positive changes.

Beginning in 1975, regulations allowed the daily harvest of two trout under 330 mm (13 in) total length (TL). Theoretically, this regulation would take advantage of compensatory survival in younger age groups and improve the population age structure. With an increase of older and larger trout, the stability and productivity of multiple age spawning stocks would ideally resemble historic levels. This regulation has remained unchanged since 1975; however, it was 1978 before it was extended to lake tributaries.

In 1984, efforts to assess the response of the Yellowstone Lake cutthroat trout to the 330 mm maximum size limit continued. Studies included a creel survey utilizing the VAR system (Jones et al 1977), the operation of the spawning trap at Clear Creek, a monthly sampling of limnological parameters, and an experimental gillnetting program.

CREEL SURVEY

During 1984, angler use on Yellowstone Lake comprised 41% of the total parkwide angler use. An estimated 49,429 anglers spent 134,645 angler days and 321,117 angler hours fishing in the lake (Table 7). Use and effort estimates remained below the 10 year average

Table 7. Fishing statistics from Yellowstone Lake, 1984.

Table 7. Fishing Statistics from Yellowstone Lake, 1964.															
Yellowstone Lake area:		% of lake total	Total VFR use reported	Predicted totals for season								% Anglers satisfied with:			
				Anglers	Y length angler day (hours)	Angler days (trips)	Angler hours	Landing rate	Creel rate	Total fish landed	Total fish creeled	Overall experience	Fish numbers	Fish sizes	Mean experience
1	Shore	5.75	282	3,054	1.86	7,728	14,372	0.76	0.15	10,981	2,164	79	69	78	1.72
	Boat	1.81	89	522	2.97	2,430	7,216	1.73	0.35	12,489	2,516	96	100	88	1.73
2	Shore	25.42	1,247	12,779	1.87	34,215	63,096	0.58	0.13	37,259	8,197	70	59	71	1.78
	Boat	19.69	966	10,408	2.84	26,502	75,248	0.88	0.23	65,906	17,419	84	76	80	1.73
3	Shore	5.01	246	2,250	2.12	6,740	14,314	0.97	0.17	13,900	2,448	85	73	78	1.79
	Boat	0.98	48	764	2.52	1,305	3,294	1.23	0.22	4,064	721	83	73	87	1.74
4	Shore	12.90	633	6,771	1.92	17,362	33,327	0.65	0.16	21,715	5340	69	62	72	1.86
	Boat	5.60	275	2,512	3.23	7,536	24,331	1.12	0.25	27,235	6,166	91	88	80	1.86
5	Shore	0.12	6	80	1.20	152	183	2.60	0.26	478	49	100	100	75	2.00
	Boat	2.89	142	1,527	3.00	3,885	11,662	1.39	0.26	16,203	2,969	99	95	88	1.75
6	Shore	---	0	---	---	---	---	---	---	---	---	---	---	---	---
	Boat	1.30	64	422	4.28	1,744	7,467	2.72	0.13	20,344	959	95	95	90	1.95
7	Shore	0.06	3	20	3.48	70	243	1.67	0.01	405	3	100	100	100	2.00
	Boat	0.84	41	362	3.13	1,113	3,488	1.79	0.21	6,229	723	100	100	100	1.89
Unknown shore		9.07	445	3,577	1.94	12,202	23,628	0.85	0.18	19,994	4,249	71	63	65	1.87
Unknown boat		8.54	419	4,380	3.31	11,488	37,983	1.34	0.19	50,877	7,332	89	77	84	1.68
All shore		58.34	2,862	28,532	1.91	78,543	150,118	0.70	0.15	104,985	22,475	72	63	72	1.81
All boat		41.66	2,044	20,897	3.05	56,090	170,967	1.19	0.23	203,803	38,866	88	80	82	1.74
Entire lake		100.00	4,906	49,429	2.38	134,645	321,117	0.92	0.18	296,877	59,467	79	71	77	1.78

since 1975 (145,900 angler days and 349,300 angler hours, respectively); however, both figures represent 19% increases over 1983 (Figure 1).

Angler use continued to be most heavily concentrated in the accessible areas including the northwest portion of the lake, the West Thumb segment, western shoreline and eastern shore. The central and southern areas sustained the lowest proportion of use (Table 7). From 1969 through 1974, an average of 86% (range: 84%-88%) of the use occurred in areas with easy access, but since the 330 mm maximum size limit was implemented in 1975, annual percentages have ranged from 89% to 94%, with a mean of 92%.

The effect of the current regulation on this apparent shift in pressure is not clear. The accessible areas have smaller trout and thereby provide a greater chance of creeling a limit. Success continues to be inversely related to angling pressure; the more remote areas sustain higher landing rates than the more heavily fished accessible areas. Rising energy prices may affect this apparent shift in use patterns; however, differences in survey techniques since 1975 also confound such a comparison. Regardless of the reason, it has been the more accessible areas which have been historically overfished.

Yellowstone Lake anglers landed an estimated 296,900 trout and released 234,400. Total angler-caused mortality was estimated at 83,200 (59,500 creeled plus an estimated 23,400 which may have died of hooking wounds following release). Overall landing and creel rates were 0.93 and 0.18 trout/hour, respectively. Landing and creel rates from the boat segment (1.19 and 0.23 trout/hour, respectively) were substantially above those from the shoreline segment (0.70 and 0.15 trout/hour, respectively) (Table 7). Sixty-eight percent of the lake's one-day anglers landed one or more trout, and 31% creeled one or more.

Based on length measurements of 17,944 trout reported from Yellowstone Lake, it is apparent that the size structure of the cutthroat population continued to improve (Table 8). Average size of landed trout in 1984 was 367 mm. Length frequencies displayed a general improvement indicating survival of proportionately more fish to older and larger size groups (Table 8). The percentage of landed trout exceeding 406 mm TL (23.6%) was substantially higher than before the regulation change. The percentage of landed trout measuring over 475 mm and 508 mm were among the highest yet reported.

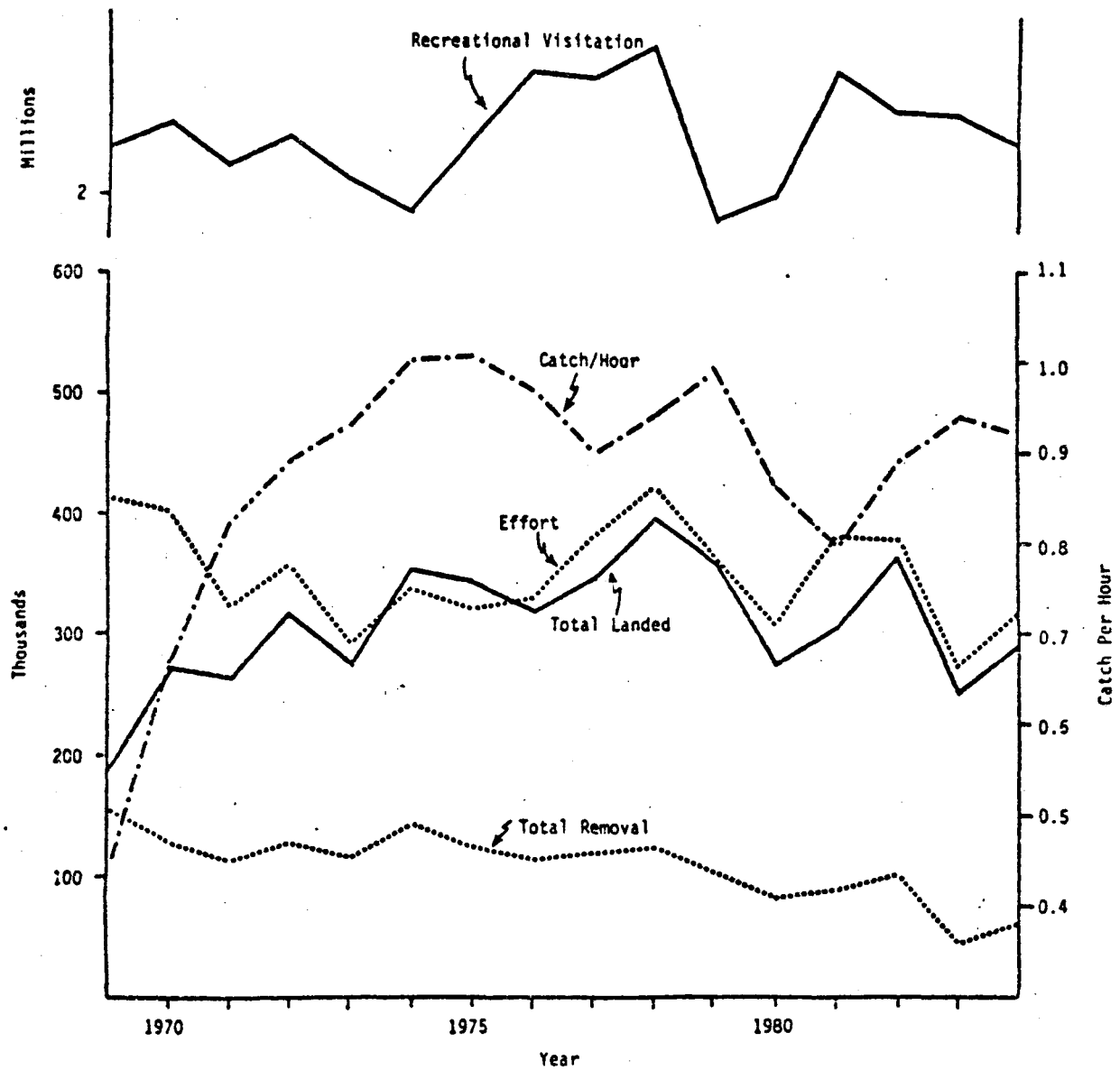


Figure 1. Catch per hour, effort, total landed, and total cutthroat trout removal estimates (including hooking mortality estimates), Yellowstone Lake, 1969-1984.

Table 8. Average length and length frequencies of cutthroat trout landed and creeled from Yellowstone Lake, 1973-1984.

Number and percentage of trout in length groups (inches):										
		<10	10-12	12-14	14-16	16-18	18-20	>20	N	
Number of trout reported landed:										
14"	1973	131	364	1,204	1,521	268	9	0	3,497	
min. size	1974	823	1,861	6,276	8,296	1,097	90	4	18,447	
13"	1975	686	2,634	8,654	8,366	1,571	155	44	22,110	
max. size	1976	816	3,415	10,160	10,123	2,295	349	94	27,252	
	1977	645	3,029	10,068	11,778	3,619	613	228	29,980	
	1978	1,174	3,878	10,322	14,794	4,523	728	188	35,607	
	1979	781	2,463	7,042	13,193	5,308	912	237	29,936	
	1980	295	1,500	5,418	8,855	3,268	699	212	20,217	
	1981	356	1,646	5,112	8,670	3,570	569	131	20,054	
	1982	771	2,702	9,909	9,965	4,186	736	226	24,495	
	1983	543	1,760	4,446	7,362	3,632	891	308	18,942	
	1984	552	1,955	4,536	6,666	3,367	655	213	17,944	
Percentage of trout reported landed:										
14"	1973	3.7	10.4	34.4	43.5	7.7	0.3	0.0	3,497	
min. size	1974	4.5	10.1	34.0	45.0	5.9	0.5	0.02	18,447	
13"	1975	3.1	11.9	39.1	37.8	7.1	0.7	0.2	22,133	
max. size	1976	3.0	12.5	37.3	37.1	8.4	1.3	0.3	27,252	
	1977	2.2	10.1	33.6	39.3	12.1	2.0	0.8	29,980	
	1978	3.3	10.9	29.0	41.5	12.7	2.0	0.5	35,607	
	1979	2.6	8.2	23.5	44.1	17.7	3.0	0.8	29,936	
	1980	1.5	7.4	26.8	43.8	16.2	3.3	1.0	20,217	
	1981	1.8	8.2	25.5	43.2	17.8	2.8	0.7	20,054	
	1982	3.1	11.0	24.1	40.7	17.1	3.0	0.9	24,495	
	1983	2.9	9.3	23.5	38.9	19.2	4.7	1.6	18,942	
	1984	3.1	10.9	25.3	37.1	18.8	3.7	1.2	17,944	

Percentage of trout landed measuring over:							Mean length landed		Mean length creeled	
		>12 in	>14 in	>16 in	>18 in	>20 in	in	mm	in	mm
14"	1973	85.8	51.4	7.9	0.3	0.0	13.8	350	--	--
min. size	1974	85.5	51.4	6.5	0.5	0.02	13.8	350	--	--
13"	1975	84.9	45.8	8.0	0.9	0.2	13.7	349	12.4	316
max. size	1976	84.8	47.5	14.1	2.0	0.3	13.8	350	12.4	314
	1977	87.8	54.2	14.9	2.8	0.8	14.2	360	12.6	319
	1978	85.8	56.8	15.3	2.6	0.5	14.2	360	12.4	314
	1979	89.2	65.6	21.6	3.8	0.8	14.6	370	12.4	316
	1980	91.9	64.3	20.5	4.4	1.0	14.6	371	12.6	320
	1981	90.0	64.5	21.3	3.5	0.7	14.6	370	12.5	316
	1982	85.8	61.7	21.0	3.9	0.9	14.4	366	12.2	311
	1983	87.6	64.4	25.5	6.3	1.6	14.7	372	12.2	309
	1984	86.0	60.8	23.6	4.8	1.2	14.5	367	12.3	313

The illegal harvest of trout over 330 mm is a continuing problem. An estimated 19,000 trout over 330 mm and 1,400 over 356 mm were creeled. Although the number of illegal trout in the creel has declined since the first year of the maximum size limit, the violation rate remains a concern. Not only does the public voice its concern over the level of violations, but 19,000 illegally creeled trout remains far above an acceptable level.

During 1984, the percentage of anglers satisfied with their overall angling experience on Yellowstone Lake was 79%; satisfaction with numbers and sizes landed was 71% and 77%, respectively (Table 5). Average expertise was 1.78.

CLEAR CREEK CUTTHROAT TROUT SPAWNING RUN

Clear Creek originates on the western slope of the Absaroka Mountains (2585 m above MSL) and flows westward at a low to moderate gradient for approximately 20.3 km before entering the eastern portion of Yellowstone Lake (Figure 2). The upper 10 km meanders through several large meadows and dense forests; most of the lower portion travels through dense forest. Peak discharge during spring floods may reach 6.7 m³/s (Jones et al 1980); by August, flows drop to approximately 0.5 m³/s (Jones et al 1979-81, 1983). Gravel suitable for spawning is distributed throughout Clear Creek and its 18.3 km of tributaries (Ball and Cope 1961).

The fish trap at the mouth of Clear Creek was used in spawn taking operations almost annually from 1913 to 1950. Since 1951, data collected at the trap have been used to investigate the dynamics of cutthroat trout spawning runs, monitor spawner numbers, and document changes in structure of the cutthroat trout spawning population.

Methods

In 1984, the cutthroat trout spawning run was monitored at the fish trap from 25 May to 7 August. Upstream migration was monitored daily between 0800 and 2000 hours, except for 31 May and 16 to 26 June. High water, resulting from spring snowmelt, necessitated closure of the upstream trap during these two periods. A permanent downstream trap was installed and utilized for the first time in 1984, and downstream migration was monitored each day between 0800 and 2400 hours.

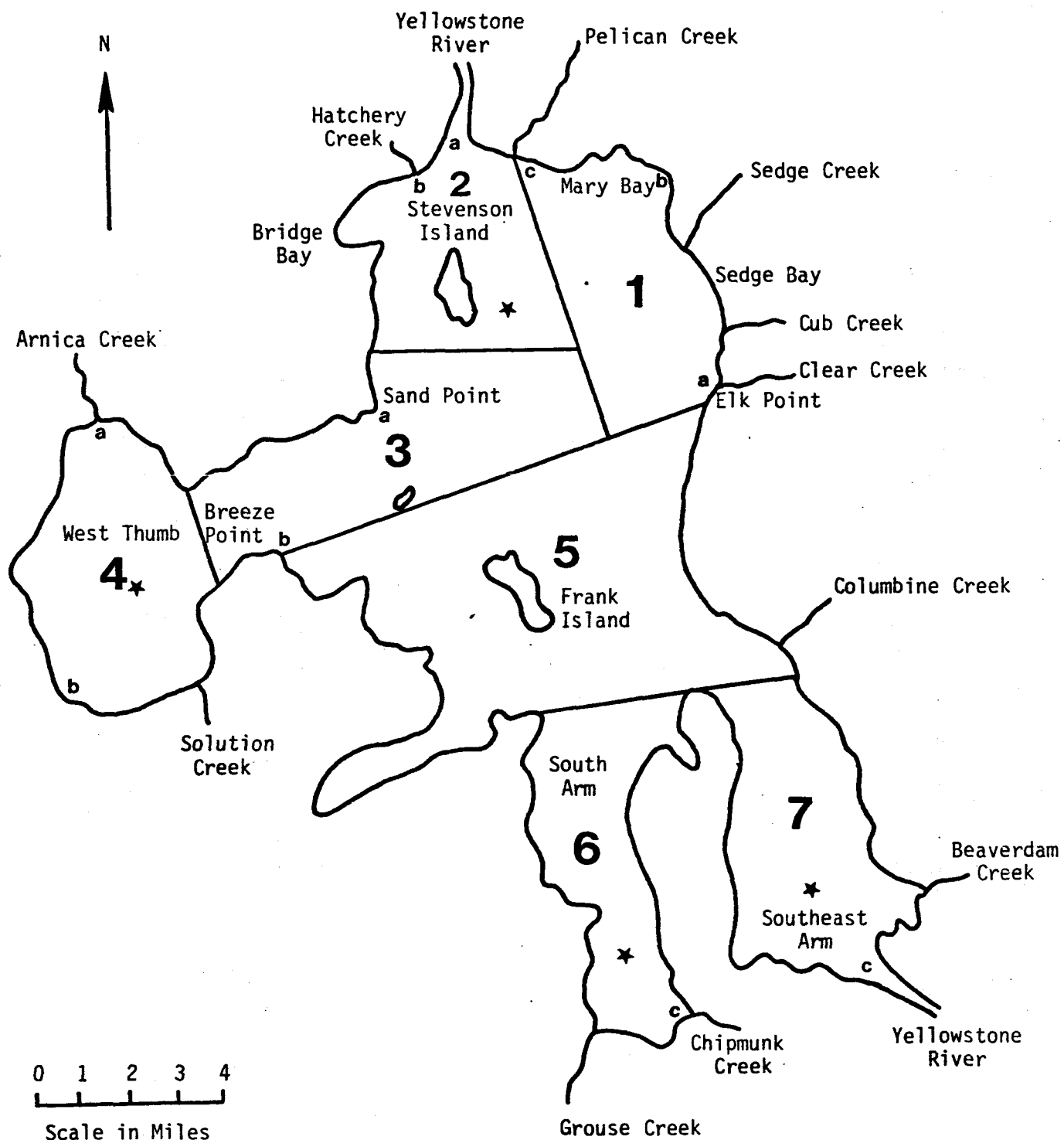


Figure 2. Creel survey, gillnetting, plankton sampling (*), and spawning trap sites, Yellowstone Lake, 1984.

Daily counts of upstream and downstream migrants (hereafter referred to as upstream and downstream trout) were made throughout the monitoring period. Each day, 75 upstream trout (fewer if less than 75 were counted for a given day) were sexed, measured to the nearest 5 mm total length (TL), and inspected for marks and tags. Beginning on 7 June, identical sampling procedures were followed for downstream trout. Diel patterns of upstream and downstream movement of cutthroat trout spawners were investigated during hourly counts from 0800 hours on 3 July to 0600 hours on 4 July.

Each week, an additional 100 upstream trout were sexed, measured to the nearest 1 mm TL, weighed to the nearest 2 g, evaluated for stage of maturity, and inspected for marks and tags. Scales from a subsample of these fish were collected in the manner described by Jones et al (1984) for age-growth analyses.

Stream discharge was monitored using a staff gauge located approximately 400 m upstream of the weir. Daily flows were estimated from a level-flow prediction equation based on 33 flow measurements; twenty-six were obtained at a transect near the gauge and seven were obtained at a transect about 100 m upstream of the gauge. Water temperatures were obtained daily at the weir with a hand held thermometer.

Casual observations of wildlife associated with the spawning run were made throughout the monitoring period. To minimize attraction of bears to the weir, cleanliness procedures (Jones et al 1978) were strictly followed, and plastic tarps were placed over the weir during the peak of the downstream run in an attempt to reduce the number of trout congregating just upstream of the weir.

Results

Upstream Migration

A total of 36,429 cutthroat trout and 16 longnose suckers were counted through the upstream trap. Nearly 82% of the trout ascended between 2 and 13 July. Substantial increases in the number of upstream trout coincided with decreasing water flow and increasing water temperature during this period (Figure 3).

The adipose fin was removed from 42,299 downstream trout in 1979 (Jones et al 1980). In 1984, 4,270 upstream trout were inspected for marks and tags, and 32 fish with adipose fin clips were noted. These data suggest

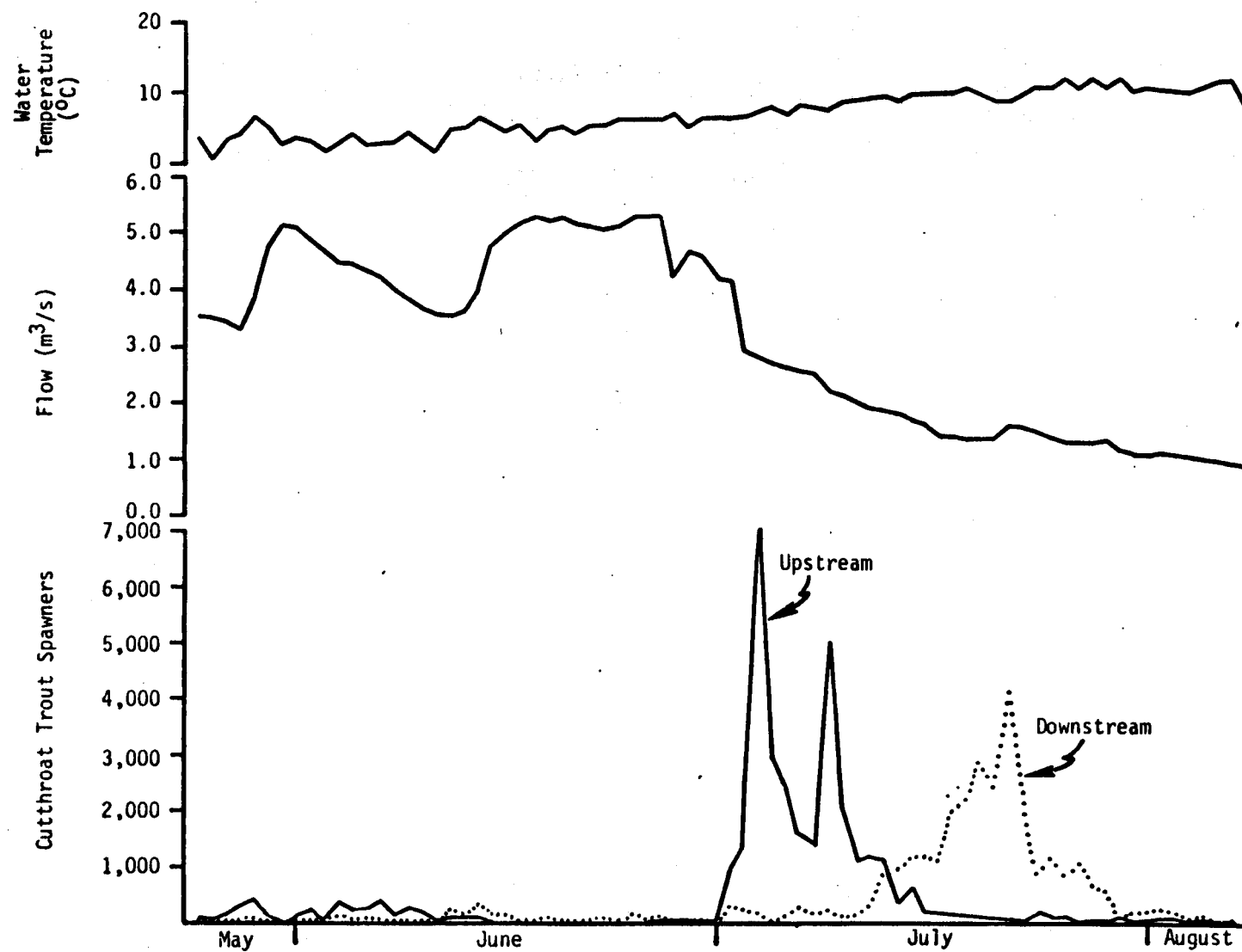


Figure 3. Pattern of daily water temperature, flow, and cutthroat trout spawning migration, Clear Creek, 1984.

that in 1984, 0.75% of the trout entering Clear Creek were clipped, yielding a 0.65% return of 1979 spawners.

Mean length and weight of upstream cutthroat trout were 395 mm (n=4,270) and 753 g (n=700), respectively, the average condition factor (K) was 0.91 (n=700), and the male:female ratio was 0.68:1 (n=4,270). Mean length of males (402 mm) was significantly greater than that of females (390 mm), but average weights were not significantly different (583 and 566 g, respectively). Weekly averages of length, weight, and condition for both sexes were highest in the first two weeks of the run and then generally decreased as the spawning migration progressed (Table 9).

Mean age for an expanded sample of 4,239 upstream cutthroat trout was 5.3 years; approximately 11.2% were age VII+ and older. Mean age of males (5.6 years) was significantly greater than that of females (5.0 years).

Downstream Migration

A total of 32,758 cutthroat trout and 9 longnose suckers were counted through the downstream trap. Approximately 80% of the trout descended between 13 and 29 July. Mean length of downstream trout was 395 mm (n=4,338), and the male:female ratio was 0.70:1 (n=4,338). Mean length of males (403 mm) was significantly greater than that of females (389 mm).

Fingerling trout were first observed near the fish trap on 15 July. Young of the year trout were first seen on 24 July.

Diel Movement

Diel movement monitored on 3 and 4 July revealed that upstream movement of 1,415 trout occurred primarily during hours of daylight. Sixty-seven percent of the upstream trout moved through the trap between 1300 and 2000 hours, and 33% passed upstream between 2200 and 0400 hours. Downstream movement was greatest between 2200 and 0400 hours, when 94% of 231 downstream trout were counted (Figure 4).

Instream Mortality

Since virtually all cutthroat trout from Yellowstone Lake that spawn in Clear Creek return to the lake after spawning (Jones et al 1979), the difference between accurate upstream and downstream counts provides an unbiased estimate of instream spawning mortality. In

Table 9. Seasonal comparison of length, weight and condition factor of cutthroat trout spawners in the upstream trap in Clear Creek, May 29 - July 23, 1984¹⁾.

Date	Males				Females				Totals				M:F ratio
	Number	Average length (mm)	Average weight (g)	Average K factor	Number	Average length (mm)	Average weight (g)	Average K factor	Number	Average length (mm)	Average weight (g)	Average K factor	
May 29-June 4	38	420	688	0.92	62	411	679	0.97	100	414	682	0.95	0.61:1
June 5-June 11	37	429	756	0.94	63	405	662	0.99	100	413	696	0.97	0.59:1
June 12-June 18	36	423	632	0.83	64	399	589	0.91	100	408	604	0.88	0.56:1
July 2-July 9	47	383	508	0.90	53	383	515	0.91	100	383	512	0.91	0.89:1
July 10-July 15	37	390	514	0.86	63	380	497	0.91	100	384	503	0.89	0.59:1
July 16-July 22	41	393	529	0.86	59	378	490	0.90	100	384	506	0.89	0.69:1
July 23-July 29	50	392	504	0.83	50	385	505	0.88	100	389	504	0.86	1.00:1
Composite	286	403	583	0.87	414	392	566	0.93	700	397	573	0.91	0.69:1

¹⁾ Based on daily samples of cutthroat trout which were both measured and weighed; from June 19 to July 1, no upstream trout were sampled.

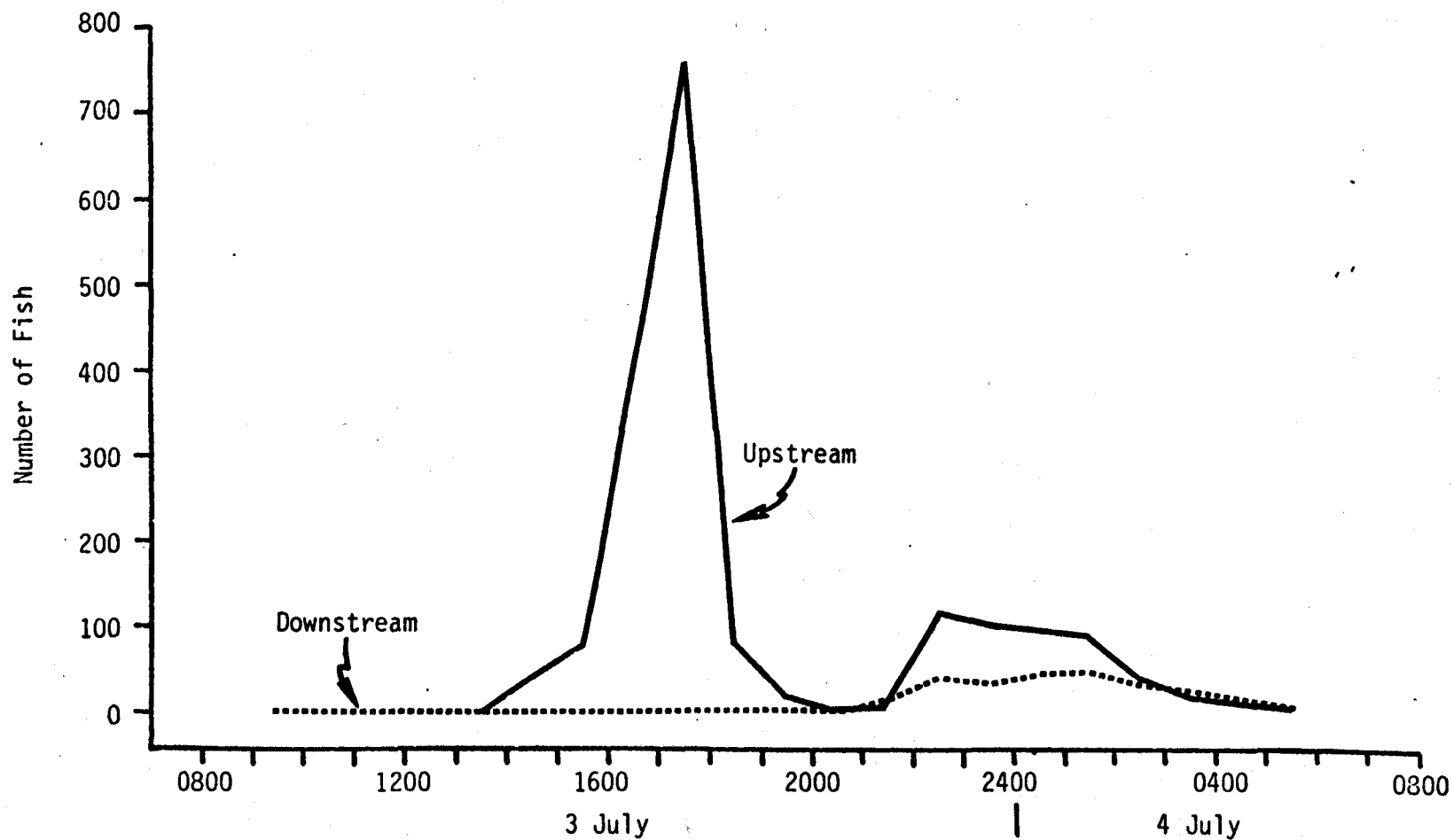


Figure 4. Hourly counts of cutthroat trout spawners passing through the upstream and downstream traps at Clear Creek, 3 July to 4 July 1984.

1984, this difference was 3,671 fish, indicating an instream spawning mortality of 10.1%.

Wildlife Use of Spawning Cutthroat Trout

Bear activity was observed in the trap area throughout the monitoring period. Evidence of bears feeding on fish at the weir was first noted on 5 July. Subsequently, bears visited the trap a few days each week, usually at night, until trap operations ended on 7 August. Other wildlife commonly associated with the spawning run include family groups of mink, common loons, common mergansers, California gulls, as well as several osprey, golden and bald eagles, great blue heron, and white pelicans.

Discussion

Dynamics of the Spawning Run

Although the number of spawners entering Clear Creek is variable, seasonal upstream migration patterns appear quite stable. Numbers generally increase as flows decrease and water temperature approaches 10 C, conditions that usually occur in late June and early July. Larger trout enter the stream first; mean length, weight, and condition gradually decline as the run progresses. Most males are ripe when they enter the stream, but females apparently ripen during upstream migration.

Diel patterns of upstream movement of cutthroat trout spawners in Clear Creek may be more complex than reported in recent years. Jones et al (1984) stated that since 1977, most upstream movement occurred between 1300 and 1700 hours; few upstream trout were seen after dark. In 1984, sampling during daylight hours generally substantiated their findings; however, some upstream movement was also observed between 2200 and 0400 hours on 3 and 4 July. Also, during the peak of the run, upstream trout were often seen congregated below the closed upstream trap between 2200 and 2400 hours. Cope (1956) reported that 81% of 4,485 spawning cutthroat trout entered Arnica Creek between 1800 and 0800 hours, Bulkley (personal communication 1978) observed nocturnal upstream migration in Clear, Cub, and Pelican Creeks in the 1950's. Clearly, additional study is needed to completely ascertain diel patterns of upstream movement of cutthroat trout spawners in Clear Creek and other Yellowstone Lake tributaries.

Downstream migration during the early weeks of the spawning run is mostly nocturnal and appears to follow increases in stream flow between 1900 and 2400 hours. These observations suggest that many postspawners move downstream during periods of heavy runoff. As stream discharge decreases later in the spawning run, the majority of downstream migration occurs between 1300 and 2000 hours.

Ball and Cope (1961) summarized data for spawning runs in five Yellowstone Lake tributaries between 1949 and 1953. They reported a mean instream spawning mortality estimate of 48.1% and stated that cutthroat trout from Yellowstone Lake seldom spawned more than once. In contrast, the mean instream spawning mortality estimate for Clear Creek from 1977 to 1984 was 12.9%, and Jones et al (1982) reported that approximately 23% of the 1979 Clear Creek spawning run survived to spawn again in 1981. Although comparisons between studies may be biased by different sample methods, recent data from Clear Creek indicate greater survival of spawning age fish.

Ball and Cope (1961) observed that the majority of repeat spawners returned in alternate years, and clip returns from Clear Creek (Jones et al 1980, 1981) support this observation. Bulkley (1961), however, found five times as many consecutive year spawners as alternate year spawners, although his sample size from Arnica Creek was small (n=25). Ball and Cope (1961) speculated that alternate year spawning was a physiological manifestation of the low productivity of Yellowstone Lake; however, further investigation is required to fully understand the factors accounting for differences in the percentages of consecutive and alternate year spawners observed between and within trout stocks in Yellowstone Lake.

Magnitude and Population Structure of the Spawning Run

The magnitude and population structure of the Clear Creek cutthroat trout spawning run are affected, in part, by fishery management practices on Yellowstone Lake and the stream itself. Numbers of spawners annually entering Clear Creek have increased substantially since 1960 (Figure 5), and since 1977, the population structure has shifted towards larger and older fish (Figure 6). These trends indicate a positive response of the cutthroat trout population to the cessation of egg-taking operations in 1950 and the implementation of increasingly restrictive angling regulations since 1969.

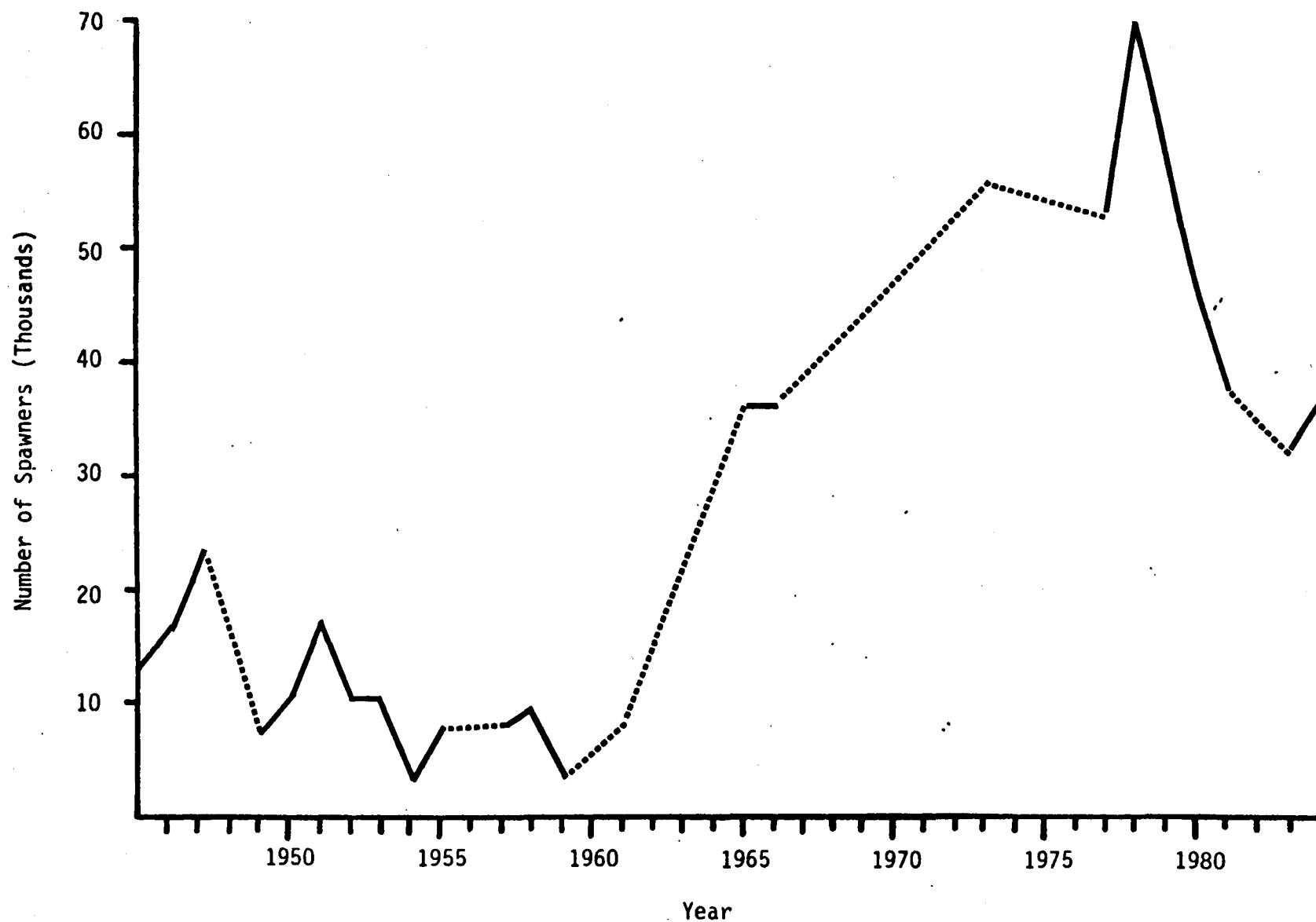


Figure 5. Number of cutthroat trout spawners entering Clear Creek during various sample years, 1945-1984.

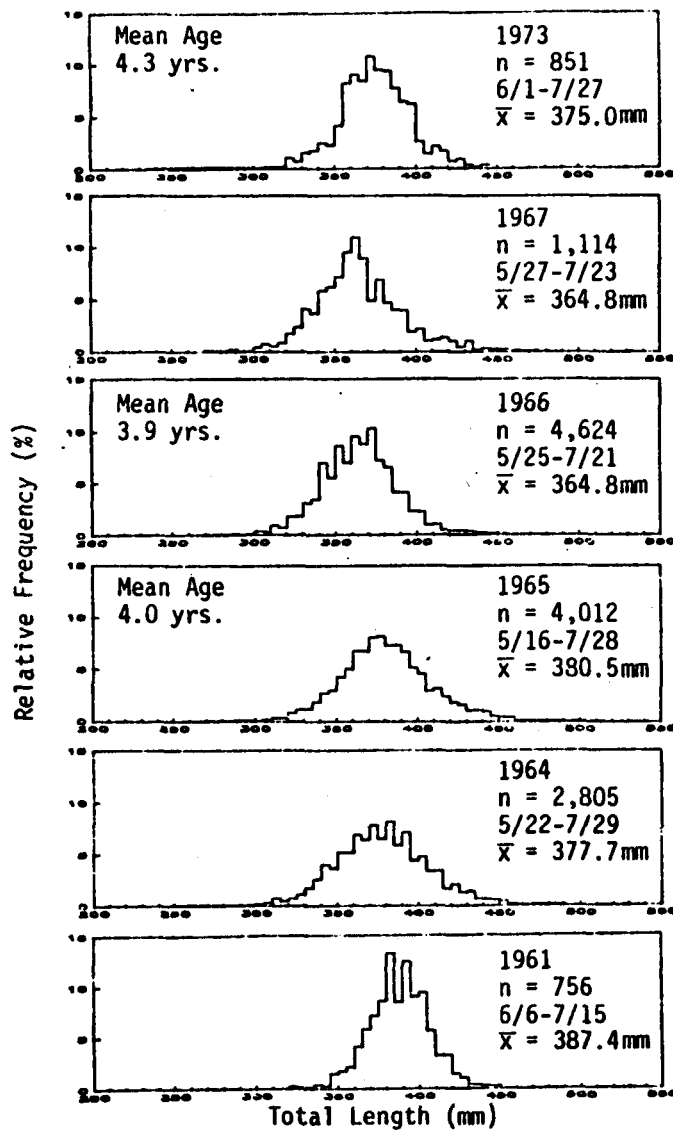
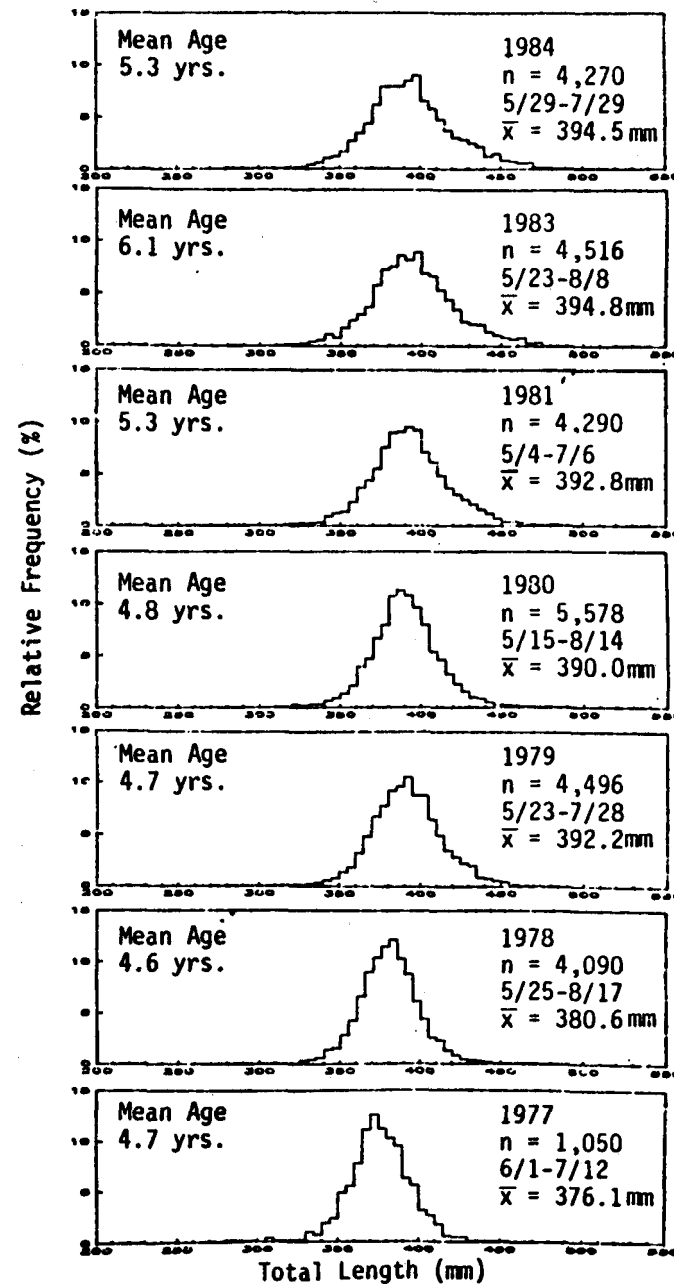


Figure 6. Length frequency, mean length, and mean age of cutthroat trout in the upstream spawning migration, Clear Creek, 1961-1984.



FECUNDITY STUDIES

Evaluation of the 330 mm maximum size limit (2 fish creel) on Yellowstone Lake has suggested several important changes in the structure of the cutthroat trout population. The proportion of older and larger trout has increased in the angler catch, gillnet samples of mature trout, and the Clear Creek and Pelican Creek spawning runs. Additionally, the number of spawners entering these two important spawning streams has increased since the cessation of spawn taking activities (1953). Data concerning absolute fecundity (number of eggs produced by individual females) and population fecundity (the number of eggs produced by all females in a single season) (Bagenal 1978) provide information necessary to interpret the significance of these changes.

During 1982, a pilot study at Clear Creek provided data for comparison of population fecundity through time (Jones et al 1983). Results suggested that absolute fecundity had increased in conjunction with mean length of spawners, and population fecundity had increased significantly in the past 40 years (Jones et al 1983). Precision and accuracy of fecundity estimates obtained in this initial study were questioned because sample size was small (n=25) and the size range of sampled trout was narrow (320-400 mm).

In 1984, a second, more comprehensive examination of fecundity relationships was initiated at Clear Creek. Effort was concentrated on the development of precise field techniques for fecundity estimates, and increasing the reliability of comparisons made with previous samples at Clear Creek.

Methods

From 3 through 25 July 1984, a total of 88 female cutthroat trout were collected as they entered the upstream fish trap at the Clear Creek weir. Trout were divided into 10 mm length groups, and 10 trout were sought for each interval.

Techniques used to estimate absolute fecundity included total egg counts, gravimetric subsamples, and volumetric subsamples. Total counts were obtained for 68 females; fecundity estimates were also completed for 15 of these fish by both gravimetric and volumetric subsampling methods. For an additional 20 females, only the gravimetric technique was used.

The number of eggs in a 5 g (gravimetric) or 5 ml (volumetric) subsample was expanded to approximate the total number of eggs in the ovary (Bagenal and Braum 1978). Each subsample was replicated four times, and the mean of the four replicates provided an absolute fecundity estimate.

Subsample methods were statistically evaluated and compared with actual counts for 15 trout using analysis of variance ($\alpha=0.05$). Length and egg counts from the entire sample were transformed to logarithms (Bagenal and Braum 1978) and fitted to a functional (GM) regression (Ricker 1973, 1975); gravimetric estimates were utilized for 20 trout from which total counts were not obtained. In order to evaluate changes in population fecundity, the number of eggs for females of various sizes was calculated from the regression and compared through time.

Results

Total length of the 88 trout in the fecundity sample ranged from 302 to 428 mm with a mean of 374 mm. Mean body weight and intact ovary weight were 473 g and 81.7 g, respectively; the gonadal-somatic index (GSI) (LeCren 1951) was 17.33.

The volumetric subsampling technique produced a mean of 1,367 eggs (± 117) for the 15 trout in the methods comparison. Average deviation from the mean number of eggs in four replicates was 2.9%, and individual estimates deviated from -8.9% to 7.4%. The predicted volumetric mean was greater than the average number actually counted (1,280 ± 125), but differences were not statistically significant. A linear regression of counted eggs on volumetric estimates yielded a coefficient of determination (R^2) of 0.87; the mean volumetric estimate predicted by the regression equation was virtually identical to the mean number actually counted.

The average estimate from the gravimetric subsamples (1,372 ± 144) was also greater than the actual count mean in the 15 trout comparison; however, differences were not statistically significant. The average deviation from the four replicate mean was somewhat lower (1.6%), and the range of individual estimates (-6.9% to 7.6%) was narrower than with the volumetric subsamples. Linear regression of the gravimetric estimates and the actual counts ($R^2=0.99$) also predicted the exact number of counted eggs.

Since the gravimetric subsampling technique was quicker and provided somewhat less variable results, this method was chosen to be used in conjunction with the linear regression correction to predict the number of eggs for 20 females which were not sampled by actual counts. These values were added to actual counts from the remaining trout (n=68) to produce an overall mean sample fecundity of 1,227 eggs per female. The length-fecundity equation for the entire sample (n=88) was: $\log F = 2.7622 (\log L) - 9.2685 (R^2=0.28)$.

A preliminary estimate of population fecundity was obtained by multiplying the predicted number of eggs (1,354) for the average length female in the spawning population (390 mm) by the total number of females in the run (21,684) (Bagenal 1978). The resulting estimate (29.4 million eggs) is only 1% greater than an estimate produced by expanding the length-fecundity relationship by the length frequency of the total female spawning population (29.0 million eggs). A third method of estimating population fecundity utilized the mean number of eggs per age group; expanding by the age distribution of females in the spawning run yielded 27.5 million eggs.

Discussion

Comparisons between fecundity estimates revealed several interesting insights concerning the various sampling techniques. Although differences were not statistically significant, variation among replicates was lower with the gravimetric method. Both of the subsampling techniques overestimated the mean number of eggs; however, the gravimetric method provided a much higher coefficient of determination when regressed with actual counts.

For field application, total egg counts were the easiest and least time consuming in the current study. After the ovaries were removed and weighed, the eggs could be preserved for counting at a later time. Replication increased sampling time with gravimetric and volumetric subsampling techniques; however, once a relationship between subsample estimates and actual counts has been established, a single gravimetric subsample should provide mean values statistically similar to actual counts at a greatly reduced level of effort.

According to Bagenal (1978), findings by Pitcher and McDonald (1973) suggest that population fecundity estimates predicted by a standard logarithmic regression of egg numbers and length commonly underestimate the

number of eggs. Pope et al (1961) and Raitt (1968) developed corrections to compensate for this underestimate, and Pitcher and McDonald (1973) suggested calculating population fecundity directly from a length frequency distribution. A GM regression (Ricker 1973) should also provide improved estimates, and in the current study, the number of eggs utilizing the GM regression of egg number and length was greater than the value obtained from the length frequency.

Determining the correct population fecundity value is difficult, but agreement between the two methods utilizing length suggests precision is adequate. The age-fecundity relationship apparently underestimates population fecundity, and Bagenal and Braum (1978) reports variability, especially in short lived species, may make this method of expansion difficult. Since one of the primary uses of fecundity estimates is comparison with previous research, the mean length and egg number prediction method is probably the most useful for Yellowstone Lake studies; past samples are generally limited to mean length, sex ratio, and spawner numbers (Benson and Bulkley 1963).

Although a large amount of data on the cutthroat trout has been collected from Yellowstone Lake, few studies have evaluated fecundity. Cope (1957) utilized data obtained during spawn taking operations to estimate mean absolute fecundity at Clear Creek. His estimate of 1,018 eggs/female represented a mean covering 12 years (1941-1952). Current estimates represent a 33% increase in mean absolute fecundity; however, factors such as the method of obtaining eggs (stripped or excised), estimation technique, and length of individual trout may influence the result.

Length data were not available for evaluation with egg estimates developed by Cope (1957). By combining spawner counts from Clear Creek for 1953-1955 (Benson and Bulkley 1963) and mean length of spawners for the same years (Bulkley 1961), a weighted mean of 368 mm was estimated for this period. This length represents all spawners, and because males are larger than females, the mean for females was probably lower. Therefore, a mean of 352 mm for female spawners for the 1941-1952 period was estimated by the current length-fecundity equation. Although there is definitely room for error in this estimate, the current (1977-1984) mean length (386 mm) for female spawners in Clear Creek suggests that the rise in absolute fecundity may be directly related to increases in mean length.

This conclusion may appear intuitive and is supported by many other studies (Bagenal 1978, Nikolsky 1969); however, a decrease in average size of eggs could also increase absolute fecundity if total ovary weight remained unchanged. Since within any species, larger eggs generally have greater survival (Nikolsky 1969), a decrease in average egg size could affect the population significantly. Comparison with hatchery data presented by Cope (1957) suggests a decline in egg size and ovary weight in recent years. Current estimates (15.3 eggs/g) indicate that egg size is only 58% of that reported for the 1941 through 1952 period (9.7 eggs/g); however, additional data presented by Cope (1957) fail to support the apparent change in egg size. Regressions with the number of eggs and ovary weight were developed for Pelican Creek, Chipmunk Creek, and Grouse Creek in 1945. Despite differences between streams, all three equations predicted values similar to those in the current study.

According to Bagenal (1978) such apparently contradictory evidence is common in comparisons of relative fecundity, and he warns that meaningful analysis of relative fecundity requires thorough knowledge of the data base and rigorous statistical analysis. Bagenal (1978) emphasizes that comparisons should be based on length-fecundity relationships. Although there have undoubtedly been variations in absolute fecundity of the cutthroat trout in Yellowstone Lake in the past 40 years, most of these changes were probably related to density dependent mechanisms, and changes in egg size have probably not been significant during that period.

Ball and Cope (1961) reported spawning trout in Yellowstone Lake tributaries seldom returned to spawn again. Although sampling error may bias comparisons (see Clear Creek this report), recent studies with fin-clipped trout at Clear Creek indicate that 23% of spawners marked in 1979 survived to return in 1981.

Since Bagenal (1978) and Nikolsky (1969) state that fecundity generally increases in repeat spawners, a rise in the incidence of repeat spawning could contribute to changes in absolute fecundity observed in recent years.

Historic data for comparisons of population fecundity of Clear Creek spawners are limited. By combining data from various studies, however, estimates of population fecundity were developed for three different periods (Table 10). Although historic estimates may not be precise, differences between periods are large enough to provide meaningful comparisons. Current population

Table 10. Fecundity estimates for various time periods, Clear Creek, 1945-1984.

Years	Number of Spawners	Sex Ratio (Male:Female)	Female Spawners (1x2)	Mean Length Females (mm)	Estimated Absolute Fecundity (Number of eggs)	Population Fecundity (Millions of eggs)
1945-1961	10,592 ¹⁾	0.73:1 ²⁾	6,122	---	1,018	6.2
	10,592	0.73:1 ²⁾	6,122	379 ⁴⁾	1,251	7.6
1965-1966	36,164 ⁶⁾	1.73:1 ²⁾	20,904	372 ⁴⁾	1,188	24.8
1973	55,818	0.73:1	88,266	372	1,188	39.5
1977	58,641	0.61:1	82,696	374	1,206	39.4
1978	70,105	0.69:1	41,482	378	1,242	51.5
1979	58,244	0.52:1	38,318	388	1,335	51.1
1980	47,115	0.52:1	30,997	388	1,335	41.4
1981	37,439	0.53:1	24,470	390	1,354	33.1
1983	32,496	0.68:1	19,343	390	1,354	26.1
1984	36,429	0.68:1	21,684	390	1,354	29.4
1977-1980 ⁶⁾	57,026	--	35,873	383	--	46.2
1981-1984 ⁶⁾	35,454	--	21,832	390	--	29.6

1) Estimated from data (1945-1961) presented by Benson and Bulkley (1963).

2) Estimated from data (1945-1953) presented by Ball and Cope (1961).

3) Cope (1957).

4) Mean length of males and females combined and therefore considered a maximum.

5) Estimated from fecundity-length equation using mean length of males and females and therefore considered a maximum.

6) Values based on arithmetic means.

fecundity at Clear Creek, 29.6 million eggs annually, appears to be slightly greater than the calculated value for the mid-1960's (24.8 million eggs) and between four and five times that estimated for the period between 1945-1961 (6.2-7.6 million eggs).

It is apparent that in addition to important changes in the population structure observed since the implementation of the 330 mm maximum size limit, there has also been an increase in the number of eggs annually produced. Although fecundity estimates are closely linked to changes in spawner numbers and average size (Table 10), they help to elucidate the importance of these structural shifts. These estimates underscore the ability of the current angling regulations to provide a high degree of protection to this fragile system, while allowing an annual harvest approaching 100,000 trout.

LARGEMESH GILLNETTING

Largemouth gillnetting has been conducted annually on Yellowstone Lake since 1969 (excluding 1973 and 1975) (Dean et al 1970-1975; Varley et al 1976; Jones et al 1977-1984). The primary objective has been to monitor relative abundance, distribution, and population structure of cutthroat trout and longnose suckers. Each year current methods and results are presented and long term trends are discussed.

Methods

In 1984, largemouth gillnetting was conducted from 17 to 21 September. Swedish experimental gillnets used in 1984 were identical to those employed in all years except 1981 (see Jones et al 1982 for a description of nets used in 1981). These monofilament nets were 38 m long, 1.5 m deep, and comprised of 7.6 m long graduated mesh panels of 19, 25, 32, 38, and 51 mm (bar measure).

Each of eleven sites (Figure 2) were sampled once during the five day period. At each site, five nets were set between 1300 and 1500 hours and retrieved the following day between 0800 and 0900 hours. Nets were set perpendicular to the shoreline in water depths ranging from 1.5 to 4.6 m. Spacing between nets was approximately 100 m.

In the laboratory, captured fish were first separated by site, net, and species; individuals of each species were then sorted from largest to smallest in length. Each fish was inspected for marks and tags, measured to the nearest 1 mm total length, and weighed to the nearest

2 g. By examining the gonads, each fish was assigned a stage of maturity according to the terminology of Jones et al (1979). Scales for age-growth analyses were collected from every third trout. The presence of Ligula intestinalis was noted in longnose suckers.

Results

Cutthroat Trout 1984

A total of 1,053 cutthroat trout were captured. Average number of trout per net was 19.5. Mean length, weight, and condition (K) of a sample of 1,052 trout were 281 mm, 259 g, and 0.92, respectively (Table 11). One trout that had been fin-clipped at Pelican Creek in 1980 was caught at site 1b; no tagged trout were captured.

Average number of trout per net differed significantly between the 11 sample sites (Appendix A Table 1). The highest number was caught at site 2b (32 trout/net). Intermediate numbers were captured at sites 1a, 1c, 7c, and 3b (25, 23, 21, and 20 trout/net, respectively). Catches at remaining sites averaged less than 17 trout/net.

Average number of trout per net also differed significantly among the four lake zones (North: 1a, 1b, 1c, 2a, 2b; Central: 3a, 3b; West Thumb: 4a, 4b; South: 6c, 7c) (Appendix A Table 2). The greatest number was captured in the North (22 trout/net). Central and South had intermediate catches (19 and 18 trout/net, respectively). The catch at West Thumb was the lowest (14.5 trout/net).

Mean lengths of trout captured at the 11 sample sites were significantly different (Appendix A Table 1). Average lengths were greatest at sites 4b, 1b, 6c, 3b, and 1c (325, 317, 309, 306, and 298 mm, respectively), and intermediate at sites 4a, 2a, 7c, 1a, and 3a (282, 271, 271, 263, and 259 mm, respectively). Mean lengths were lowest at site 2b (239 mm). Mean lengths of trout captured at each site were inversely correlated with average number per net at each site ($r=-0.62$).

Significant differences also occurred in mean lengths of trout captured in the four lake zones (Appendix A Table 2). Average length was largest at West Thumb (304 mm), intermediate at South and Central (286 and 286 mm, respectively), and smallest in the North (272 mm). Mean length of trout captured in each zone were negatively correlated with average numbers per net in each zone ($r=-0.99$).

Table 11. Length frequency distribution, average lengths, weights, and condition factors of nonspawning and prespawning cutthroat trout and longnose suckers captured in largemouth gillnets, 1.5-4.6 m depth interval, Yellowstone Lake, 1984.

Species	Maturity category ¹⁾	Size-group (lower length of interval - mm)									Total number	Average total length (mm)	Average weight (g)	Average condition factor (K)
		100	150	200	250	300	350	400	450	500				
Cutthroat Trout	Nonspawners	2	233	213	180	98	90	20	1		837	254	185	0.92
	Prespawning males		1	2	3	11	43	44	8		112	389	571	0.93
	Prespawning females		1			12	56	33	1		103	382	523	0.92
	TOTALS AND AVERAGES	2	235	215	183	121	189	97	10		1052	281	259	0.92
Longnose Sucker	Nonspawners	3	62	119	40	28	4				256	227	160	1.17
	Prespawning males			1	10	46	63	99	10		229	385	679	1.17
	Prespawning females					10	40	76	111	13	250	439	683	0.85
	TOTALS AND AVERAGES	3	62	120	50	84	107	175	121	13	735	349	500	1.06

¹⁾ Prespawning fish defined as those judged to have sufficient gonadal development to spawn in 1985; nonspawners include immature, and mature fish which were judged to lack sufficient gonadal development to spawn in 1985.

Approximately 20% of all trout captured were categorized as prespawners (prespawning fish were those judged to have sufficient gonadal development to spawn in 1985) (Table 12). Mean length, weight, and condition (K) of prespawners were 386 mm, 548 g, and 0.93, respectively. The prespawner male:female ratio was 1.09:1. Nearly 88% of male prespawners and 98% of female prespawners were between 300 and 450 mm in length (Table 12). Mean length of prespawners was poorly correlated with average number of trout per net in either sites ($r=-0.08$) or zones ($r=-0.01$).

Longnose Suckers 1984

A total of 737 longnose suckers were captured (Appendix A Table 3). Average number per net was 13.6. Mean length, weight, and condition (K) of a sample of 735 longnose suckers were 349 mm, 500 g, and 1.1, respectively (Table 11). Two longnose suckers that had been fin-clipped at Pelican Creek in 1980 were captured; one was caught at site 1c and the other at site 2b.

Approximately 65% of all longnose suckers captured were categorized as prespawners. The prespawner male:female ratio was 0.29:1. Ninety-one percent of male prespawners were between 300 and 450 mm in length and 91% of female prespawners were between 350 and 500 mm in length (Table 13).

Discussion

Although the experimental design of the largemouth gillnetting program has been modified since the program began in 1969, data are comparable for 13 of 14 years in which studies have been conducted. Significant differences in efficiency were found between nets used in 1981 and those used in all other years (Jones et al 1982); therefore, data from 1981 have been deleted to prevent confounding comparisons between years.

Cutthroat Trout 1969-1984

Relative Abundance and Distribution. The average number of trout per net has varied significantly since 1969 (Table 12). The increasing trend observed from 1970-1977 was thought to be due to reduced harvests under increasingly restrictive angling regulations (Jones et al 1978), and the decreasing trend seen from 1978-1982 was believed to be associated with a shift in biomass towards larger fish under the 330 mm maximum size limit (2 fish creel) (Jones et al 1983). No data are available to test the accuracy of these speculations;

Table 12. Comparative largemouth gillnetting results, cutthroat trout, 1.52-4.57 m depth interval, Yellowstone Lake, 1969-1972, 1974, 1976-1980, and 1982-1984.

Year	Number of gillnet sets ¹⁾	Average number trout per net	95% confidence interval of number trout/net	Mean length (mm)	% of trout over 356 mm (TL)	% of trout over 406 mm (TL)	% of trout over 457 mm (TL)	Percent of prespawning trout ²⁾	Prespawning male:female ratio	Average length of prespawning males (mm)	Average length of prespawning females (mm)	Condition factor (K)
1969	9	12.22	+6.71	311	29.1	1.8	0.0	53.6	1.06:1	353	346	0.924
1970	11	12.27	+5.90	315	26.7	3.0	0.0	46.6	1.73:1	359	351	0.917
1971	5	14.40	+9.76	321	37.5	1.4	0.0	54.3	1.50:1	360	368	0.853
1972	11	13.63	+3.57	313	32.7	3.3	0.0	39.8	0.52:1	358	369	0.937
1974	11	15.45	+4.75	298	34.7	0.6	0.0	56.4	1.00:1	349	359	0.859
1976	11	15.00	+3.06	317	37.6	2.4	0.0	48.6	1.43:1	370	365	0.877
1977	44	15.55	+1.98	290	33.0	4.7	0.2	75.6	0.98:1	376	362	0.892
1978	55	13.93	+1.06	308	37.5	5.4	0.3	65.7	1.06:1	383	372	0.923
1979	55	13.60	+1.27	303	32.3	7.4	0.1	59.0	0.91:1	387	374	0.915
1980	55	13.00	+1.53	309	40.6	7.1	0.3	50.1	1.05:1	389	376	0.884
1982	55	10.60	+1.05	322	47.1	12.7	0.7	61.7	1.10:1	389	379	0.909
1983	55	18.05	+1.67	288	32.5	9.6	0.8	52.2	1.12:1	396	360	0.901
1984	54	19.50	+1.88	281	26.1	7.6	0.5	52.6	1.09:1	389	382	0.921

1) Number of sets has been limited to the 1.52-4.57 m depth interval to ensure comparability.

2) Percentage of cutthroat trout over 304 mm (TL) which were judged to have sufficient gonadal development to spawn the following spring.

Table 13. Comparative largemouth gillnetting results, longnose suckers, 1.52-4.57 m depth interval, Yellowstone Lake, 1969-1972, 1974, 1976-1980, and 1982-1984.

Year	Number of gillnet sets ¹⁾	Average number suckers per net	95% confidence interval of number suckers/net	Mean length (mm)	% of suckers over 356 mm	% of suckers over 406 mm	% of suckers over 457 mm	Percent of prespawning suckers ²⁾	Prespawning male:female ratio	Average length prespawning males (mm)	Average length prespawning females (mm)	Condition factor (K)
1969	9	16.33	+10.65	365	66.0	29.2	6.1	92.1	1.28:1	382	419	1.207
1970	11	6.45	+5.01	393	83.1	59.2	12.7	100.0	0.08:1	386	440	1.235
1971	5	37.00	+42.17	316	34.0	17.8	2.7	100.0	2.00:1	357	417	1.207
1972	11	2.54	+1.29	335	42.9	28.6	7.1	83.2	2.00:1	378	428	1.205
1974	11	15.91	+5.92	370	69.7	29.1	5.7	100.0	1.28:1	372	415	1.215
1976	11	14.55	+5.36	389	80.6	44.4	7.5	95.2	1.07:1	387	425	1.227
1977	44	7.25	+1.83	401	80.9	55.5	14.7	100.0	1.48:1	390	441	1.229
1978	55	7.25	+1.99	363	58.3	38.9	11.1	92.5	1.13:1	385	435	1.187
1979	55	12.64	+2.07	371	62.6	45.2	13.0	87.8	0.99:1	399	440	1.197
1980	55	9.98	+1.82	365	59.3	39.4	12.6	78.1	1.12:1	370	432	1.171
1982	55	8.64	+2.13	356	51.1	37.2	12.5	65.2	0.95:1	373	438	1.209
1983	55	11.36	+1.87	341	50.1	36.5	12.8	57.3	1.21:1	381	442	1.183
1984	54	13.65	+2.29	349	55.2	39.3	14.0	98.6	0.92:1	386	439	1.059

1) Number of sets has been limited to the 1.5-4.6 m depth interval to ensure comparability.

2) Percentage of longnose suckers over 310 mm (TL) which were judged to have sufficient gonadal development to spawn the following spring.

however, a direct correlation ($r=0.61$) between the percentage of trout in the catch less than 203 mm and average number of trout per net suggests that the relative abundance of age I and age II trout influences the total number of trout caught each year.

Combining 13 years of gillnetting data, differences in the average number of trout per net were significant between the 11 sample sites (Appendix A Table 1). Differences were not significant, however, among the four lake zones (Appendix A Table 2). Interpretation of these data is confounded by the absence of observable trends.

Population Structure. Mean length of captured trout has varied significantly since 1969 (Table 12). Similar results were obtained when data were combined over years and compared by site and zone (Appendix A Tables 1 and 2). An inverse correlation ($r=-0.89$) between the percentage of trout less than 203 mm in the catch and the mean length of all captured trout probably reflects year-class fluctuations of smaller trout.

Since the mean length of prespawners is not affected by the proportion of smaller trout in the catch, yearly comparisons of prespawners may be used to detect length trends in mature trout. Mean length of prespawners has risen almost every year since 1974 (Figure 7). Although the extent of the change has been more pronounced for males than for females, increases for both sexes are viewed as a positive response to the 330 mm maximum size limit (2 fish creel) instituted on Yellowstone Lake in 1975.

Changes in length-distribution patterns of the gillnetting catch have also occurred since the 330 mm maximum size limit was instituted in 1975 (Figure 8). The shift towards larger trout in the 330 to 400 mm and 400 to 500 mm length groups suggests a greater survival of older age groups. The decline in relative abundance of trout between 260 and 330 mm may be related to the fact that approximately 91% of all trout creeled from Yellowstone Lake are between 230 and 360 mm (Jones et al 1984); however, other unknown factors may also be involved. Future gillnetting operations, in conjunction with other Yellowstone Lake investigations, should address whether the observed decline in the relative abundance of trout between 260 and 330 mm in the gillnetting catch represents a real decrease and, if so, whether this decrease is severe enough to negatively affect the cutthroat trout population as a whole.

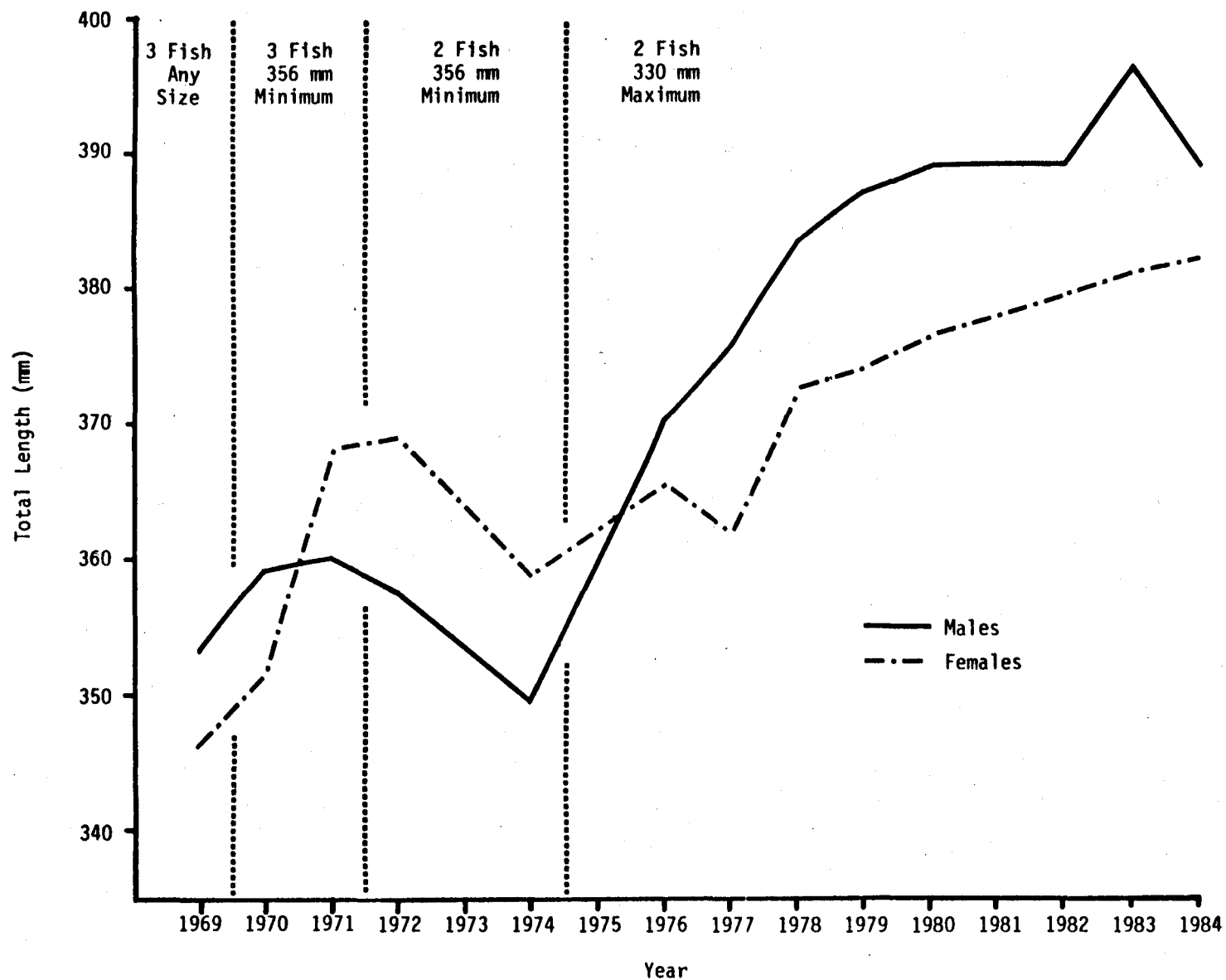


Figure 7. Mean total length of prespawning cutthroat trout captured in largemouth gillnets, Yellowstone Lake, 1969-1984

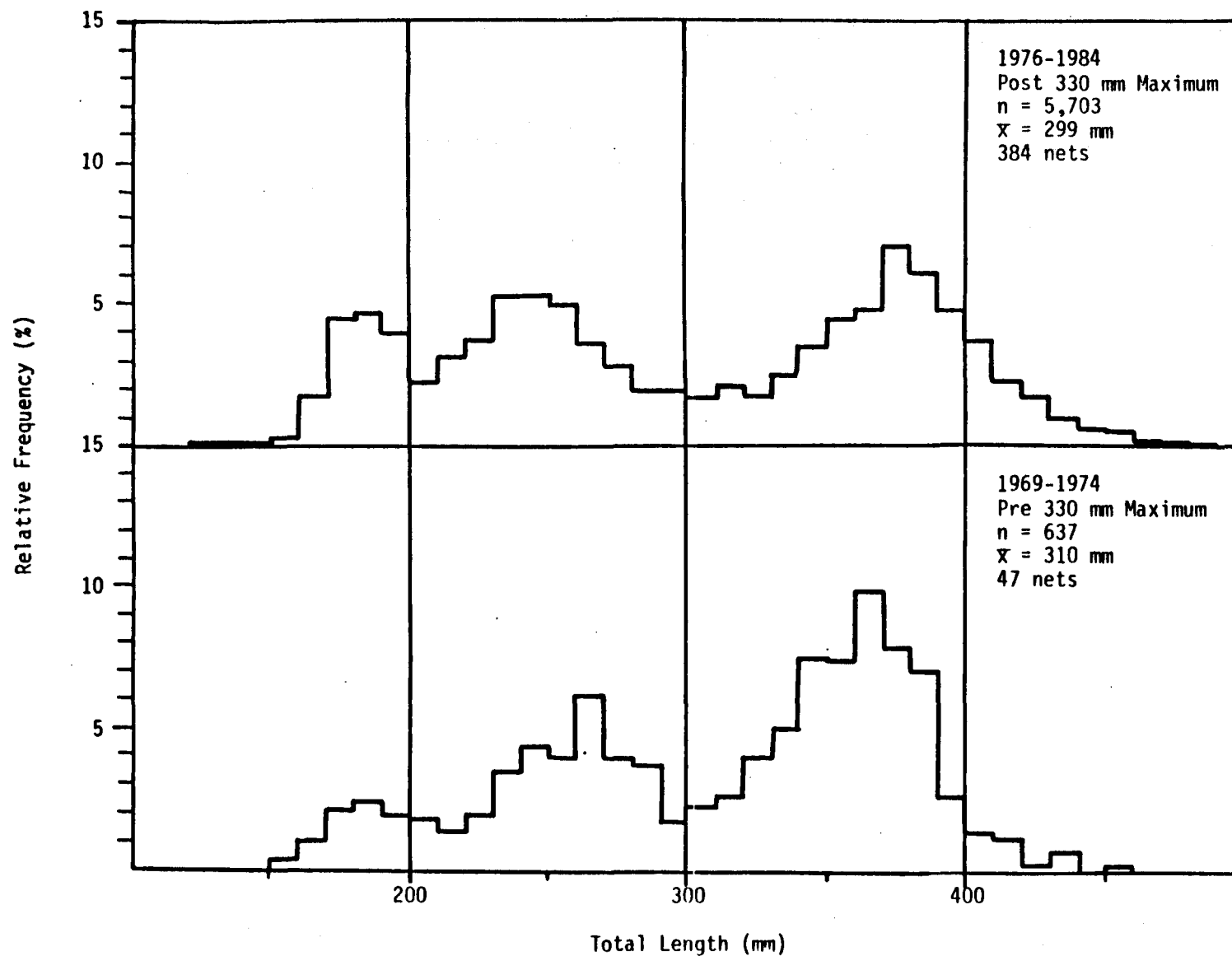


Figure 8. Length frequencies of cutthroat trout captured in largemouth gillnets at the 1.5-4.6 m depth interval in Yellowstone Lake, 1969-1984 (excluding 1981).

Longnose Suckers 1969-1984

Average number per net. Although differences between years in the number of suckers captured are significant (Table 13), reasons for these changes remain unidentified. It is doubtful these differences are due to population fluctuations since the longnose sucker is believed to be long-lived in Yellowstone Lake (Jones et al 1977). These fluctuations may be partially due to schooling behavior; such behavior would intensify variation in the gillnet catch.

Average size. Comparisons between years (Table 13) yield significant differences in mean length. Mean length of suckers has been inversely correlated to the male:female ratio ($r=-0.78$) and directly correlated to the percentage of suckers over 310 mm ($r=0.94$) (Jones et al 1981). Since the latter two factors are probably related to distribution, annual variations affecting numbers captured may also affect variations in mean length.

The largemesh gillnetting program has provided only minimal information concerning the longnose sucker. Although a more suitable method of monitoring the sucker population might be developed, an increasing amount of evidence suggests that the longnose sucker and cutthroat trout are probably not competing either temporally or spatially in Yellowstone Lake. It would be more beneficial, therefore, to channel future effort to further describing the relationship between the two species.

CONCLUSIONS

It appears that the 330 mm maximum size limit is accomplishing the objective of increasing the proportion of older and larger cutthroat trout in Yellowstone Lake. Scattered historic size data and current estimates utilizing the Walford line (Ricker 1975) suggest a maximum of 11 age groups prior to modern angler exploitation. Since Ricker (1963) has stated that exploitation as low as 5% annually may significantly alter a pristine population, the cutthroat trout population may never reach historic levels under current regulations.

It is apparent, however, that the 330 mm maximum size limit has been more successful at approaching historic levels than any regulations utilized thus far. Average age at Clear Creek is the highest it has been in the past three decades; the appearance of age IX+ trout is

significant. Average lengths of trout landed in the fishery, spawners at Clear Creek, and prespawners in fall-set gillnets are among the greatest yet recorded (Figures 9 and 10). Fecundity estimates suggest that current reproductive potential in Clear Creek is five times greater than it was during the 1950's.

What may be as important as the shift in population structure is that these changes are occurring while use (in the range of 150,000 angler days annually) and effort (over 350,000 angler hours) remain high. Despite these levels of pressure, the landing rate has been excellent, averaging 0.94 trout/hour since 1975. The continued decrease in creel rate during this period is indeed curious, but data indicate that it is not related to a depletion of legal size trout.

The biological response to altered harvests patterns associated with the 330 mm maximum size regulation are not completely understood at present, but harvesting trout prior to maturity shifts fishing mortality to life stages which may better be able to withstand high levels of exploitation. The relatively short period that trout are vulnerable to harvest in Yellowstone Lake may also influence results. Most trout do not enter the fishery until approximately 300 mm (11.8 in) and are beyond the legal limit within one growing season.

As angler use and effort steadily increased, creel limits as low as three trout per day failed to protect the structure of this cutthroat population. Fishing closure or "no kill" (catch and release) regulations would undoubtedly provide maximum protection. The 330 mm maximum size limit, however, not only provides substantial protection, but allows a daily creel limit which satisfies most anglers. Currently five large trout (356-457 mm) are captured and released for each trout under 330 mm creeled. Over two-thirds of all anglers catch one or more trout, and over one-third creel one or more. Excellent landing rates, often associated with "no kill" regulations, have been sustained while anglers have retained the privilege of harvesting trout for a campfire meal.

Results from the Yellowstone Lake fishery during the first ten years of the 330 mm maximum size limit are indeed encouraging; however, it should be emphasized that these results may not describe an equilibrium condition. Future increases in angler use may have a profound effect on the cutthroat trout population despite the protection afforded under the current regulation. Continued research is essential to the evaluation of the 330 mm maximum size limit especially under higher levels of use.

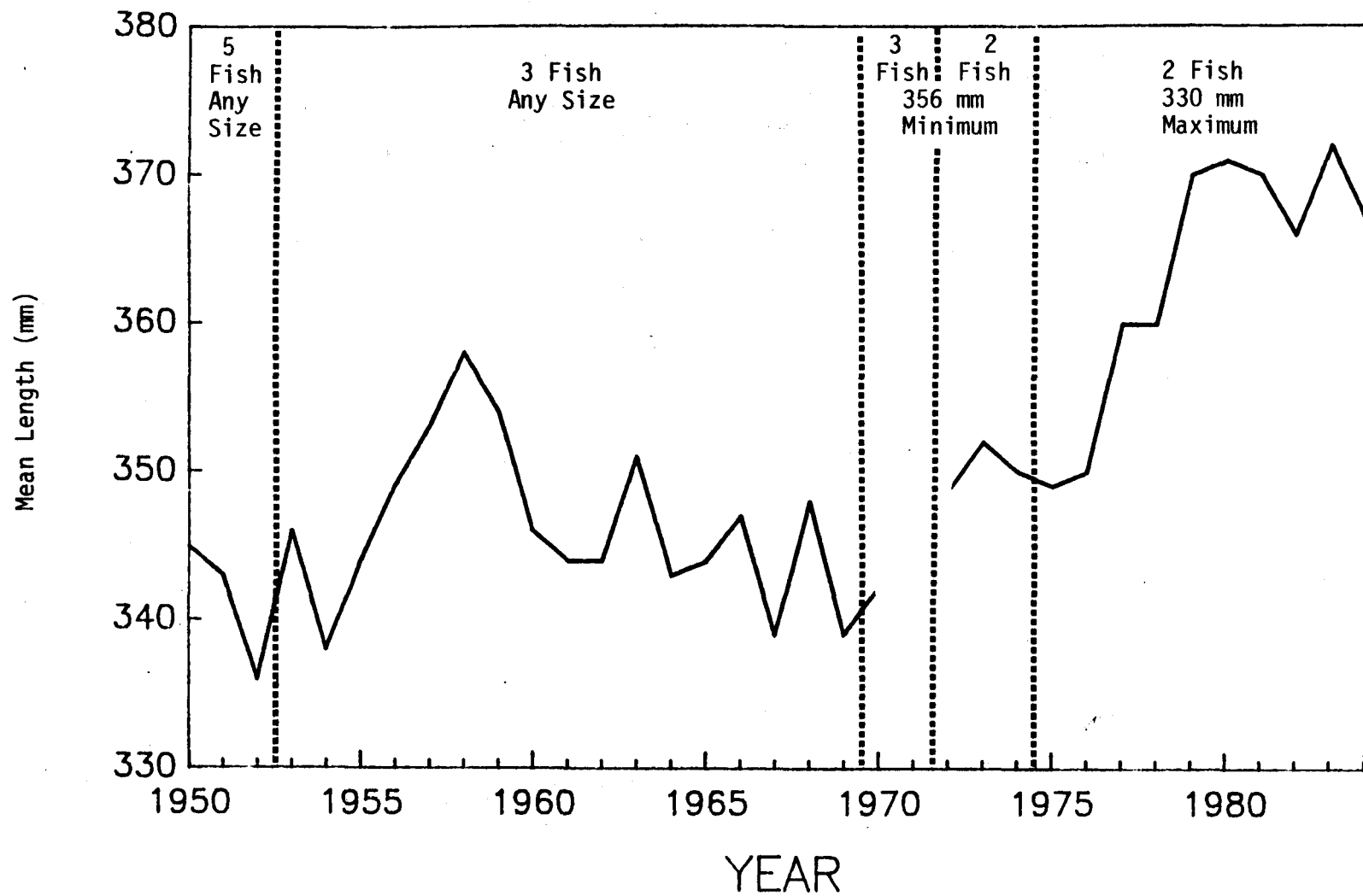


Figure 9. Mean length of cutthroat trout captured in the fishery measured at boatdocks (1950-1962) and shoreline-boatdocks combined (1963-1984).

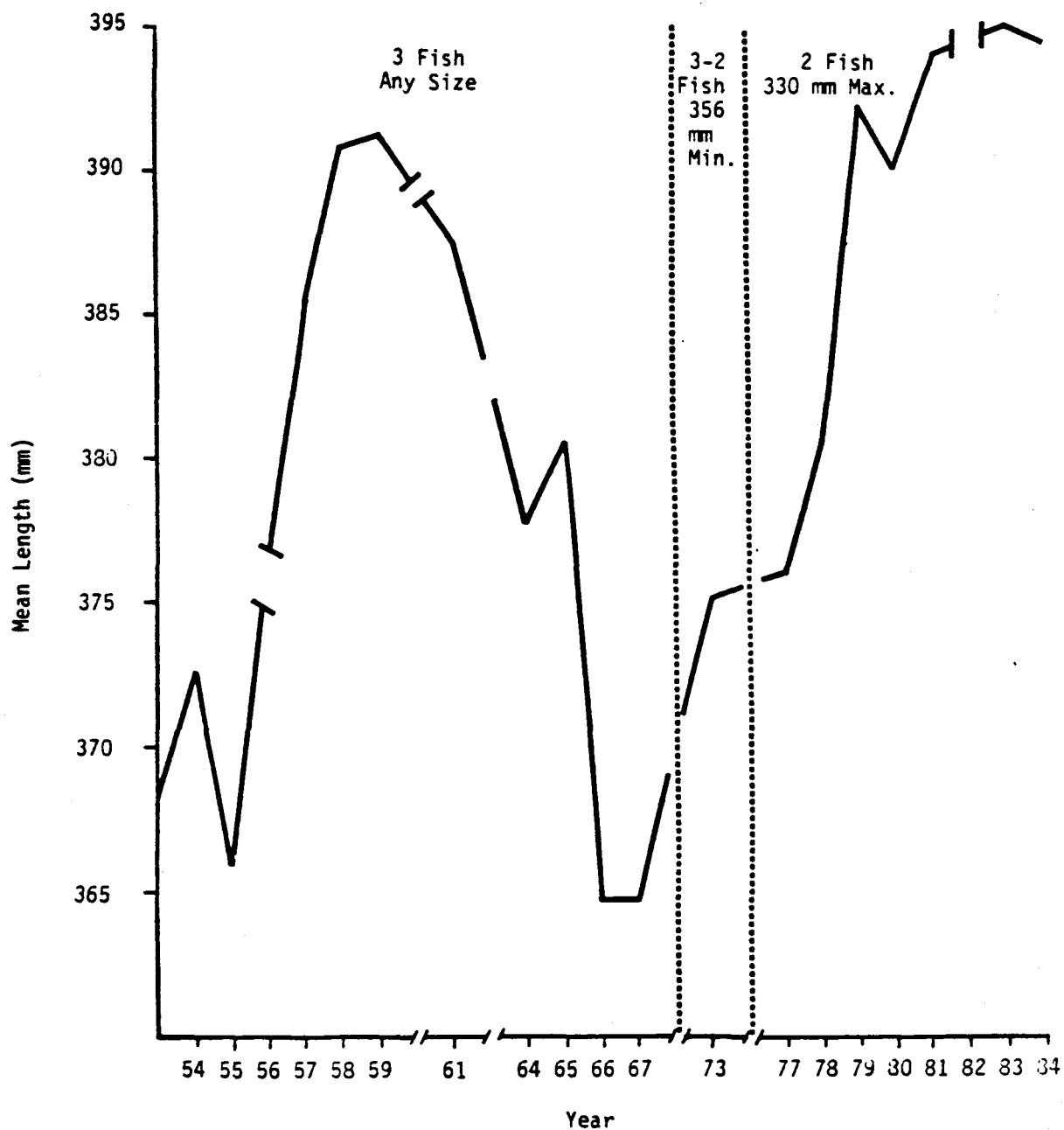


Figure 10. Mean length of cutthroat trout spawners entering Clear Creek, 1953-1984.

YELLOWSTONE RIVER (CATCH AND RELEASE AREA)

Approximately 14 km (8.8 mi) of the Yellowstone River between Yellowstone Lake and Upper Falls have been managed under a catch and release regulation since 1973. This area annually supports over 80% of the total angler use on the Yellowstone River (114 km or 71 mi in the Park) and is the second most popular Park fishery. Although there may be some interaction with cutthroat trout from Yellowstone Lake, this area is treated as a discrete fishery.

Fishery research on the Yellowstone River between the lake and the falls dates back to 1950 (Moore et al 1952). Since that time, various studies have been conducted to monitor angler impact on this important cutthroat trout fishery. Research since 1973 has been concentrated on the evaluation of the catch and release regulation. In 1984, studies included a creel survey utilizing the VAR system (Jones et al 1977) and continued sampling of spawning trout at LeHardy Rapids.

CREEL SURVEY

In 1984, angler use on the catch and release segment of the Yellowstone River (44,500 angler days) rose to the second highest level since 1973. An estimated 17,300 anglers spent 114,000 hours and captured 109,021 cutthroat trout. Approximately 2,537 of these trout were illegally creeled. Despite the high level of use, catch rate was 0.96 trout/hour (Table 14).

When the upper and lower portions of the catch and release area were examined separately, the upper section (9.8 km) sustained 93% of the angler use for the entire area (41,500 angler days or 4,200 angler days/km). A total of 15,700 anglers captured 105,400 trout while expending 108,700 hours of effort. Catch rate was 0.97 trout/hour.

The number of angler days in the lower section increased approximately 36% (3,000 angler days or 700 angler days/km) from 1983. Approximately 1,600 anglers expended 5,200 angler hours. Although effort is much lower in this section, catch rate was only 0.68 trout/hour. Expanded results indicate that of 3,600 trout landed, approximately 140 were illegally creeled.

Average size of cutthroat trout landed for the entire catch and release area rose to a record high of 401 mm (15.8 in). Trout from the upper portion were significantly larger than those in the lower section

Table 14. Creel survey summary, Yellowstone River between Fishing Bridge and Chittenden Bridge, 1951-1955, 1967, 1976, 1970, 1972, 1973 through 1984¹⁾.

Regulation	Year	Angler Days (trips)	Mean Length Trip (hours)	Total Hours Fished	Landing Rate	Total Trout Landed	Creel Rate	Total Trout Creel	Angler Days Per mile ²⁾	Angler Days Per Acres ²⁾	Angler Hours Per Acres ²⁾	Mean Angler Expertise ³⁾	Percent Trout Landed And Released	Average Length Trout Creel ⁴⁾	Average Length Trout Landed
4.2 Fish creel limit ⁵⁾ No size limit Bait fishing permitted	1951-1955 Average	45,430	1.97	89,500	6)	6)	0.41	36,700	2,800	99	195	-	6)	6)	6)
3 Fish creel limit No size limit Bait fishing permitted	1967-1968 Average	44,300	2.00	88,625	6)	6)	0.43	38,100	4,600	167	334	-	6)	13.5"	6)
3 Fish creel limit 14" Minimum size limit Bait fishing prohibited	1970-1972 Average	45,120	1.87	84,700	0.74	62,500	0.18	14,825	4,700	170	318	-	76.2	14.7"	6)
Catch and release	1973	25,000	2.35	58,750	1.74	102,200	0.01	590	2,900	106	250	-	99.4	6)	14.3"
Lures and flies only	1974	23,900	2.31	55,700	2.25	124,200	0.01	550	2,700	102	235	-	99.9	6)	14.4"
Bait fishing prohibited	1975	27,900	2.48	69,200	2.04	141,100	0.01	690	3,200	119	295	-	99.5	6)	14.5"
	1976	30,900	2.45	75,700	1.43	108,200	0.01	980	3,600	132	322	2.00	99.8	6)	14.7"
	1977 ⁷⁾	26,900	2.44	65,600	1.43	93,900	0.02	1,300	3,100	114	279	1.98	99.6	14.3"	14.7"
	1978	26,300	2.50	65,700	1.23	80,800	0.02	1,100	3,000	112	280	1.99	99.6	13.3"	15.1"
	1979	28,900	2.60	75,300	1.10	82,800	0.02	1,500	3,300	123	320	2.02	99.3	13.2"	15.3"
	1980	34,900	2.44	85,100	1.06	88,700	0.02	2,000	4,000	148	362	2.04	99.0	13.5"	15.3"
	1981	48,800	2.60	126,800	1.00	127,100	0.01	1,800	5,600	208	540	2.01	98.6	13.1"	15.4"
	1982	35,000	2.46	86,600	1.10	95,400	0.02	1,400	4,000	150	369	2.00	98.5	12.4"	15.6"
	1983	39,300	2.61	102,400	1.06	109,000	0.01	1,400	4,500	167	436	1.98	99.8	12.5"	15.6"
	1984	44,500	2.56	114,000	0.96	109,000	0.02	2,500	5,100	189	485	2.00	97.7	11.8"	15.8"

1) Statistics for 1951 through 1972 have been converted from summer to season-long estimates.

2) Yellowstone River between Fishing Bridge and Chittenden Bridge is 16 miles long and averages 458 acres. Area open to fishing was 9.7 miles and 265 acres between 1965 and 1972. Beginning in 1973, the area open was 8.7 miles and 235 acres.

3) Based on formula: 1.0 = inexperienced, 2.0 = experienced, 3.0 = expert.

4) Illegal beginning in 1973.

5) 3 years of 5 fish creel limit plus 2 years of 3 fish creel limit.

7) Revised upward 6% from that reported (Jones et al 1978).

6) Not measured.

(402 and 387 mm, respectively). Mean length of creeled trout for the entire catch and release area was 300 mm, and mean length was the same for both of the respective sections.

Approximately 85% of the anglers were satisfied by their overall experience, and 80% were satisfied with numbers landed and 90% were satisfied with size fish landed. Levels of satisfaction decreased from 1983; however, estimates remain well above the Park mean. The proportion of single day anglers landing one or more trout was 67%; average expertise remained high at 2.00.

LEHARDY RAPIDS

Catch and release angling was implemented on the Yellowstone River between Fishing Bridge and Upper Falls in 1973 (Dean et al 1974). Annual monitoring of cutthroat trout migrating through LeHardy Rapids was initiated in 1974 (Dean et al 1975) to evaluate the effects of this regulation on cutthroat trout population structure. Sampling techniques established by Dean et al (1975) have been followed each year, except for scale samples, which are collected in the manner described by Varley et al (1976).

Results and Discussion

In 1984, 526 adult cutthroat trout were captured during weekly sampling between 8 June and 27 July. No subadult cutthroat trout or other fish species were observed. Peak movement apparently occurred between 15 June and 6 July, as weekly samples of 100 fish were readily obtained during this period.

Mean lengths of all adults (399 mm), males (408 mm, n=321), and females (386 mm, n=199) captured in 1984 are the highest yet reported (Table 15 and Figure 11). The percentage of trout larger than 406 mm TL (39.0%) in the current sample is also the greatest on record (Figure 12). Average age of an expanded sample of 510 adults (5.3 years) is the oldest since 1980 (Figure 13).

Increases in mean length of all adults, the percentage of all trout greater than 406 mm TL, and average age of all adults have been observed in most years since 1974 (Figures 11, 12, and 13). General trends towards larger and older fish suggest that the catch and release regulation, by substantially reducing angling mortality, has had a positive impact on cutthroat trout migrating through this section of the Yellowstone River.

Table 15. Total number and average length, weight and condition factor of cutthroat trout for each year sampled at LeHardy Rapids, Yellowstone River, 1974-1984.

Year	Adult Males				Adult Females				All Adults				Immatures and Subadults			
	Number captured	Average length (mm)	Average weight (g)	Average K factor	Number captured	Average length (mm)	Average weight (g)	Average K factor	Number captured	Average length (mm)	Average weight (g)	Average K factor	Number captured	Average length (mm)	Average weight (g)	Average K factor
1974 ¹⁾	177	375	394	0.75	244	352	339	0.78	453	362	363	0.76	43	177	60	0.84
1975	338	385	451	0.78	426	359	363	0.78	775	370	401	0.78	40	205	118	1.04
1976 ¹⁾	531	384	431	0.75	423	362	360	0.75	964	375	399	0.75	29	173	71	1.04
1977 ¹⁾	133	382	429	0.77	111	362	370	0.78	245	373	402	0.77	2	250	139	0.87
1978	399	386	458	0.78	358	364	413	0.85	759	376	437	0.81	68	169	62	0.96
1979	334	394	514	0.83	237	371	431	0.84	571	385	480	0.83	5	225	122	0.91
1980	293	391	488	0.81	190	372	418	0.80	483	384	460	0.81	2	247	184	0.94
1981	383	394	496	0.80	188	373	440	0.84	571	387	478	0.82	7	308	286	0.89
1982	327	401	517	0.80	367	380	474	0.86	694	389	494	0.83	26	281	218	0.70
1983	338	402	546	0.83	232	380	276	0.86	570	394	517	0.84	1	225	100	0.88
1984 ²⁾	321	408	530	0.79	199	386	477	0.82	526	399	515	0.80	0	---	---	---

1) Due to erroneous measurements, fish were deleted from average weight and K factor calculations only, as follows: 6 males and 2 females from 1974, 1 male and 2 females from 1976, and 1 male and 1 female from 1977.

2) Six adults not identified to sex.

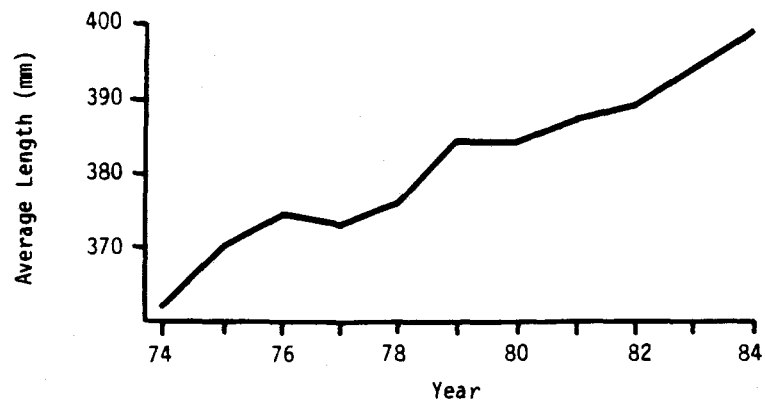


Figure 11. Average length for the entire season for all adults, LeHardy Rapids, 1974-1984.

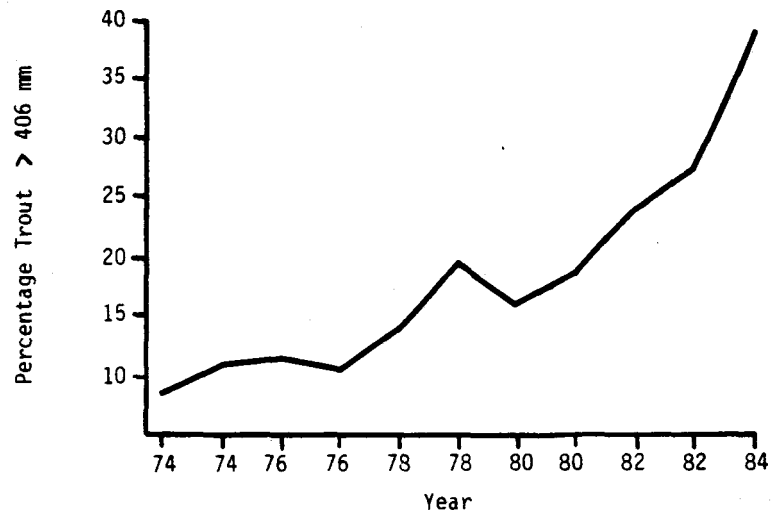


Figure 12. Percentage of adult trout greater than 406 mm captured at LeHardy Rapids, 1974-1984.

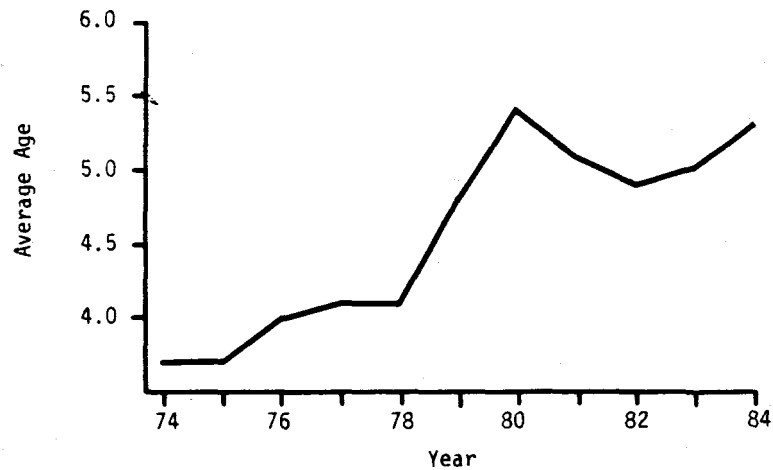


Figure 13. Average age of all adult trout captured at LeHardy Rapids, 1974-1984.

In 1984, the male:female ratio of a sample of 520 adults was 1.61:1. Sex ratios observed at LeHardy Rapids are high compared to those found at three cutthroat spawning tributaries of Yellowstone Lake. Since 1977, male:female ratios at LeHardy Rapids have ranged from 0.89:1 to 2.04:1 while those at Clear, Cub, and Pelican Creeks have ranged from 0.52:1 to 0.79:1. Based on the assumption that males are more susceptible to angling mortality than females, Jones et al (1983) speculated that high sex ratios at LeHardy Rapids were associated with the elimination of harvest under the catch and release regulation. The assumption has not been formally tested, and other unknown reasons may account for the high sex ratios observed at LeHardy Rapids; however, none of the various size and creel limit regulations implemented on Yellowstone Lake since 1945 have appreciably changed the male:female ratios found in Clear, Cub, and Pelican Creeks.

CONCLUSION

Angler use and effort have increased steadily since the catch and release regulation was implemented in 1973. Despite a precipitous decline in use after this regulation was initiated, current levels are among the highest yet recorded (Table 15). These figures equated to 3,179 angler days/km (5,100 angler days/mi), or 468 angler days/ha (189 angler days/acre) in 1984. According to these data, the catch and release portion of the Yellowstone River sustains the highest level of use in the Park and is probably one of the most intensively fished wild trout fisheries in North America. Angler effort per unit area on this section of the river (1,200 angler hours/ha or 485 angler hours/acre) has only been surpassed once (1981) since the 1950's (Table 15).

Increasing use and effort have affected the landing rate. As effort declined after implementation of catch and release, landing rate more than doubled and rose to a high of 2.25 trout/hour in 1974 (Table 15). As effort increased, landing rates gradually declined. Most significant, however, is that despite record levels of effort, landing rate remains over 0.90 trout/hour.

Regardless of increases in effort and concomitant decreases in landing rate, size structure of the population appears to be moving toward historic proportions. Length frequency analysis of cutthroat trout captured in the spawning run at LeHardy Rapids reveals a definite shift towards larger trout (Figures 11 and 12 and Table 15). Length frequency and

mean length of cutthroat trout landed by anglers also indicates a substantial increase in larger trout (Tables 14 and 16). A general rise in average age has accompanied the increase in size at LeHardy Rapids.

Table 16. Percentage of trout in various length categories, catch and release section, Yellowstone River, 1973-1984.

Year	305 mm	356 mm	406 mm	457 mm	508 mm
1973	36.3	62.5	17.3	3.1	0.7
1974	89.5	63.3	26.6	6.6	1.2
1975	92.7	60.4	15.4	2.6	0.3
1976	90.0	67.7	24.3	4.4	0.7
1977	89.2	68.7	26.2	5.3	0.9
1978	91.1	71.6	33.2	9.0	1.8
1979	92.5	77.5	35.9	8.7	1.0
1980	93.8	77.8	37.6	9.2	1.2
1981	95.4	82.6	35.8	7.6	1.1
1982	96.4	82.3	40.7	8.6	1.5
1983	96.7	85.9	39.9	10.7	2.3
1984	95.9	84.3	46.6	12.3	1.9

Although there is an inverse relationship between effort and landing rate, changes in population structure have also influenced landing rate. As biomass shifts toward older and larger trout, the number of trout will probably decrease (Nikolsky 1969). The interaction of these two factors (increases in effort and shifts in structure) may gradually lower landing rates in the future; however, since 1979, rates have remained quite stable.

Hooking mortality and recatchability are critical to the success of the catch and release regulation. Schill et al (In press) report hooking mortality of 0.3% on a per capture basis, or 3% of the total population for a portion of the upper catch and release section. The recatchability of the cutthroat trout is evidenced in these estimates. Comparison of total landings for the upper portion of the catch and release section (123,800 cutthroat trout) and population estimates for the 9.8 km segment (1,750 trout/km) suggests that trout may be captured an average of seven times during the 108 day season. This figure emphasizes the value of the catch and release regulation and illustrates how such a regulation can support high levels of effort on cutthroat trout.

Although it is possible that effort may rise to a point that the catch and release regulation can no longer maintain angling excellence, it is evident that this regulation currently supports record levels of use while still providing the important elements of quality. Population estimates and creel data reveal the necessity for low mortality and high recatchability to accomplish these management goals. It is evident that both factors are closely related to the species and the habitat involved. The high recatchability of cutthroat trout and excellent habitat conditions in this portion of the Yellowstone River undoubtedly contribute to the continued success of the catch and release regulation.

LAKE SURVEY PROGRAM

INTRODUCTION

Since 1963, data describing physical, chemical, and biological parameters of 112 Park lakes have been collected in conjunction with the lake survey program. The objective of this program is the fundamental inventory of lacustrine systems which provide baseline data necessary to assess changes through time. Analysis of angler impact is an integral part of this program and has been utilized to monitor the effects of various angling regulations. In 1984, aquatic surveys were conducted on two lakes.

Although sampling techniques have varied during the past 22 years, data are reasonably comparable. With few exceptions, current methods are those described by Dean and Mills (1970). Since 1974, one water sample from each lake has been comprehensively analyzed by a commercial laboratory. In order to enhance comparability, additional samples were collected for many of the lakes surveyed prior to 1974.

Plankton samples have been collected with a Wisconsin plankton net; a single 9.1 m oblique tow, or the equivalent, has been made for each lake survey since 1973. From 1973 through 1980, plankton were enumerated by a method modified from McNabb (1960). Beginning in 1981, zooplankton and phytoplankton samples were quantified using methods described by Wetzel and Likens (1979).

Both largemouth and smallmouth experimental gillnets have been utilized to sample aquatic vertebrate populations since 1971. Largemouth nets are 38.1 m long with 7.6 m graduated mesh panels of 19, 25, 32, 38, and 51 mm bar mesh. Smallmouth nets are 30.5 m long with four 7.6 m panels of 10, 13, 16, and 19 mm bar mesh. Both types are approximately 1.8 m deep and constructed of monofilament materials.

RIDDLE LAKE

Riddle Lake is a moderate size backcountry lake with a surface area of 110.9 ha. A well marked trail (3.5 km long) provides easy access from the trailhead located approximately 4 km south of Grant Village on the South Entrance Road. The area is extremely popular for day use and overnight camping at four campsites along the lake shore.

Cutthroat trout are native to Riddle Lake and were the only species present historically. Currently both longnose suckers (Catostomus catostomus) and reidside shiners (Richardsonius balteatus) also inhabit the lake. It is assumed that the cutthroat trout and the nonnative species originally gained entry from Yellowstone Lake via Solution Creek.

Lake surveys conducted in 1970 and 1971 described physical and chemical properties of the lake and presented data concerning the fish population under the 356 mm minimum size (2 fish creel) regulation in effect at that time (Dean 1972). The regulation changed to a 356 mm maximum size limit in 1974, but creel limit remained unaltered. In that year, the lake was resurveyed in order to determine the method of recruitment for the cutthroat trout population and to evaluate angler response to the new regulation (Dean et al 1975). The size limit was changed again in 1975 to coincide with the 330 mm maximum size regulation on Yellowstone Lake. A fourth survey conducted in 1981 indicated that the 330 mm maximum size limit had failed to provide adequate protection for the cutthroat trout in Riddle Lake. Since the recommended catch and release regulation could not be initiated, the lake was closed to all sport angling in 1982.

Results of a survey conducted in 1983 indicated that the cutthroat trout population had continued to decline. Lack of Volunteer Angler Report (VAR) data due to the angling closure limited the means of evaluating changes in the Riddle Lake cutthroat trout population. An increase in sampling was recommended in order to improve documentation and interpretation of current trends.

On 7-8 August 1984, an abbreviated survey was conducted on Riddle Lake in order to continue monitoring activities on the cutthroat trout population.

Physical

A detailed physical description of Riddle Lake was previously provided by Jones et al (1982). Water temperature in 1984 varied from 18.3 C at the surface to 9.4 C at the bottom (7.0 m). Surface warming was evident to 2.6 m, but temperatures dropped steadily from that point. A secchi disc reading (3.4 m) in the tea-brown water was the same as reported in 1983 (Jones et al 1984); both readings were somewhat below that reported in 1981 (Jones et al 1982).

Chemical

On the basis of the water sample collected at 1.8 m below the surface, Riddle Lake (TDS = 13 ppm) was again classified as a dilute lake (TDS < 50 ppm). Predominant ions were calcium and bicarbonate (Table 17). Dominant ions continued to vary in Riddle Lake; such changes have occurred often among samples from dilute Park waters. This variability is probably related to the extremely low chemical concentrations in conjunction with differences in physical and biological conditions at the time of sampling. Thus far, Riddle Lake has displayed at least five different ion types (Jones et al 1982).

Of principal interest, however, is the nutrient paucity of Riddle Lake. Most chemical constituents are below the Park mean for dilute lakes (n=54). Silica levels were below the level of detection (0.1 ppm). Low levels of essential nutrients may possibly inhibit the recovery of the cutthroat trout population in Riddle Lake despite the cessation of angler harvest.

Limnoplankton

Total plankton diversity (14 genera) and density declined again in 1984; however, diversity of phytoplankton (6 genera), rotifers (4 genera), and crustaceans (5 genera) (Table 18) remained above average for Park lakes. Density differences were due to declines in phytoplankton numbers; zooplankton numbers were the highest yet recorded for Riddle Lake. Plankton samples continue to represent an oligotrophic type of diatom-blue-green algae association (Wetzel 1975) common in nutrient poor Park lakes. Dominance of rotifers and small cladocerans among the zooplankton suggests significant piscine grazing (Wetzel 1975).

Aquatic Vertebrates

Two largemouth and one smallmouth gillnets captured 25 cutthroat trout and 127 longnose suckers.

Cutthroat Trout

Average length and weight for the 25 trout were 217 mm and 120 g, respectively, and mean condition factor (K) was 0.85 (Table 19). Total length ranged from 140 to 326 mm. The male:female ratio was 4:1; all females were immature.

All of the cutthroat trout were aged using the scale method (Lagler 1956). Back-calculated lengths were 63,

Table 17. Chemical characteristics of backcountry lakes surveyed in Yellowstone National Park, 1984.

	Riddle Lake 8/7/84	Sylvan Lake 7/19/84
Water Temp. °C*	18.3	16.9
Spec. Cond. (umhos)*	20.9	72
pH*	6.75	7.3
Dissolved Oxygen (ppm)*	6.2	7.8
Pheno. Alkalinity	0	0
Total Alkalinity	8.1	33.4
Ca Hardness	4.99	24.8
Total Hardness	<9.11	32.0
Total Diss. Solids	13	48
Carbonate Alkalinity	0	0
Bicarbonate Alkalinity	8.1	33.4
Carbonates	0	0
Bicarbonates	9.9	40.7
Hydroxides	0	0
Carbon dioxide	2.63	1.72
Chloride	<1.0	<1.0
Sulfate	2.1	2.4
Fluoride	0.041	0.046
Potassium	<1.0	0.29
Mg Hardness	<4.12	7.27
Calcium	2.00	9.91
Magnesium	<1.00	1.77
Sodium	1.02	2.69
Iron	0.29	<0.10
Manganese	<0.05	<0.05
Copper	<0.01	0.01
Silica	<0.1	3.74
Color (PCU)	30	0
Turbidity (NTU)	1.4	0.2
Total Organic Carbon	<1.0	6.6
Total Phosphate	<0.03	<0.03
Nitrate N*	--	<0.01

* Field measurements, all others made by commercial laboratory.

Table 18. Occurrence and density (number per liter) of common net plankton from Yellowstone National Park, 1984.

Genera		Riddle Lake	Sylvan Lake
Division	Pyrophyta (brown algae)		
	<u>Ceratium</u>	36	1
Division	Chrysophyta (yellow-green algae)		
	<u>Asterionella</u>	2	P
	<u>Meridion</u>	P	
	Unidentified diatoms	4	
Division	Cyanophyta (blue-green algae)		
	<u>Anabaena</u>		1
	<u>Gleotrichia</u>	2	
	<u>Nostoc</u>	22	
Class	Rotatoria (rotifers)		
	<u>Asplanchna</u>	12	2
	<u>Conochilus unicornis</u>	64	8
	<u>Kellicottia longispina</u>	129	23
	<u>Keratella</u> sp.	43	2
Order	Cladocera (water fleas)		
	<u>Daphnia schødleri</u>		18
	<u>Daphnia</u> sp.	27	
	<u>Holopedium gibberum</u>		19
Order	Copepoda (copepods)		
	<u>Cyclops bicuspidatus thomasi</u>	4	5
	<u>Diaptomus ashlandi</u>	22	
	<u>Nauplii</u>	13	2
TOTAL PHYTOPLANKTON PER LITER		66	2
TOTAL ZOOPLANKTON PER LITER		314	79
TOTAL PLANKTERS PER LITER		380	81
NUMBER GENERA PER LAKE		14	11

P = Present

Table 19. Gillnetting results from Yellowstone backcountry lakes surveyed in 1984.

Location	Species	Year	Number of Nets ¹⁾		Total Number Captured	Length (mm)			Weight (g)			Mean K Factor
			Largemesh	Smallmesh		mean	n	range	mean	n	range	
Riddle Lake	Cutthroat Trout	1970 ²⁾	3	0	50	298	50	175-415	264	50	56-604	0.86
		1971 ²⁾	3	1	63	308	63	90-455	298	63	6-836	0.91
		1974 ³⁾	3	2	77	261	77	117-420	221	77	12-600	0.89
		1981 ⁴⁾	2	1	35	189	29	75-282	79	29	6-182	0.90
		1983 ⁵⁾	2	1	13	250	13	138-332	150	13	112-322	0.83
		1984	2	1	25	217	25	140-326	120	24	21-321	0.85
	Longnose Sucker	1970	3	0	14	238	14	190-250	142	14	76-164	1.04
		1971	3	1	1	270	1	---	220	1	---	1.12
		1974	3	2	87	163	87	112-392	67	87	12-624	0.98
		1981	2	1	140	208	139	105-448	346	66	90-986	1.14
		1983	2	1	69	325	69	214-453	397	69	100-928	1.05
		1984	2	1	127	312	127	174-435	360	103	80-796	1.00
Sylvan Lake	Cutthroat Trout	1978 ⁶⁾	2	2	504	162	433	75-330	125	92	16-338	0.96
		1981	2	1	200	167	96	75-307	81	96	6-216	0.83
		1984	2	1	132	198	132	88-272	81	132	8-234	0.92
	Longnose Sucker	1978	2	2	46	194	40	173-212	96	15	70-118	1.17
		1981	2	1	123	253	112	125-360	321	77	40-572	1.12
		1984	2	1	50	294	50	122-387	317	50	22-608	1.12

1) Largemesh: monofilament experimental gillnets 38.7 m long x 1.5 m deep with 7.6 panels of 19, 25, 32, 38, and 51 mm bar mesh;

smallmesh: monofilament experimental gillnets 30 m long x 1.8 m deep with 7.6 m panels of 10, 13, 16, and 19 mm bar mesh.

2) Dean 1972.

3) Dean et al 1975.

4) Jones et al 1982.

5) Jones et al 1984.

6) Jones et al 1979.

152, 236, and 298 mm for ages I-IV, respectively (Table 20). Only one of the aged trout displayed the retarded scale pattern (Laakso 1955). Average age was only 2.1 years; approximately 67% of the sample were age II+ or less (Table 21).

Comparison with previous surveys indicates a slight increase in density in 1984 (Figure 14), but mean length of captured trout declined (Figure 15). There were no trout over 330 mm in the gillnet sample (Figure 16).

Longnose Suckers

Total length of 127 suckers ranged from 124 to 435 mm with a mean of 312 mm (Table 19). Mean weight and condition factor (K) were 360 g and 1.00, respectively.

Despite a substantial decline in the number of suckers captured between 1981 and 1983, the current estimate of 42 suckers per net is the second highest level yet reported at Riddle Lake (Figure 14). Average length has varied significantly among sample years, and there appears to be a trend toward larger suckers (Figure 15). The slight decrease in mean length in 1984 was accompanied by the first decline in the proportion of suckers greater than 330 mm total length since 1970.

Angler Use

Angler use more than doubled between 1975 and 1981 (Jones et al 1982); however, sport angling closure eliminated all fishing beginning in 1982. This sudden decrease in angler use at Riddle Lake was evident in the overnight camping at the four campsites. Although direct comparisons of all summer months are confounded by various area closures and restrictions for bear management purposes, limiting comparisons to August and September (months normally unaffected by camping restrictions) revealed a significant decrease in overnight use since 1982. Annual estimated use for August and September was 271 nights for 1976 to 1981 and only 123 nights for 1982 and 1983. In 1984, Riddle Lake was closed to human use until 15 July as part of the Park grizzly bear management plan. Since road construction beginning 9 August prevented any further use of the area, 1984 could not be included in the preceding comparison.

Discussion

Evaluation of the angling closure on Riddle Lake continues to be hampered by the lack of VAR data.

Table 20 Back-calculated total length at annulus formation of fish captured in Yellowstone backcountry lakes, 1984.

Location	Species	Year	Sample Size	Annulus					
				I	II	III	IV	V	VI
Riddle Lake	Cutthroat Trout	1971 ¹⁾	19	61	130	221	297	351	
		1974 ²⁾	41	66	132	183	249	312	
		1983	13	57	141	223	249		
		1984	23	46	108	194	246		
Sylvan Lake	Cutthroat Trout	1978 ³⁾	67	71	142	202	264	289	290
		1981 ⁴⁾	42	58	144	201	229	283	
		1984	79	59	133	186	206		

1) Dean 1972.

2) Dean et al 1975.

3) Jones et al 1979.

4) Jones et al 1982.

Table 21. Age frequency (by percentage) of fish captured in Yellowstone backcountry lakes, 1984.

Location	Species	Year	Sample size	Percentages in each age						Mean age (years)
				I	II	III	IV	V	VI	
Riddle Lake	Cutthroat Trout	1971 ¹⁾	19	5	11	26	53	5		3.4
		1983	13	15	15	62	8			2.6
		1984	24	42	25	17	17			2.1
Sylvan Lake	Cutthroat Trout	1978 ²⁾	349	32	47	17	3			1.9
		1981 ³⁾	161	44	28	25	2	1		1.9
		1984	132	21	53	26				2.1

1) Dean 1972.

2) Jones et al 1979.

3) Jones et al 1982.

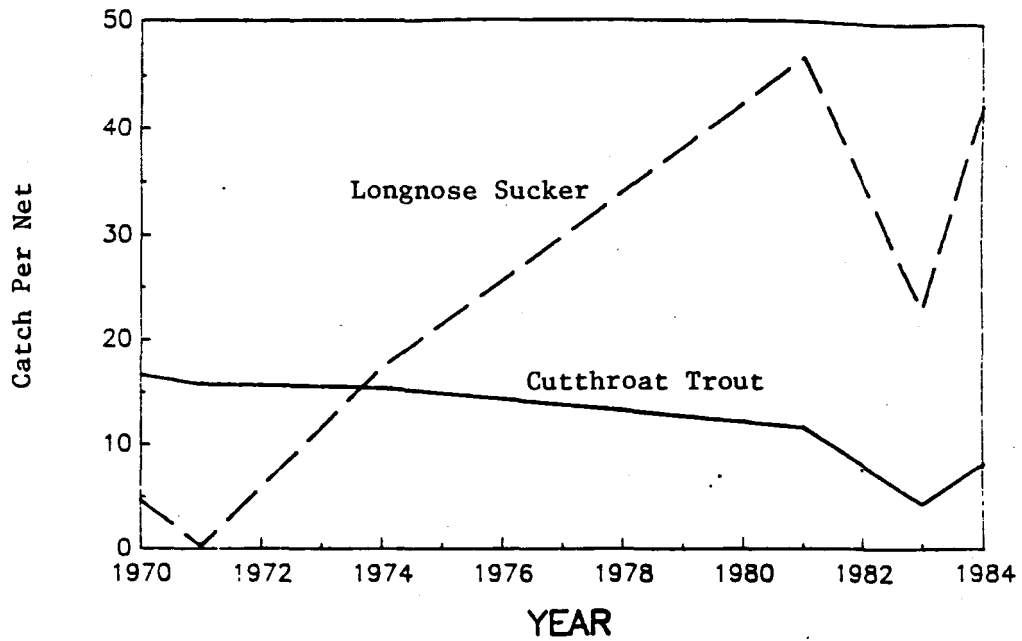


Figure 14 Mean number of cutthroat trout and longnose suckers captured per net in experimental gillnets, Riddle Lake, 1970-1984.

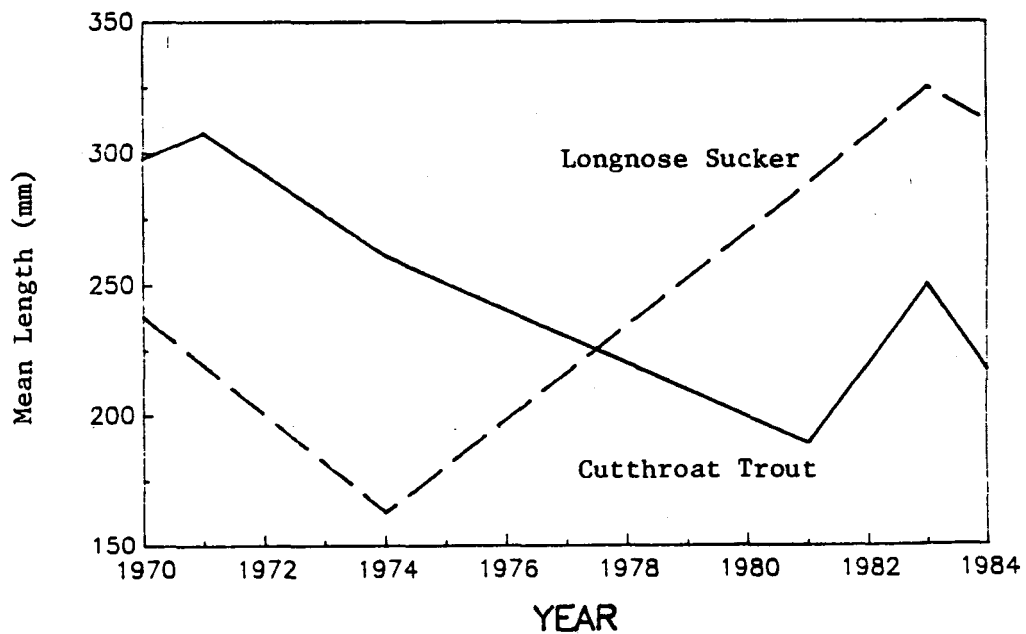


Figure 15. Mean length of cutthroat trout and longnose suckers captured in gillnets, Riddle Lake, 1970-1984.

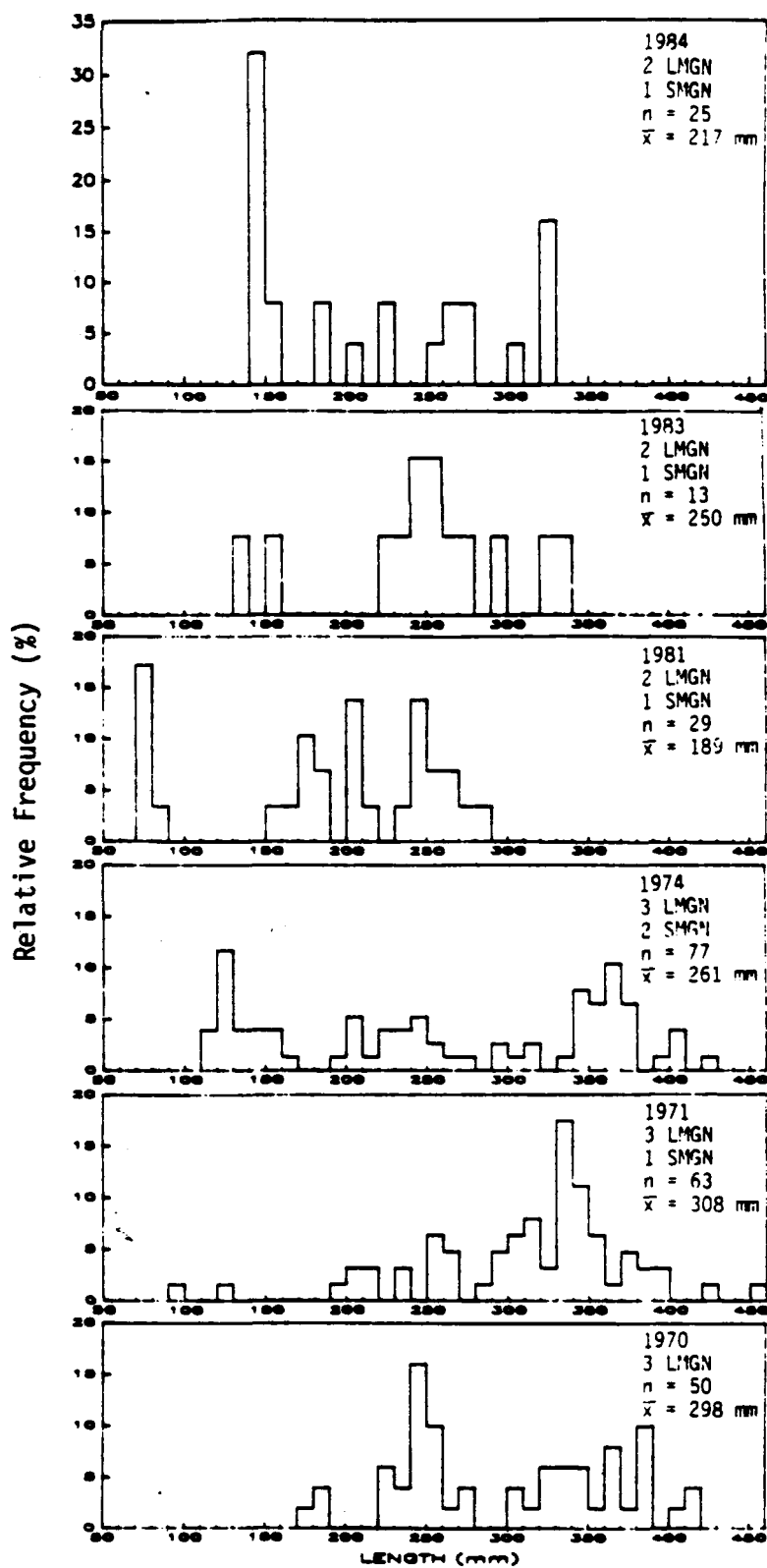


Figure 16. Length frequency of cutthroat trout captured in experimental gillnets, Riddle Lake, 1970-1984.

Current data suggest increases in densities of cutthroat trout and longnose suckers in Riddle Lake. Variation remains high, however, and since temporal and meteorological changes often have significant influence on gillnetting results (Lagler 1978), a more intensified sampling program may be necessary to effectively monitor the piscine community in the lake.

Mean length of cutthroat trout remains low despite a slight increase in 1983. Average age continues to decline, and growth rate has increased slightly. These changes in population structure are apparently associated with declining densities indicated by gillnet catches since the early 1970's.

Expected increases in cutthroat trout density and improvement in population structure have not been observed since Riddle Lake was closed to angling in 1982. Absence of mature females suggests a poor reproductive potential, and observed changes in population structure may be a function of extreme variation in reproductive success. Reexamination of available spawning habitat should be incorporated in future surveys of Riddle Lake in order to evaluate this important component of the cutthroat trout population in Riddle Lake.

With the exception of current decreases in sucker catch per net, longnose suckers in Riddle Lake have increased while trout densities declined; however, a causal relationship has not been established. Studies in Yellowstone Lake have failed to substantiate competition between the two species, but it is possible that the habitat of Riddle Lake might be more conducive to competition. On the other hand, the longnose sucker has been aged up to 30 years old in Yellowstone Lake (Jones et al 1976), and therefore, expansion of the population would be slow (Nikolsky 1969). In Yellowstone Lake significant increases were first noted 10 to 20 years after routine eradication of sucker spawners was curtailed. The current expansion of suckers in Riddle Lake may be associated with increases in Yellowstone Lake and Solution Creek and thus, coincidental to declines in trout numbers.

Increases in sucker mean length may be a manifestation of the "pioneering" effect as the longnose sucker begins to expand into an unoccupied niche in Riddle Lake. A similar increase in size might occur if sporadic reproductive success produces greatly fluctuating year-class strength; however, current shifts in the length frequency of captured suckers suggest that this species may be reproducing successfully in Riddle Lake.

Restoration of the Riddle Lake cutthroat population has not developed rapidly and may be retarded by the infertile environment of the lake. It appears that protection from harvest is imperative and should be continued either by a catch and release regulation or complete angling closure. It is also apparent that sampling should be increased to improve interpretation of current trends and to document and substantiate future changes.

SYLVAN LAKE

Sylvan Lake is located 14.2 km from the East Entrance in the headwaters of Clear Creek near Sylvan Pass. Several automobile pullouts and a picnic area provide easy access to this small (11.4 ha) roadside lake. Ease of access has historically contributed to high levels of angler use for this unproductive subalpine lake.

Yellowstone cutthroat trout were native to Sylvan Lake; however, almost 2.6 million cutthroat trout were stocked in the lake from 1913 through 1943 (Varley 1981). The longnose sucker was first collected from Sylvan Lake in 1978, and it was assumed that this species gained access through Clear Creek from Yellowstone Lake (Jones et al 1979).

The creel limit was three fish of any size per day from 1953 to 1972, but beginning in 1973, only two fish per day could be creeled. Catch and release regulations were implemented on Sylvan Lake in 1978 because levels of exploitation were no longer compatible with Park fishery management objectives (see Introduction, this report). Sylvan Lake remains the only roadside lake in the Park under this "no harvest" restriction.

Arnold and Sharpe (1967) conducted the initial survey of Sylvan Lake in 1966. In 1978, the lake was resurveyed to provide baseline data necessary for evaluation of the catch and release regulation. A third survey, conducted in 1981, revealed a significant increase in the density of longnose suckers and a decline in cutthroat trout numbers despite the catch and release regulation. Trout size structure appeared stable, however, and VAR data indicated a significantly improved landing rate despite increases in angler use.

On 19-20 July 1984, an abbreviated lake survey was conducted on Sylvan Lake. The purpose of the survey was to assess the current status of the cutthroat trout fishery. Additional information concerning the longnose sucker population was also collected.

Physical

Jones et al (1979) provide a detailed description of the physical characteristics of Sylvan Lake and the surrounding drainage basin. During the current survey, the secchi disc was visible to a depth of 6.7 m through dark green-brown waters on a calm, sunny day. Water temperature varied from 16.9 C at the surface to 6.1 C at the bottom (7.2 m). Incomplete stratification was noted with a thermocline between 1.8 and 5.2 m.

Chemical

Nutrient concentration (TDS = 48 ppm) dropped from the 1981 level (TDS = 60 ppm) but was only slightly lower than that measured in 1978 (TDS = 50 ppm). Sylvan Lake can be classified as a dilute water (TDS < 50 ppm) on the basis of the current sample, and although levels of most chemical constituents were above the mean for dilute Park waters, they were well below average values for more concentrated (TDS > 50 ppm) waters. Predominant ions were calcium and bicarbonate. Nitrate and phosphate were below levels detectable by current analytical techniques (<0.01 and <0.03 ppm, respectively) (Table 17).

Limnoplankton

Total plankton diversity (11 genera) increased slightly from 1981 (Table 18) and was above the mean for Park lakes (10 genera). Although phytoplankton diversity was similar to 1981, densities were among the lowest ever recorded in Yellowstone Park. Diversity of rotifers (4 genera) and crustaceans (4 genera) were well above average (2 genera for each form). Rotifer densities have increased since 1981 but remain below the Park mean. Crustaceans were almost absent from the 1981 sample; however, densities in 1984 were above the Park average and among the highest reported for Sylvan Lake.

The oligotrophic diatom-blue-green algae association (Wetzel 1975) found in Sylvan Lake is common in the less productive waters in the Park. According to Hutchinson (1967) and Wetzel (1975) the dominance of rotifers and smaller crustaceans among the zooplankters suggest significant piscine grazing.

Aquatic Vertebrates

One smallmesh and two largemesh experimental gillnets yielded 132 cutthroat trout and 50 longnose suckers. No other aquatic vertebrates were captured.

Cutthroat Trout

Total length of cutthroat trout ranged from 88 to 272 mm with a mean of 198 mm. Mean weight and condition factor (K) were 81 g and 0.92, respectively. The male:female ratio was 1.10:1 (Table 19).

Age was determined for 81 of the cutthroat trout using the scale method; only four displayed a retarded pattern of growth (failure to form an annulus at age I) (Laakso and Cope 1956). Ages were expanded for 132 trout using an age-length key (Westerheim and Ricker 1975). Mean age was 2.1 years, and all trout were age I-III+ (Table 21). Back-calculated lengths at annulus formation were 64, 151, and 214 mm for ages I-III, respectively (Table 20).

Although differences in number of smallmesh and largemesh nets used during the survey confounded comparisons, the previously detected decline in number of trout per net (Jones et al 1982) has continued in Sylvan Lake. Relative densities remain high for Park backcountry lakes; however, the current number per net (44) represents a 34% reduction from 1981 and a 65% reduction from 1978.

The increase in mean length noted in the current results (Table 19) was statistically significant (0.05). This in itself could be assumed to be a general shift in biomass associated with the catch and release regulation. Length frequency analysis, however, suggests that the actual proportion of fish in the larger size categories has diminished. Comparisons of the proportion of mature trout indicate close agreement between 1978 and 1981 (35% and 31%, respectively), but only 17% of the trout captured in 1984 were mature.

Mean age increased slightly in the current study, and back-calculated lengths suggest a slight increase in growth (Tables 20 and 21). Despite the rise in average age, however, the number of age groups has declined from six to three. Increases in growth may be associated with apparent decreases in population density.

Longnose Suckers

Mean total length of captured suckers was 294 mm with a range of 122 to 387 mm. Mean weight was 317 g and mean K factor was 1.12. The male:female ratio was 3.3:1 (Table 19).

Sucker numbers dropped abruptly in 1984 but remain almost twice that reported in 1981. Mean lengths and size distribution appear to have stabilized, and the appearance of sexually mature suckers suggests this species is reproducing successfully in Sylvan Lake.

Angler Use

The Volunteer Angler Report (VAR) provides angler use and creel data for Sylvan Lake dating back to 1974. Arnold and Sharpe (1967) had no creel survey records but estimated annual use ranging from 500-1,000 angler days. Current data indicate that use levels averaged about 960 angler days during the four years prior to the catch and release regulation but dropped to 560 angler days in 1978 (the first year of the new regulation). Angler use rose to a record high of 1,451 angler days in 1982 but has declined steadily since that time. Angler effort has fluctuated in a similar manner since 1974 (Figure 17).

Landing rate appeared fairly stable (mean=0.59 trout/hour) during the four years preceding the catch and release restriction (Figure 17). Rates increased rapidly to a record 1.84 trout/hour in 1982, but sharp decreases have occurred since that time.

Despite some variation, mean length of landed trout remained relative stable until 1982, but size has decreased substantially in the past two years. The increase in mean length of gillnetted trout since 1981 presents an apparent anomaly; however, the shift in population structure and the decrease in the proportion of mature trout seem to substantiate VAR results.

Discussion

Although nutrient levels are low in Sylvan Lake, it is probably the abbreviated growing season at an elevation over 2500 m which limits production. The oligotrophic nature of the lake is reflected in its plankton community, which is dominated by genera adapted to nutrient poor environments. The preponderance of smaller zooplankton forms, such as rotifers, suggests a high level of predation of larger forms by the native cutthroat trout.

There has been an apparent decline in cutthroat trout densities since 1978. Catch per net in the gillnet samples and landing rate of anglers have both declined substantially in the past several years. Although plankton samples generally display a high degree of

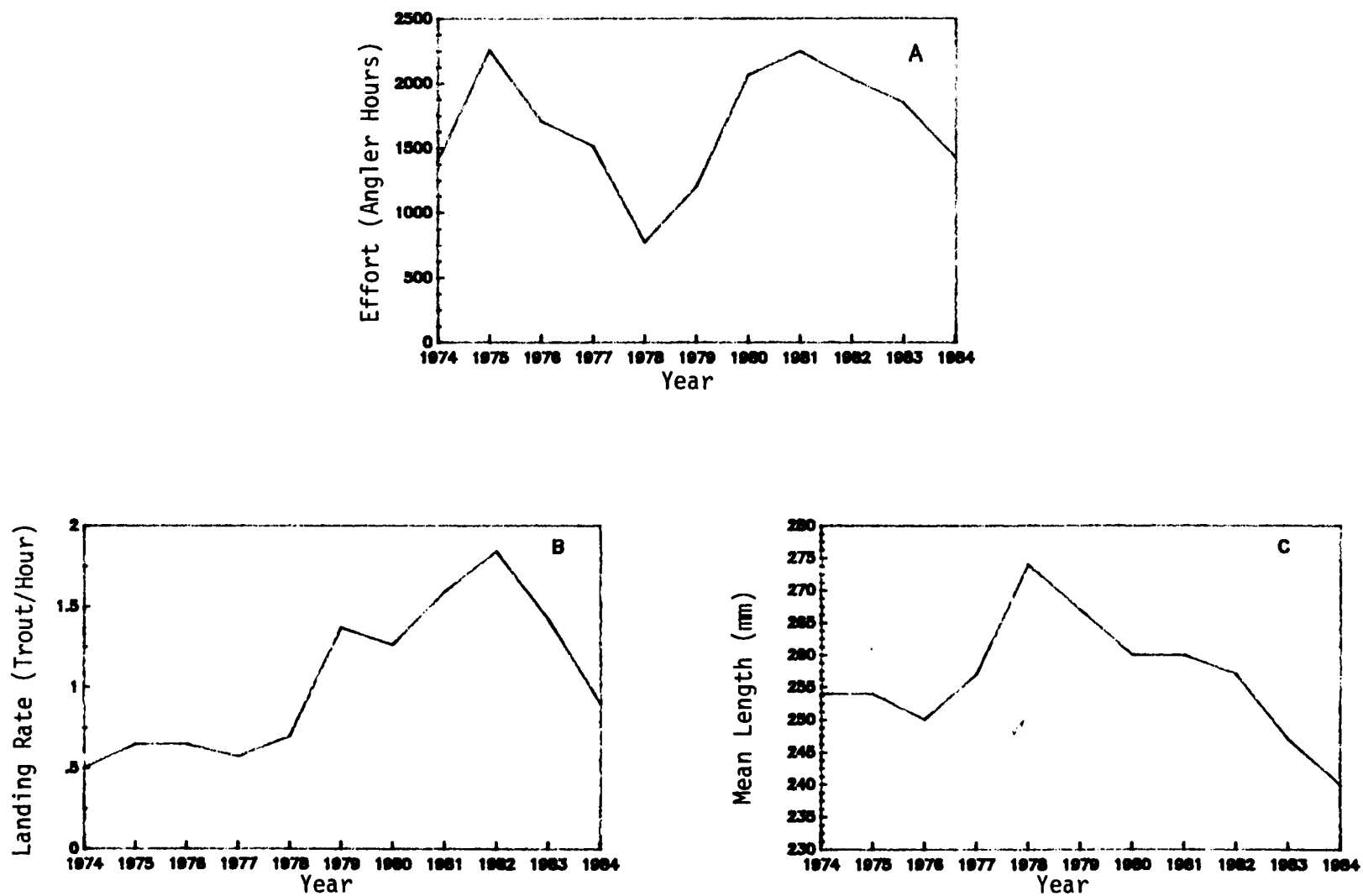


Figure 17. Angler effort (A), landing rate (B), and mean length of landed trout (C), Sylvan Lake, 1974-1984.

seasonal and annual variation, the increase in crustaceans in the 1984 sample could also be the result of reduced trout densities. Changes in population structure including a notable decrease in mature trout provide additional data which indicate a reduction in trout numbers.

Some decrease in density is usually associated with a biomass shift toward older and larger trout under catch and release regulations. Size shifts in Sylvan Lake are toward smaller trout, however, and it is doubtful that current decreases in density are associated with the regulation. On the other hand, since current regulations restrict harvest completely, they allow changes in the piscine community of Sylvan Lake to continue without the influence of angler harvest.

In addition to the numerical increase in the sucker population, the current study reconfirms an increase in size diversity of this species in Sylvan Lake since 1978. Although gillnetting surveys on Yellowstone Lake have indicated that the high degree of variability associated with the capture of suckers greatly confounds trend analysis, current size distribution suggests that the longnose sucker is reproducing successfully in Sylvan Lake.

The extent of possible competition between the cutthroat trout and longnose sucker in Sylvan Lake is unknown. If competition for a limited resource does occur between these species, it seems logical that the effects of this interaction would be readily evident in this unproductive lake. Cutthroat trout spawning habitat is limited (Jones et al 1978); therefore, the reproductive success of this species may be low. Since the longnose sucker is more fecund (Carlander 1969) and has less stringent spawning requirements (Brown 1971), it may have a reproductive advantage in Sylvan Lake. Food may also be limiting in this unproductive subalpine lake, especially for larger trout which require larger food organisms such as benthic invertebrates. With a distinct adaptation for benthic feeding, the sucker may have an additional competitive advantage for a limited food resource. Even if this species is not a more efficient feeder, numbers alone could cause additional stress in this unproductive environment.

Since a robust cutthroat trout population is probably the best defense against adverse effects, the protection of the current catch and release regulation may be significant. Continual monitoring is necessary to determine future population trends of these species and

evaluate effects of this restrictive angling regulation. Additionally, a comprehensive investigation of reproductive success and suggested competition for a possible limited food resource should be initiated. The use of electrofishing as an alternative fish sampling method may be appropriate for future surveys in Sylvan Lake since the effects of trout removal, especially in an intensified sampling program, may also inhibit the response of cutthroat trout in Sylvan Lake.

STREAM SURVEY PROGRAM

The goal of the stream survey program is to identify and document the biological, physical, and chemical processes regulating stream ecosystems within Yellowstone National Park (YNP). Muttkowski (1929) developed the first classification system for YNP streams. In this system, streams were categorized based on visual estimates of flow patterns, gradients, and fish carrying capacity. Until 1963, however, no systematic attempt was made to measure physical, chemical, or biological attributes of YNP stream systems. From 1963 through 1975, baseline information (water flow, chemistry, and presence or absence of fish) on streams was collected, but little quantitative evidence concerning the influence of habitat parameters on stream systems was obtained. In 1976, investigation of the relationship between fish standing crops and attributes of stream systems was initiated (Jones et al 1977). Habitat evaluation techniques that rated fish carrying capacity of streams (stream reach inventory, channel stability rating, habitat quality index, habitat suitability index, and weighted usable area) were employed to study this relationship through 1981. No meaningful conclusions concerning fish biomass and stream habitat, however, were drawn from that investigation.

We are currently working on a procedure to categorize YNP streams based on biological, chemical, and/or physical processes regulating aquatic ecosystems. Once the procedure is developed, many streams might be classified without onsite visits. Eventually, stream types might be identified based on synecological parameters similar to classification of YNP terrestrial ecosystems by habitat type (Daubenmire 1968, Despain 1984).

Methods

To develop a stream classification procedure, three types of surveys (cursory, reconnaissance, and ecological performance) are performed on streams within each of the six major drainage systems in YNP (Table 22). In 1984; 68 cursory, 7 reconnaissance, and 7 ecological performance surveys were performed within the Lamar, Madison, and Snake River drainages. With the addition of data collected in 1984, baseline information, comparable to cursory surveys, has been collected on approximately 45% of YNP streams.

Table 22. Type of information collected during cursory, reconnaissance, and ecological performance surveys in Yellowstone National Park, 1984.

<u>Cursory</u>	<u>Reconnaissance (by reach)</u>	<u>Ecological Performance</u>
Stream Order	Stream Order	Stream Order
Watershed Size	Elevation	Elevation
Elevation	Beaver Activity	Beaver Activity
Length	Wildlife Observations	Wildlife Observations
Gradient	Weather	Weather
Water Flow	Presence or Absence of Fish	Presence or Absence of Fish
Water Temperature	Stream Bottom Contour	Stream Bottom Contour
pH	Water Flow	Water Flow
Conductivity	Water Column Features:	Water Column Features:
Macroinvertebrate Species Composition	Channel Width	Channel Width
Presence or Absence of Fish	Stream Width	Stream Width
	Water Depth	Water Depth
	Riffle Width	Riffle Width
	Pool Width	Pool Width
	Pool Quality	Pool Quality
	Solar Incidence	Solar Incidence
	Solar Angle	Solar Angle
	Channel Morphology Features:	Channel Morphology Features:
	Streambank Alteration	Streambank Alteration
	Vegetative Stability	Vegetative Stability
	Undercut	Undercut
	Channel-bank Angle	Channel-bank Angle
	Stream Bottom Features:	Stream Bottom Features:
	Gradient	Gradient
	Sinuosity	Sinuosity
	Substrate Particle Size	Substrate Particle Size
	Embeddedness	Embeddedness
	Channel Vegetative Cover	Channel Vegetative Cover
	Riparian Zone Features:	Riparian Zone Features:
	Streamside Cover	Streamside Cover
	Vegetative Use	Vegetative Use
	Vegetation Overhang	Vegetation Overhang
	Habitat Type	Habitat Type
		Fish Population Features:
		Species Composition
		Estimation of Number
		Length
		Weight

During reconnaissance surveys, streams are subdivided into regions (reaches) that are relatively uniform with respect to discharge, water depth, riparian vegetation, and slope. Within each reach, 29 stream features are measured, and a cursory survey is performed on all tributaries. Measurement of stream features has generally followed procedures outlined in Platts et al (1983). Reconnaissance surveys have been performed on approximately 65 YNP streams.

During ecological performance surveys an estimate of the number and size (length to nearest 1 mm and/or weight to nearest 1 g) of fish is generally made in conjunction with measurement of the same stream features taken during reconnaissance surveys (Table 22). In this way, the ecological performance of the stream (fish biomass and/or size distribution) is compared to stream habitat features. To provide a means of further evaluating the length distribution of populations, the length-categorization system outlined by Gabelhouse (1984) was included in this analysis. The influence of angling on the fish community is also considered. This type of survey has been performed on less than 0.2% of YNP streams.

Results and Discussion

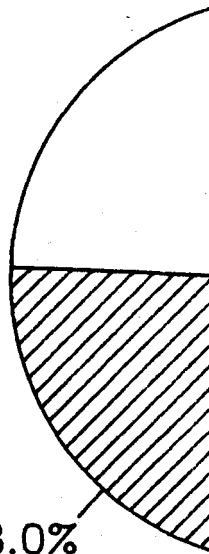
With use of the VAR, angling statistics have been compiled on approximately 100 streams for 12 years. This information has been reported for more than 3 years on only 75 streams (Table 23). These 75 streams may be grouped into general categories of annual angler use (Figure 18). Generally, a few streams have received the majority of angler use (Table 23, Figure 18). Since 1974, 5% of the fished streams in YNP received approximately 65% of average annual angler stream use (141,000 angler days); whereas, 77% of the fished streams accumulated approximately 10% of average annual angler stream use. Currently, the most heavily used stream fisheries (over 2,000 angler days/year) are generally managed with special regulations (catch and release or size limits) (Table 23, Figure 19), and most of the other streams are managed with creel limits. Yellowstone River contains the most popular stream fishery in YNP. This stream represents 1.3% of all the fished streams, yet it has received over 32% of the angler stream use.

LAMAR RIVER DRAINAGE

Within YNP, Lamar River is the largest tributary to the Yellowstone River. This subdrainage contains 20%

Table 23. Angler use on the 75 most heavily fished streams in YNP from 1973-1984.

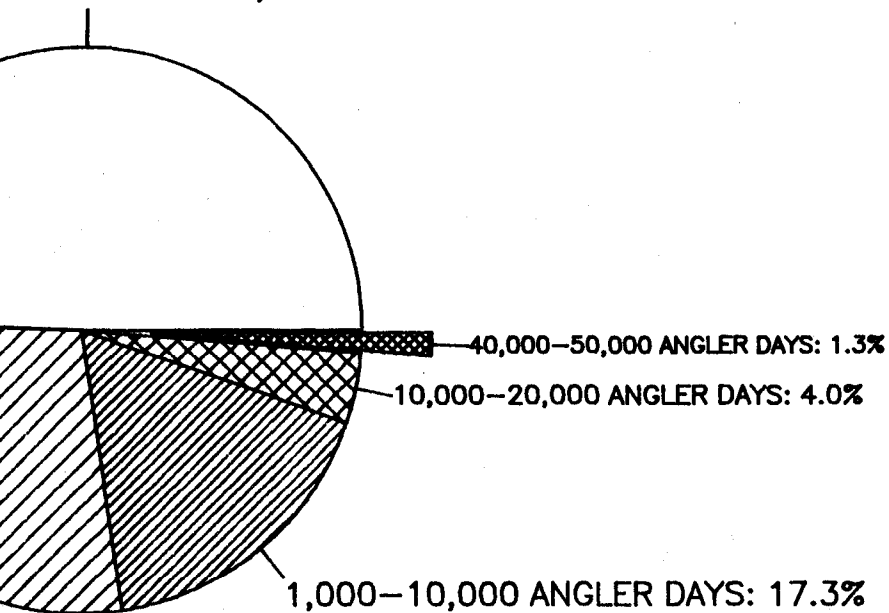
Stream	Length (km)	Angler Days	Access
Yellowstone River	99.36	45778.00	Road; Trail
Madison River	29.50	17755.36	Road
Firehole River	42.77	16764.45	Road; Trail
Gibbon River	41.30	12102.27	Road; Trail
Slough Creek	24.67	7047.73	Road; Trail
Gardner River	39.29	4825.36	Road; Trail
Lamar River	68.25	4553.43	Road; Trail
Lewis River	21.72	4473.45	Road
Soda Butte Creek	25.61	3767.09	Road; Trail
Pelican Creek	38.62	2086.27	Trail; Road
Nez Perce Creek	17.70	1966.73	Road; Trail
Bechler River	29.90	1858.18	Trail
Indian Creek	14.88	1809.82	Road; Trail
Gallatin River	36.20	1265.10	Trail; Road
Falls River	33.12	1233.55	Trail
Snake River	44.52	1100.00	Trail
Obsidian Creek	16.76	781.91	Road; Trail
Pebble Creek	20.78	751.30	Road; Trail
Cub Creek	11.13	647.78	Road; Trail
Tower Creek	20.92	594.45	Road; Trail
Clear Creek	15.02	576.55	Trail; Road
Little Firehole Creek	13.81	512.91	Trail
Cache Creek	23.73	485.18	Trail
Grouse Creek	7.24	473.67	Trail
Duck Creek	3.49	392.45	Road; Trail
Middle Creek	12.34	373.09	Road; Trail
Hellroaring Creek	9.79	368.09	Trail
Lava Creek	22.79	329.00	Road; Trail
Crawfish Creek	5.63	318.80	Road; Trail
Boundary Creek	31.11	301.80	Trail
Iron Spring Creek	6.03	297.55	Road; Trail
Blacktail Deer Creek	16.89	284.00	Road; Trail
DeLacy Creek	10.06	261.73	Road; Trail
Grayling Creek	26.28	244.27	Road; Trail
Meadow Creek	3.49	242.00	Trail
Cold Creek	16.49	241.00	Trail
Glen Creek	13.14	224.00	Road; Trail
Shoshone Creek	10.06	211.25	Trail
Cascade Creek (YSR)	29.50	190.09	Road; Trail
Bacon Hind Creek	4.56	185.38	Road; Trail
Solfatara Creek	9.65	181.11	Trail
Mountain Ash Creek	15.55	178.50	Trail
Heart River	6.17	166.00	Trail
Panther Creek	10.46	161.78	Trail
Fan Creek	15.82	158.09	Trail
Otter Creek	7.51	152.50	Road; Trail
Broad Creek	23.06	148.14	Trail
Specimen Creek	15.15	132.78	Road; Trail
Sentinel Creek	13.01	130.69	Trail
Beaverdam Creek	14.21	122.64	Trail
Cougar Creek	27.49	118.60	Trail
Miller Creek	19.58	106.60	Trail
Cottonwood Creek	4.83	103.67	Trail
Moose Creek	11.67	96.43	Trail
Straight Creek	10.59	94.75	Trail
Rose Creek	8.31	88.50	Road; Trail
Fawn Creek	12.60	86.00	Trail
Ward Creek	---	83.00	---
Little Thumb Creek	6.03	77.25	Road; Trail
Fairy Creek	6.57	75.78	Trail
Thumb Creek	11.80	63.75	Road; Trail
Winter Creek	11.87	61.38	Road; Trail
Sedge Creek	12.47	54.71	Trail
Maple Creek	19.58	53.40	Trail
Antelope Creek	11.40	43.43	Road; Trail
Lost Creek	12.74	37.20	Road; Trail
Cascade Creek (Falls R.)	1.21	31.33	Trail
Aster Creek	7.78	29.00	Road; Trail
Bear Creek	8.85	28.00	Trail
Thorofare Creek	22.53	23.75	Trail
Raven Creek	13.14	21.67	Trail
Mist Creek	7.60	21.00	Trail
Arnica Creek	9.38	17.80	Road; Trail
Buffalo Creek	9.78	17.60	Trail



0-100 ANGLER DAYS: 28.0%

Figure 18. Percentage of streams receiving varying degrees of angler use, YNP.

100-1,000 ANGLER DAYS: 49.3%



(1,241 km) of the total stream distance in YNP. Nineteen of the tributaries to the Lamar River are named, and 38 are unnamed (Figure 20); these streams range in elevation from 1,880 to 2,972 m above MSL. In 1984, cursory information was collected on 34 tributaries to the Lamar River. Reconnaissance surveys were performed on Cache, Calfee, Chalcedony, Crystal, Jasper, Miller, and Rose Creeks. Ecological performance surveys were conducted on Soda Butte Creek (Northeast Entrance and Footbridge) and Lamar River (picnic area).

The Lamar River is characterized by high peaks and steep ridges that are separated by broad U-shaped valleys; Absaroka volcanic rocks are the dominant parent rocks (Parsons 1978). Precambrian gneiss and schist occur in Slough Creek drainage and Yellowstone tuff and related lava flows are found on the Mirror Plateau. Relatively few lakes occur in the Absaroka Range compared to the Beartooth Mountains northeast of YNP; Parsons (1978) attributed this difference to the Absaroka rocks, which are more easily eroded, more fractured, and more porous.

Lamar drainage forest types include lodgepole pine (Pinus contorta), whitebark pine (Pinus albicaulis), Douglas fir (Pseudotsuga menziesii), and Engelmann spruce-subalpine fir complex (Picea engelmanni-Abies lasiocarpa) (Despain 1984). Despain (1984) found that lodgepole pine dominate the drainage and occur mainly in lower elevations; the spruce-fir complex occurred in the upper reaches of the drainage. Whitebark pine and Douglas fir are found in isolated pockets throughout the area. Since initiation of YNP's natural fire policy (1972), one major fire has occurred in the drainage (Willow Creek, 1974) and 15 starts have been reported.

Streams in the Lamar drainage receive about 12% of the angler stream use in YNP. Slough Creek contains the fifth most popular stream fishery in YNP, and the most popular fishery in the drainage. This stream receives over 7,000 days of angler use/year (Table 24, Figure 21). Since implementation of catch and release regulations in 1973, this fishery has gained in angler use (popularity), average size of fish landed has increased, and catch rate has declined.

Approximately 10% of the fish caught in Lamar drainage streams have been kept (creeled). The highest number of fish creeled has occurred in Soda Butte Creek where 2,000 fish/year are removed. Since 1974, angler use and effort in Soda Butte Creek has closely followed the same patterns of use and effort as in the Lamar River. Of the 10 most heavily used stream fisheries in YNP, Soda

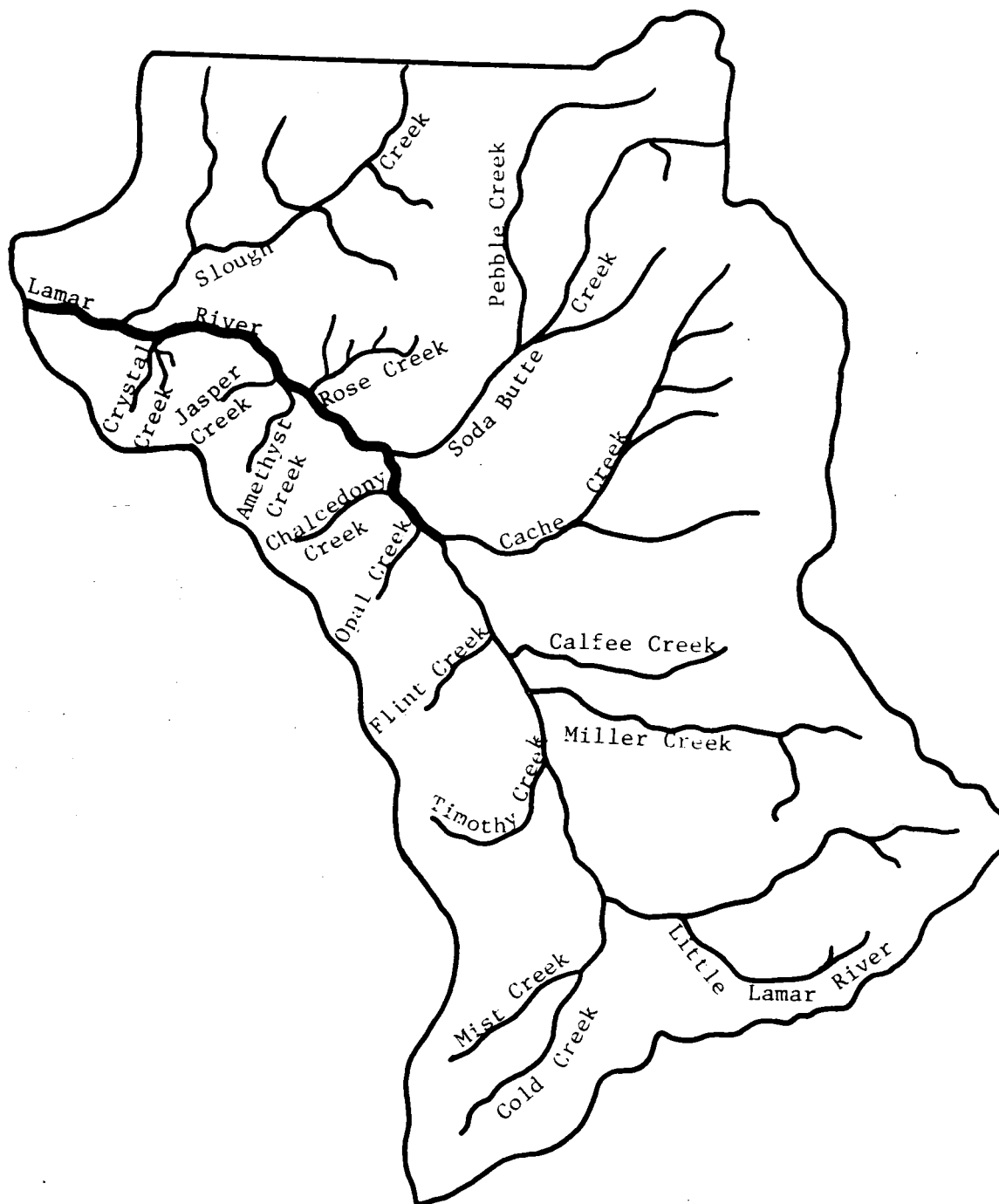


Figure 20. Named streams in the Lamar River drainage, YNP.

Table 24. Angler statistics for fished streams in the Lamar River drainage, 1984.

	Buffalo Creek	Cache Creek	Cold Creek	Lamar River				Miller Creek	Pebble Creek	Slough Creek	Soda Butte Creek
				Lower	Valley	Headwater	All Areas				
<u>Stream Characteristics</u>											
Length (km)	9.20	25.37	17.17	6.40	15.20	36.40	58.00	20.48	21.24	32.40	26.00
Width (m)	9.40	9.45	5.50	29.61	29.61	14.80	22.20	5.60	4.88	14.80	12.70
Area (ha)	8.65	23.97	9.44	18.95	45.01	53.87	128.76	11.47	10.36	47.95	33.02
<u>Angling Characteristics</u>											
<u>Use (Angler Days)</u>											
Mean	17.60	486.18	231.67	865.83	2783.33	486.83	4553.43	106.60	751.30	7047.73	3767.09
Standard Deviation	14.93	205.45	341.22	424.99	1695.21	405.17	1680.20	58.00	280.39	3135.91	1317.30
Standard Error	6.68	61.94	197.01	173.50	692.09	165.41	635.06	25.94	88.67	945.51	397.18
Mean Use/km	1.91	19.12	13.49	135.29	183.11	13.37	78.51	5.21	35.37	217.52	296.61
Mean Use/ha	2.04	20.24	24.54	45.69	61.84	9.04	35.36	9.29	72.57	146.97	114.08
<u>Effort (Angler Hours)</u>											
Mean	25.00	1021.45	706.67	2085.33	6609.83	902.33	10849.14	157.00	1361.90	20558.18	7809.27
Standard Deviation	24.12	502.04	1094.47	1163.57	4014.81	808.45	4373.85	145.27	549.20	8964.71	2738.91
Standard Error	10.79	151.37	631.89	475.03	1639.04	330.05	1653.16	64.97	173.67	2702.96	825.81
Mean Effort/km	2.72	40.26	44.16	325.83	434.86	24.79	187.05	7.67	64.12	634.51	614.88
Mean Effort/ha	2.89	42.61	74.86	110.04	146.86	16.75	84.26	13.69	131.46	428.72	236.49
<u>Landing Rate</u>											
Mean	1.44	2.03	1.30	1.41	1.55	2.46	1.55	3.61	1.89	1.51	1.33
Standard Deviation	1.86	0.68	1.05	0.26	0.54	1.15	0.42	2.79	0.75	0.31	0.53
Standard Error	0.93	0.20	0.61	0.11	0.22	0.47	0.16	1.25	0.24	0.09	0.16
<u>Creel Rate</u>											
Mean	0.01	0.34	0.50	0.06	0.02	0.48	0.06	0.63	0.31	0.02	0.25
Standard Deviation	0.00	0.11	0.31	0.08	0.01	0.19	0.01	0.65	0.05	0.01	0.05
Standard Error	0.00	0.03	0.18	0.03	0.00	0.08	0.01	0.29	0.02	0.00	0.02
<u>Fish Landed</u>											
Mean	25.60	1967.64	284.00	2661.67	10134.83	2489.00	17300.71	554.60	2607.00	29362.00	10329.36
Standard Deviation	38.69	931.08	320.29	1726.09	5964.40	2476.88	8760.02	412.26	1395.94	10535.71	4913.15
Standard Error	17.30	280.73	184.92	704.67	2434.96	1011.18	3310.98	184.37	441.44	3176.64	1481.37
Fish Landed/km	2.78	77.56	16.54	415.89	666.77	68.38	298.29	27.08	122.74	906.23	813.31
Fish Landed/ha	2.96	82.07	30.08	140.45	225.18	46.20	134.36	48.36	251.64	612.32	312.81
<u>Harvest</u>											
Mean	0.60	342.55	135.67	177.55	131.20	503.09	652.57	74.00	406.30	382.09	1996.09
Standard Deviation	0.89	161.47	157.81	132.63	80.70	251.24	314.98	68.38	145.40	214.09	1021.93
Standard Error	0.40	48.69	91.11	39.99	25.52	75.75	119.05	30.58	45.98	64.55	308.12
Harvest/km	0.07	13.50	7.90	27.74	8.63	13.82	11.25	3.61	19.13	11.79	157.16
Harvest/ha	0.07	14.29	14.37	9.37	2.92	9.34	5.07	6.45	39.22	7.97	60.45

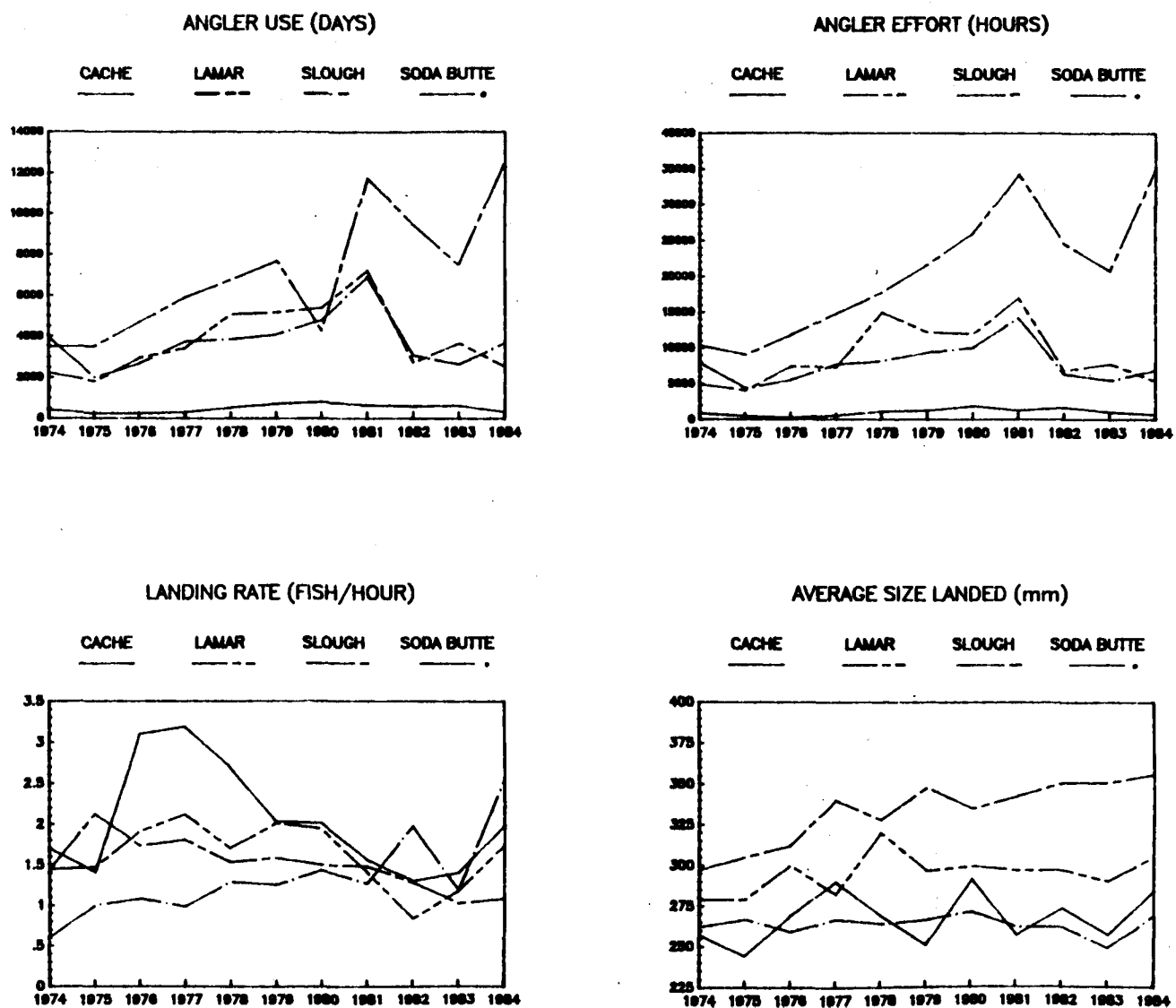


Figure 21. Angler statistics for Cache, Lamar, Slough, and Soda Butte Creek, 1974-1984.

Butte Creek and Gardner River are the only streams currently managed without special regulations (Table 23, Figure 19).

Lamar River

Tributaries

Jones et al (1984) indicated physical characteristics of tributaries to the Gallatin River were closely correlated to stream order (position in hierarchy of tributaries) and drainage basin size. As stream order increased, gradient decreased, but values for stream flow, channel width, and stream depth increased. Capacity to maintain fish was also higher in streams with larger stream orders and watersheds.

The largest tributaries to the Lamar River (Cache and Slough Creeks) are fourth order streams (Table 25). Six Lamar River tributaries are third, 11 are second, and 26 are first order streams. Physical characteristics of streams in the Lamar drainage were not as closely related to stream order as streams in the Gallatin drainage; however, they were correlated with drainage basin size.

Cache Creek and stream #0560 drained the largest and smallest watershed, respectively (Table 25). Generally, watershed size had a significant influence on the physical characteristics of the tributaries (Table 25, Figures 22 and 23). Streams with large drainage basins had flatter gradients, more water flow, wider stream channels, and were deeper than streams with small drainages. Nine streams with watersheds larger than 2,000 ha had physical conditions favorable for fish: gradient less than 10%, over 0.2 m³/s of stream flow, channels wider than 3.3 m, and depths over 18 cm.

Comprehensive water chemistry analysis was performed at 17 different locations in tributaries to the Lamar River (Table 26). Eight streams were calcium-bicarbonate waters and six were sodium-potassium bicarbonate waters. The Lamar River changed from a sodium-potassium water type in the upper area (above Little Lamar) to a calcium-bicarbonate water type at its outlet. Mean total dissolved solids (TDS) of these streams (83.67 ppm) was approximately 27% lower than the mean TDS for all streams sampled to date (114.6 ppm). The upper sample site on Lamar River was the most dilute sample collected. Crystal Creek had the highest TDS. Lamar River tributaries generally had a mean total hardness and total alkalinity 1.2 and 1.1 times greater

Table 25. Results of cursory surveys performed on tributaries to Lamar River, 1984.

Streams	Stream Order	Watershed Size (ha)	Stream Length (km)	Stream Elevation (m)		Gradient	Stream Flow (m ³ /s)	Mean Width (m)	Mean Depth (cm)	Mean Velocity (cm/s)	Mean Temperature (°C)
				Max.	Min.						
Cache Creek	4	21002.30	25.37	2871.21	2060.44	3.19	2.847	18.89	29.26	49.32	14.40
Slough Creek	4	19490.14	53.70	2971.80	1871.47	2.05	2.736	29.61	67.00	47.55	14.44
Average		20246.22	39.54	2921.51	1965.96	2.62	2.792	24.25	48.13	48.43	14.42
Soda Butte Creek	3	17704.94	34.50	2339.34	2006.49	0.96	1.409	10.73	30.48	57.91	12.00
Cold Creek	3	15391.06	17.17	2791.96	2215.89	3.36	2.826	11.00	34.29	115.82	7.70
Miller Creek	3	10480.15	20.48	2773.68	2072.64	0.34	1.673	11.61	25.91	61.56	12.20
Timothy Creek	3	5255.82	13.11	2667.00	2145.79	3.97	0.337	3.36	17.98	63.70	20.00
Little Lamar Creek	3	3969.85	13.41	2962.65	2261.61	5.22	1.494	8.47	78.03	76.20	13.30
Calfee Creek	3	3260.60	11.76	2755.39	2072.64	5.80	0.153	3.31	19.66	42.67	12.20
Mean		9343.74	18.41	2715.00	2129.18	3.28	1.315	8.08	34.39	69.64	12.90
SE		2519.03	3.47	84.80	39.49	0.91	0.400	1.56	9.09	10.23	1.63
Rose Creek	2	2357.50	8.98	2919.98	2002.53	10.22	0.218	4.72	59.69	45.14	12.00
Willow Creek	2	1764.19	8.09	2542.03	2170.17	4.59	0.417	4.48	17.98	47.24	17.70
Crystal Creek	2	1598.45	4.15	2467.35	1980.61	14.13	0.155	0.91	18.29	10.41	11.11
#0590	2	1527.91	6.26	2737.10	2228.03	8.13	0.581	5.43	10.67	100.28	11.67
Opal Creek	2	1443.90	4.87	2667.00	2036.06	12.93	0.099	3.51	15.24	18.65	12.00
Chalcedony Creek	2	1317.69	5.21	2633.47	2011.68	11.92	0.053	1.52	10.97	27.83	12.50
#0603	2	1018.51	4.15	2877.31	2343.91	12.84					
#0566	2	924.12	5.95	2889.50	2206.75	11.46	0.212	2.89	14.94	48.77	12.22
Flint Creek	2	876.84	5.02	2731.00	2084.83	12.86	0.096	3.31	12.04	42.67	10.00
Jasper Creek	2	850.59	4.30	2322.57	1993.39	7.66	0.001	0.61	16.51	6.35	26.67
Amethyst Creek	2	624.28	7.67	2713.40	2036.10	8.83					
Mean		1195.17	5.88	2681.88	2090.37	10.51	0.205	3.04	19.59	38.59	13.99
SE		167.38	0.51	55.73	40.05	0.88	0.060	0.57	5.10	9.42	1.74
Twin Creek	1	1853.45	5.79	2694.43	2060.44	10.94	0.404	1.76	8.84	50.59	11.10
#0510	1	1139.38	5.95	2743.20	2011.68	12.28					
#0518	1	693.07	2.41	2435.35	2084.53	14.52					
#0594	1	677.32	4.74	2950.46	2241.80	14.92					
#0532	1	666.82	3.15	2657.85	2072.64	18.55					
#0536	1	572.31	2.84	2648.71	2145.79	17.65					
#0604	1	546.06	3.26	3011.42	2368.29	19.68					
Clover Creek	1	535.55	3.62	2660.90	2145.79	14.22					
#0530	1	535.55	1.78	2633.47	2072.64	31.39					
#0600	1	488.30	1.81	2816.35	2289.04	28.99	0.006	1.07	5.58	10.67	15.56
#0553	1	441.04	4.02	2651.76	2157.98	12.27					
#0602	1	441.04	2.28	2871.21	2322.57	24.00	0.003	0.90	4.88	6.10	17.22
#0601	1	435.79	1.20	2706.62	2304.29	33.30					
#0489	1	419.38	2.00	1981.20	2279.40	14.91					
#0458	1	409.54	4.40	1981.20	2438.40	10.39					
#0532	1	383.59	3.62	2916.93	2209.80	19.52					
#0538	1	362.83	1.64	2212.84	2145.79	4.08					
#0569	1	347.72	2.81	2657.85	2203.70	16.12	0.081	2.01	8.99	45.11	9.44
#0519	1	336.04	2.70	2426.20	2084.83	12.62					
#0564	1	330.78	1.89	2548.12	2194.56	18.61					
#0551	1	325.53	2.65	2535.93	2151.88	14.46					
#0487	1	283.53	2.60	1987.30	2218.94	8.91					
#0515	1	245.49	1.12	2212.84	2042.16	15.15					
#0562	1	241.52	2.07	2535.93	2173.22	17.47					
#0500	1	210.40	2.86	2493.30	1999.50	17.27					
#0560	1	199.52	1.77	2523.74	2171.70	19.88					
Mean		504.67	2.88	2557.50	2176.60	17.00	0.124	1.44	7.07	28.12	13.33
SE		66.41	0.25	56.16	21.72	1.30	0.100	0.27	1.07	11.49	1.83

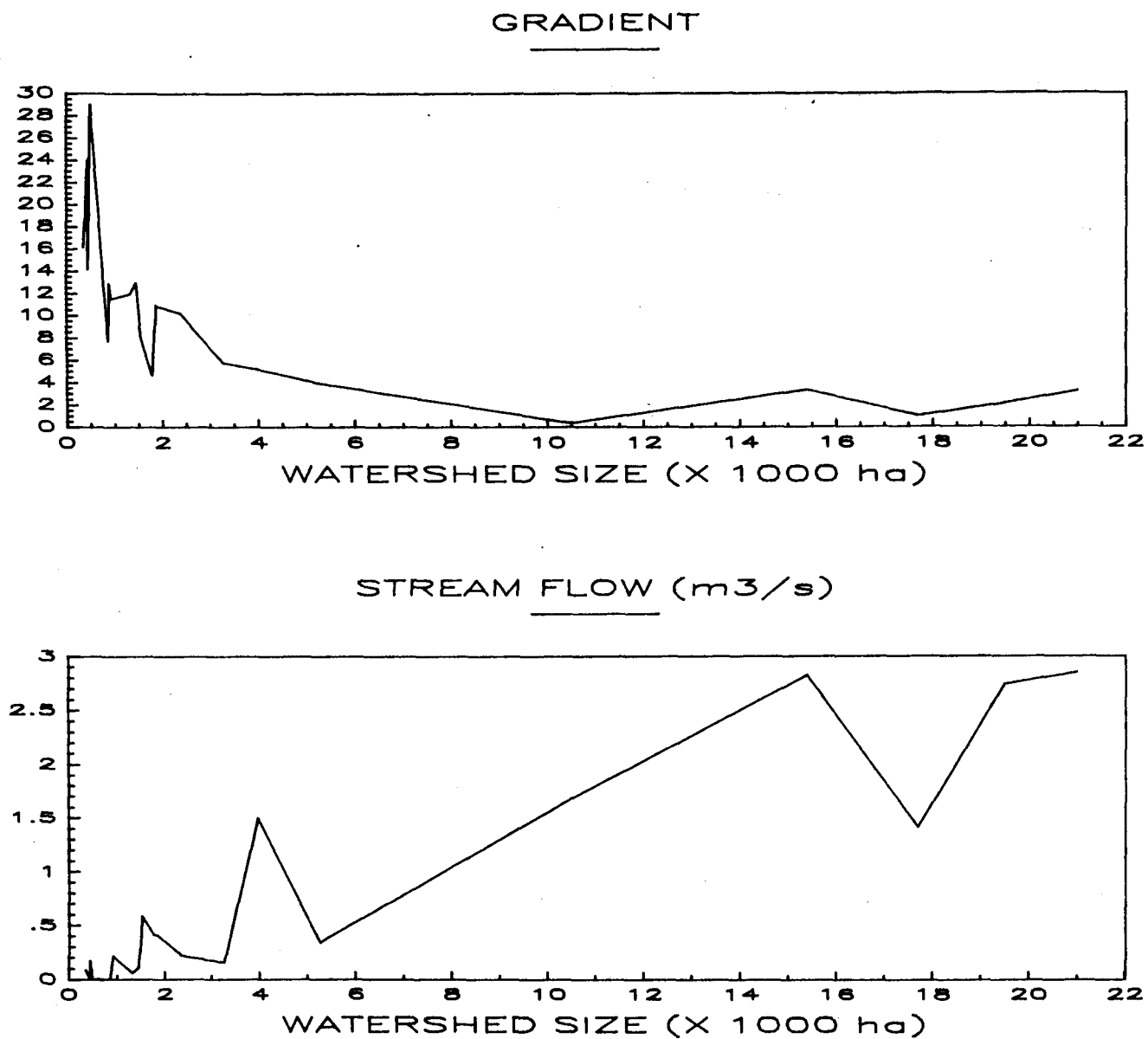


Figure 22. Relationships between stream gradient, stream flow, and watershed size for tributaries to Lamar River, 1984.

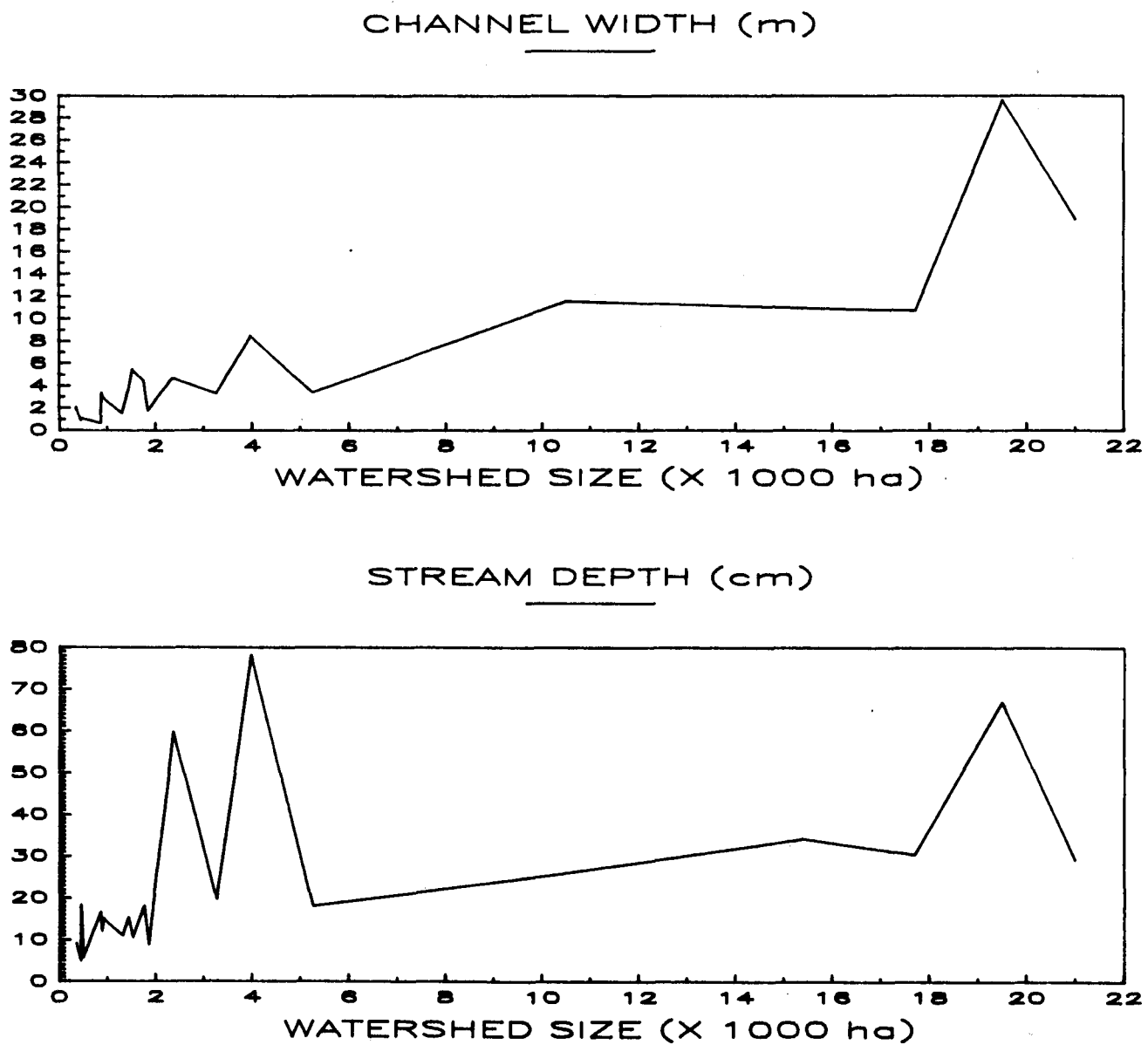


Figure 23. Relationships between stream channel width, stream depth, and watershed size for tributaries to Lamar River, 1984.

Table 26. Chemical characteristics of backcountry streams surveyed, Lamar River drainage, Yellowstone National Park, 1984.

	Cache Creek 8/2	Calfee Creek 8/16	Chalcedony Creek 8/7	Cold Creek 7/18	Crystal Creek 9/28	Little Lamar Creek 7/17	(upper) Lamar Creek 7/17	Miller Creek 8/23	Opal Creek 8/6	Rene Creek 8/9	Slough Creek 9/28	(upper) Soda Butte Creek 9/28	(lower) Soda Butte Creek 9/28	South Cache Creek 8/3	Timothy Creek 7/18	Willow Creek 7/18
Total Diss. Solids	68.00	80.00	52.00	38.00	265.00	31.00	29.00	65.00	58.00	118.00	116.00	19.00	149.00	44.00	72.00	70.00
Pheno. Alkalinity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Alkalinity	45.40	60.90	45.50	29.40	246.00	28.30	23.30	47.40	56.60	106.00	93.00	13.40	124.00	39.40	54.70	65.90
Carb. Alkalinity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarb. Alkalinity	45.40	60.90	45.50	29.40	246.00	28.30	23.30	47.40	56.60	106.00	93.00	13.40	124.00	39.40	54.70	65.90
Carbonates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonates	55.40	74.30	55.50	35.90	300.00	34.50	28.40	57.80	69.10	129.00	113.00	16.30	151.00	48.10	66.70	80.40
Hydroxides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carbon dioxide	2.33	1.98	2.94	3.80	2.20	2.30	2.39	2.44	5.81	1.72	0.30	4.33	1.30	1.61	3.54	2.14
Chloride	1.50	1.00	1.00	3.80	1.94	3.33	2.85	1.00	1.00	1.00	1.00	1.00	1.00	1.00	9.51	14.70
Sulfate	7.90	4.21	2.90	1.90	9.90	1.40	1.40	9.20	2.96	4.00	6.20	2.60	8.80	7.00	4.10	3.00
Fluoride	0.10	0.17	0.06	0.13	0.31	0.07	0.05	0.13	0.07	0.09	0.05	0.07	0.08	0.07	0.25	0.40
pH	7.60	7.80	7.50	7.20	8.00	7.40	7.30	7.60	7.30	8.10	8.00	6.80	8.00	7.70	7.50	7.80
pHe	8.68	8.56	8.69	7.90	7.50	9.26	9.59	8.93	8.62	7.98	8.20	9.45	7.90	9.07	9.02	8.97
Stat.	9.75	9.32	9.88	8.59	7.00	11.10	11.90	10.30	9.95	7.86	8.40	12.10	7.80	10.40	10.50	10.10
Sat.	-1.08	-0.76	-1.19	-0.70	0.50	-1.86	-2.29	-1.33	-1.32	0.12	0.20	-2.65	0.10	-1.37	-1.52	-1.17
Color (PCU)	30.00	5.00	15.00	5.00	5.00	5.00	5.00	5.00	10.00	0.00	0.00	5.00	5.00	15.00	5.00	5.00
Odor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turbidity (NTU)	7.70	3.20	3.40	4.90	0.80	4.60	3.90	4.20	1.00	0.90	0.20	4.20	3.10	3.20	2.00	1.40
Silica	5.40	10.00	7.60	8.90	10.80	3.80	4.60	7.00	7.90	8.50	6.70	0.50	9.40	3.30	7.40	7.60
Hydrogen sulfide	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sodium	9.26	7.24	4.51	7.32	20.70	5.83	6.56	9.48	4.52	2.62	3.17	1.46	4.66	9.26	20.63	20.82
Potassium	1.38	1.00	1.14	0.96	2.80	0.45	0.29	1.00	1.00	1.96	1.37	1.00	1.91	1.00	0.95	0.74
Total Hardness	46.30	45.10	36.40	12.70	258.00	16.90	10.00	24.10	33.10	103.00	100.00	20.70	139.00	22.70	15.30	13.50
Ca Hardness	24.30	23.90	22.70	8.31	149.00	9.64	5.42	12.90	21.60	57.40	66.80	12.90	86.40	10.90	9.07	8.42
Mg Hardness	22.00	21.20	13.70	4.39	109.00	7.23	4.62	11.20	11.60	46.10	33.00	7.80	52.30	11.80	6.26	5.09
Calcium	9.70	9.57	9.10	3.32	59.60	3.86	2.17	5.15	8.62	23.00	26.70	5.14	34.60	4.34	3.63	3.37
Magnesium	5.35	5.14	3.33	1.07	26.50	1.76	1.12	2.71	2.82	11.20	8.01	1.90	12.70	2.88	1.52	1.24
Iron	1.09	0.17	0.18	0.27	0.10	0.32	0.45	0.42	0.14	0.10	0.10	0.26	0.38	0.68	0.14	0.25
Manganese	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Copper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOC	4.73	5.80	3.52		8.90			3.70	3.42	3.10	5.20	1.00	4.20	1.90		
Total Ortho-phosphate	0.06	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.03	0.03
Total Susp. Phosphate	0.06	0.03	0.03	0.03	0.02	0.06	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.15	0.03
Total Diss. Phosphate	0.06	0.03	0.03	0.03	0.02	0.12	0.04	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.15	0.04

Table 26 (continued)

	Drainage		
	MEAN	SE	MAX
Total Diss. Solids	82.00	14.46	265.00
Pheno. Alkalinity	0.00	0.00	0.00
Total Alkalinity	68.95	13.31	246.00
Carb. Alkalinity	0.00	0.00	0.00
Bicarb. Alkalinity	68.95	13.31	246.00
Carbonates	0.00	0.00	0.00
Bicarbonates	84.02	16.22	300.00
Hydroxides	0.00	0.00	0.00
Carbon dioxide	2.45	1.26	5.81
Chloride	2.75	0.91	14.70
Sulfate	5.24	0.79	11.60
Fluoride	0.13	0.02	0.40
pH	7.65	0.29	8.10
pHs	8.59	0.59	9.59
Stab.	9.52	1.35	11.90
Sat.	-0.91	0.81	0.50
Color (PCU)	7.67	7.53	30.00
Odor	1.00	0.00	1.00
Turbidity (NTU)	3.33	0.54	7.90
Silica	7.05	0.67	10.80
Hydrogen sulfide	0.02	0.02	0.07
Sodium	8.78	1.52	20.82
Potassium	1.17	0.15	2.80
Total Hardness	58.37	15.67	258.00
Ca Hardness	34.42	9.25	149.00
Mg Hardness	23.97	27.89	109.00
Calcium	13.77	3.70	59.60
Magnesium	5.83	1.58	26.50
Iron	0.34	0.07	1.09
Manganese	0.05	0.00	0.05
Copper	0.01	0.00	0.01
TOC	4.69	0.95	15.90
Total Ortho-phosphate	0.03	0.00	0.06
Total Susp. Phosphate	0.04	0.01	0.15
Total Diss. Phosphate	0.04	0.01	0.15

Parkwide				
MIN	Mean	SE	Max	Min
19.00	114.60	10.20	690.00	23.00
0.00	0.00	0.00	0.00	0.00
13.40	59.43	4.47	246.00	0.02
0.00	0.00	0.00	0.00	0.00
13.40	59.43	4.47	246.00	0.02
0.00	0.00	0.00	0.00	0.00
16.33	71.14	5.45	300.00	1.22
0.00	0.00	0.00	0.00	0.00
0.30	2.45	1.26	5.81	0.30
0.90	6.26	1.41	104.00	0.00
1.40	15.00	3.52	260.00	0.00
0.05	1.07	0.15	8.30	0.00
7.20	7.65	0.29	8.10	7.20
7.50	8.59	0.59	9.59	7.50
7.00	9.52	1.35	11.90	7.00
-2.29	-0.91	0.81	0.50	-2.29
0.00	7.67	7.53	30.00	0.00
1.00	1.00	0.00	1.00	1.00
0.20	1.80	0.21	9.30	0.00
0.50	18.68	1.89	125.00	1.00
0.01	0.02	0.02	0.07	0.01
1.42	13.46	2.35	186.00	0.00
0.29	1.17	0.15	2.80	0.29
10.00	53.42	5.59	281.00	4.00
5.42	35.30	3.71	193.00	2.00
4.39	23.97	27.89	109.00	4.39
2.17	14.04	1.47	77.20	0.87
1.07	4.43	0.50	26.50	0.00
0.09	0.19	0.03	1.82	0.00
0.05	0.06	0.01	1.00	0.00
0.01	0.23	0.17	19.00	0.00
0.90	4.54	0.44	20.00	0.30
0.02	0.14	0.02	0.93	0.01
0.02	0.08	0.01	0.65	0.01
0.02	0.12	0.02	0.60	0.01

than the mean for all YNP streams. The most turbid stream sampled was Cache Creek (7.70 NTU). Mean turbidity for all the tributaries (2.9 NTU) was 1.7 times greater than the mean value for all streams (1.8 NTU).

Mayflies (Order Ephemeroptera) were the dominant (based on numbers) group of aquatic macroinvertebrates captured in tributaries to the Lamar River during cursory surveys (Table 27). In 13 of the 15 streams sampled, Ephemeroptera species were the most frequently sampled macroinvertebrates. Baetis bicaudatus was dominant in Little Lamar, upper Lamar, Opal Creek, and stream #0590. Baetis tricaudatus was dominant in Calfee and Cold Creeks. Ephemerella infrequens was dominant in Willow Creek. Seratella teresa was dominant in stream #0569. Epeorus longimanus was dominant in Cache Creek, Miller Creek, Timothy Creek, and stream #0600. Rithrogena sp. was dominant in Flint Creek. Caddisflies (Order Trichoptera) were the most frequently sampled species in two streams: Helicopsyche borealis in Twin Creek, and a Hydropsyche sp. in stream #0566. Willow Creek and stream #0569 contained the most diverse communities; these were the only streams with beetles (Order Coleoptera). Stoneflies (Order Plecoptera) were absent in Little Lamar, upper Lamar, Miller, Opal, and Twin Creeks.

Main stem

The mainstem of the Lamar River supports the seventh most heavily used stream fishery in YNP (Table 23). This use is distributed over three sections: below the Lamar River canyon (Below Canyon), between the Lamar River canyon and Cache Creek (Valley), and above Cache Creek (Headwaters) (Table 24, Figure 24). Since 1973, Below Canyon and Valley sections have been managed under catch and release regulations. These areas have generally received the highest angler use (866 and 2,783 angler days/year, respectively). After a sharp increase in use during 1981, the fishery has declined in popularity over the past three years. Approximately 660 fish/km/year (225 fish/ha/year) are landed in the Valley section. This area has an average yearly catch rate of 1.6 fish/hour.

Ecological performance surveys of the fish community in the mainstem of the Lamar River, from the confluence of Soda Butte Creek downstream to the Lamar River Picnic Area (2.4 km), were conducted on 15 June and 22 August 1984. Three species of fish were present on both sampling dates: cutthroat x rainbow trout hybrids

Table 27 Occurrence and densities of macroinvertebrates found in tributaries to the Lamar River, 1984.

STREAMS:	Cache	Calfee	Cold	Flint	Little	Upper	Miller	Opal	Timothy	Twin	Willow	#0566	#0569	#0590	#0602A
	Creek	Creek	Creek	Creek	Lamar	Lamar	Creek	Creek	Creek	Creek	Creek	Unam.	Unam.	Unam.	Unam.
Arthropoda															
Insecta															
Coleoptera (beetles)															
Elmidae															
<u>Cleptelmia</u> sp.														8	
<u>Zelotavia</u> parvula											7				
Diptera (true flies)															
Blephariceridae															1
Chironomidae															
<u>Cricotopus</u> sp.			1			1		2						3	
Epididae										1			2		
Psychodidae															
<u>Pericoma</u> sp.										1					
Rhagionidae															
<u>Atherix</u> pachypus							2								
Tipulidae															
<u>Dicranota</u> sp.							1				8				
<u>Hexatoma</u> sp.						1									
<u>Limonia</u> sp.					1										
Ephemeroptera (mayflies)															
Baetidae															
<u>Baetis</u> bicaudatus				4	4	12	8		23		7	4		18	18
<u>Baetis</u> tricaudatus	2	9		7					5	8			4		
Ephemerelellidae															
<u>Caudatella</u> hystrix							1					3			
<u>Caudatella</u> sp.				1											
<u>Drunella</u> doddsi	6			3			2			2		1			
<u>Drunella</u> coloradensis	2			3	2			2		1	1		3	2	
<u>Drunella</u> spinifera													4		
<u>Ephemerelella</u> infrequens		1								1	45				
<u>Seratella</u> teresa	1							4					32		
Heptageniidae															
<u>Cinygmula</u> sp.	3	6	2	7	6		1			4	3	6	3	5	14
<u>Epeorus</u> albertae		1	1	8				3				4			
<u>Epeorus</u> deceptivus				3				2						1	1
<u>Epeorus</u> grandis	3			1											
<u>Epeorus</u> longimanus	22			2			8	7	32		8				39
<u>Rithrogena</u> sp.	3			1	10			1		1				1	
Siphonuridae															
<u>Ameletus</u> sp.		3			2							1			
<u>Siphonurus</u> occidentalis												1			
Plecoptera (stoneflies)															
Capniidae															
<u>Capnia</u> sp.														1	
Chloroperlidae					4				3		1		3		1
<u>Sweltsa</u> coloradensis	1														
Nemouridae															
<u>Podmosta</u> sp.													3	1	
<u>Zapada</u> sp.					2						3	1			
Perlidae															
<u>Mesoperoperla</u> pacifica									3		2				
<u>Doroneuria</u> theodora		3		1											
Perlodidae															
<u>Mergarcys</u> sp.		1													
Trichoptera (caddisflies)															
Brachycentridae															
<u>Brachycentrus</u> sp.	7						1								
<u>Micrasema</u> sp.														1	
Glossosomatidae															
<u>Anagapetus</u> sp.								2							
<u>Glossosoma</u> sp.										1					
Helicopsychidae															
<u>Helicopsyche</u> borealis											14				
Hydropsychidae															
<u>Hydropsyche</u> sp.									1				71		
<u>Parapsyche</u> elais				3			1								
Lepidostomatidae															
<u>Lepidostoma</u> sp.														1	
Limnephilidae															
<u>Parula</u> sp.													2		
<u>Limnephilus</u> sp.										2				1	
Rhyacophilidae															
<u>Rhyacophila</u> sp.	3			2	1					3	3			6	1
TOTAL NUMBER OF SPECIES:	11	8	12	12	3	3	7	7	7	11	15	6	13	9	7

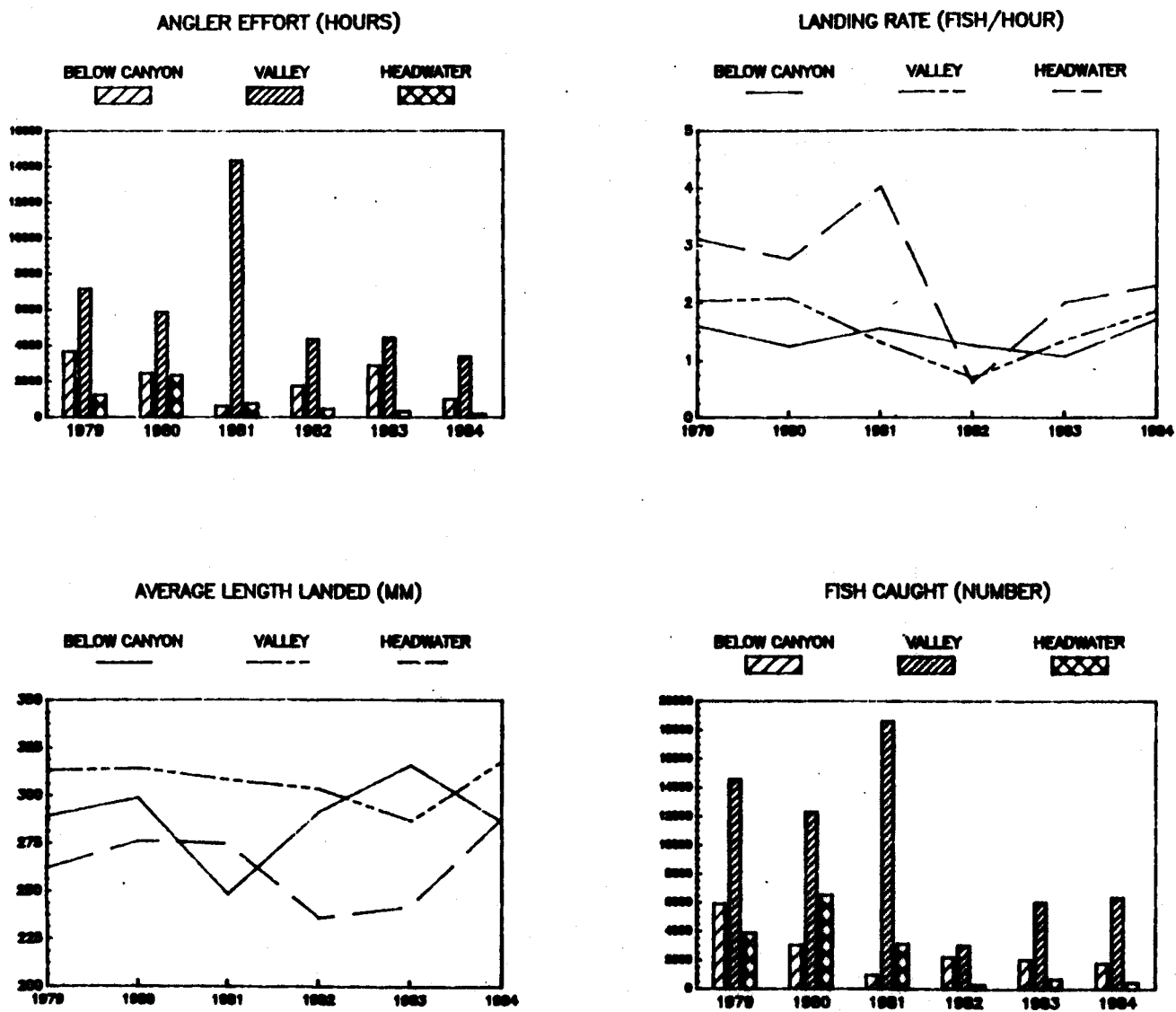


Figure 24. Angler statistics for below canyon, valley, and headwater section of Lamar River, 1979-1984.

(Salmo clarki x Salmo gairdneri), longnose dace (Rhinichthys cataractae), and mountain sucker (Catostomus platyrhynchus). Cutthroat x rainbow trout hybrids comprised 68% of the total number of fish sampled on each occasion. An estimated 736 (+519) and 748 (+571) hybrid trout inhabited this section of the Lamar River in June and August, respectively (Table 28). Efficiency rates for these two estimates were 7.9% and 7.4%, respectively. Based on this information and angler catch statistics, trout in this section of the Lamar River are caught and released at least two times per year (660 trout/km caught, 310 trout/km present).

Mean length, mean weight, and Proportional Stock Density (PSD) were 259 mm (n=68), 170 g, and 15.6% in June, and 303 mm (n=67), 268 g, and 16.4% in August (Table 28). Total biomass estimates for these hybrid fish was estimated at 52.1 kg/km (17.6 kg/ha) in June and 83.5 kg/km (28.2 kg/ha) in August. Average empirical growth rate for trout captured in August was 92 mm/year (Table 29). Differences in length distribution (Figure 25), PSD, and biomass estimates between the spring and fall samples might be attributed to the spawning migration of larger fish out of the Lamar River in June.

No population estimates were made for longnose dace and mountain suckers. Longnose dace had a mean TL of 70 mm (n=21) in June and 93 mm (n=30) in August. Two mountain suckers (85-125 mm) were captured in June and one (135 mm) was captured in August.

Cache Creek

Cache Creek drains the largest watershed of all tributaries to the Lamar River. cursory surveys were performed on 18 tributaries to this stream from 31 July through 3 August 1984. A reconnaissance survey was performed on Cache Creek during the same period.

Tributaries

Two of Cache Creek's tributaries are third order, three are second order, and 17 are first order streams (Table 30, Figure 26). Approximately 64% (14/22) of the tributaries had watersheds less than 500 ha. Only four tributaries (South Cache, #0650, #0655, and #0665) had watersheds larger than 1,500 ha, water flows over 0.26 m³/s, channels wider than 4.2 m, average stream depths over 19 cm, and gradients less than 6.6%. Four streams (#0640, #0641, #0644, and #0645) were completely dewatered. Stream #0645 had the largest watershed (410 ha) of the dewatered tributaries.

Table 28 Results of fish population size estimations performed on YNP streams, 1984.

Stream	Species	Date	Length (km)	Area (ha)	Population Estimate						Mean length (mm)	Mean weight (g)	PSD	Method
					N	95% CI	Fish/km	Fish/ha	kg/km	kg/ha				
Lamar River	Rainbow-cutthroat hybrid	06/15/84	2.400	7.077	736	+519	307	104	52.10	17.60	259	170	15.60	Petersen
		08/22/84	2.400	7.077	748	+571	312	105	83.50	28.20	303	268	16.40	Petersen
Lewis River	Brown trout	06/26/84	5.000	18.700	3,030	+1,535	606	162	38.80	10.54	95	8	0.00	Petersen
		08/28/84	5.000	18.700	9,599	+3,412	1,920	513	67.00	17.91	155	35	50.00	Petersen
Madison River National Park Meadows	Brown trout	06/05/84	2.667	10.053	1,942	+523	728	193	139.05	36.86	277	191	14.58	Petersen
		09/04/84	2.667	10.053	3,430	+567	1,286	341	272.63	72.29	287	212	13.66	Petersen
	Rainbow trout	06/05/84	2.667	10.053	683	+457	256	68	38.91	10.34	256	152	2.86	Petersen
		09/04/84	2.667	10.053	1,057	+362	396	105	57.02	15.12	252	144	2.31	Petersen
	Mountain whitefish	06/05/84	2.667	10.053	997	+537	374	99	210.19	55.64	350	562	98.80	Petersen
		09/04/84	2.667	10.053	1,635	+971	613	163	338.38	89.98	347	552	94.30	Petersen
Barns	Brown trout	06/06/84	6.000	22.615	805	+398	134	36	35.24	9.47	301	263	28.57	Petersen
		09/03/84	6.000	22.615	1,765	+479	294	78	98.78	26.21	327	336	37.66	Petersen
	Cutthroat trout	06/06/84	6.000	22.615	--	--	--	--	--	--	266	--	0.00	Petersen
		06/06/84	6.000	22.615	1,080	+1,197	180	48	32.04	8.54	273	178	18.75	Petersen
	Rainbow trout	09/03/84	6.000	22.615	622	+408	104	28	17.68	4.76	269	170	9.80	Petersen
		06/06/84	6.000	22.615	9,376	+1,674	1,563	415	276.65	73.46	273	177	81.90	Petersen
	Mountain whitefish	09/03/84	6.000	22.615	10,638	+1,493	1,773	470	400.69	106.22	295	226	96.07	Petersen
		06/06/84	6.000	22.615	9,376	+1,674	1,563	415	276.65	73.46	273	177	81.90	Petersen
Soda Butte Creek Footbridge	Cutthroat trout	06/15/84	2.333	3.569	891	+506	382	250	59.02	38.63	250	154	4.20	Petersen
		08/22/84	2.333	3.569	1,460	+357	626	409	94.21	61.55	248	150	2.10	Petersen
Northeast Entrance	Cutthroat trout	08/21/84	0.305	0.356	295	+287	967	829	76.59	65.66	202	79	0.00	Petersen

Table 29. Empirical lengths by age group, of fish captured during stream surveys in YNP, 1984.

	Species	Sample Size	Length at Age ¹⁾						
			I+	II+	III+	IV+	V+	VI+	VII+
Lamar River	Cutthroat Trout	46	--	213 (4)	275 (20)	360 (16)	405 (6)	---	---
Lewis River	Brown Trout	36	125 (16)	198 (12)	246 (3)	417 (2)	451 (3)	---	---
Madison River	Rainbow Trout	23	102 (1)	184 (5)	231 (13)	298 (3)	425 (1)	---	---
	Brown Trout	45	113 (3)	213 (9)	282 (12)	334 (14)	355 (6)	433 (1)	---
	Mountain Whitefish	10	127 (1)	172 (3)	240 (1)	282 (3)	402 (2)	---	---
Sedge Creek	Cutthroat Trout	7	122 (4)	178 (3)	---	---	---	---	---
Soda Butte Creek (upper)	Cutthroat Trout	19	---	204 (8)	235 (10)	279 (1)	---	---	---
	(lower)	45	---	214 (16)	264 (20)	334 (6)	370 (3)	---	---
	(combined)	64	---	211 (24)	255 (30)	326 (7)	370 (3)	---	---
Snake River	Cutthroat Trout	3	150 (2)	153 (1)	---	---	---	---	---
	Brown Trout	2	204 (1)	188 (1)	---	---	---	---	---
	Mountain Whitefish	38	155 (3)	202 (1)	248 (1)	309 (12)	374 (9)	365 (4)	381 (2)

1) Values given as means with sample size in parentheses.

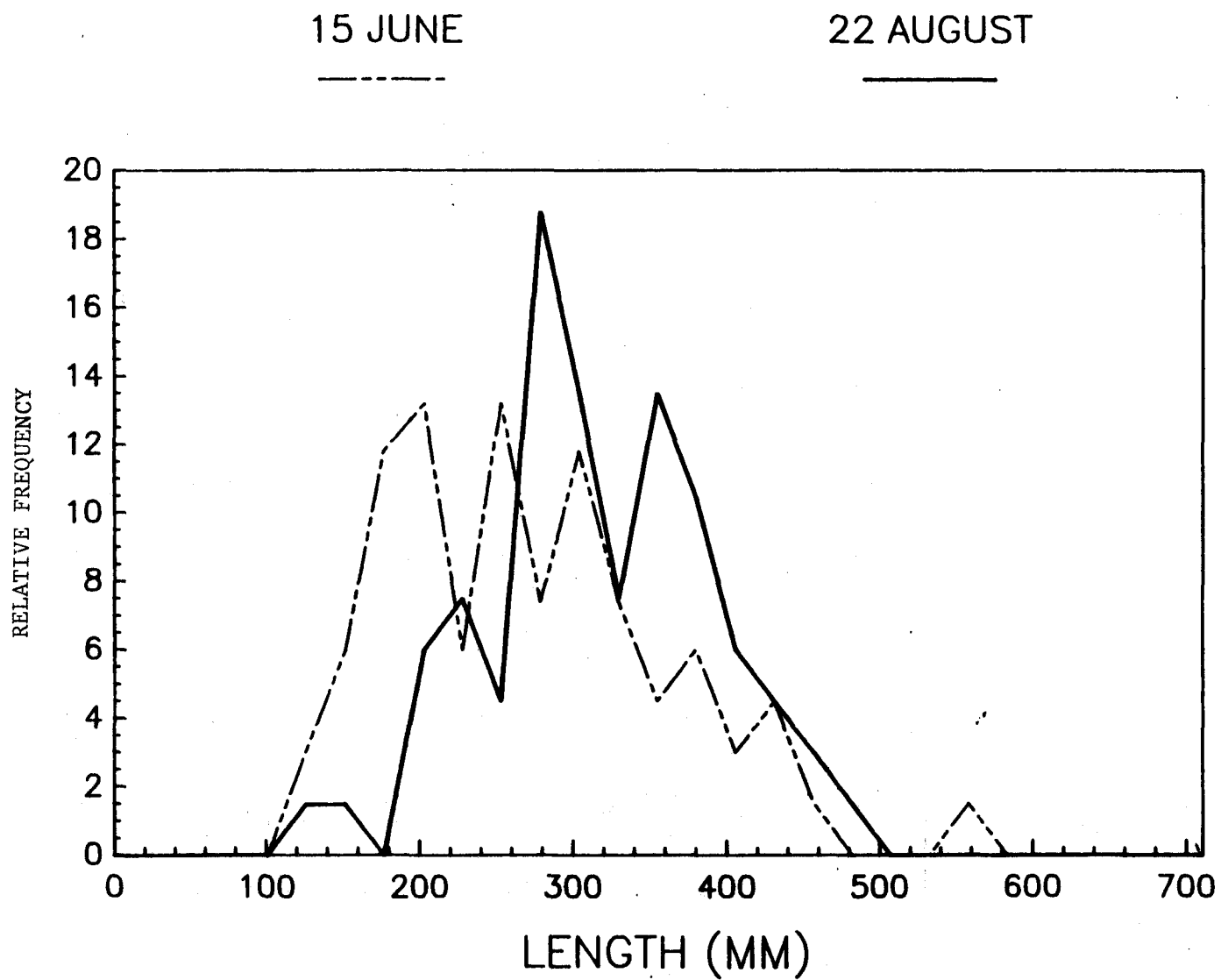


Figure 25. Length distribution of hybrid trout (Salmo clarki X Salmo gairdneri) captured in Lamar River on 15 June and 22 August, 1984.

Table 30. Results of cursory surveys performed on tributaries to Cache Creek, 1984.

Streams	Stream Order	Watershed Size (ha)	Stream Length (km)	Stream Elevation (m)		Gradient	Stream Flow (m3/s)	Mean Width (m)	Mean Depth (cm)	Mean Velocity (cm/s)	Mean Temperature (C)
				Max.	Min.						
Named:											
South Cache Creek	3	5796.64	12.71	2926.08	2090.93	6.56	0.830	6.65	16.76	74.06	15.56
Unnamed:											
#0637	1	322.91	2.45	2389.63	2054.35	13.70	0.006	1.09	5.18	11.28	13.90
#0638	1	441.05	3.23	2444.50	2072.64	11.49	0.021	1.56	8.23	17.06	10.50
#0639	1	614.32	4.63	2602.99	2072.64	11.44	0.061	2.70	6.64	34.14	12.80
#0640	1	299.33	2.49	2465.83	2072.64	15.76	0.000				
#0651	1	199.52	1.58	2420.11	2072.64	22.03	0.000				
#0642	2	740.34	4.80	2627.38	2097.02	11.05					
#0644	1	267.78	2.06	2490.22	2090.93	19.38	0.000				
#0645	1	409.55	2.93	2633.47	2145.79	16.65	0.000				
#0646	2	551.31	4.30	2767.58	2170.18	13.90					
#0647	1	199.52	3.03	2584.70	2170.18	13.70	0.013	1.43	8.23	11.60	10.50
#0648	1	165.39	2.09	2584.70	2170.18	19.81					
#0649	1	259.90	3.15	2804.16	2185.42	19.61	0.041	1.54	19.81	13.41	11.20
#0650	2	2803.81	10.01	2758.44	2218.94	5.38	0.650	6.04	19.51	54.60	10.00
#0651	1	307.13	2.96	2779.78	2194.56	19.76	0.024	1.65	6.71	21.95	12.30
#0652	1	393.79	2.67	2779.78	2218.94	20.99	0.030	1.40	10.67	20.73	14.50
#0653	1	441.05	2.64	2804.16	2243.33	21.24	0.133	4.05	10.67	30.78	12.80
#0655	1	1835.08	10.73	2865.12	2316.48	5.11	0.269	4.21	9.05	33.53	12.20
#0661	1	275.66	1.69	2804.16	2414.02	23.00	0.014	0.90	7.62	20.72	6.60
#0662	1	204.77	1.45	2804.16	2456.69	23.93					
#0663	1	157.52	1.30	2755.39	2569.46	14.26	0.150	1.92	12.50	62.48	9.40
#0665	3	1548.92	7.82	2779.78	2346.96	5.53	0.570	5.74	20.57	48.16	8.33
Total:		24031.93	103.43				3.639				
Mean:		1044.87	4.50	2686.88	2142.61	14.82	0.240	3.17	12.59	35.24	11.74
SE:		339.55	0.75	33.96	65.93	1.28	0.080	0.56	1.44	5.72	0.67

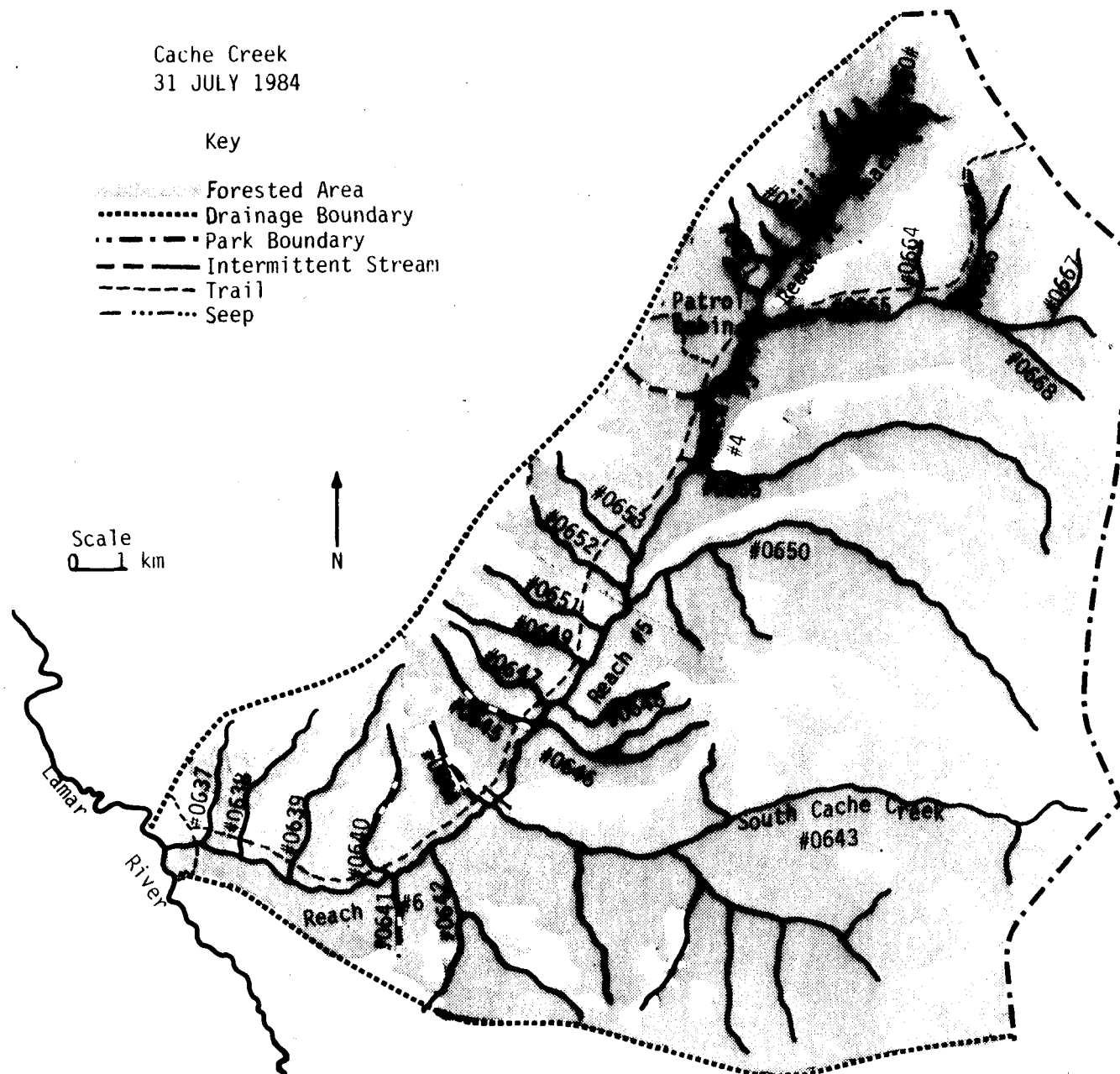


Figure 26. Hydrographic Map of Cache Creek, YNP, 1984.

Approximately 26 species of macroinvertebrates were sampled in the Cache Creek drainage (Table 31). Stream #0661 contained the macroinvertebrate community with the greatest diversity. This was the only stream where seed shrimp (Ostracoda) were captured. Planarians (Turbellaria) were found in two streams: #0637 and #0649. Beetles were only captured in stream #0637. Mayflies (Cinygmula sp.) were the most widely distributed group of macroinvertebrates in the drainage. They were the dominant organisms in South Cache, stream #0653, #0650, and #0665. True flies (Order Diptera) were dominant in stream #0637, stoneflies were dominant in stream #0639, and caddisflies were dominant in stream #0638.

Main stem

Six reaches were established in Cache Creek (Table 32, Figure 26). This stream progressed from highly disturbed areas in the headwaters to a fairly stable environment at the outlet. Reach 1 had the highest degree of streambank alteration (99%) and steepest gradient (12.3%) of all six reaches. Only 12.4% of the stream channel in reach 1 was submerged. Reach 2 represented a canyon area. Bedrock formed the channel on both banks. Log jams and other evidence of flooding were prevalent from this reach downstream through reach 4. The stream channel and banks in reach 5 were fairly stable. Over 89% of the stream channel was submerged, streambank alteration was 33%, gradient was less than 3%, and vegetative overhang was 36.6 cm. In reach 6, almost 57% of the stream channel contained pools and vegetative overhang was 85.3 cm.

The distribution of macroinvertebrates in the main channel of Cache Creek also indicated the upper reaches were not as stable as the lower reaches (Table 31). In reach 1, only one organism (Chironomidae) was captured. A single organism was also captured in reach 3 (Rhyacophila sp.) and reach 4 (Baetis bicaudatus). Reaches 5 and 6 contained at least seven different species. Epeorus albertae was the dominant species in reach 5 and a simuliid (Prosimulium sp.) was dominant in reach 6. A large number of mayflies (Drunella doddsi) was also present in reach 6.

Calfee Creek

Calfee Creek drains the smallest third order watershed in the Lamar drainage. cursory surveys were performed on seven tributaries of this stream from 14 to 16 August 1984. During this same period, a reconnaissance survey of Calfee Creek was performed.

Table 31. Occurrence and densition of macroinvertebrates found in Cache Creek, tributary to Lamar River, 1984.

REACH:	Reach #1	Reach #2	Reach #3	Reach #4	Reach #5					Reach #6					
	Main Stem	Trib #0661	Main Trib Stem #0665	Main Stem	Main Trib Stem	Trib #0649	Trib #0650	Trib #0652	Trib #0653	Trib #0655	Main Trib Stem	Trib #0637	Trib #0638	Trib #0639	South Cache
Platyhelminthes															
Turbellaria (planarians)					1						4				
Arthropoda															
Crustacea															
Ostracoda (seed shrimp)		2													
Insecta															
Coleoptera (beetles)															
Elmidae															
Stenelmis sp.											3				
Diptera (true flies)															
Chironomidae	1	42						3			18			2	
Cricotopus sp.		23						2							
Rhagionidae															
Atherix pachypus		2									1				
Simuliidae															
Prosimulium sp.											31				
Ephemeroptera (mayflies)															
Paetidae															
Baetis bicaudatus			3	1						4			1		
Baetis tricaudatus					1						3				
Ephemerellidae															
Drunella coloradensis			1												
Drunella doddsi			1								21				
Heptageniidae															
Gnypmula sp.			4		2	1	8		6	3	9		2	1	3
Epeorus albertae					7			1							
Epeorus deceptivus					1		1				1				
Epeorus longimanus										1					
Rithrogena sp.			2		3	3									
Siphonuridae															
Ameletus sp.										5					
Plecoptera (stoneflies)															
Chloroperlidae		4										1		2	2
Svelta coloradensis											1				
Nemouridae															
Podrosta sp.		8													
Visoka cataractae									1					3	
Zapada sp.		7	1		1						3			3	1
Perlidae															
Doroneuria theodora									1		1	2		1	
Hesperoperla pacifica					1										
Perlodidae															
Megarcys sp.													2		
Trichoptera (caddisflies)															
Hydropsychidae															
Parapsyche elais			3											1	
Limnephilidae															
Neothremma sp.															
Rhyacophilidae															
Rhyacophila sp.		2	1				2								1
TOTAL NUMBER OF SPECIES:	1	8	1	7	1	7	3	3	1	3	4	7	6	6	4

Table 32. Reconnaissance survey results for Cache Creek, 1984.

Habitat Features	Reach #1	Reach #2	Reach #3	Reach #4	Reach #5	Reach #6
Sample Date:	7/31/84	7/31/84	8/01/84	8/01/84	8/02/84	8/03/84
Time (hrs):	1430	1810	1100	1400	1200	1020
Length (km):	4.7	1.5	2.7	0.8	3.0	7.0
Stream Order:	2	2	3	3	3	4
Drainage Size (ha):	1408	1716	4707	4884	12465	21002
Water Column:						
Water Flow (m ³ /s)	0.069	0.384	0.747	0.677	1.398	1.377
Channel Width (m)	13.35	8.68	21.39	8.66	13.79	25.45
Stream Width (m)	1.66	6.52	11.26	6.28	12.30	17.54
Stream Depth (cm)	7.92	9.75	12.80	32.92	21.95	21.47
Stream Shore Water Depth (cm)	0.00	0.00	0.00	0.00	0.20	6.70
Riffle Width (m)	1.66	6.52	9.74	6.11	10.87	47.63
Pools:						
Width (m)	0.00	0.00	0.00	3.15	2.44	9.90
Quality	0.0	0.0	0.0	2.3	1.0	1.3
Feature	0	0	0	4	4	4
Solar Incidence	76.7	43.3	73.3	31.3	50.0	139.7
Solar Angle	137.3	70.7	107.0	94.0	67.7	86.7
Channel Morphology:						
Streambank Alteration	99.0	26.8	73.3	15.0	33.3	54.2
Vegetative Stability	1.0	1.0	1.5	1.3	2.8	2.7
Undercut (cm)	0.9	0.0	8.1	0.5	1.5	2.4
Channel-Bank Angle	116.7	117.5	105.0	131.8	125.0	150.8
Stream Bottom:						
Gradient (%)	12.3	5.2	2.3	4.4	2.7	2.2
Sinuosity	1.49	1.13	1.19	1.07	1.07	1.09
Substrate:						
Boulder > 356 mm	12.1	27.0	0.0	62.9	34.4	9.5
Cobble 64-356 mm	37.1	28.4	23.8	9.9	45.3	29.6
Gravel 2-64 mm	40.9	44.6	44.2	6.2	11.7	27.7
Sand 0.6-2 mm	3.0	0.0	2.2	2.5	0.0	9.1
Silt < 0.6 mm	7.6	0.0	29.8	18.5	8.6	24.1
Embeddedness	1.7	2.0	2.3	2.3	2.0	3.0
Channel Vegetative Cover (cm)	13.7	0.0	132.1	20.4	0.0	2.0
Riparian Zone						
Streamside Cover	1.0	1.0	1.7	1.5	2.7	5.0
Vegetative Use	0.0	0.0	0.0	0.0	0.0	1.7
Vegetation Overhang (cm)	0.0	0.0	25.4	5.2	36.6	85.3
Habitat Type	11	12	9,12,13	13,13,12	14,14,13	12

Tributaries

All of the tributaries to Calfee Creek are unnamed and drain south facing slopes (Figure 27). Stream #0629 drains the largest watershed (461 ha) and is a second order stream (Table 33). All tributaries had gradients over 9%, waterflows less than $0.035 \text{ m}^3/\text{s}$, channels narrower than 4.0 m, and water under 16 cm in depth. Average water temperature of these streams was 12.7 C.

Tributaries close to the headwater area generally had fewer macroinvertebrate species than tributaries lower in the drainage (Table 34). Stream #0632 contained only chironomids. At least five species of organisms were sampled in stream #0631. Streams #0627 and #0629 contained at least 16 species. In both these streams, and #0628, stoneflies (Zapada sp.) were the dominant organisms. Only one stream (#0628) contained beetles and two streams (#0627, #0633) contained planarians. Dipterans (Chironomidae) were dominant in one stream (#0630).

Main stem

Three reaches were established in Calfee Creek (Table 35, Figure 27). Water flow in reach 3 ($0.077 \text{ m}^3/\text{s}$) was over 15 times higher than in reach 1 ($0.004 \text{ m}^3/\text{s}$) and the stream drained a watershed over 19 times larger in reach 3 than reach 1. Substrate composition also changed significantly in the channel between reach 1 and 3. In reach 1, almost 90% of the substrate particles had diameters greater than 356 mm; whereas, in reach 3 most substrate particles were between 2 and 64 mm in diameter. Reach 2 generally contained the largest pools and deepest channel. This section of stream also contained the deepest undercut banks.

Distribution of macroinvertebrates in the main channel of Calfee Creek may reflect the change in substrate composition from upstream to downstream reaches (Table 34). Reach 1 contained only two species: Baetis bicaudatus and a stonefly (Megarcys sp.). Nine groups of organisms were captured in reach 2. Stoneflies (Zapada sp.) were the dominant species in that reach. Mayflies (Rithrogena sp.), however, were the dominant organisms in reach 3. Reach 3 also contained the only dipteran (Hexatoma sp.) captured in the mainstem. Only three organisms (Epeorus deceptivus, Megarcys sp., and Parapsyche elsis) that were captured in reach 2 were absent in reach 3.

CALFEE CREEK
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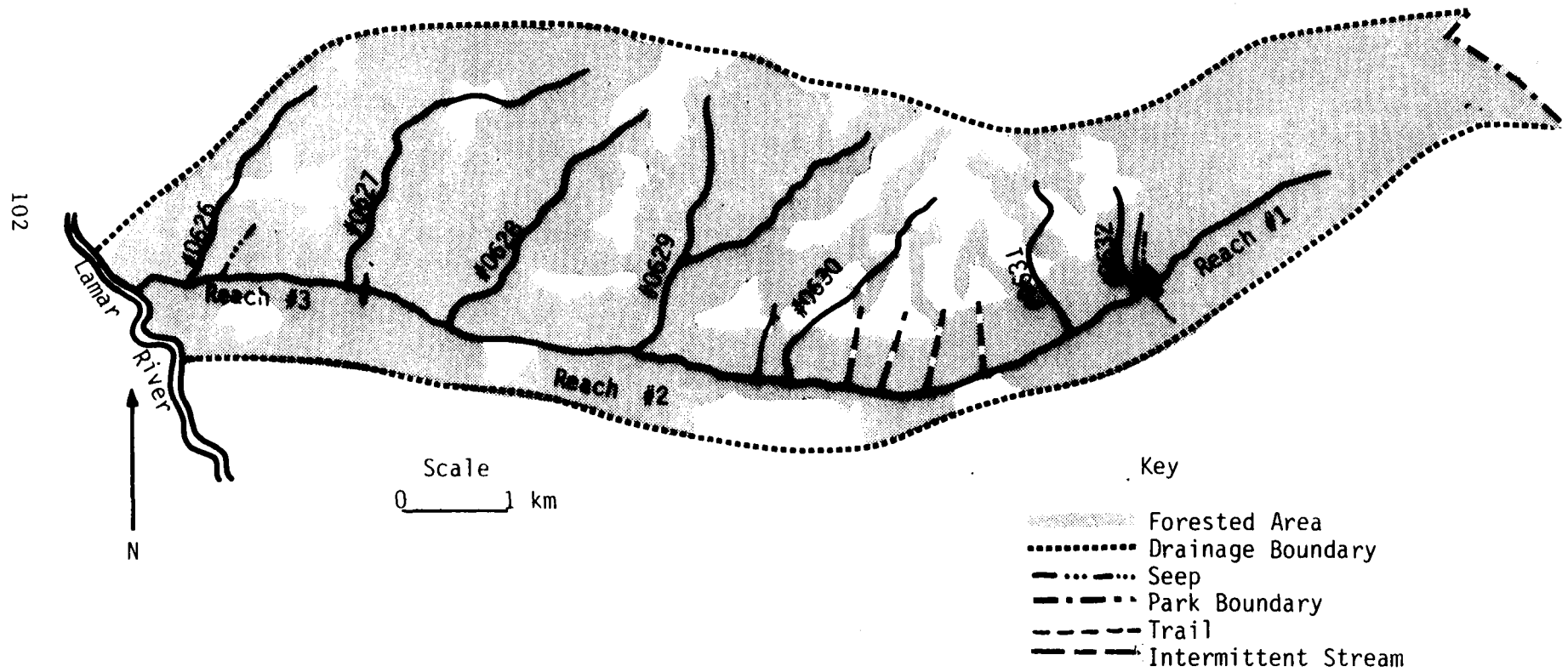


Figure 27. Hydrographic Map of Calfee Creek, YNP, 1984.

Table 33. Results of cursory surveys performed on tributaries to Calfee Creek, 1984.

Stream	Stream Order	Watershed Size (ha)	Stream Length (km)	Stream Elevation (m)		Gradient	Stream Flow (m ³ /s)	Mean Width (m)	Mean Depth (cm)	Mean Velocity (cm/s)	Mean Temperature (C)
				Max.	Min.						
Unnamed:											
#0626	1	143.26	2.27	2682.24	2438.40	10.74	0.013	2.04	6.10	14.42	12.00
#0627	1	449.22	4.00	2633.47	2194.56	10.97	0.030	2.68	10.67	15.03	12.00
#0628	1	376.37	2.93	2584.70	2231.14	12.07	0.021	2.83	8.38	12.58	9.50
#0629	2	461.36	3.27	2682.24	2304.29	11.56	0.035	2.83	15.48	15.05	13.00
#0630	1	368.28	2.33	2657.86	2365.25	12.56	0.008	2.83	6.98	7.77	18.00
#0631	1	299.48	1.80	2657.86	2487.17	9.48	0.006	3.90	5.33	9.60	13.00
#0632	1	--	--	--	--	--	0.003	1.98	3.81	18.98	11.50
Total:		2097.97	16.60	--	--	--	0.116	--	--	--	--
Mean:		349.66	2.77	2649.73	2336.80	11.23	0.020	2.73	8.11	13.35	12.71
SE:		47.81	0.33	14.99	46.97	0.45	0.000	0.24	1.48	1.42	0.99

Table 34. Occurrence and densities of macroinvertebrates found in Calfee Creek, tributary to Lamar River, 1984.

Reaches:	Reach #1		Reach #2						Reach #3	
	Main Stem	Main Stem	Trib. #0632	Trib. #0631	#0630	#0633	#0629	#0628	Main Stem	Trib. #0627
Platyhelminthes										
Turbellaria (planarians)						2				2
Insects										
Coleoptera (beetles)										
Elmidae										
<u>Zaitzevia parvula</u>								2		
Diptera (true flies)										
Chironomidae			2		9	6	6			6
Tipulidae										
<u>Hexatoma</u> sp.									1	
<u>Limonia</u> sp.								1		
<u>Tipula</u> sp.								2		
Ephemeroptera (mayflies)										
Heptageniidae										
<u>Baetis bicaudatus</u>	4	3		8		10	7	4	3	10
Ephemerellidae										
<u>Drunella coloradensis</u>		1					2	4	4	
<u>Drunella doodai</u>					2	5				5
Heptageniidae										
<u>Cinygmula</u> sp.		1		6	3	3	1	22	4	3
<u>Epeorus albertae</u>				4			3			
<u>Epeorus deceptivus</u>		2						1		
<u>Epeorus grandis</u>							1			
<u>Epeorus longimanus</u>								3		
<u>Heptagenia</u> sp.				1						
<u>Rithrogena</u> sp.		5				13		11	22	13
Siphonuridae										
<u>Amelutus</u> sp.					1	1	1	1		1
Plecoptera (stoneflies)										
Capniidae										
<u>Capnia</u> sp.								1		
Chloroperlidae						8	15	11		8
Nemouridae										
<u>Podmosta</u> sp.						5	2			5
<u>Zapada</u> sp.		9		2	4	18	1	24	5	18
Peltoperlidae										
<u>Yoraperia brevis</u>								1		
Perlidae										
<u>Doroneuria theodora</u>					1	2		1	3	2
Perlodidae										
<u>Meturcus</u> sp.	1	5				1				1
Trichoptera (caddisflies)										
Brachycentridae										
<u>Micranera</u> sp.							1			
Glossosomatidae										
<u>Glossosoma</u> sp.						1				1
<u>Acanthetusa</u> sp.		1							1	
Hydropsychidae										
<u>Parapsyche elois</u>		1								
Limnephilidae										
<u>Apatania</u> sp.						2				2
<u>Cryptochia</u> sp.								1		
<u>Parula</u> sp.									1	
<u>Neothremma</u> sp.						2				2
Rhyacophilidae										
<u>Rhyacophila</u> sp.						1	2	5	2	1
TOTAL NUMBER OF SPECIES:	2	9	1	5	6	16	14	15	10	16

Table 35. Reconnaissance survey results for Calfee Creek, 1984.

Habitat Features	Reach #1	Reach #2	Reach #3
Sample Date:	8/15/84	8/15/84	8/16/84
Time (hrs):	1230	0900	1730
Stream Order:	1	1	3
Length (km):	1.0	1.7	9.4
Drainage Size (ha):	206.4	481.6	3124.3
Water Column:			
Water Flow (m ³ /s)	0.004	0.008	0.077
Channel Width (m)	3.65	5.82	9.14
Stream Width (m)	2.31	3.21	4.43
Stream Depth (cm)	2.38	12.80	11.28
Stream Shore Water Depth (cm)	0.52	0.91	5.18
Riffle Width (m)	2.05	2.44	3.42
Pools:			
Width (m)	0.58	3.38	1.17
Quality	1.0	4.0	1.5
Feature	4	1	1,4
Solar Incidence	68.3	61.7	68.3
Solar Angle	102.8	75.0	45.0
Channel Morphology:			
Streambank Alteration	15.0	43.3	60.0
Vegetative Stability	3.0	3.7	3.0
Undercut (cm)	0.0	14.6	13.1
Channel-Bank Angle	147.2	92.3	99.3
Stream Bottom:			
Gradient (%)	10.6	6.6	3.8
Sinuosity	1.09	1.12	1.12
Substrate:			
Boulder > 356 mm	89.8	4.8	14.5
Cobble 64-356 mm	--	25.4	19.7
Gravel 2-64 mm	3.4	22.2	36.8
Sand 0.6-2 mm	--	12.7	11.8
Silt < 0.6 mm	6.8	34.9	17.0
Embeddedness	4.7	2.0	2.3
Channel Vegetative Cover (cm)	0.0	45.7	90.5
Riparian Zone:			
Streamside Cover	2.0	3.0	3.0
Vegetative Use	0.0	0.0	0.0
Vegetation Overhang (cm)	2.1	18.3	212.4
Habitat Type	12	13,12,13	13

Chalcedony Creek

Chalcedony Creek drains an approximately 1,300 ha watershed. A reconnaissance survey was performed on this stream on 7 August 1984. Although most maps indicate that a significant tributary enters Chalcedony Creek, only a dry stream channel was encountered during the survey.

Two reaches were established in the main channel of Chalcedony Creek (Table 36, Figure 28). Both reaches had steep gradients (16.9% and 17.3%). A series of waterfalls (6-9 m high) present in reach 2 were a barrier to upstream fish migration. Water flows in reach 2 had probably not been as stable as in reach 1. In reach 2, stream bank alteration was 35% and only 58% of the channel was submerged. Substrate particle sizes were also considerably different in the two areas. Almost 88% of the substrate particles in reach 2 were larger than 356 mm in diameter. No significant difference was apparent in the amount of forest cover in the two areas. Solar incidence in both reaches was less than 50%. Vegetative overhang, however, was 3 times greater in reach 2 than reach 1.

Macroinvertebrate species composition was significantly different in the two reaches. Nine species of organisms were captured in the stream; but no species were common to both reaches (Table 37). Planarians were the dominant organisms in reach 1. Caddisflies (*Farula* sp.) were the dominant species in reach 2. Caddisflies were not captured in reach 1 and planarians were not captured in reach 2. Although no differences in stream reach characteristics were apparent that explain the complete shift in species composition between the two areas, the difference might be due to an increase in water temperature from 9 to 12.5 C between reach 1 and 2 or the presence of the waterfalls.

Crystal Creek

Crystal Creek drains the third largest watershed of all second order tributaries to the Lamar River. On 24 July 1984, a cursory survey was conducted on the only tributary (#0478) to Crystal Creek that contained water. During the same day, a reconnaissance survey was performed on the main channel of Crystal Creek.

Tributaries

Crystal Creek contains seeps throughout the entire length of its channel (Figure 29); most seeps occur in

Table 36. Reconnaissance survey results for Chalcedony Creek, 1984.

Habitat Features	Reach #1	Reach #2
Sample Date:	8/7/84	8/7/84
Time (hrs):	1230	1545
Stream Order:	1	2
Length (km):	1.6	2.4
Drainage Size (ha):	764.8	1177.7
Water Column:		
Water Flow (m ³ /s)	0.073	0.053
Channel Width (m)	6.55	3.18
Stream Width (m)	5.06	1.86
Stream Depth (cm)	10.97	10.36
Stream Shore Water Depth (cm)	4.57	2.53
Riffle Width (m)	1.88	1.47
Pools:		
Width (m)	1.22	--
Quality	1	--
Feature	4	--
Solar Incidence	28.3	46.3
Solar Angle	26.7	30.0
Channel Morphology:		
Streambank Alteration	21.7	35.0
Vegetative Stability	3.3	--
Undercut (cm)	6.1	9.8
Channel-Bank Angle	94.2	91.7
Stream Bottom:		
Gradient (%)	17.3	16.9
Sinuosity	1.07	1.09
Substrate:		
Boulder > 356 mm	57.8	87.9
Cobble 64-356 mm	31.3	12.1
Gravel 2-64 mm	9.4	--
Sand 0.6-2 mm	1.6	--
Silt < 0.6 mm	--	--
Embeddedness	4.7	5.0
Channel Vegetative Cover (cm)	40.5	20.4
Riparian Zone:		
Streamside Cover	3.0	3.7
Vegetative Use	0.0	0.0
Vegetation Overhang (cm)	13.1	40.5
Habitat Type	13	13,12,13

Chalcedony Creek
07 AUG 1984

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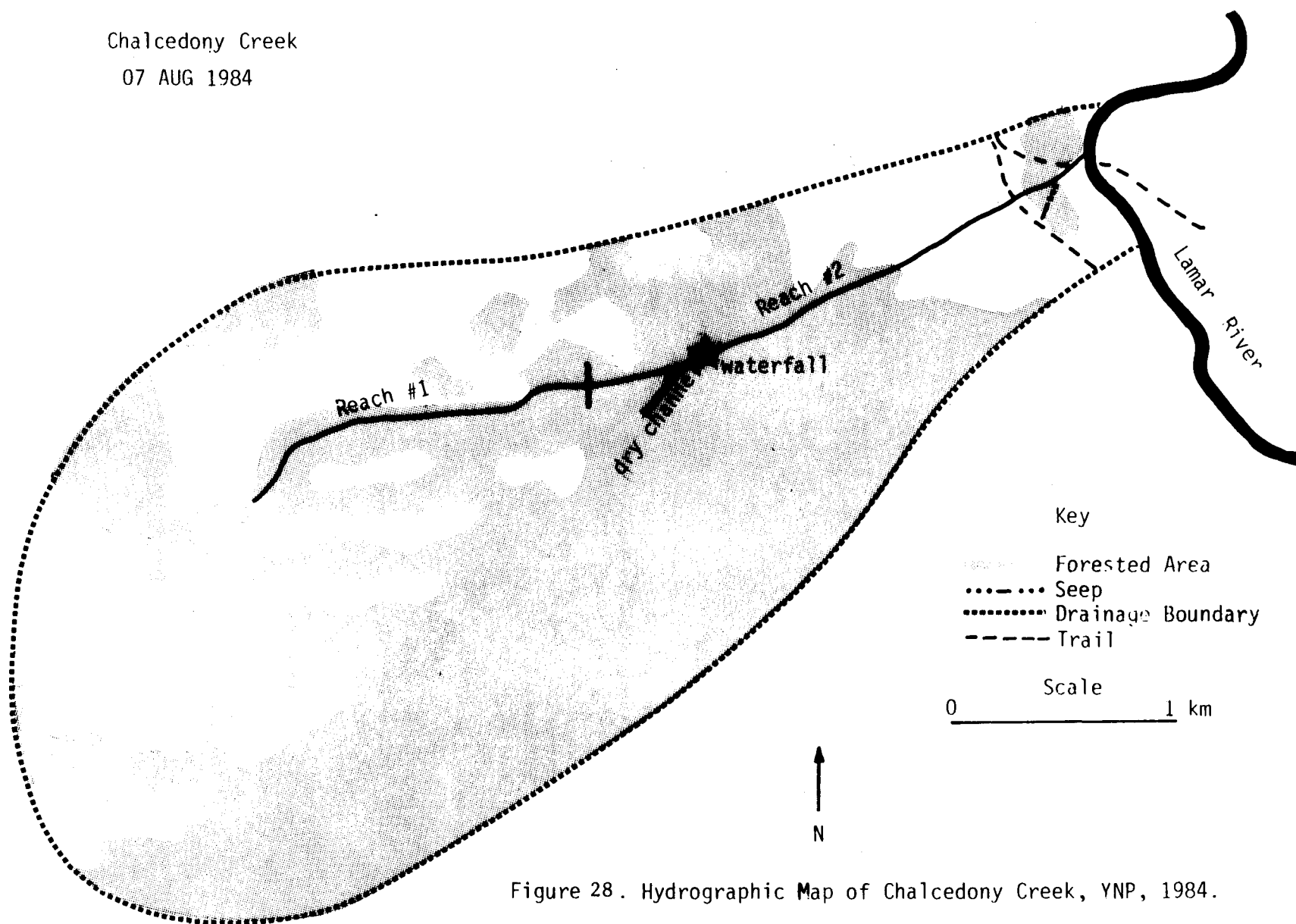


Figure 28. Hydrographic Map of Chalcedony Creek, YNP, 1984.

Table 37. Occurrence and densities of macroinvertebrates found in Chalcedony Creek, tributary to Lamar River, 1984.

Reach #:	Reach #1	Reach #2
Platyhelminthes		
Turbellaria (planarians)	6	
Arthropoda		
Insecta		
Ephemeroptera (mayflies)		
Baetidae		
<u>Baetis bicaudatus</u>	1	
Heptageniidae		
<u>Cinygmula</u> sp.		3
<u>Epeorus deceptivus</u>		4
Siphonuridae		
<u>Ameletus</u> sp.	2	
Plecoptera (stoneflies)		
Chloroperlidae		2
Nemouridae		
<u>Zapada</u> sp.	1	
Perlidae		
<u>Doroneuria theodora</u>		1
Trichoptera (caddisflies)		
Limnephilidae		
<u>Farula</u> sp.		41
TOTAL NUMBER OF SPECIES:	4	5

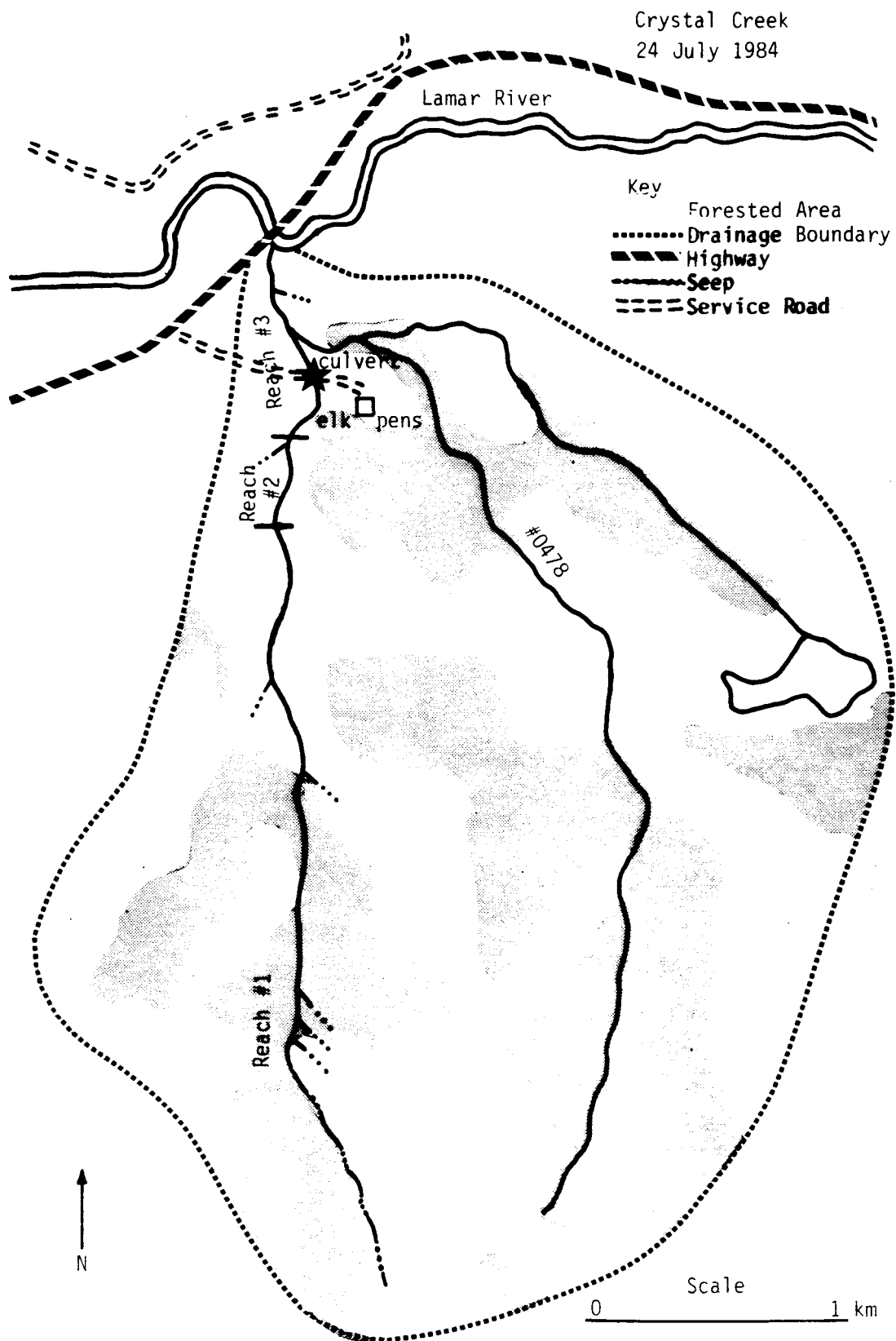


Figure 29. Hydrographic Map of Crystal Creek, YNP, 1984.

the headwater area. Only one tributary to Crystal Creek had a defined channel longer than 100 m with flowing water (Table 38). This stream (#0478) drains a larger watershed (1157.4 ha) than the main channel of Crystal Creek (441.1 ha) above their confluence. Water flow in this stream, furthermore, was 2.4 times greater than in Crystal Creek at their confluence. Stream #0478 also had the most diverse macroinvertebrate community in the Crystal Creek drainage (Table 39). Earthworms (Annelida) were the dominant organisms captured. More species of true flies were captured than in any other order. Planarians were also present in this stream.

Main stem

The main channel of Crystal Creek may be divided into three reaches (Table 40). All three reaches had a high degree of vegetation overhang (over 20.4 cm) and received a low amount of direct sunlight (solar incidence less than 45%). The stream bottoms in these areas contained more vegetation than most of the streams in the Lamar drainage. Water flow between reach 1 and 3 increased 8.5 times, and the drainage basin increased 4.9 times. Reach 2 was the only area which contained well defined pools. Reach 3 provided habitat features that might support fish (water depth over 19 cm and water flow greater than $0.017 \text{ m}^3/\text{s}$); however, no fish were observed.

Jasper Creek

Jasper Creek is one of the smallest second order tributaries to the Lamar River. A cursory survey was performed on Jasper Creek's only tributary (#0491) from 25 to 26 July 1984. During the same period, a reconnaissance survey was performed on Jasper Creek.

Tributaries

Jasper Creek contains one tributary and several seeps throughout its main channel (Table 38, Figure 30). The tributary (#0491) enters Jasper Creek in the headwater area. For streams with flowing water, #0491 drained the smallest watershed of all streams surveyed in 1984. Discharge in stream #0491 was $0.002 \text{ m}^3/\text{s}$. Average width of this stream was 0.4 m and average depth was 6.3 cm. The macroinvertebrate community in this stream had the highest diversity in the Jasper Creek drainage (Table 41). Earthworms and mayflies (*Baetis bicaudatus*) were the dominant organisms. True flies, however, were represented by more species than any other order. Stoneflies and caddisflies were not captured.

Table 38. Results of cursory surveys performed on tributaries to Crystal, Jasper, and Rose Creeks, 1984.

Streams	Stream Order	Watershed Size (ha)	Stream Length (km)	Stream Elevation (m)		Gradient	Stream Flow (m ³ /s)	Mean Width (m)	Mean Depth (cm)	Mean Velocity (cm/s)	Mean Temperature (C)
				Max.	Min.						
Crystal Creek Tributary #0478	2	1157.4	4.3	2438.4	1889.8	12.9	0.016	0.69	12.8	20.7	13.3
Jasper Creek Tributary #0491	1	48.6	0.8	2304.3	2145.8	19.8	0.002	0.40	6.3	11.3	11.1
Rose Creek Tributaries											
#0496	1	878.2	4.6	2560.3	2048.3	11.1	0.080	3.14	14.4	17.7	9.5
#0497	1	222.6	2.3	2779.8	2255.5	22.5	0.011	1.51	5.8	12.8	8.0
#0498	1	153.8	2.2	2901.7	2450.6	20.5	0.013	1.74	7.3	10.4	10.0
#0499	1	113.3	1.6	2901.7	2584.7	19.8	0.015	2.06	4.8	14.9	9.0
Total:		1367.9	10.7	--	--	--	0.120	--	--	--	--
Mean:		342.0	2.7	2785.9	2334.8	18.5	0.030	2.11	8.1	13.9	9.1
SE:		180.2	0.7	80.5	117.0	2.5	0.017	0.36	2.2	1.6	0.4

Table 39. Occurrence and densities of macroinvertebrates found in Crystal Creek, tributary to Lamar River, 1984.

REACH:	Reach #1 Main Stem	Reach #2 Main Stem	Reach #3 Main Stem Tributary (#0478)	
Platyhelminthes				
Turbellaria (planarians)			2	2
Annelida				24
Arthropoda				
Arachnida				
Acarina				
Hydracarina (water mites)			3	
Insecta				
Coleoptera (beetles)				
Elmidae				
Stenelmis sp.			2	
Diptera				
Chironomidae	2			1
Simuliidae				
Prosimulium sp.				1
Simulium sp.				2
Ephemeroptera (mayflies)				
Baetidae				
Baetis bicaudatus	18	1	2	
Baetis tricaudatus				1
Heptageniidae				
Cinygmula sp.	16	1		
Leptophlebiidae				
Paraleptophlebia sp.				1
Plecoptera (stoneflies)				
Chloroperlidae	2			
Nemouridae				
Zapada sp.	1			1
Perlodidae				
Mergarcys sp.	1			
Trichoptera (caddisflies)				
Glossosomatidae				
Glossosoma sp.		1		
Lepidostomatidae				
Lepidostoma sp.	1			
Rhyacophilidae				
Rhyacophila sp.		1		3
TOTAL NUMBER OF SPECIES:	7	4	4	9

Table 40. Reconnaissance survey results for Crystal Creek, 1984.

Habitat Features	Reach #1	Reach #2	Reach #3
Sample Date:	7/24/84	7/24/84	7/25/84
Time (hrs):	1500	1650	0955
Stream Order:	1	1	2
Length (km):	3.0	0.4	0.7
Drainage Size (ha):	327.8	372.3	1598.4
Water Column:			
Water Flow (m ³ /s)	0.002	0.007	0.017
Channel Width (m)	2.00	1.77	1.46
Stream Width (m)	1.08	0.85	0.69
Stream Depth (cm)	9.45	11.58	19.51
Stream Shore Water Depth (cm)	3.66	3.96	7.62
Riffle Width (m)	0.98	0.58	0.69
Pools:			
Width (m)	--	0.25	--
Quality	--	3	--
Feature	--	1	--
Solar Incidence	18.3	30.0	43.3
Solar Angle	21.0	0.0	30.0
Channel Morphology:			
Streambank Alteration	10.2	43.3	36.7
Vegetative Stability	3.5	2.0	4.0
Undercut (cm)	6.7	3.9	8.5
Channel-Bank Angle	82.2	125.0	95.0
Stream Bottom:			
Gradient (%)	15.2	11.9	8.7
Sinuosity	1.20	1.15	1.06
Substrate:			
Boulder > 356 mm	20.0	--	--
Cobble 64-356 mm	50.0	22.2	44.1
Gravel 2-64 mm	10.0	66.7	41.2
Sand 0.6-2 mm	--	--	--
Silt < 0.6 mm	20.0	11.1	1.5
Embeddedness	4.3	4.0	3.0
Channel Vegetative Cover (cm)	30.5	20.4	69.2
Riparian Zone:			
Streamside Cover	3.0	3.0	4.0
Vegetative Use	0.0	0.0	0.0
Vegetation Overhang (cm)	15.2	27.4	64.0
Habitat Type	13	13	20

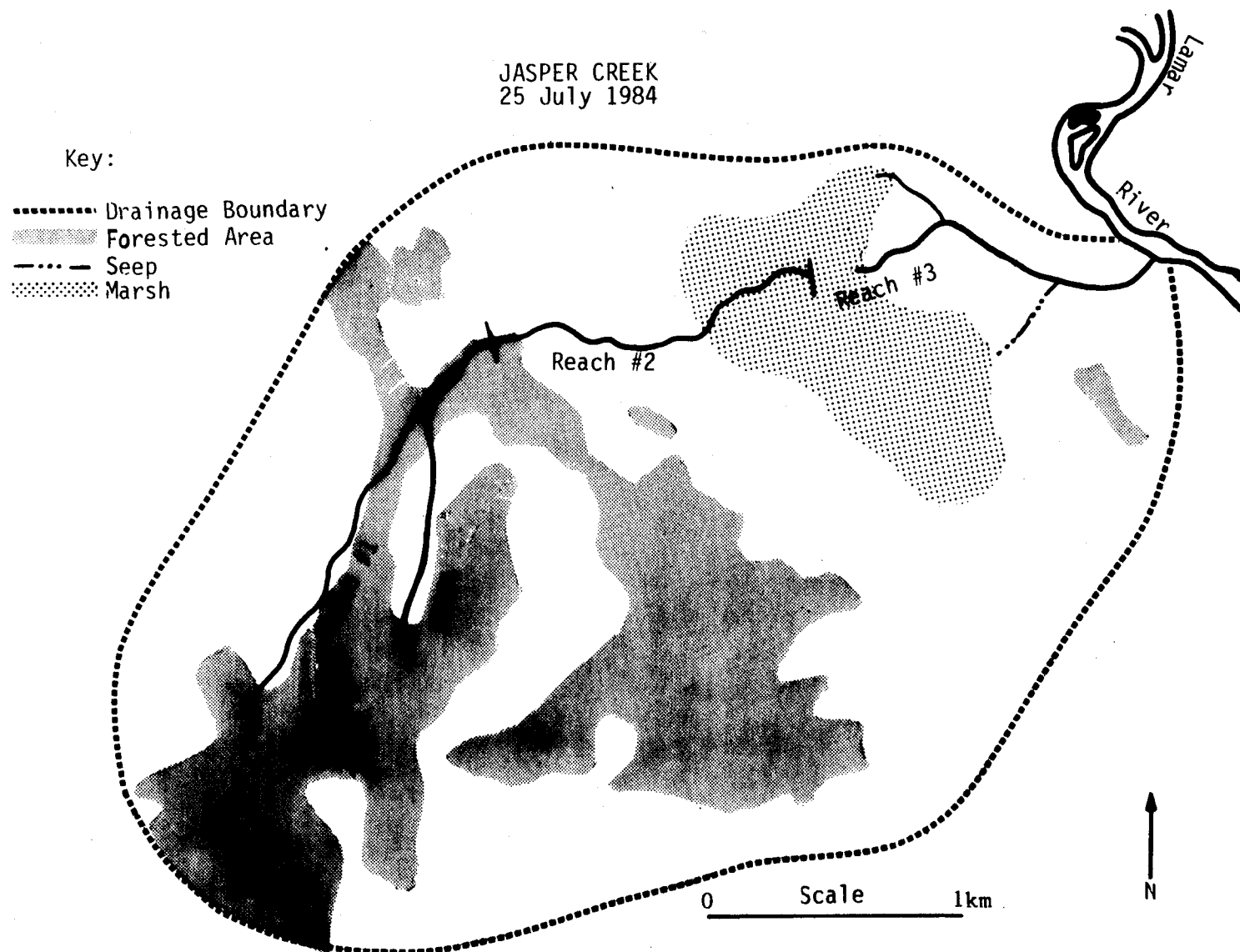


Figure 30. Hydrographic Map of Jasper Creek, YNP, 1984.

Table 41. Occurrence and densities of macroinvertebrates found in Jasper Creek, tributary to Lamar River, 1984.

Reach #:	Reach #1		Reach	Reach
	Main Stem	Trib #0491	#2	#3
Platyhelminthes				
Turbellaria (planarians)	2			1
Annelida		16		
Arthropoda				
Crustacea				
Ostracoda (seed shrimp)		1		
Arachnida				
Acarina				
Hydracarina (water mites)			1	
Insecta				
Coleoptera (beetles)				
Dytiscidae			1	2
Diptera (true flies)				
Chironomidae		6	4	26
Rhagionidae				
Atherix pachypus		3		
Simuliidae				
Simulium sp.				2
Twinnia sp.		1		
Tipulidae				
Antocha sp.			1	
Lipsothrix sp.		1		
Ephemeroptera (mayflies)				
Baetidae				
Baetis bicaudatus	1	12		
Heptageniidae				
Cinygmula sp.	3	3		
Siphonuridae				
Ameletus sp.	2	1		
Siphonurus occidentalis			3	
Plecoptera (stoneflies)				
Chloroperlidae	1			
Nemouridae				
Amphinemoura sp.			18	
Trichoptera (caddisflies)				
Limnephilidae				
Limnephilus sp.				2
Onocosmoecus sp.			1	
Rhyacophilidae				
Rhacophila sp.	1			
TOTAL NUMBER OF SPECIES:	6	9	7	5

Seed shrimp, which were found in only one other stream in the Lamar drainage (#0661), were also present.

Main stem

Three reaches were established in the mainstem of Jasper Creek (Table 42). All three reaches were noticeably different from one another. Most of reach 1 was braided and much of the stream flow was under and around trees. Gradient in this section was 9.3%, channel vegetative cover was 55.7 cm, and vegetative overhang was 81.4 cm. Discharge did not increase from reach 1 through reach 3. In reach 2, all of the substrate particles had diameters less than 0.6 mm. In reach 3, solar incidence was 99.0% as the channel crossed an unforested area.

Number of invertebrate species captured in all three reaches was the same, but species composition was different (Table 41). Planarians were captured in reach 1 and 3. Water mites were only captured in reach 2. True flies were dominant in reach 3. Mayflies were dominant in reach 1, but were not found in reach 3. Stoneflies were dominant in reach 2.

Miller Creek

Miller Creek is one of the largest tributaries to Lamar River. This stream drains a 10,480 ha watershed. Between 20 and 24 August 1984, 11 cursory surveys were conducted on Miller Creek's tributaries. During this period, a reconnaissance survey was performed on Miller Creek.

Tributaries

Five of Miller Creek's tributaries are second order streams, and six are first order (Table 43, Figure 31). Total stream distance of all these tributaries was approximately 40 km. Stream #0621 drains the largest watershed; however, stream #0618 contained the largest water flow. Stream #0612 was the deepest (53.3 cm), and stream #0621 had the widest channel. Two streams (#0613 and #0619) had gradients less than 10%. All but three streams (#0612, #0621, #0622) had water depths that were probably too shallow (less than 14 cm) to sustain fish life.

Miller Creek tributaries with the largest watersheds contained the fewest numbers and types of macroinvertebrates (Table 44). Streams #0616, #0618, and #0622 had the most diverse macroinvertebrate communities. These streams had watersheds between 567

Table 42. Reconnaissance survey results for Jasper Creek, 1984.

Habitat Features	Reach #1	Reach #2	Reach #3
Sample Date:	7/25/84	7/26/84	7/26/84
Time (hrs):	1440	1245	1425
Stream Order:	1	2	2
Length (km):	1.6	1.3	1.3
Drainage Size (ha):	384.5	570.7	773.1
Water Column:			
Water Flow (m ³ /s)	0.001	0.001	0.001
Channel Width (m)	2.26	0.78	1.09
Stream Width (m)	1.27	0.58	0.73
Stream Depth (cm)	3.66	5.79	6.10
Stream Shore Water Depth (cm)	3.91	3.66	6.10
Riffle Width (m)	0.91	0.48	0.70
Pools:			
Width (m)	0.48	0.30	0.75
Quality	4	1	1
Feature	1	2	2
Solar Incidence	18.3	93.3	99.0
Solar Angle	6.0	0.0	0.0
Channel Morphology:			
Streambank Alteration	17.5	13.8	14.2
Vegetative Stability	2.2	3.0	3.0
Undercut (cm)	0.9	0.9	0.0
Channel-Bank Angle	122.5	110.0	122.5
Stream Bottom:			
Gradient (%)	9.3	0.6	3.8
Sinuosity	1.12	1.11	1.17
Substrate:			
Boulder > 356 mm	--	--	--
Cobble 64-356 mm	7.7	--	18.1
Gravel 2-64 mm	46.2	--	81.9
Sand 0.6-2 mm	--	--	--
Silt <0.6 mm	46.1	100.0	--
Embeddedness	0.0	0.0	4.0
Channel Vegetative Cover (cm)	55.7	20.4	25.3
Riparian Zone:			
Streamside Cover	3.0	2.0	2.0
Vegetative Use	0.0	0.0	0.0
Vegetation Overhang (cm)	81.4	17.4	15.2
Habitat Type	13	13	13

Table 43. Results of cursory surveys performed on tributaries to Miller Creek, 1984.

Stream Order	Watershed Size (ha)	Stream Length (km)	Stream Elevation (m)		Gradient	Stream Flow (m ³ /s)	Mean Width (m)	Mean Depth (cm)	Mean Velocity (cm/s)	Mean Temperature (C)	
			Max.	Min.							
Unnamed:											
#0612	2	514.56	3.07	2554.22	2194.56	11.72	0.028	2.34	53.34	9.51	8.00
#0613	2	1181.38	6.67	2706.62	2194.56	7.75	0.131	5.91	9.14	37.20	13.00
#0614	1	593.32	2.53	2676.14	2243.33	17.10	0.008	2.20	2.38	19.40	8.00
#0616	1	703.58	3.60	2633.47	2243.33	10.84	0.029	2.77	9.66	13.29	10.50
#0617	1	858.47	3.93	2865.12	2267.71	15.20	0.066	3.32	8.14	34.93	8.00
#0618	1	567.06	3.67	2706.62	2267.71	11.96	0.200	2.32	7.22	13.75	10.70
#0619	2	1317.90	5.60	2804.16	2292.10	9.14	0.066	9.07	7.86	36.88	12.00
#0621	2	1575.17	5.87	2926.08	2316.48	10.39	0.114	11.92	14.72	28.95	7.50
#0622	2	795.46	3.93	2889.50	2414.02	12.10	0.118	5.49	18.29	21.64	9.50
#0623	1	204.77	1.20	2798.06	2560.32	19.81	0.010	2.47	5.73	11.43	8.00
#0624	1	141.77	0.80	2767.58	2633.49	16.76	0.007	3.17	5.85	14.96	13.00
Total:		8453.44	40.87	--	--	--	0.777	--	--	--	--
Mean:		768.49	3.72	2757.05	2329.78	12.98	0.070	4.63	12.94	21.99	9.84
SE:		134.25	0.55	34.36	44.04	1.13	0.020	0.97	4.25	3.21	0.64

MILLER CREEK
20 AUG 1984

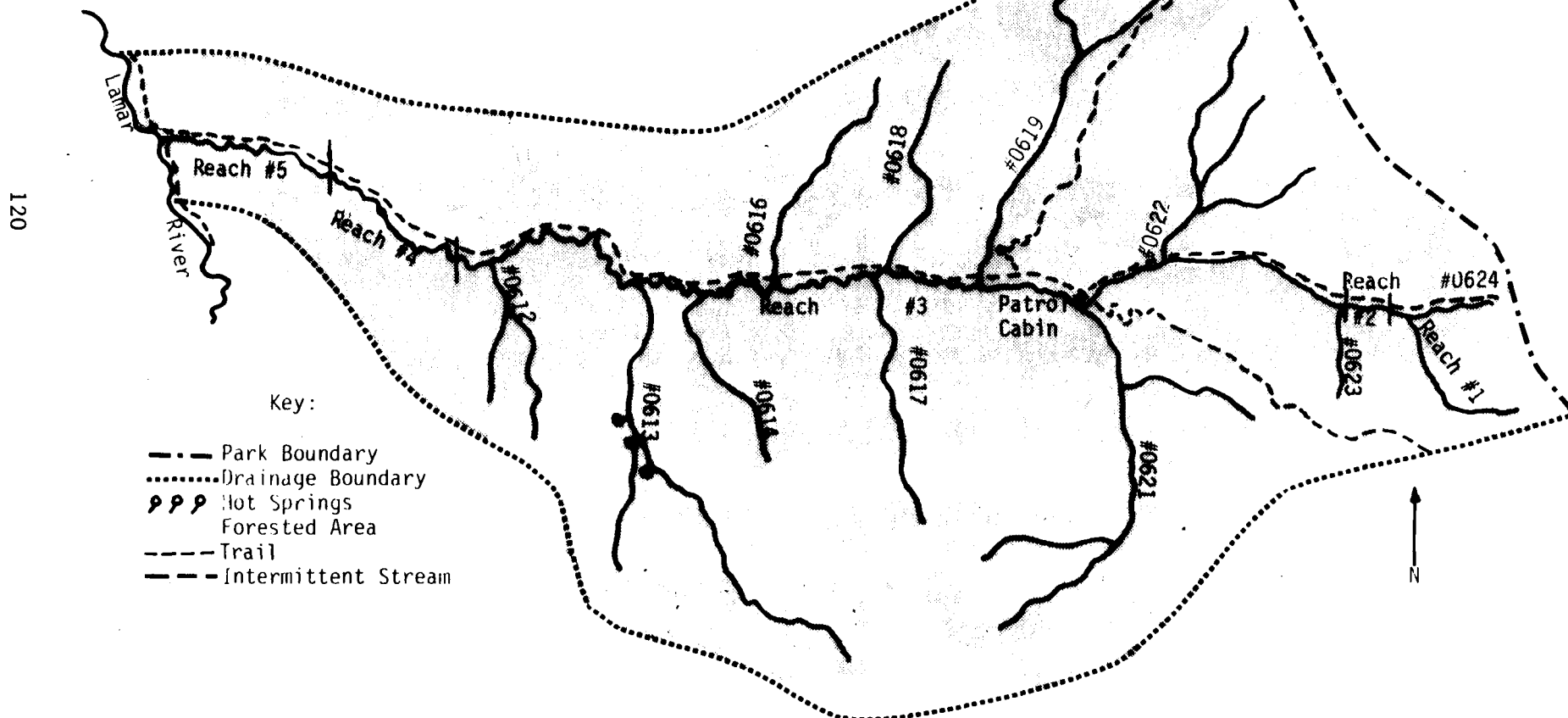


Figure 31. Hydrographic Map of Miller Creek, YNP, 1984.

Table 44. Occurrence and densities of macroinvertebrates found in Miller Creek, tributary to Lamar River, 1984.

Reach #1	Reach #1		Reach #2		Reach #3										Reach #4		Reach #5	
	Main	Trib	Main	Trib	Main	Trib	Trib	Trib	Trib	Trib	Trib	Trib	Trib	Trib	Main	Trib	Main	Trib
	Stem	#0624	Stem	#0612	Stem	#0613	#0614	#0616	#0617	#0618	#0619	#0621	#0622	#0623	Stem	#0623	Stem	#0623
Platyhelminthes																		
Turbellaria (planarians)									5				1					
Arthropoda																		
Arachnida																		
Acarina																		
Hydracarina (water mites)				1		1												
Insecta																		
Coleoptera (beetles)																		
Elmidae																		
Claptelmia ornata																	1	
Diptera (true bugs)																		
Chironomidae	1	3				4		3				1	4					
Rhagionidae																		
Simuliidae																		
Simulium sp.									2									
Tipulidae																		
Hexatoma sp.			1															
Tipula sp.																		1
Ephemeroptera (mayflies)																		
Baetidae																		
Baetis bicaudatus		14	3	1			1	8	21	28	1	6	21	4	5			
Ephemerellidae																		
Drumella coloradensis												2					1	
Drumella doddsi			1										11				11	1
Serratella teresa																		
Heptageniidae																		
Cinygmula sp.							1	1					6	1				
Epeorus albertae				3				2				7						
Epeorus deceptivus				16		3	2	4	1			7	12	14	10			
Epeorus longimanus												2						
Heptagenia sp.			1															
Rithrogena sp.				9				5	3	10			30	7	7			
Siphonuridae																		
Ameletus sp.					1			2		4				4				
Plecoptera (stoneflies)																		
Capniidae																		
Capnia sp.														1				
Chloroperlidae		1		1	1		5	3		3			6	1			1	
Nemouridae																		
Podmosta sp.								6										
Visoka cataractae				1						4				1				
Zapada sp.		2		5			1	5	1	11		2	8					
Perlidae																		
Doroneuria theodora								5		2	3							
Perlodidae																		
Hergaraya sp.			1									2	3	3				
Isoperla sp.		1						1	2									
Trichoptera (caddisflies)																		
Glossosomatidae																		
Glossosoma sp.														1			1	
Anagapetus sp.							3										2	
Hydropsychidae																		
Cheumatopsyche sp.																	6	
Parapsyche elsis																		
Limnephilidae																		
Apatania sp.									1									
Chyranda sp.							1											
Neothremma sp.			1					1		3				1				
Onocosmoecus sp.												1						
Rhyacophilidae																		
TOTAL NUMBER OF SPECIES:	2	7	5	7	3	3	7	13	9	12	5	9	13	7	9		3	

to 795 ha and drained south facing slopes. In six tributaries (#0616, #0617, #0618, #0622, #0623, and #0624) mayflies were dominant. Baetis bicaudatus was dominant in four streams, and Epeorus deceptivus and a species of Rithrogena were each dominant in one stream. Stoneflies were dominant in two streams, Chloroperlidae in #0614, and Doroneuria theodora in #0619. Caddisflies (Rhyacophila sp.) were dominant in #0621, and true flies were dominant in #0613. Planarians were found in two streams (#0618 and #0622), and water mites (Hydracarina) were found in two streams (#0612 and #0613).

Main stem

The main channel of Miller Creek was subdivided into five reaches (Table 45). All reaches had gradients less than 10%. Reaches 1, 2, and 3 were shallow (less than 12 cm), contained flows less than 0.2 m³/s, had no undercut banks, channel-bank angles over 104°, and substrates with a high percentage (mean 21.2%) of particles less than 0.6 mm in diameter. The percentage of altered streambanks generally increased from reach 1 to 5. Solar angle and the degree of solar incidence also increased from upstream to downstream reaches. Reaches 4 and 5 generally had conditions that were favorable for fish. In addition, these reaches had a high measure of vegetation overhanging the channel.

Macroinvertebrate species composition changed significantly from upstream to downstream reaches (Table 44). Only two groups of organisms (Chironomidae and Rhyacophila sp.) were sampled in reach 1. Mayflies (Baetis bicaudatus) were the dominant organism of seven species captured in reach 2. Dominance shifted to Epeorus deceptivus in reach 3. Seratella teresa was dominant in reach 4. Three groups of organisms (Hexatoma sp., Seratella teresa, and Chloroperlidae) were captured in reach 5. Reach 4 contained the most diverse community with at least nine species. It was the only area in the Miller Creek drainage where beetles (Cleptelmis ornata) were captured.

Rose Creek

Rose Creek drains the largest watershed of the second order tributaries to the Lamar River. Four cursory surveys were performed on tributaries to Rose Creek from 8 - 10 August 1984. During this period, a reconnaissance survey was performed on Rose Creek.

Table 45 . Reconnaissance survey results for Miller Creek, 1984.

Habitat Features	Reach #1	Reach #2	Reach #3	Reach #4	Reach #5
Sample Date:	8/22/84	8/22/84	8/23/84	8/23/84	8/20/84
Time (hrs):	1650	1800	0850	1545	1700
Stream Order:	2	2	3	3	3
Length (km):	2.8	0.5	14.2	3.3	2.1
Drainage Size (ha):	530.2	700.1	9429.5	10170.1	10485.8
Water Column:					
Water Flow (m ³ /s)	0.018	0.009	0.112	0.297	0.494
Channel Width (m)	6.19	2.53	13.24	16.86	18.14
Stream Width (m)	1.33	1.28	5.77	6.49	9.39
Stream Depth (cm)	3.35	11.58	6.61	12.45	30.48
Stream Shore Water Depth (cm)	0.52	0.00	0.00	0.91	2.04
Riffle Width (m)	1.33	0.47	5.47	5.78	7.35
Pools:					
Width (m)	--	0.82	0.31	0.91	1.65
Quality	--	1.5	1.0	1.0	1.0
Feature	--	5	4	2	4
Solar Incidence	45.0	30.0	56.7	78.3	71.7
Solar Angle	66.7	36.0	75.7	135.0	97.7
Channel Morphology:					
Streambank Alteration	9.2	1.7	20.8	23.3	29.2
Vegetative Stability	3.3	4.0	2.3	3.0	3.0
Undercut (cm)	0.0	0.0	0.0	5.3	7.6
Channel-Bank Angle	109.5	104.0	142.5	130.0	92.7
Stream Bottom:					
Gradient (%)	7.3	8.2	7.3	0.9	1.8
Sinuosity	1.13	1.09	1.22	1.12	1.22
Substrate:					
Boulder > 356 mm	6.4	41.4	10.7	--	18.2
Cobble 64-356 mm	6.4	6.9	51.5	66.7	43.2
Gravel 2-64 mm	41.3	34.5	6.8	8.8	30.4
Sand 0.6-2 mm	17.5	10.3	2.9	4.7	4.7
Silt < 0.6 mm	28.6	6.9	28.2	19.8	3.4
Embeddedness	2.3	3.3	2.3	3.0	2.7
Channel Vegetative Cover (cm)	10.1	0.0	142.3	106.7	250.9
Riparian Zone					
Streamside Cover	1.0	1.0	2.0	2.0	3.0
Vegetative Use	0.0	0.0	0.0	0.0	0.0
Vegetation Overhang (cm)	0.0	0.0	69.2	14.3	237.7
Habitat Type	12	13	13	9	13

Tributaries

Four tributaries to Rose Creek contained water flow (Table 38, Figure 32). Stream #0496 drained the largest watershed (878.2 ha), had the largest water flow ($0.08 \text{ m}^3/\text{s}$), and was the deepest (14.4 cm) tributary to Rose Creek. The remaining tributaries (#0497, #0498, and #0499) drained watersheds that averaged 163.2 ha, contained water flows that averaged $0.013 \text{ m}^3/\text{s}$, and had average stream depths of 5.9 cm. Stream #0496 had an average channel gradient of 11.1% and the other tributaries had gradients over 19.8%.

Tributaries to Rose Creek had the most diverse macroinvertebrate communities of all streams surveyed in the Lamar drainage in 1984 (Table 46). The average number of macroinvertebrate species captured per stream was 13. No significant relationship was apparent between stream size and macroinvertebrate community composition. Stream #0498 contained the most diverse community. The dominant organism in this stream was a species of caddisfly (*Neothremma* sp.). Approximately 43% of the species in stream #0498 were mayflies. The dominant organism in stream #0496, the largest tributary, was also a caddisfly (*Rhyacophila* sp.). Fifty-eight percent of the species in this stream were mayflies. Planarians were found in two streams (#0497 and #0498), and true flies were captured in two streams (#0496 and #0498).

Main stem

Four reaches were established in the main channel of Rose Creek (Table 47, Figure 32). Factors favorable for supporting a viable fish population increased from reach 1 to reach 4. The channel in reaches 1 and 2 received almost 39% less solar incidence than reaches 3 and 4, and the solar angle in reaches 1 and 2 was 3 times lower than the solar angle in reaches 3 and 4. Stream flow increased almost 12.8 times from reach 1 to 3, and watershed size increased almost five times in the same distance. Mean stream depth, however, did not change significantly from reach 1 to 4. Reach 4 was divided into three channels. Approximately 72% of the substrate particles in this reach had a diameter size (2-64 mm) that was suitable for trout spawning.

The mainstem of Rose Creek had the highest macroinvertebrate species diversity of all streams sampled in the Lamar drainage in 1984. An average of 14 species were captured in each reach. The shift in community composition from reach 1 to reach 4 probably

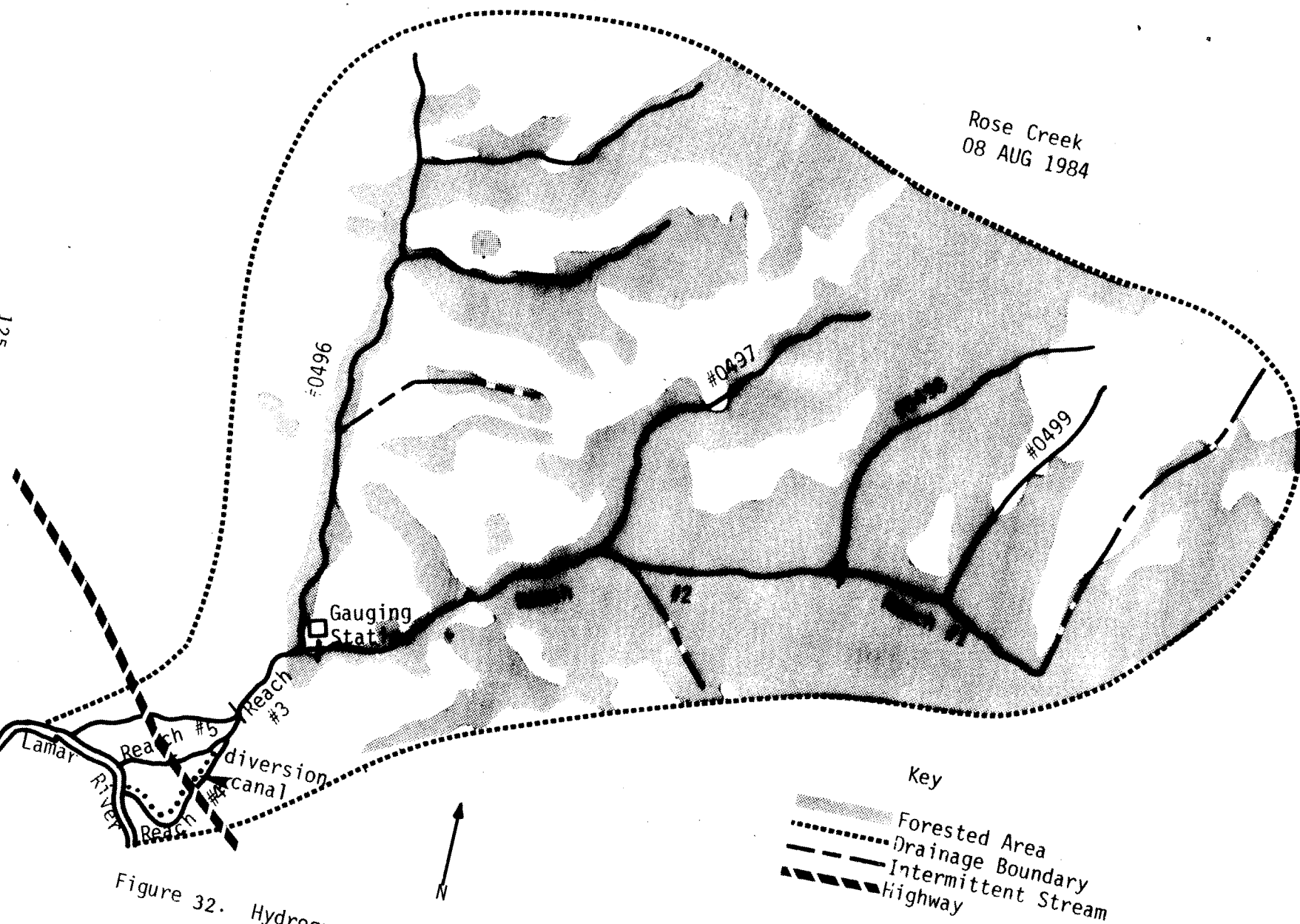


Figure 32. Hydrographic Map

Table 46 Occurrence and densities of macroinvertebrates found in Rose Creek, tributary to Lamar River, 1984.

Reach #:	Reach #1		Reach #2			Reach #3		Reach #4		
	Main Stem	Trib #0499	Main Stem	Trib #0498	Trib #0497	Main Stem	Trib #0496	Main Stem	Branch #2	Branch #3
Platyhelminthes										
Turbellaria (planarians)	1		2	17	1					
Arthropoda										
Insecta										
Coleoptera (beetles)										
Elmidae										
<u>Cleptelmis</u> sp.								6		
<u>Cleptelmis ornata</u>									11	2
<u>Lara avara</u>						2				
<u>Stenelmis</u> sp.						1			5	
<u>Rhizelmis</u> sp.						1				
<u>Zaitzevia parvula</u>								1		
Diptera (true flies)										
Chironomidae			6	6		6				
<u>Cricotopus</u> sp.				2						
Tipulidae										
<u>Hexatoma</u> sp.							1			
<u>Holorusia</u> sp.								1		
Ephemeroptera (mayflies)										
Baetidae										
<u>Baetis bicaudatus</u>		8		12	2		1			
<u>Baetis tricaudatus</u>	23		10			13	5	13	10	6
Ephemerellidae										
<u>Drunella coloradensis</u>	3	1	4	7			2			
<u>Drunella doddsi</u>			1							
<u>Ephemerella infrequens</u>				2						
<u>Seratella teresa</u>						8	2	1		5
Heptageniidae										
<u>Cinygmula</u> sp.	5	3	7	12	8	32	4	12	6	27
<u>Epeorus albertae</u>	14		9	4		59				16
<u>Epeorus deceptivus</u>	9		15	8	10		1			
<u>Epeorus longiranus</u>		4				14		21		6
<u>Rithrogena</u> sp.	5		15		16					
Leptophlebiidae										
<u>Paraleptophlebia</u> sp.							1			
Siphonuridae										
<u>Ameletus</u> sp.	1			16	1	2			2	2
Plecoptera (stoneflies)										
Chloroperlidae	2	2			6					2
Leuctridae		3			3					
Meconuridae										
<u>Amphimerouria</u> sp.						4				4
<u>Malenka coloradensis</u>					6					
<u>Visoka cataractae</u>	1									
<u>Zapada</u> sp.	2	1	9	23	11	6				7
Peltoperlidae										
<u>Yoraperla brevis</u>	1	3		6						
Perlidae										
<u>Doroneuria theodora</u>							5	1	1	3
<u>Hesperoperla pacifica</u>						5		5		
Perlodidae				8						
<u>Megarcys</u> sp.	3	4								
Trichoptera (caddisflies)										
Brachycentridae									3	
<u>Brachycentrus</u> sp.										
<u>Micrasena</u> sp.						5	1			
Glossosomatidae										
<u>Glossosoma</u> sp.	3						1			
Hydropsychidae										
<u>Parapsyche elsis</u>	1			2						
Limnephilidae										
<u>Farula</u> sp.			10							
<u>Homophylax</u> sp.		1								
<u>Limnephilus</u> sp.								9		
<u>Neothremma</u> sp.	3	1		92	11			1		
<u>Onozymoeus</u> sp.										
Rhyacophilidae										
<u>Rhyacophila</u> sp.	6	1	10	3	1	8	7		4	3
TOTAL NUMBER OF SPECIES:	17	13	12	16	12	15	12	12	8	12

Table 47. Reconnaissance survey results for Rose Creek, 1984.

Habitat Features	Reach #1	Reach #2	Reach #3	Reach #4 Mainstem	Reach #4 Branch #2
Sample Date:	8/8/84	8/9/84	8/9/84	8/10/84	8/10/84
Time (hrs):	1400	0850	1200	0930	0930
Stream Order:	2	2	3	3	3
Length (km):	1.2	3.4	0.6	1.2	0.7
Drainage Size (ha):	473.5	1290.9	2245.9	--	--
Water Column:					
Water Flow (m ³ /s)	0.017	0.046	0.218	0.125	0.035
Channel Width (m)	3.45	2.64	4.67	3.24	1.18
Stream Width (m)	2.96	2.25	3.41	3.00	1.09
Stream Depth (cm)	11.89	10.97	12.80	7.32	13.11
Stream Shore Water Depth (cm)	3.05	6.86	3.66	0.00	7.62
Riffle Width (m)	1.08	2.08	2.86	3.00	0.60
Pools:					
Width (m)	1.32	0.20	0.56	--	0.51
Quality	2	2	1	--	1
Feature	4	4	4	--	2
Solar Incidence	48.3	55.0	73.3	95.0	86.7
Solar Angle	45.0	55.3	114.0	158.3	180.0
Channel Morphology:					
Streambank Alteration	15.0	36.7	15.0	21.7	63.3
Vegetative Stability	4.0	3.0	3.0	3.3	3.7
Undercut (cm)	20.7	12.2	3.9	0.0	7.6
Channel-Bank Angle	67.2	82.8	109.7	129.5	82.3
Stream Bottom:					
Gradient (%)	16.4	9.3	7.6	1.8	0.7
Sinuosity	1.17	1.14	1.20	1.33	1.17
Substrate:					
Boulder > 356 mm	37.1	24.0	15.2	--	--
Cobble 64-356 mm	34.3	28.0	47.8	20.7	--
Gravel 2-64 mm	28.6	40.0	37.0	72.4	27.3
Sand 0.6-2 mm	--	4.0	--	3.4	9.1
Silt < 0.6 mm	--	4.0	--	3.4	63.6
Embeddedness	4.7	5.0	4.7	4.2	3.0
Channel Vegetative Cover (cm)	46.7	25.3	5.2	61.9	15.2
Riparian Zone:					
Streamside Cover	3.0	2.0	2.0	2.0	2.0
Vegetative Use	0.0	0.0	0.0	0.0	0.0
Vegetation Overhang (cm)	45.7	30.5	10.1	15.2	40.5
Habitat Type	13	13	9, 17, 17	17, 13, 13	17

reflected the same shifts noted in physical characteristics. Mayflies were the dominant group of organisms in all reaches. Approximately 45% of the species in each reach community were mayflies. Planarians were found in reach 1 and 2, true flies were captured in reach 2 through 4, and beetles were found in reach 3 and 4. Stoneflies and caddisflies were more abundant in reach 1 than any other reach.

Soda Butte Creek

Soda Butte Creek contains the ninth most popular stream fishery in YNP (Table 23). This fishery, supported by a cutthroat trout population introgressed with rainbow trout genes, has been managed under a two fish creel limit since 1973. Angler use of this stream may be divided into two segments: upstream and downstream of Icebox Canyon (Figure 33). Over the past 8 years, the lower section has received 71% more use than the upper section. Highest recorded use for both sections was in 1981. Since 1977, landing rate and average length of trout landed has been variable, and no trends are apparent.

Approximately 80% of the fish landed in Soda Butte Creek are released; however, this fishery sustains the third highest exploitation rate of all stream fisheries in YNP. The number of trout creeled averages 2,000/year. Highest number creeled occurred in 1981, when an estimated 4,500 fish were removed. An average of 313 fish/ha (813 fish/km) are landed and 60 fish/ha (157 fish/km) are kept each year. Anglers generally creel the largest fish. Since 1977, average size of fish kept (287 mm) has averaged 25 mm longer than average size of fish landed (262 mm).

Ecological performance surveys of fish communities in Soda Butte Creek were conducted from the Northeast Entrance 305 m downstream (Northeast section), and from the footbridge 2,333 m downstream (Footbridge section). Two surveys were conducted at each site. Northeast section was sampled on 19 June and 21 August. In the Footbridge section, fish population analysis was conducted on 15 June and 22 August. Fish communities in these areas were previously evaluated in 1981 (Jones et al 1982).

Northeast Section

Introgressed cutthroat trout was the only fish species captured in the Northeast section on both sample dates. Because of adverse sampling conditions, an estimate of

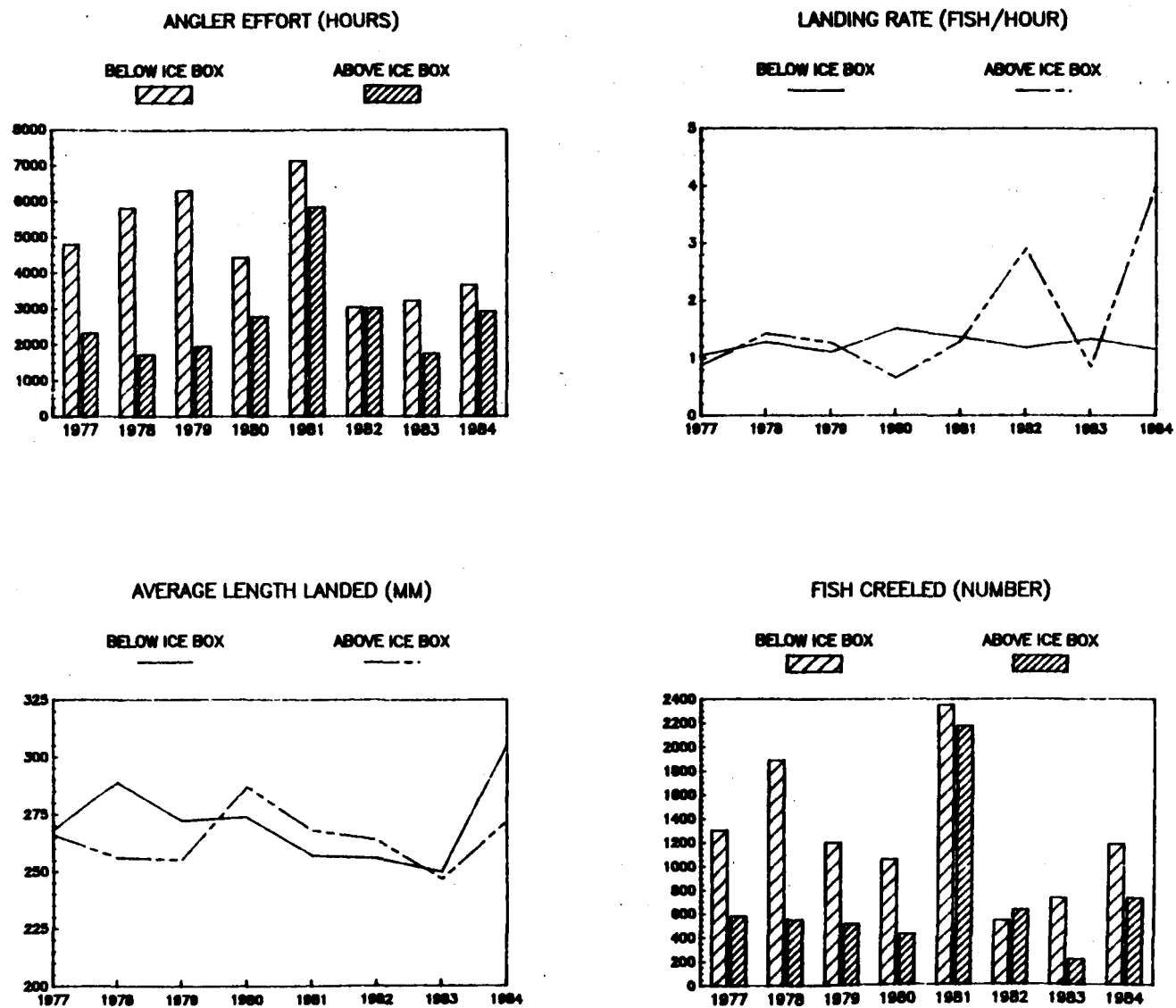


Figure 33. Angler Statistics for below Ice Box and above Ice Box sections of Soda Butte Creek, 1977-1984.

the number of fish was not made in June. In August, an estimated 295 (+87) trout inhabited this 0.305 km (0.356 ha) area (Table 28). Efficiency rate of this estimate was 44.0%. Approximately 7% of the fish standing crop has been harvested from this area on an annual basis.

Mean length, mean weight, and PSD were 183 mm (n=24), 60 g, and 0.0% in June, respectively; and 202 mm (n=132), 79 g, and 0.0% in August, respectively (Figure 34). In June, 42% of the fish were longer than 203 mm and no fish were longer than 330 mm. In August, 48% and 1% of the fish were longer than 203 and 330 mm, respectively. Mean TL and weight of trout in 1981 were 201 mm (n=22) and 129 g, respectively, and the percentage of fish longer than 203 and 330 mm TL was 55% and 5%, respectively. Age III+ was the most frequently sampled age group in 1981 and 1984. Average empirical growth rate for all age groups combined was 74 mm/year in both years. In August 1984, estimated trout biomass was 65.7 kg/ha (76.6 kg/km).

Footbridge Section

Three species of fish (cutthroat trout, longnose dace, and mountain sucker) were captured in the Footbridge section on both sample dates. Trout comprised over 87% and 94% of the total number of fish sampled in June and August, respectively. An estimated 891 (+506) and 1,460 (+357) trout inhabited this section during the same months, respectively (Table 28). Efficiency rate was 6.8% for the June estimate and 25.0% for the August estimate. In June and August 1984, approximately 250 fish/ha (382 fish/km) and 409 fish/ha (626 fish/km), respectively, were present. In August 1981, an estimated 523 fish/ha (679 fish/km) inhabited this section. Based on the August 1984 population estimate and the average number of fish harvested, approximately 14.7% of the fish standing crop has been harvested each year.

Mean TL, mean weight, and PSD were 250 mm (n=66), 155 g, and 4.2%, respectively, for trout captured in June; and 248 mm (n=370), 151 g, and 2.1%, respectively, for trout captured in August (Figure 35). In June 73% and 20% of the trout were longer than 203 and 330 mm, respectively; in August, 61% and 8% were longer than these lengths, respectively. In August 1981, mean length and weight were 201 mm (n=114) and 129g, respectively. The percentage of fish longer than 203 and 330 mm was 33% and 2%, respectively. Age III+ was the most frequently sampled age group and average empirical growth rate was 76 mm/year (Table 29).

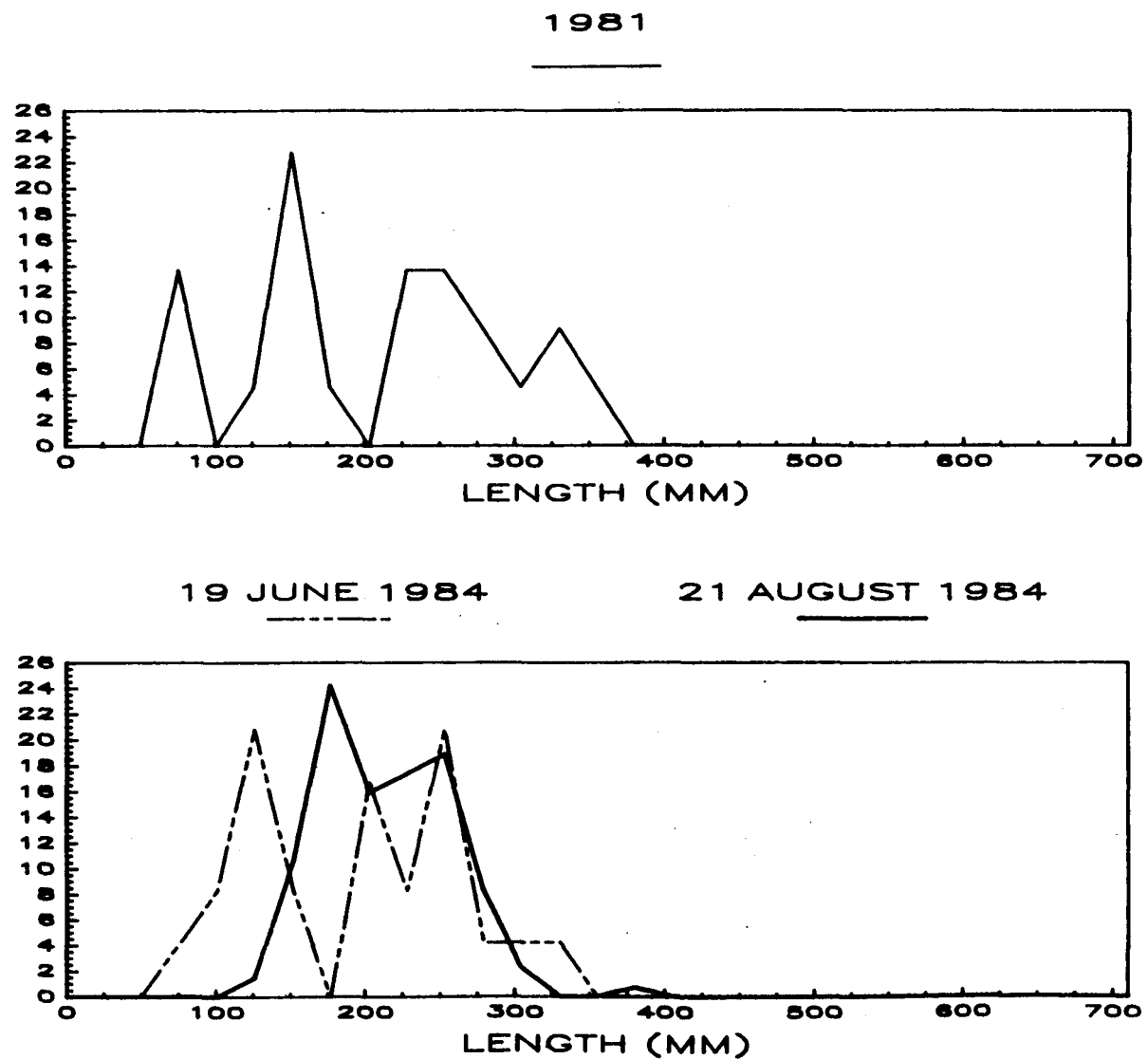


Figure 34. Length distribution of introgressed cutthroat trout captured in the northeast entrance sample section of Soda Butte Creek, 1981 and 1984.

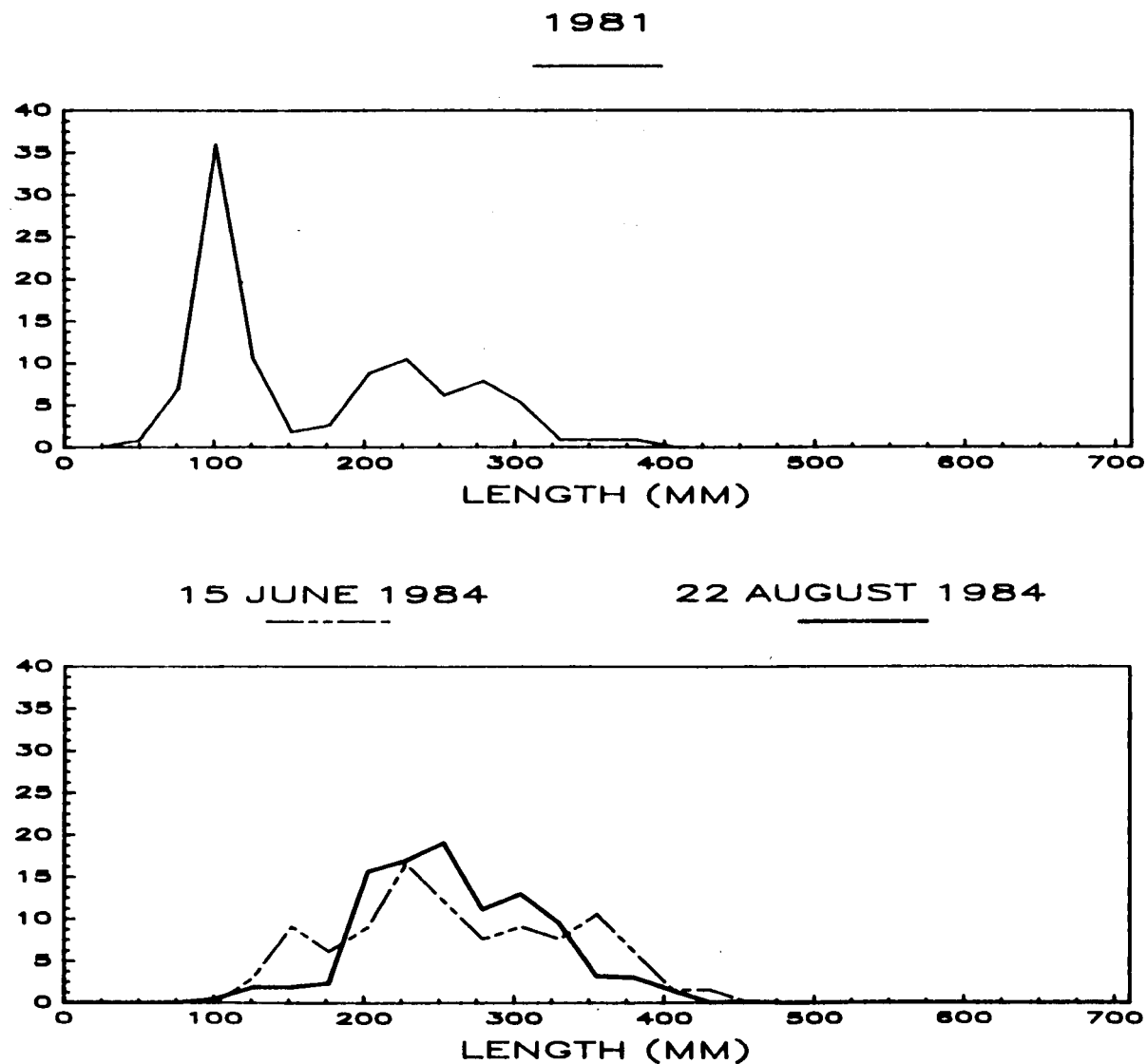


Figure 35. Length distribution of introgressed cutthroat trout captured in the footbridge sample section of Soda Butte Creek, 1981 and 1984.

A decrease in angler use has been the most obvious change in the Soda Butte fishery since it was last surveyed in 1981. An increase in fish numbers in the upper section signifies improving conditions for the trout population. However, since this stream has the third highest exploitation rate of all streams in YNP and harvest is concentrated on the largest fish, further monitoring is necessary.

Madison River

The Madison River supports the second most popular stream fishery in YNP (Table 23). This fishery is supported by five fish species: brown trout (Salmo trutta), rainbow trout (Salmo gairdneri), cutthroat trout (Salmo clarki bouvieri), mountain whitefish (Prosopium williamsoni), and Montana grayling (Thymallus articus). Since 1951, fishing gear has been restricted to artificial flies with a single hook. Since 1970, the fishery has been managed with a 406 mm minimum size limit (2 fish creel) and grayling have been protected with a catch and release regulation. Angler use may be divided into two segments: downstream (below Seven-Mile Bridge) and upstream (above Seven-Mile Bridge) (Figure 36). Angler use, landing rate, average length of fish landed, and creel rate have been higher downstream of Seven-Mile Bridge than upstream of it. Since 1980, number of fish harvested has averaged almost 2.6 times (1340/520) greater in the lower section. Approximately 100 fish/km and 65 fish/km are harvested in the lower and upper sections, respectively. In the lower section, an average of 40 rainbow trout, 38 brown trout, and 20 mountain whitefish per kilometer are harvested each year. In the upper section, approximately 30 brown trout, 20 rainbow trout, and 2 mountain whitefish per kilometer have been creeled each year.

The most noticeable change in angler statistics for the Madison River fishery has been a shift in the species composition of fish caught since 1954 (Figure 37). The main shift occurred from 1976 through 1981 when the percentage of brown trout caught decreased and the percentage of whitefish caught increased. Since 1982, however, the percentage of brown trout has increased in the catch as the percentage of mountain whitefish has decreased.

Ecological performance surveys of fish communities in the Madison River were conducted from the confluence of the Gibbon and Firehole Rivers downstream for 2.667 km (National Park Meadows), and from the barns for 6.000 km

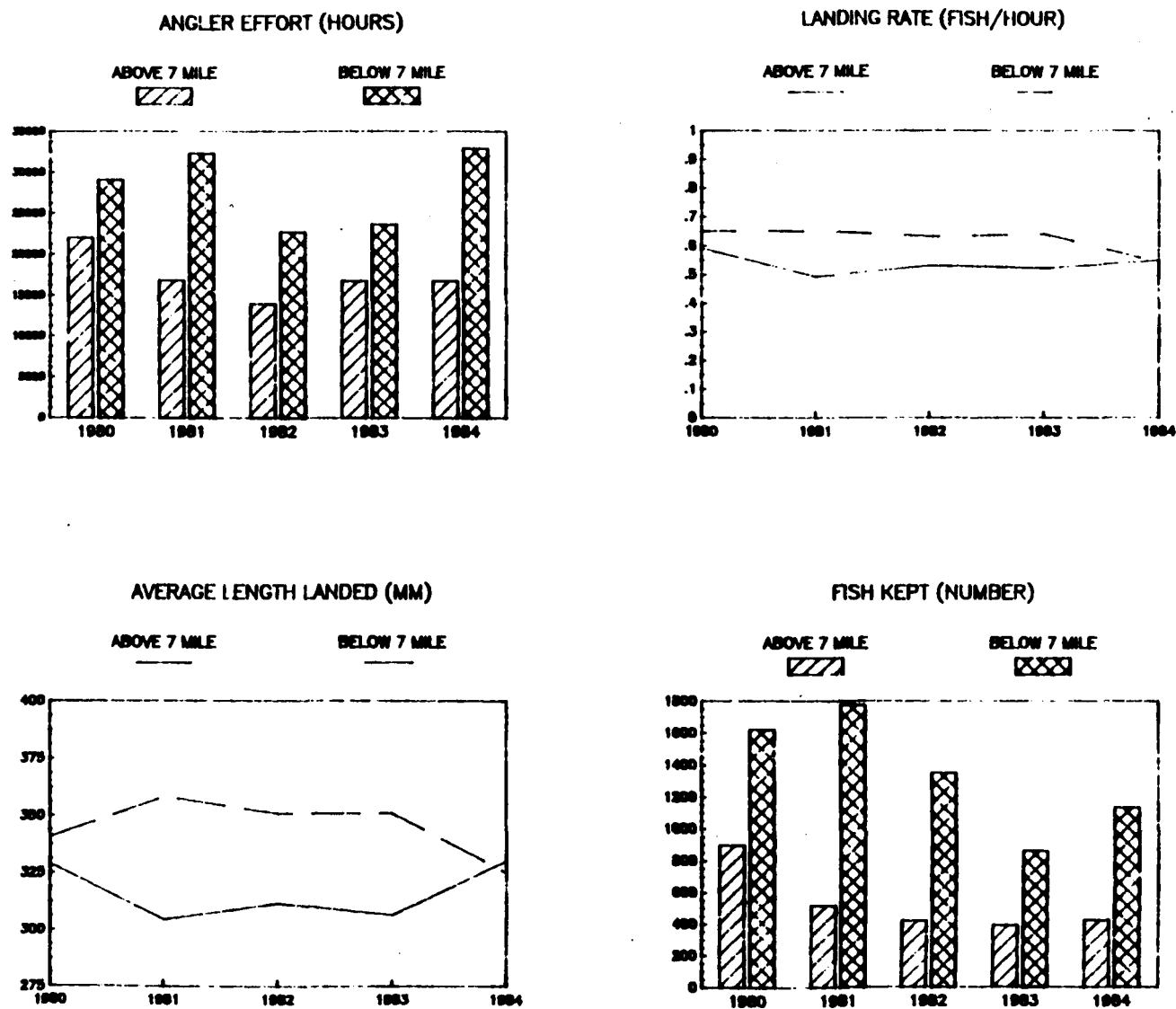


Figure 36. Angler statistics for above 7-mile and below 7-mile sections of the Madison River, 1980-1984.

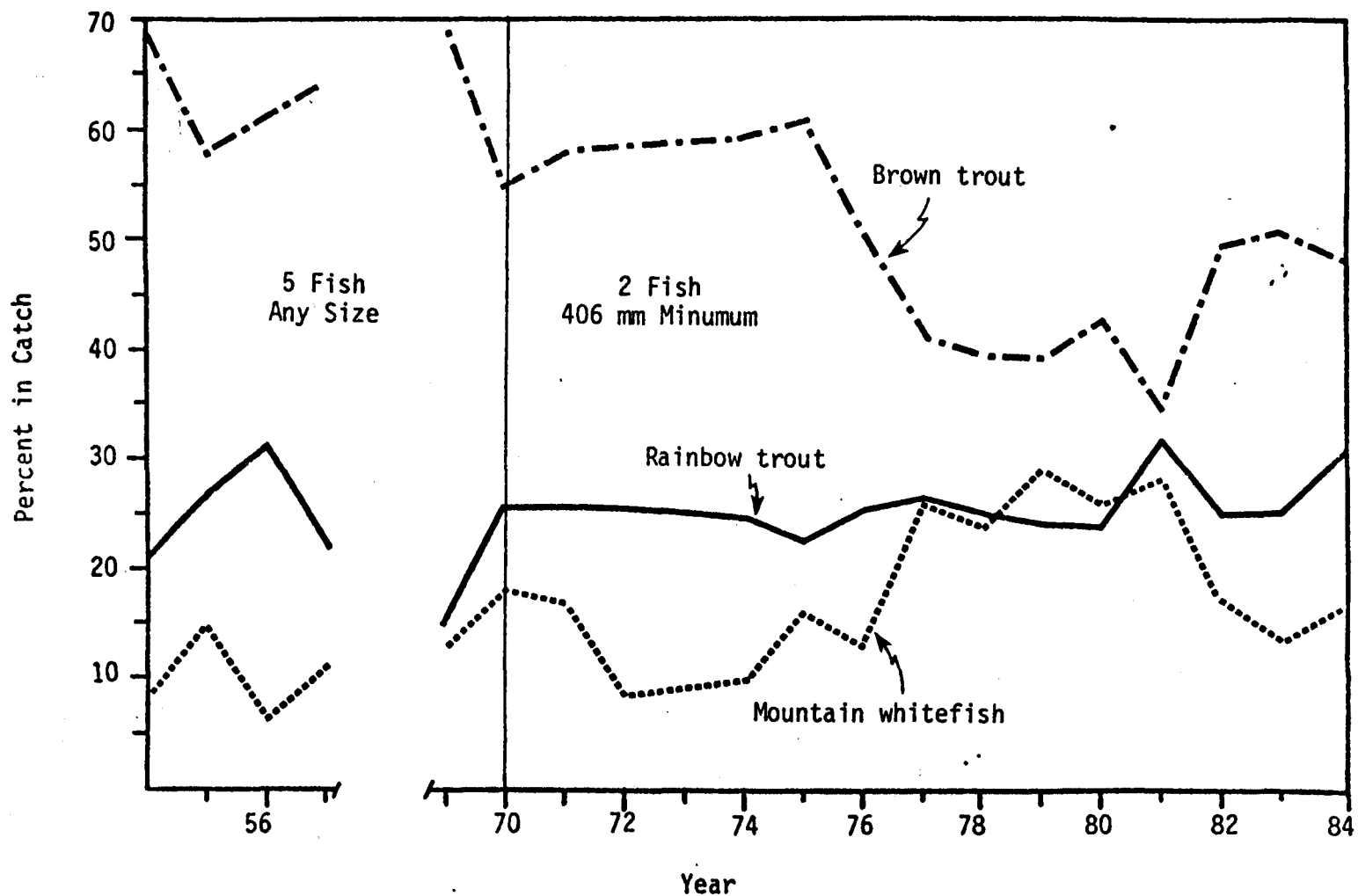


Figure 37. Species composition of fish caught by anglers in the Madison River, YNP, 1954-1984.

downstream (Barns). Both areas were sampled in 1957 and 1978 (Jones et al 1981). Two surveys were conducted at each site in 1984. Fish population analysis was conducted at National Park Meadows on 5 June and 4 September. The Barns site was sampled on 6 June and 3 September.

National Park Meadows

Six species of fish were captured at National Park Meadows on 6 June: brown trout, mountain whitefish, rainbow trout, longnose dace, mountain sucker, and mottled sculpin (*Cottus bairdi*). Total number of fish captured was 318. Over 57% of the fish sampled were brown trout, 26% were mountain whitefish, and 14% were rainbow trout. An estimated 1,942 (+523) brown trout, 997 (+537) mountain whitefish, and 683 (+457) rainbow trout were present (Table 28). Efficiency rate for these estimates were 9.5%, 7.5%, and 6.7%, respectively. Number of fish longer than 406 mm was estimated at 93 mountain whitefish/km, 32 brown trout/km, and 6 rainbow trout/km.

Brown trout averaged 277 mm, rainbow trout averaged 256 mm, and mountain whitefish averaged 350 mm (Figures 38-40). PSD for brown trout was 14.58%, rainbow trout was 2.86%, and mountain whitefish was 98.8%. Mean weight of these species was 191, 152, and 562 g, respectively. Biomass estimates were 210.19 kg/km (55.64 kg/ha) for mountain whitefish, 139.05 kg/km (36.86 kg/ha) for brown trout, and 38.91 kg/km (10.34 kg/ha) for rainbow trout.

On 4 September, eight species of fish were captured at National Park Meadows: Montana grayling, brown trout, rainbow trout, mountain whitefish, brook trout, longnose dace, mountain sucker, and mottled sculpin. Total number of fish caught was 960. One Montana grayling and one brook trout were captured. Almost 63% of the fish caught were brown trout, 16% were rainbow trout, and 14% were mountain whitefish. Numbers of brown trout, rainbow trout, and mountain whitefish inhabiting this section were estimated at 3,430 (+567), 1,057 (+362), and 1,635 (+971), respectively. Efficiency rates for these estimates were 17.5%, 14.3%, and 7.4%, respectively. Number of fish longer than 406 mm was estimated at 124 mountain whitefish/km, 73 brown trout/km, and 8 rainbow trout/km.

Mean TL of brown trout was 287 mm, rainbow trout was 252 mm, and mountain whitefish was 347 mm (Figures 38-40).

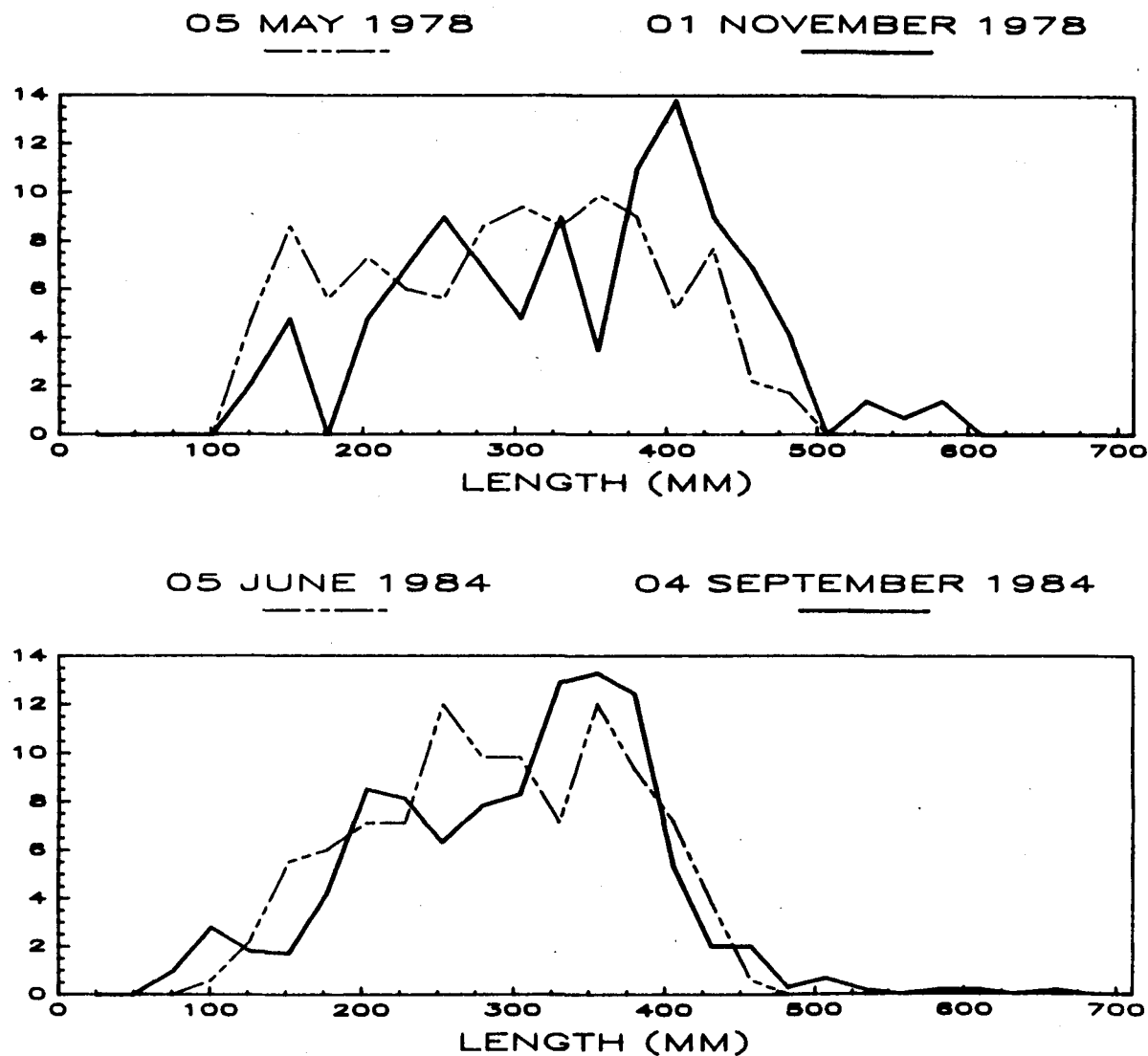


Figure 38. Length distribution of brown trout captured in the National Park Meadows sample section of the Madison River, 1978 and 1984.

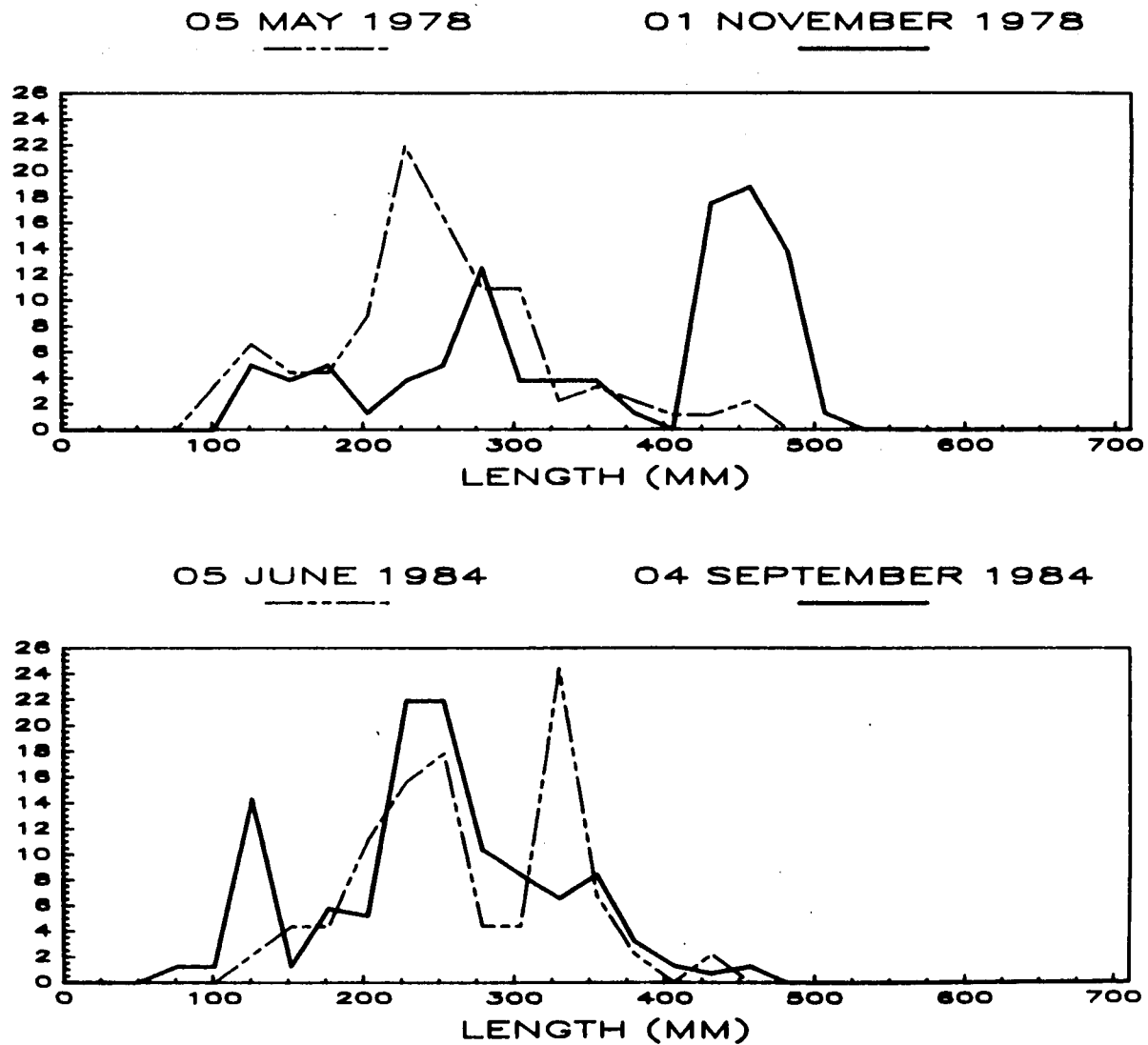


Figure 39. Length distribution of rainbow trout captured in the National Park Meadows sample section of the Madison River, 1978 and 1984.

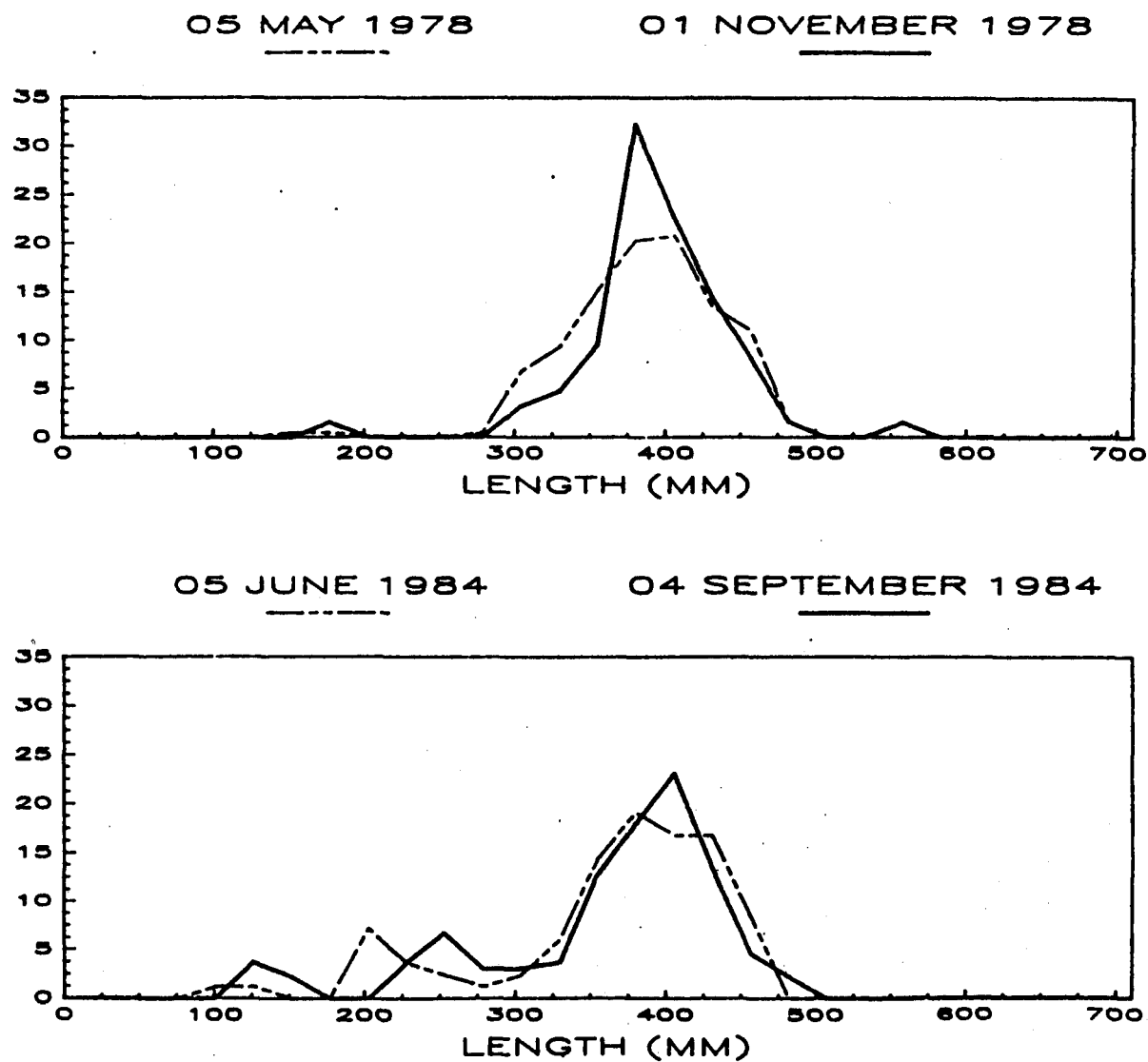


Figure 40. Length distribution of mountain whitefish captured in the National Park Meadows sample section of the Madison River, 1978 and 1984.

PSD value for brown trout was 13.66%, rainbow trout was 2.31%, and mountain whitefish was 94.3%. Mean weight was 212, 144, and 552 g, respectively. Biomass estimates were 338.38 kg/km (89.98 kg/ha) for mountain whitefish, 272.63 kg/km (72.29 kg/ha) for brown trout, and 57.02 kg/km (15.12 kg/ha) for rainbow trout.

Barns

Six species of fish were captured in the Barns section on 6 June: cutthroat trout (Salmo clarki bouvieri), mountain whitefish, rainbow trout, brown trout, longnose dace, and mottled sculpins. Total number of fish captured was 530. Approximately 66% were mountain whitefish, 22% were brown trout, 8% were rainbow trout and 2% were cutthroat trout. An estimated 9,376 (+1,674) mountain whitefish, 1,765 (+479) brown trout, and 1,080 (+1,197) rainbow trout inhabited this section (Table 28). Efficiency rates for these estimates were 3.5%, 13.6%, and 2.1%, respectively. Total number of sport fish in this area was estimated at 1,877 fish/km. Density of fish longer than 406 mm was estimated at 66 brown trout/km, 25 rainbow trout/km, and 20 mountain whitefish/km.

Mountain whitefish averaged 273 mm, brown trout averaged 301 mm, rainbow trout averaged 273 mm, and cutthroat trout averaged 266 mm TL. PSD was 81.90% for whitefish, 28.57% for brown trout, and 18.75% for rainbow trout. Mean weight for these fish was 177, 263, and 78 g, respectively. Total biomass of sport fish was estimated at 343.93 kg/km (91.47 kg/ha). Estimated biomass of mountain whitefish was 276.65 kg/km (73.46 kg/ha), brown trout was 35.24 kg/km (9.47 kg/ha), and rainbow trout was 32.04 kg/km (8.54 kg/ha).

Five fish species were captured in the Barns section on 3 September. These included mountain whitefish, rainbow trout, brown trout, longnose dace, and mottled sculpins. Total number of captured fish was 1,869. Approximately 79% were mountain whitefish, 15% were brown trout, and 3% were rainbow trout. Number of mountain whitefish in this section was estimated at 10,638 (+1,493), number of brown trout was 1,765 (+479), and number of rainbow trout was 622 (+408) (Table 28). Efficiency rates of these estimates were 13.8%, 15.2%, and 9.1%, respectively. Density of sport fish in this section was estimated at 2,070 fish/km. Number of fish longer than 406 mm was estimated at 65 brown trout/km, 41 mountain whitefish/km, and 8 rainbow trout/km.

Mean TL of mountain whitefish was 295 mm, brown trout was 327 mm, and rainbow trout was 269 mm (Figures 41 - 43).

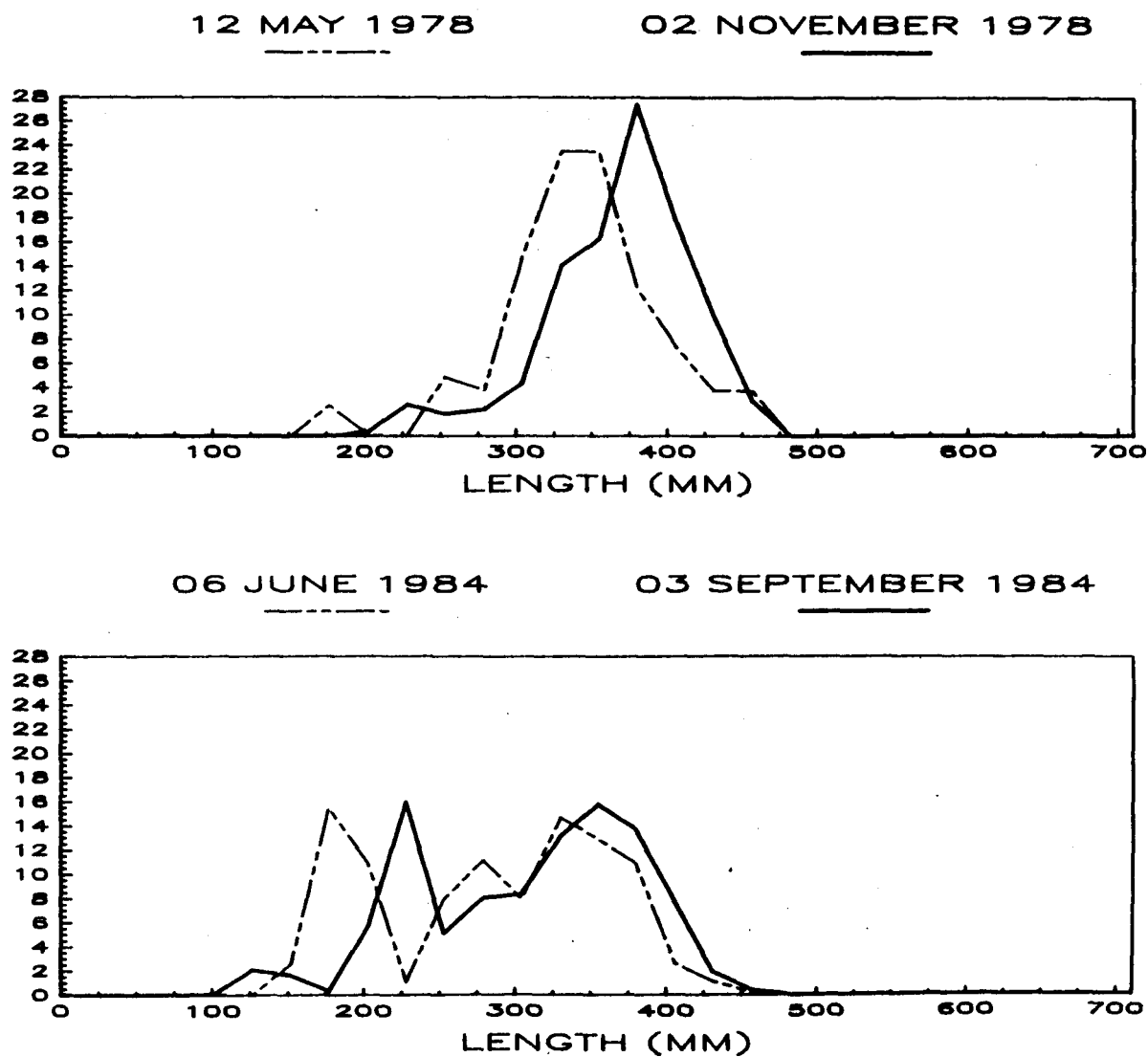


Figure 41. Length distribution of mountain whitefish captured in the Barns sample section of the Madison River in 1978 and 1984.

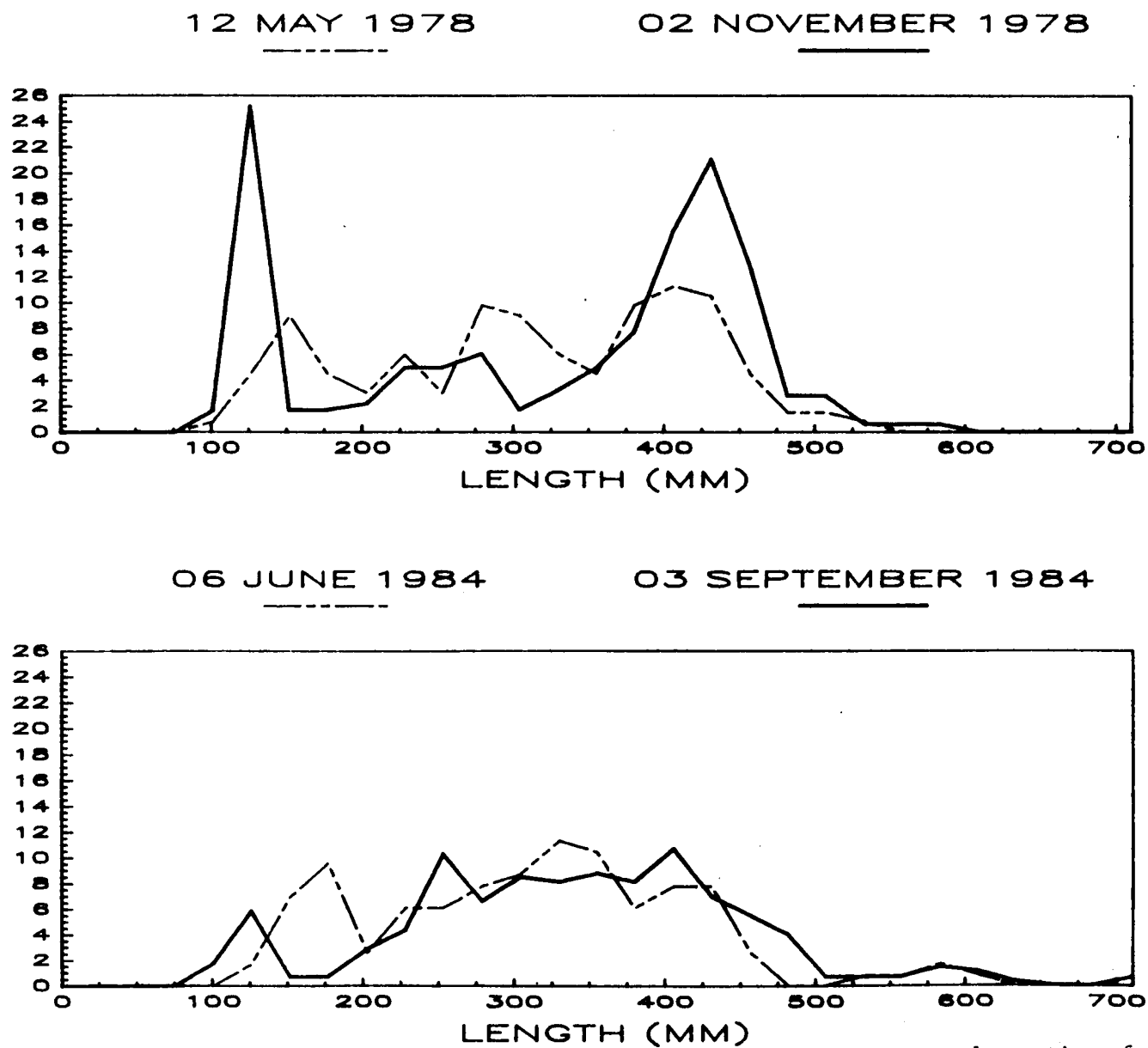


Figure 42. Length distribution of brown trout captured in the Barns sample section of the Madison River in 1978 and 1984.

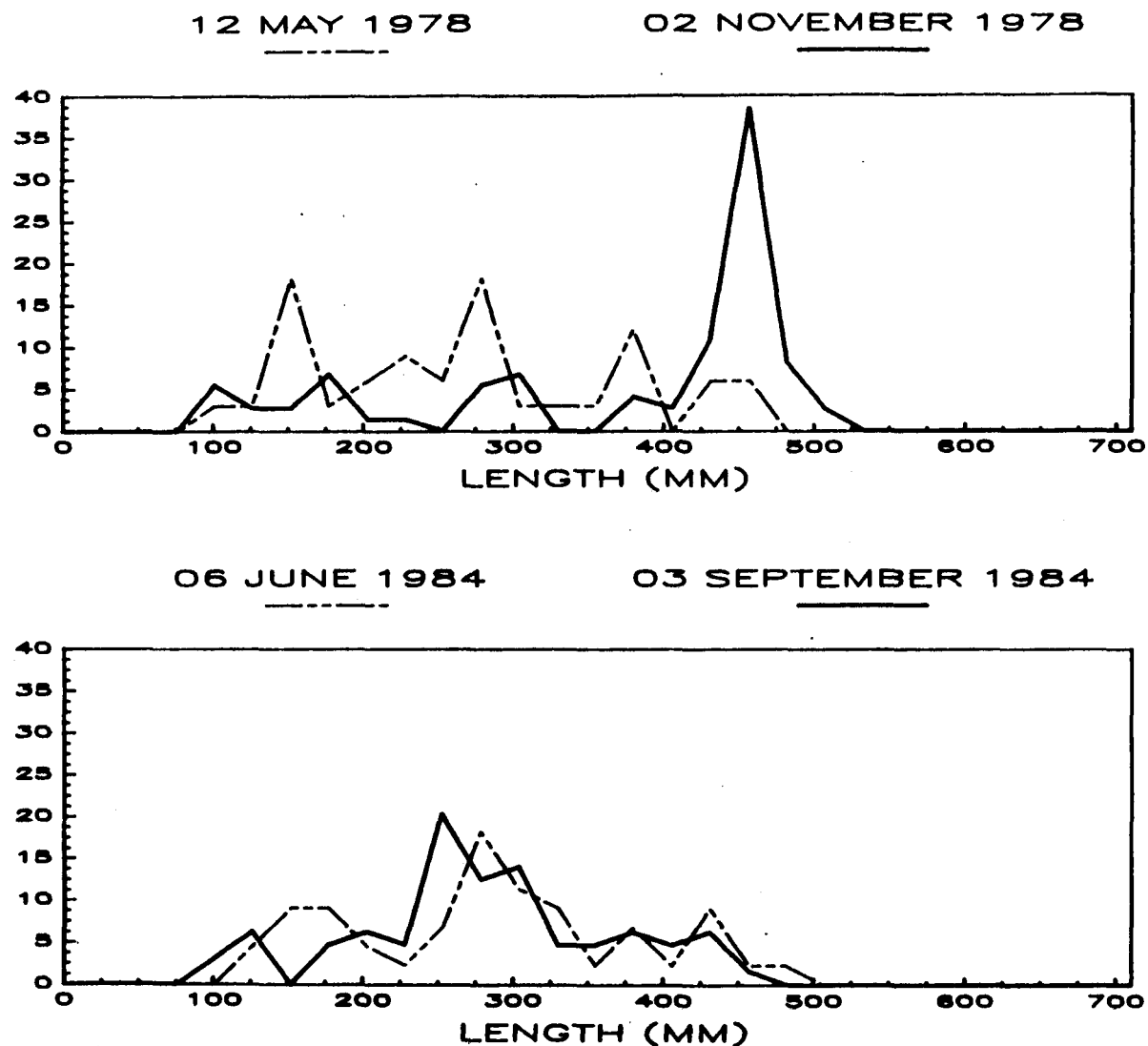


Figure 43. Length distribution of rainbow trout captured in the Barns sample section of the Madison River in 1978 and 1984.

PSD was 96.07% for mountain whitefish, 37.66% for brown trout, and 9.80% for rainbow trout. Mean weight of these species was 226, 336, and 170 g, respectively. Total biomass was estimated at 517.15 kg/km (137.19 kg/ha). Estimated biomass of Mountain whitefish was 400.69 kg/km, brown trout was 98.78 kg/km, and rainbow trout was 17.68 kg/km.

Several differences were evident between results of fish population surveys conducted in 1978 and 1984. Grayling and cutthroat trout were captured in 1984 but not in 1978. The percentage of brown trout in the National Park Meadows increased from 51% to 63% of the catch, while the percentage of brown trout in the Barns section continued to decline (1957=44%; 1978=34%; 1984=15%). The large percentages of fish longer than 406 mm in both sections during November of 1978 could have been part of a spawning migration from Hebgen Lake.

Results from surveys conducted in 1978 and 1984 indicate that most brown and rainbow trout longer than 406 mm were located in the Barns section. Approximately 23% more brown trout and 143% more rainbow trout longer than 406 mm, inhabited the Barns than National Park Meadows section. The percentage of each population of these species longer than 406 mm was also higher in the Barns section. Approximately 21% of the brown trout, and 11% of the rainbow trout in the Barns section were longer than 406 mm TL. In the National Park Meadows section, 7% of the brown trout, and 2% of the rainbow trout were longer than 406 mm TL.

Dissimilarity in the size distribution of fish species in the two areas might be attributed to differences in fish habitat and angler use. The Barns section supports almost six times more fish per kilometer than the National Park Meadows section. Despite the higher carrying capacity, only 12% more fish per kilometer have been landed in the Barns section since 1980. Over the past five years, landing rate in upper and lower sections has been low (0.62 and 0.54, respectively), and the number of fish caught per hour has averaged 15% higher in the Barns section. Approximately 8% and 6% of the fish landed have been harvested upstream and downstream of Seven-Mile Bridge, respectively. An average of 1 fish/20 hours of angling and 1 fish/35 hours of angling has been harvested from the two sections. Exploitation rate of fish longer than 406 mm has been highest in the Barns section. Approximately 39% and 44% of the standing crop of fish longer than 406 mm/km has been harvested each year in the National Park Meadows and Barns sections,

respectively. In both areas, over 80% of the harvested fish have been brown and rainbow trout. Exploitation rate of the entire fish standing crop of brown trout, rainbow trout, and mountain whitefish has averaged 3%, 6%, and 1%, respectively, in the National Park Meadows section and 18%, 28%, and 1%, respectively, in the Barns section.

Jones et al (1981) recommended that brown trout and mountain whitefish in the Madison River be managed under a maximum size restriction and rainbow trout be managed under a catch and release regulation; however, these regulations have never been implemented. Since the percentage of large brown and rainbow trout is small in the National Park Meadows section, this fishery might benefit under such a management scheme. It is doubtful, however, that a significant change in the size structure of fish populations in the Barns section would occur. With the extension of the angling season on the Madison River in 1984, further analysis is needed before definitive recommendations can be made.

Lewis River

The Lewis River supports the eighth most heavily used stream fishery in YNP (Table 23). Use is distributed over four areas: the channel between Lewis and Shoshone Lakes (Channel), from Lewis Lake to Lewis Falls (Lake to Falls), from Lewis Falls to the mouth of Lewis Canyon (Roadside), and from the mouth of Lewis River to the confluence with the Snake River (Canyon) (Figure 44). Since 1973, Roadside and Canyon sections have been managed under catch and release regulations, while Channel and Lake to Falls sections have been managed under a 2 fish creel limit. Over the past 6 years, angler effort on the four areas has been variable, but most of the effort has occurred in the Channel section. Average length of trout landed has been highest in the two sections managed under a creel limit (Channel and Lake to Falls), and landing rate has been highest in the two catch and release sections (Roadside and Canyon).

In the Roadside section, approximately 551 fish/km/year (147 fish/ha/year) have been caught. This area has an average annual landing rate of 1.1 fish/hour. Angler use and effort have averaged 260 days/km/year (70 days/ha/year) and 452 hours/km/year (121 hours/ha/year) since 1974, respectively.

Ecological performance surveys of the fish community in the Roadside section were conducted on 26 June and 28 August. This section was previously surveyed in September 1978.

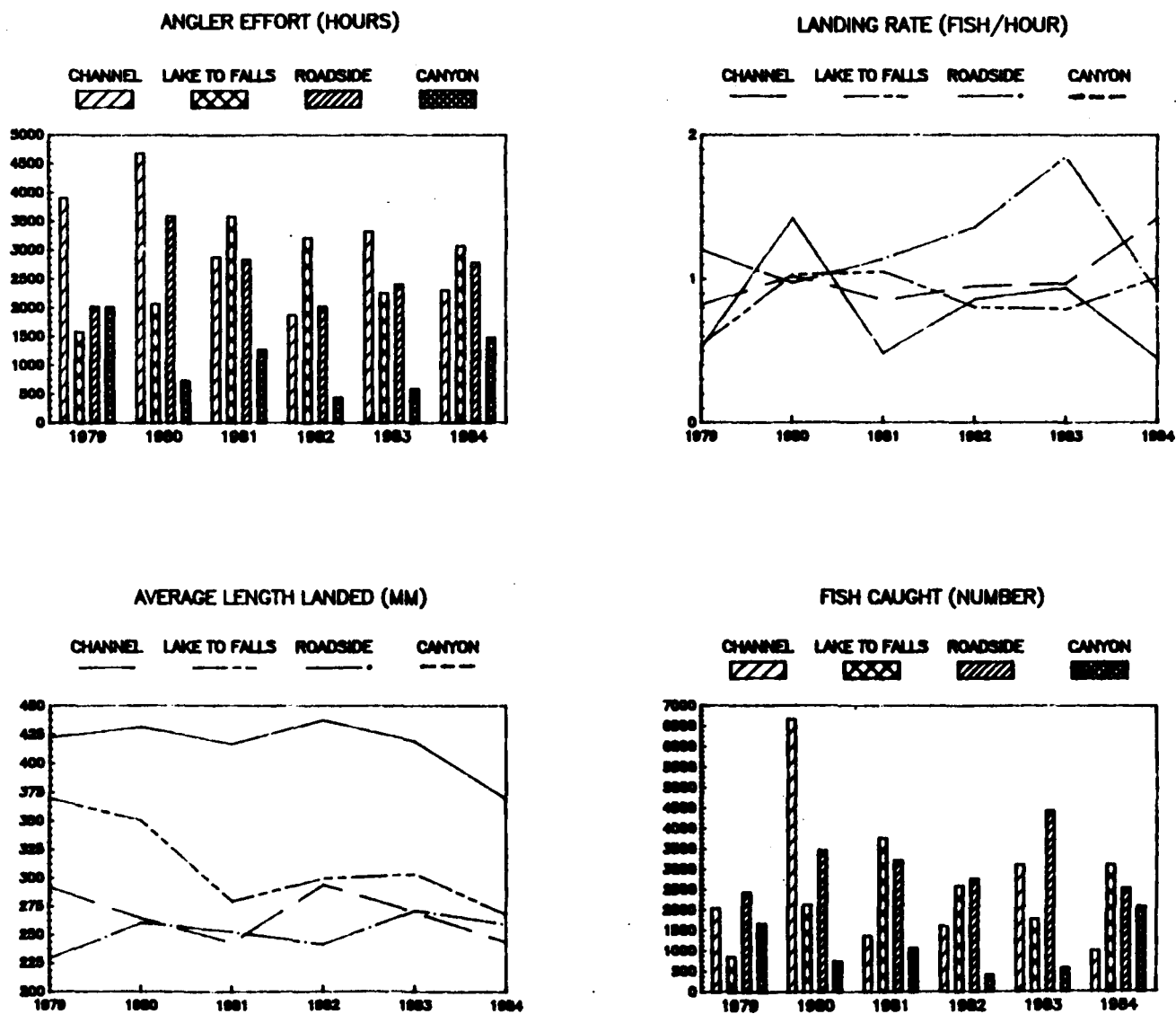


Figure 44. Angler statistics for the channel, lake to falls, roadside, and canyon sections of Lewis River, 1979-1984.

On 26 June, brown and brook trout were the only fish captured. An estimated 3,030 (+1,535) brown trout and 456 (+224) brook trout were present (Table 28). Efficiency rated for these two estimates were 5.9% and 16.9%, respectively. Approximately 2,520 fish/km inhabited this section. Only 1.9% of these fish (47 fish/km) were longer than 203 mm.

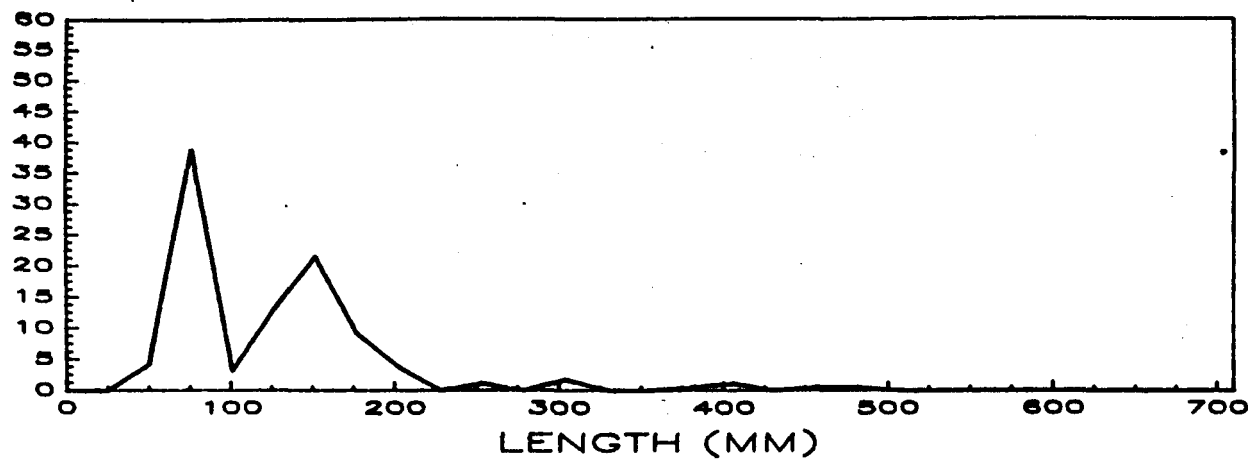
Brown trout averaged 95 mm and brook trout averaged 123 mm TL (Figures 45 and 46). PSD for both species was 0.0%. Mean weight for brown trout was 8.0 g. Biomass estimate for brown trout was 17.91 kg/ha (67.00 kg/km). An estimate of mean weight, and therefore biomass, was not made for brook trout.

On 28 August, four species of fish (brown trout, brook trout, lake trout, and reidside shiner) were captured. A total of 457 fish were caught, including one lake trout and two reidside shiners. Approximately 97% of the captured fish were brown trout. The number of brown trout inhabiting this section was estimated at 9,599 (+3,412) (Table 28). A population size estimate for brook trout was not made because no marked fish were recaptured. Efficiency rate for the brown trout estimate was 4.5%. Number of brown trout per kilometer was estimated at 1,920. Eighteen percent of these fish (346 fish/km) were longer than 203 mm.

Mean length of brown and brook trout were 155 and 145 mm, respectively (Figures 45 and 46). PSD was 50.0% for brown trout and 0.0% for brook trout. Mean weight and biomass estimate for brown trout were 35 g and 67.00 kg/km (17.91 kg/ha), respectively. In September 1978, mean lengths of brown and brook trout were 78 and 68 mm, respectively. Mean weight of brown trout was 10 g and mean weight of brook trout was 3 g. Biomass estimates for brown and brook trout were 27.33 kg/km (4.38 kg/ha) and 0.94 kg/km (0.25 kg/ha), respectively. The average number of trout larger than 203 mm was not noticeably different from 1978 (169 fish/km) to 1984 (197 fish/km).

Based on the 1984 estimate, each fish is caught and released three times during a fishing season. The percentage of fish longer than 203 mm, therefore, may be limited by fish habitat. Although the catch and release regulation has not been as effective at improving the quality of this fishery, as it has been in cutthroat trout populations in YNP, it appears to be providing needed protection for fish longer than 203 mm. Further analysis of the relationships between fish habitat, fish size, and fishing pressure in the Lewis River will be completed in 1985.

12 SEPTEMBER 1978



26 JUNE 1984

28 AUGUST 1984

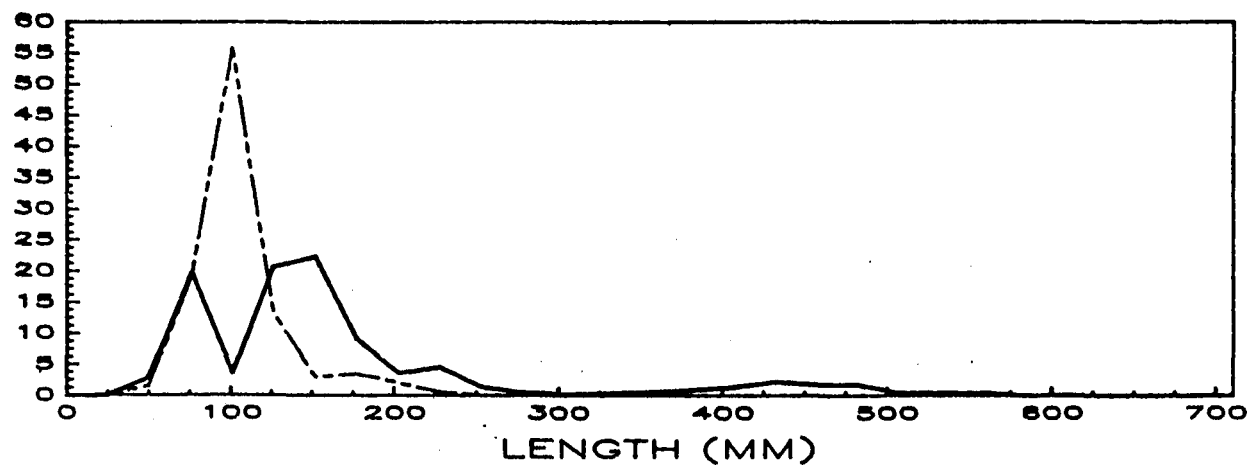
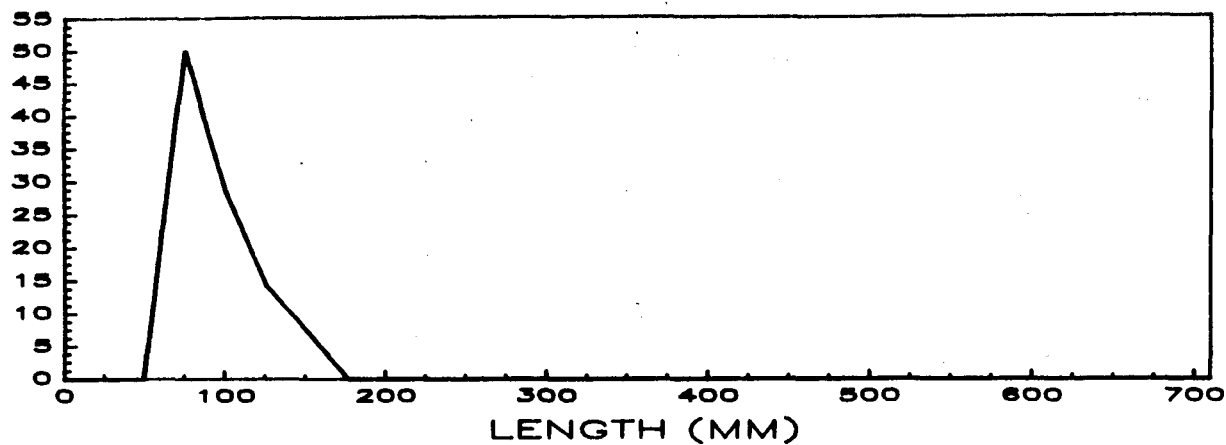


Figure 45. Length distribution of brown trout captured in the roadside section of the Lewis River, 1978 and 1984.

13 SEPTEMBER 1978



26 JUNE 1984

28 AUGUST 1984

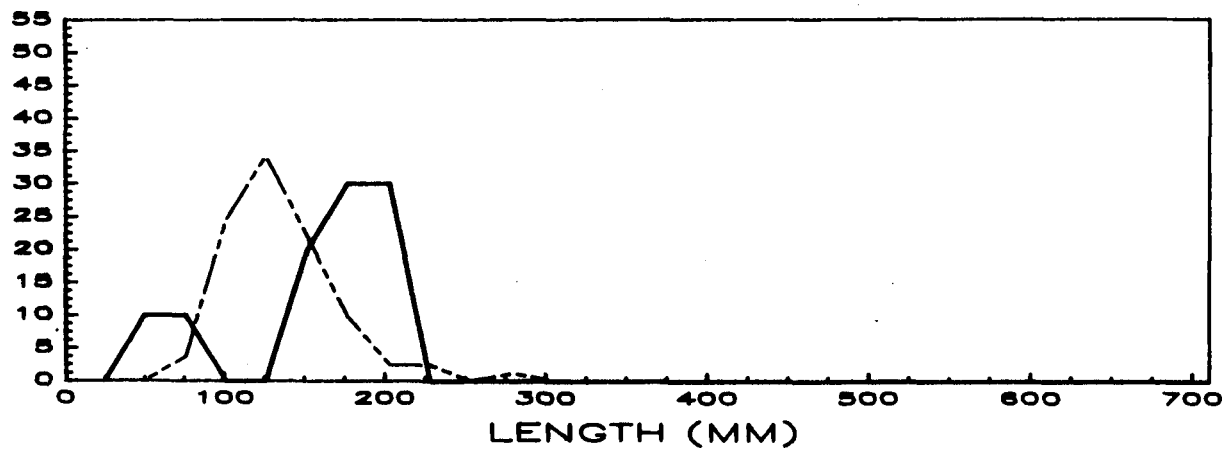


Figure 46. Length distribution of brook trout captured in the roadside section of Lewis River, 1978 and 1984.

Snake River

The Snake River contains the sixteenth most popular stream fishery in YNP (Table 23). Since 1974, landing rate has generally declined, length of fish landed has increased, and an average of 17% of the fish landed (1,920) each year have been creeled (335). The highest degree of angler effort occurred in 1981 (Figure 47). Most of this effort is probably confined to a 0.67 km section between the confluence of the Lewis River and the Park boundary (Roadside).

Ecological performance surveys were conducted on the Roadside section of the Snake River on 27 June and 28 August. Because recapture efficiencies were low, population size estimates could not be completed.

During each sampling period, eight species of fish were captured (Table 48). Mountain whitefish were the most numerous fish sampled. Approximately 48% of the fish captured in June and 64% of the fish captured in August were mountain whitefish. The number of brown trout was consistent between spring and late summer samples, while almost six times more cutthroat trout were present in the spring.

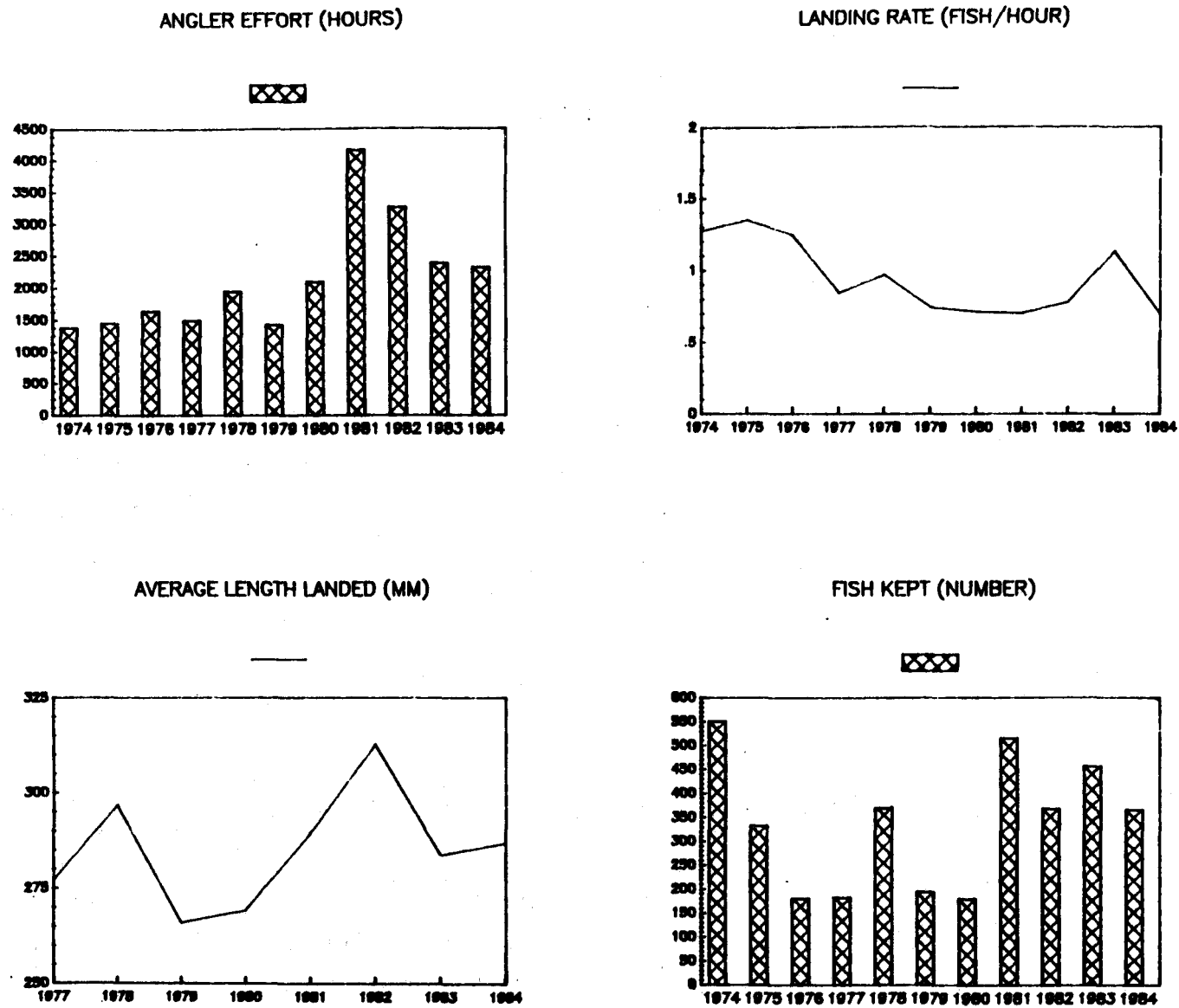


Figure 47. Angler statistics for the Snake River, 1974-1984.

Table 48. Number and length characteristics of fish caught in Snake River, YNP, 1984.

Species	June				August			
	Sample Size	Length (mm)		PSD (%)	Sample Size	Length (mm)		PSD (%)
		Mean	Range			Mean	Range	
Salmonids								
Cutthroat trout	17	173	(47-385)	33.33	3	149	(109-196)	---
Brown trout	3	144	(135-154)	---	3	131	(84-158)	---
Lake trout	2	---	(200-420)	---	-	---	---	---
Mountain whitefish	84	300	(110-464)	92.86	76	285	(87-467)	86.67
Cyprinids								
Longnose dace	2	---	(61-71)	---	5	68	(55-84)	---
Redside shiner	-	---	---	---	8	98	(81-121)	---
Speckled dace	4	82	(74-90)	---	12	81	(56-98)	---
Catostomids								
Utah sucker	60	415	(343-508)	---	7	228	(111-432)	---
Cottids								
Mottled sculpin	2	---	(60-66)	---	5	67	(56-78)	---

REESE CREEK

Reese Creek flows from Cache Lake north to Yellowstone River and drains 3,437.9 ha (Figure 48). The stream and its major tributaries, Electric Creek and Stream #1146, flow entirely accross YNP lands. Reese Creek flows within 1 m of the park boundary before joining the Yellowstone River, and several privately owned irrigation diversions are located along the stream channel (Figure 48). At least some of these diversions have been active for about 100 years (Evermann 1892). Because the State of Montana is currently reviewing all water rights in the state, the National Park Service is involved in an adjudication process to maintain stream flows in Reese Creek. During 1984, a preliminary study was initiated to document stream flows and fish distribution in the stream.

Methods

Stream Flow

On 21 May, two staff gauges were installed, one upstream and one downstream of all active diversions. The staff gauges were read weekly and calibrated by estimating flows with a gurley meter on 11 dates between 13 May through 19 November. The use of irrigation ditches was also observed and noted weekly (Table 49).

Fish Distribution

Reese Creek was sampled by electrofishing on 21 May, 3 July, and 14 August. Captured fish were identified to species, checked for gonad condition, and measured to the nearest 1 mm total length.

Results

Stream Flow

At the upper Reese Creek site, a stronger predictive ability existed between stream discharge and staff gauge height ($R^2=0.98$) than at the lower site ($R^2=0.84$) (Figure 49). Possible movement of the lower gauge might account for the weaker linear relation.

Estimated discharge ranged from 0.11 to 0.51 m³/s at the upper staff gauge, and 0.00 to 0.23 m³/s at the lower staff gauge (Figure 50). Lower Reese Creek was dry for at least one week during the first part of August. During the time irrigation was in progress, discharge at the lower gauge averaged 0.19m³/s less than at the

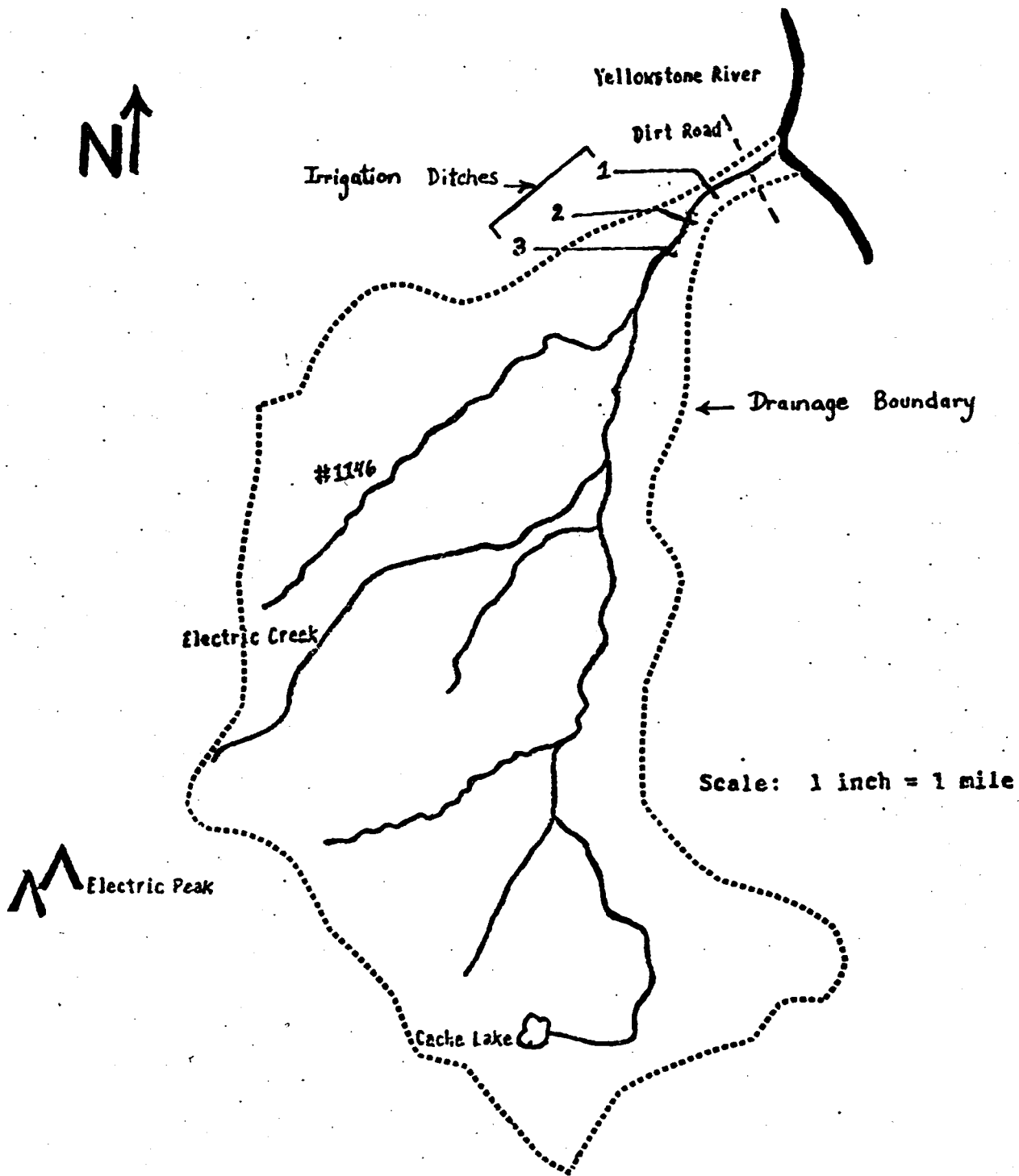


Figure 48. Hydrographic map of Reese Creek, YNP.

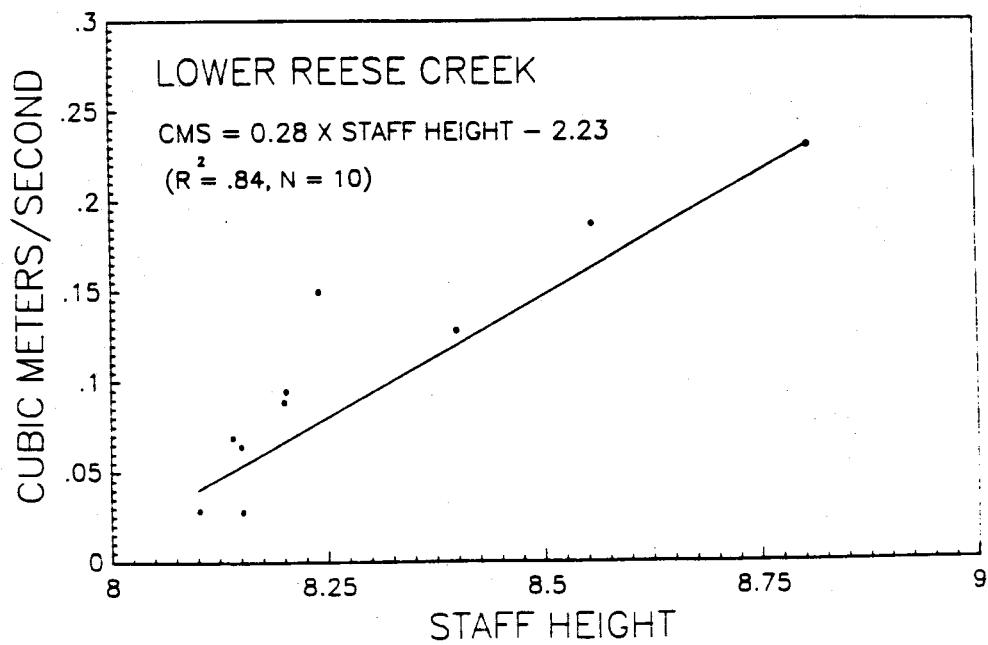
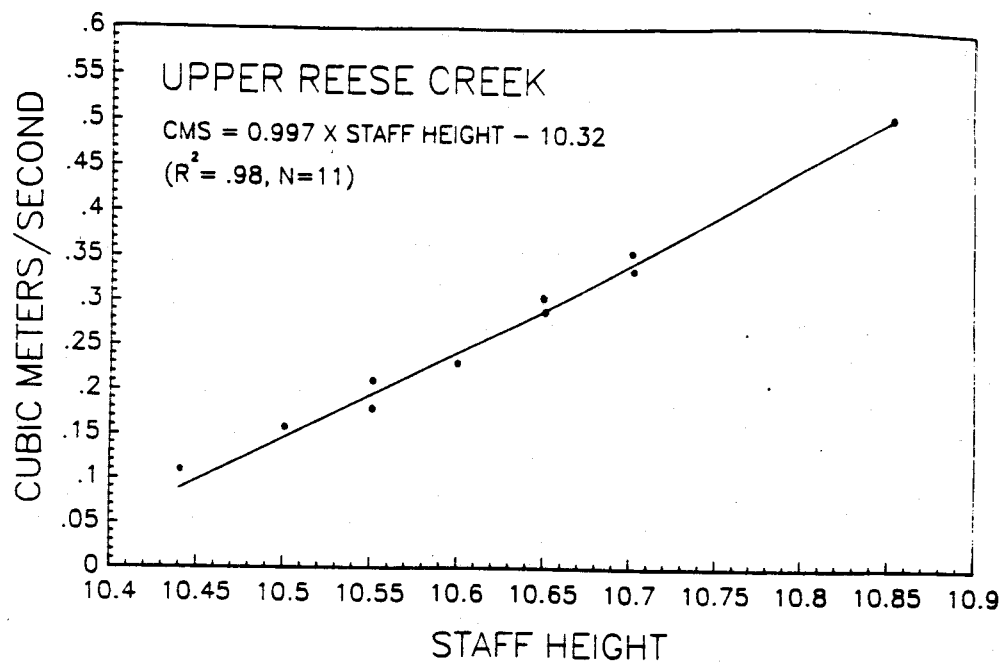


Figure 49. Rating curves for the upper and lower Reese Creek staff gauges, 1984.

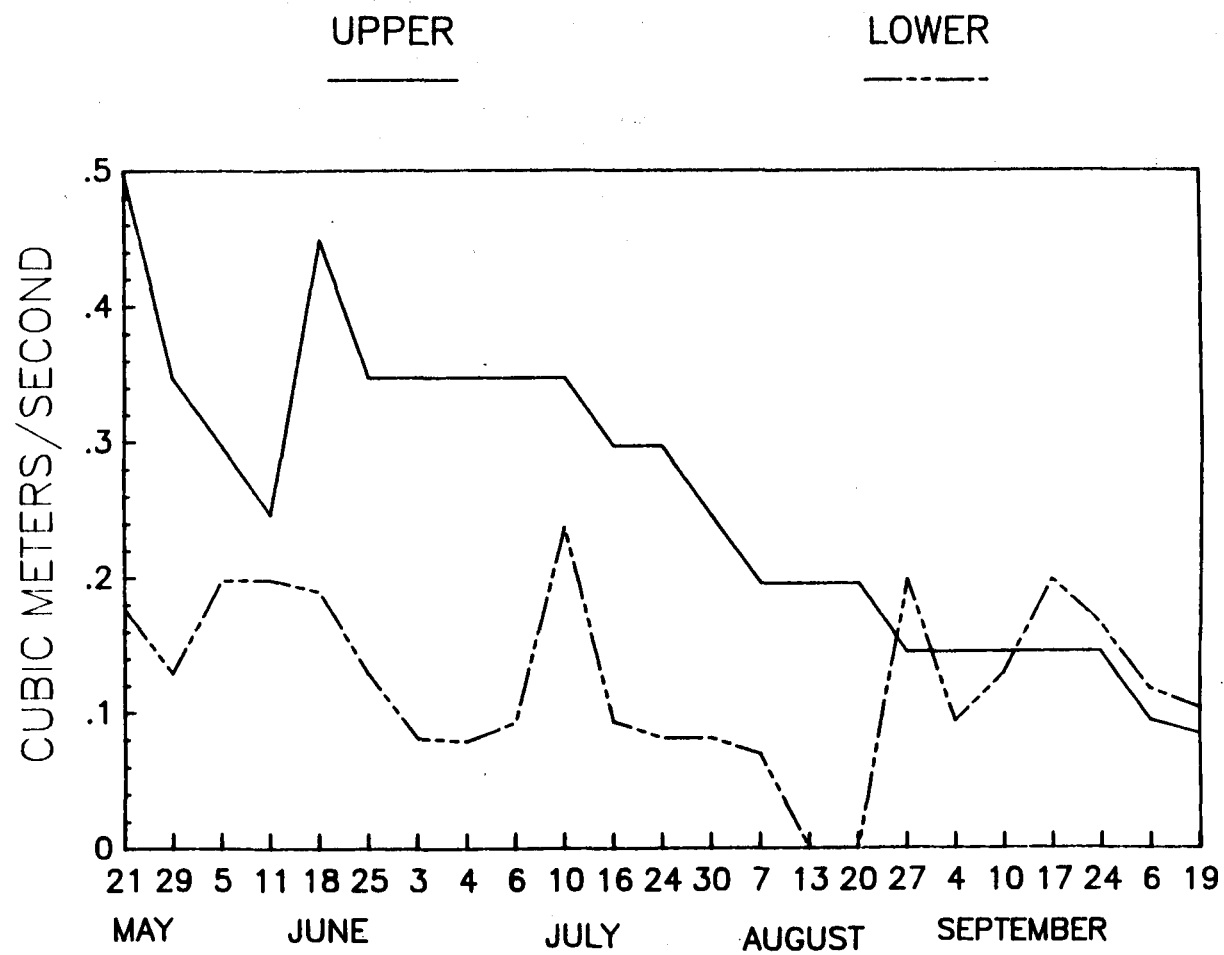


Figure 50. Weekly discharge patterns at the upper and lower Reese Creek staff gauges, 1984.

upper gauge (range 0.33 to 0.04 m³/s). This difference may have actually been greater because stream #1146 enters Reese Creek between the two gauges. On 19 November when irrigation had stopped, discharge was 0.04 m³/s greater at the lower gauge than at the upper gauge.

The upper irrigation diversion was full and remained in use from May through September (Table 49). The second and third diversions contained water sporadically from May through August. Lowest flows in the main channel of Reese Creek occurred during periods of heaviest irrigation use, 17 July through 20 August (Table 49 and Figure 50).

Table 49. Flow in irrigation ditches in Reese Creek, 1984-1985.

Date	Lower (#1)	Middle (#2)	Upper (#3)
5/29/84	Full	Full	Full
6/11/84	Full	Full	Full
6/18/84	Dry	1/16 Full	Full
6/25/84	Dry	1/2 Full	Full
7/3/84	1/2 Full	Full	Full
7/6/84	1/2 Full	Full	Full
7/10/84	Full	Dry	Full
7/16/84	3/4 Full	Dry	Full
7/24/84	1/16 Full	Full	Full
7/30/84	1/16 Full	Full	Full
8/7/84	1/16 Full	Full	Full
8/13/84	1/2 Full	Full	Full
8/20/84	1/3 Full	Full	Full
9/4/84	Full	1/2 Full	1/2 Full
9/10/84	Full	Dry	1/2 Full
9/17/84	1/2 Full	Dry	1/2 Full
9/24/84	1/2 Full	Dry	1/2 Full
11/6/84	Dry	Dry	1/16 Full
1/3/85	Dry	Dry	Dry

Fish Distribution

Cutthroat Trout. Cutthroat trout (*Salmo clarki*) were found on all three sample dates. When water flows were high (21 May), six trout were captured in the creek. By 3 July, water flow below the diversions was significantly reduced; however, cutthroat trout still occupied the main channel. On 14 August, the main channel below diversion #1 was dewatered. Water flow in irrigation ditch #3 was higher than in the main channel

below diversion #3 and the other irrigation ditches. One or two cutthroat trout were seen in irrigation ditch #3 on this date. These fish probably entered the ditch because it contained the highest flow.

Brown Trout and Mottled Sculpins. Brown trout (Salmo trutta) and mottled sculpins (Cottus bairderi) were sampled on only one occasion (3 July). These fish were captured below all diversions and probably moved into Reese Creek to feed on the large amount of insect drift in the stream at that time (Table 50).

Discussion

Although water has been diverted from Reese Creek since the late 1800's, some evidence indicates that cutthroat trout from Yellowstone River use the stream for spawning. These fish spawn between 15 May and 30 July with the peak of spawning activity occurring in the first week of July (C. Clancy, Montana Fish, Wildlife, and Parks, personal communication). Fertilized eggs incubate through August. Since the lower section of Reese Creek was dewatered for at least 8 days in August, any eggs deposited for incubation in this area were probably destroyed.

Montana Department of Fish, Wildlife, and Parks recently (1983) imposed catch and release regulations on cutthroat trout in the Yellowstone River above Yankee Jim Canyon. This action was partially in response to the limited reproductive success of these fish; only three other tributaries provide spawning habitat for cutthroat trout in this section of the Yellowstone River (C. Clancy, Montana Fish, Wildlife, and Parks, personal communication). With the dewatering of Reese Creek in August, a potential spawning tributary has been virtually eliminated.

Table 50. Occurrence and densities of macroinvertebrates found in Reese Creek, 1984.

	Density (Number)
Arthropoda	
Insecta	
Ephemeroptera (mayflies)	
Baetidae	
<u>Baetis bicaudatus</u>	15
Ephmerellidae	
<u>Drunella coloradensis</u>	1
<u>Drunella doddsi</u>	2
Heptageniidae	
<u>Epeorus grandis</u>	1
Trichoptera (caddisflies)	
Limnephilidae	
<u>Neothremma sp.</u>	1
TOTAL NUMBER OF SPECIES:	5

LAKE TROUT SPAWN TAKING OPERATION

Lewis Lake was historically fishless (Jordan 1891), and initial plants of lake trout (Salvelinus namaycush) and brown trout (Salmo trutta) occurred in 1890 (Varley 1981, Visscher 1983). Lake trout for this introduction were collected from spawning reefs near the Beaver Islands in Lake Michigan (Visscher 1983). Since Lewis Lake is only 4.8 km downstream from Shoshone Lake, rainbow trout (Salmo gairdneri) and brook trout (Salvelinus fontinalis) probably gained access to Lewis Lake soon after they were stocked into tributaries of Shoshone Lake (1893 and 1895, respectively) (Varley 1981). The only other occasion when fish were planted into either lake occurred in 1941; 5,890 lake trout fingerlings were obtained from Bozeman Montana Fisheries Station and released into Lewis Lake (Visscher 1983).

Efforts to reestablish lake trout in the Great Lakes have been hampered by the use of poorly suited donor stocks. These failures have resulted in current strategies that include selecting stocks which have habitat characteristics similar to those of the receiving habitat (Ihssen 1984). Limited lake trout introductions in Lewis Lake have reduced the potential for genetic mixing within this species, and thus, the integrity of the Beaver Island strain has probably been maintained. Virtual genetic isolation of lake trout in Lewis Lake, therefore, make this stock an excellent candidate for reestablishment efforts in Lake Michigan.

To this end, annual collection of sex products from Lewis Lake lake trout was initiated in 1982 (Jones et al 1983). Both eggs and sperm were collected in 1982 and 1983, but 1984 collections were limited to sperm alone.

Methods

Disease samples were collected from 61 lake trout of both sexes on 12 September 1984. Samples were shipped to the USFWS Disease Control Center (Ft. Morgan, Colorado) for analysis. Tests were made for the following pathogens: Aeromonas salmonicida, enteric redmouth bacterium, salmonid kidney disease bacterium, viral hemorrhagic septicemia virus, infectious hematopoietic necrosis virus, and infectious pancreatic necrosis virus.

Sperm was collected by personnel from the Jackson National Fish Hatchery (NFH) on 1 October 1984. Collections were made at three different sites along the northeast shore of Lewis Lake (Figure 51).

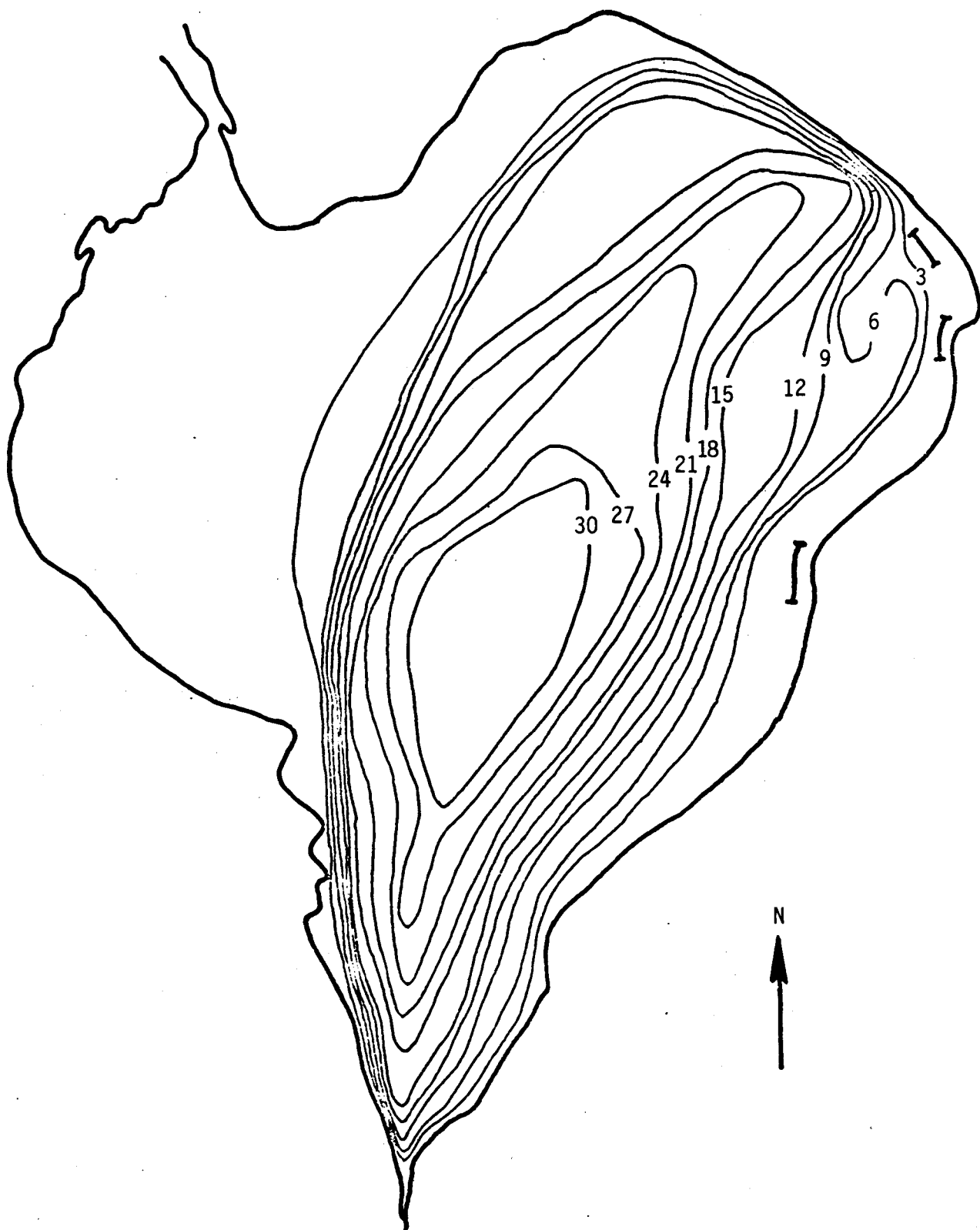


Figure 51. Map of Lewis Lake with the locations of sampling sites for the 1984 spawn taking operation indicated.

Sex determination, total length measurements (to the nearest 1 mm), and weight (to the nearest 2 g) were recorded for all trout in the disease sample. Additionally, total length (5 mm intervals) was collected from 128 of the lake trout males on 1 October.

Results

All trout in the disease sample tested negative for the selected pathogens. Mean length of males and females was 444 mm and 446 mm, respectively, and the male:female ratio was 1.1:1. Mean length for the combined sample was 444 mm. Differences in mean weight for males (700 g) and females (835 g) were not statistically significant ($=0.05$).

Approximately 500 adult lake trout were collected on 1 October, and sperm was obtained from 203 males. Mean length for 128 of the stripped males was 441 mm. Eggs from 216 females of the Jackson NFH broodstock were fertilized by one of the following manners:

- 1) fertilized at Lewis Lake, 2) sperm from Lewis Lake males transported to Jackson NFH for fertilization, and 3) ripe males transported to Jackson NFH, stripped, and resulting sperm utilized for egg fertilization.

A 54.4% eye up of approximately 1.2 million eggs resulted in 665,754 eyed eggs. Over 96% of these were shipped for eventual stocking in Lake Michigan; remaining eggs were to be used for research purposes.

Discussion

Difficulty in collecting a sufficient number of ripe females in the initial years of the program (Jones et al 1983) resulted in altered procedures in 1984. Limiting collections to ripe males greatly reduced the field time necessary to complete the operation. Since females from the broodstock at Jackson NFH came from Jenny Lake (a result of another planting of fry from Lewis Lake), the resulting fish should enhance stocking success into Lake Michigan. Broodstocks created from previous operations will be available for production in the next several years, and results from initial plants of the Lewis Lake strain should be forthcoming.

NONCONSUMPTIVE USE OF THE AQUATIC RESOURCE

In Yellowstone Park there are presently two sections of Yellowstone River which are closed to angling for the protection of spawning trout. These closed areas yield an excellent opportunity to study the level of visitation in an aquatic setting available only to nonangling uses, such as photography or observation.

Fishing Bridge spans the Yellowstone River at the outlet of Yellowstone Lake; the area from the lake to a point 1.6 km downstream of the bridge has been closed to fishing since 1973. Although once very popular with anglers, Fishing Bridge was not considered a high quality fishery. Average landing rate for 1963 (Sharpe 1964) was 0.20 trout/hour, varying from a high of 0.48 during the first week of July to a low of 0.00 trout/hour during the first week of September. In 1966, Sharpe and Arnold (1967) reported the catch per unit effort was lower than most Park waters. Dean and Varley (1973) concluded that few anglers returned to the bridge after an initial experience because of crowding and low success rates.

LeHardy Rapids, located approximately 5.7 km downstream from the lake on Yellowstone River, has been closed to fishing for 90 m upstream and downstream from the rapids since 1949. During high water (May through July) fish congregate near the west bank in pools immediately below the rapids. From here the fish jump the rapids, often having to make several attempts, providing an extraordinary sight for the visitor. In 1984, a new boardwalk and viewing platform were constructed at LeHardy Rapids to facilitate visitor access and prevent continued erosion of the trail to the rapids.

Effects of angling closures were monitored at Fishing Bridge and LeHardy Rapids for the seventh consecutive year in 1984. Visitor use and mean length of stay were estimated at Fishing Bridge in 1984, but only visitor use was determined at LeHardy Rapids.

Methods

Since effort for counts was limited, a "time available" method (Matheson 1949, Bulkley 1966, Geiger 1972, and Brown 1978) of data collection was employed. Instantaneous counts of visitors were made whenever possible at both Fishing Bridge and LeHardy Rapids, usually while en route to a work site. The location of project activities precluded an equal sampling effort at each site; therefore, sample size at LeHardy Rapids was small.

Critical aspects of this method are accurate estimates of average time spent per person and daily use pattern. Accuracy increases as the number of time intervals increase; however, if interval sizes become too small, the increase in time periods without counts causes a decrease in the resulting estimate. Using these criteria, a 15 minute time interval appears to be optimum for Fishing Bridge and LeHardy Rapids use estimates.

A daily use curve was determined by averaging all counts for each interval. Total visitor hours for each interval were then calculated using the following formula:

Effort (visitor hours) = $1/2I(t_i + t_{i+1})$, where
I is the time interval, and t_i is the mean
number counted at interval i.

To obtain a daily total for visitor hours, instantaneous counts were expanded by the proportion of daily use represented by each time interval. On days when more than one count was made, the mean number of visitor hours was used. Total number of visitors for each day was obtained by dividing visitor hours by the mean length of stay. Season totals were calculated by summing daily totals and then expanding by the proportion of days actually counted.

Results

In 1984, mean length of stay at Fishing Bridge for 578 people was 10.7 minutes/person. Total number of visitors decreased from 1983 (approximately 14.7%) to 178,009 visitors. Total visitor hours also decreased (approximately 5.6%) from 1983 to 31,686 hours (Table 51).

Using an average stay of 8.1 minutes (1982) at LeHardy Rapids, total number of visitors was estimated to be 20,718 people, and total time spent at the rapids was 1,657 hours. Both values increased approximately 69% over 1983.

Discussion

Creel census data for the last 8 years (1965-1972) of angling on Fishing Bridge yielded an average of 33,275 total anglers and 36,714 total angler hours/year (Table 52). While the 1984 figures represent slightly lower total hours on Fishing Bridge, the number of people enjoying this area has increased almost 400%

Table 51. Nonconsumptive use of the aquatic resource, 1978-1984.

	Year	Number of Counts	Total Number of Visitors	Mean Minutes per Person	Total Visitor Hours
Fishing Bridge					
	1978	582	132,966	10.8	23,934
	1979	670	170,383	--	30,669
	1980	551	130,305	10.7	23,238
	1981	1,015	173,679	12.3	35,604
	1982	425	167,333	9.7	26,941
	1983	421	208,672	--	33,580
	1984	430	178,009	--	31,686
LeHardy Rapids					
	1978	222	17,287	8.4	2,420
	1979	206	17,627	--	2,798
	1980	94	45,610	5.3	4,029
	1981	155	12,056	16.2	3,255
	1982	154	26,768	8.1	3,600
	1983	93	12,245	--	1,647
	1984	131	20,718	--	2,787

Table 52. Fishing Bridge creel census data, 1965-1972.

Year	Total Anglers	Total Hours
1965	41,387	41,387
1966	30,135	30,135
1968	40,153	40,262
1970	25,699	31,644
1972	22,824	38,079

since the bridge was closed to fishing; concomitantly, Park visitation has only risen approximately 16%.

Use at LeHardy Rapids has varied extensively since 1978. Because the rapids are not as visible from the road, use would be expected to be lower and more variable. The boardwalk was not completed until after the cutthroat spawning migration in the Yellowstone River was completed; however, improved access may attract a larger number of visitors in the future. While not necessarily a major factor, low sample size would also tend to accentuate annual variation.

Comparing nonconsumptive use to Park fisheries, more people made use of Fishing Bridge than any single fishery in the Park (Table 51). LeHardy Rapids ranks behind the Yellowstone River in total use. In terms of total number of man hours expended, Fishing Bridge ranks ninth and LeHardy Rapids eighteenth when compared to angler use among Park fisheries.

Estimates of nonangler use during the past 7 years emphasize the value of these viewing sites and the demand for this type of visitor activity. Observing the interactions of fish with their natural habitat, including reproduction, feeding, and as prey, is truly an educational experience for anglers and nonanglers alike.

OTHER PROJECT ACTIVITIES

Assistance to Independent Researchers

The Yellowstone fishery project functions as an administrative liason and provides logistical support to independent researchers working on aquatic related studies in Yellowstone Park. Project personnel work closely with researchers in order to facilitate an economical and timely completion of research in the Park. Project equipment, manpower, and facilities are also provided without compensation for small studies, and on a reimbursable basis for larger ones.

In 1984, the project provided assistance to Dr. Allen J. Medine of the Civil and Environmental Engineering School at the University of Colorado. Dr. Medine is performing a study entitled "Environmental Assessment of Heavy Metal Contamination in Yellowstone National Park." The project provided laboratory space and some equipment to Mr. Stephen Klein, a Ph. D. candidate who spent approximately four months in the Park collecting data for the study. The purpose of this study is to assess the contamination of roadside waters of Yellowstone National Park due to intensive summer automobile traffic and increasing winter visitation with oversnow vehicles.

Objectives of the research are to define the level of metal contamination within the Park through a combined analyses of environmental transport, bioaccumulation and environmental chemistry. This study will provide a detailed analysis and assessment of contamination and its significance to the health of aquatic environments and Park visitors.

The project also provided laboratory space, boats and four man-days of assistance to Dr. Jerry Caster of the University of Wisconsin - Milwaukee Center for Great Lakes Studies. This research, "The Study of Substrate Characterization of Retrogressive Oligotrophy in Yellowstone Lake", will attempt to determine if Yellowstone Lake is becoming more oligotrophic, by investigating the bottom sediments.

Yellowstone and Heart Lake Limnology

Limnological monitoring was continued on Yellowstone and Heart Lakes in 1984. Lewis and Shoshone Lakes were dropped from the program after six years because of budgetary constraints. The South Arm of Yellowstone Lake and Heart Lake have been retained to support studies of the fire program in these drainages. The

objective of this program is to provide baseline limnological data for these lakes. This data is necessary for evaluation of the effects of the natural fire program and comparison with future limnological investigations.

Yellowstone Aquatic Library

The Yellowstone Aquatic Library was begun in 1973 and consists of over 700 titles including most of the historical works. The library is limited to aquatic resources in Yellowstone Park, and the titles are cross-referenced by author, species, water, and subject.

Information Distribution

Information on the Yellowstone fishery program is made available to the scientific field and the general public in several ways. The annual Fishery and Aquatic Management Program Technical Report has a distribution of approximately 130 copies a year. The project receives 50 to 75 information requests by phone or mail each year. Response time on informational requests runs from 10 minutes on the phone to several days of gathering data for a research request. Project personnel also give several formal presentations each year. In 1984, papers were presented at the National Meeting of the American Fishery Society, Wild Trout III, and the Montana Accademy of Science - Northwest Scientific Association annual meeting. Presentations were also made at the Montana Chapter of the American Fishery Society; the Gardiner, Montana Chapter of Federation of Fly Fishermen; and the Yellowstone Park naturalist seasonal training program.

Volunteer Program

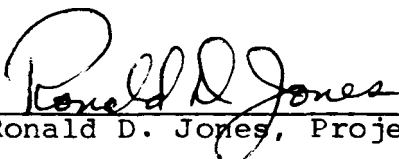
Volunteer programs of the Fish and Wildlife Service and the National Park Service have been utilized for many years. The programs provide a needed manpower source for the project and a valuable training experience for the volunteer. In 1984, the project had one full time volunteer for a 4 month period and four volunteers on a part-time basis. They were involved in angler interviews, fish trap operations, gillnetting, electrofishing, backcountry stream and lake surveys, and a variety of clerical and maintenance jobs. The effort and dedication of these volunteers is very important to the Yellowstone Fishery Program.

ACKNOWLEDGEMENTS

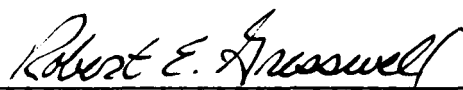
The success of our program is due to hard work from a small group of dedicated individuals who definitely deserve recognition for their efforts. Therefore, we would like to thank the following persons: Fred Greider, Dan Mahony, and Jeff Shenot contributed significantly to our field work as paid seasonals. Denise Peska, a member of the VIP program, and Susan Walker, a SCA, worked as full time volunteers during the hectic field season. All five of these individuals proved to be virtually invaluable throughout the summer months. Although they did not participate on a full-time basis, Lisa Bausom, Marion Jones, Pat Newby, and Jeff Boyce volunteered their time whenever possible, and provided significant input on several crucial projects. Crystal Hudson, a permanent staff member, served as the project administrative assistant and oftentimes provided needed help in the field. Crystal also participated in the preparation of this report. Karrie West, for some unknown but greatly appreciated reason, returned for her fifth winter season; she was responsible for manuscript typing, table and figure preparation, and most of the data punching. Kerry Gunther aged trout collected during the stream surveys and prepared a special analysis of grizzly bear data from Clear Creek. Mary Wunderlich identified plankton samples, and George Roemhild provided needed expertise for macroinvertebrate samples for both streams and lakes. Ellen Gresswell entered much of the VAR data into the computer. Ann Marie Chytra, the Heart Lake ranger, collected monthly limnological data in a competent and professional manner. Fish and Wildlife personnel from stations in Bozeman and Ennis made the fall gillnetting both a pleasure and success, and the crew from Jackson NFH efficiently expedited the lake trout spawning program at Lewis Lake.

Our special thanks to all of the above and also those who contributed but have not been specifically cited.

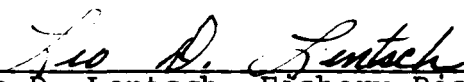
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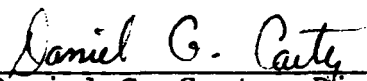
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APPENDIX A

Table 1. Gillnet catches of cutthroat trout by site, Yellowstone Lake, 1969-1972, 1974, 1976-1980, and 1982-1984¹⁾.

	Number per net ²⁾											Total
	1a	1b	1c	2a	2b	3a	3b	4a	4b	6c	7c	
1969	3	19	5	17	5	3)	3)	3)	28	14	16	110
1970	10	18	10	11	15	20	9	2	32	7	1	135
1971	15	5	23	21	8	3)	3)	3)	3)	3)	3)	72
1972	15	13	21	16	12	17	3	9	19	8	17	150
1974	11	12	25	21	26	6	12	19	12	6	20	170
1976	19	9	22	11	21	19	15	13	10	12	14	165
1977	10	23	15	16	21	19	12	7	15	12	22	682
1978	14	9	15	10	17	16	14	15	18	13	13	766
1979	12	18	12	10	9	19	12	16	18	12	10	748
1980	7	21	17	6	14	12	12	13	18	15	9	715
1982	12	10	9	8	11	11	11	8	12	10	12	582
1983	23	18	24	16	22	22	13	18	14	14	13	993
1984	25	165	23	16	32	17	20	14	15	16	21	1053

	Average total length (mm)											Average
	1a	1b	1c	2a	2b	3a	3b	4a	4b	6c	7c	
1969	277	293	322	328	378	3)	3)	360	290	341	300	311
1970	290	308	327	365	279	352	352	352	280	364	224	315
1971	291	363	306	326	379	3)	3)	3)	3)	3)	3)	321
1972	297	293	262	329	321	296	368	358	334	349	329	313
1974	249	330	304	300	266	284	311	290	301	348	324	298
1976	315	322	306	337	291	302	324	331	324	330	337	317
1977	301	261	305	290	286	265	341	283	269	344	292	290
1978	286	327	281	313	298	293	319	286	302	342	365	308
1979	276	281	312	322	306	280	306	288	294	374	335	303
1980	279	302	310	344	309	308	341	268	286	339	345	309
1982	276	280	342	345	306	274	356	324	358	362	327	322
1983	256	276	263	297	290	249	328	276	324	353	323	288
1984	263	317	298	271	239	259	306	282	325	307	271	281

	Average weight (g)											Average
	1a	1b	1c	2a	2b	3a	3b	4a	4b	6c	7c	
1969	213	272	317	359	527	3)	3)	411	261	403	249	312
1970	311	279	348	450	223	382	390	320	349	488	108	320
1971	249	363	267	318	452	3)	3)	3)	3)	3)	3)	305
1972	269	276	231	350	352	262	410	405	358	459	349	320
1974	167	341	267	269	200	253	290	265	285	361	309	266
1976	322	337	280	363	267	285	322	331	306	353	358	314
1977	273	214	292	268	258	219	399	256	215	430	270	271
1978	254	360	235	336	292	283	337	260	290	416	497	316
1979	222	245	316	339	300	239	304	255	280	517	400	301
1980	357	302	316	418	314	309	410	217	255	430	414	329
1982	233	240	403	406	319	239	470	369	455	471	360	359
1983	188	226	216	294	272	168	375	248	347	455	378	271
1984	199	399	250	244	165	191	318	250	354	375	227	259

- 1) Experimental gillnets (38.1 m long) set overnight (7.6 m graduated mesh panels 19, 25, 32, 38, and 51 mm) in the 1.5-4.6 m depth interval.
- 2) From 1969-1974, only 1 set was made in each area at the specified depth interval; for 1977, the number represents an average of 4 sets, and 1978-1984 represents an average of 5 sets.
- 3) Areas not sampled.

Table 2. Gillnet catches of cutthroat trout by general area, Yellowstone Lake, 1969-1972, 1974, 1976-1980, and 1982-1984¹⁾.

Year	Number/net				Average total length (mm)				Percentage under 210 mm				
	North	Central	W. Thumb	South	North	Central	W. Thumb	South	North	Central	W. Thumb	South	Total
1969	10	--	16	15	316	--	296	319	12.2	--	9.7	10.0	10.9
1970	13	14	17	4	311	352	285	346	7.8	0.0	17.6	0.0	8.1
1971	14	--	--	--	321	--	--	--	1.4	--	--	--	1.4
1972	15	10	14	12	297	307	342	336	11.7	0.0	0.0	4.0	6.7
1974	19	9	16	13	289	302	294	329	14.7	16.7	25.8	0.0	14.7
1976	16	17	13	13	310	311	328	333	11.0	5.9	4.3	7.7	8.5
1977	17	15	11	17	284	293	273	309	28.2	23.1	30.3	13.3	24.6
1978	13	15	17	13	298	305	294	353	13.2	8.6	5.4	0.8	8.5
1979	12	15	17	11	297	290	291	356	18.1	21.0	14.5	6.1	16.0
1980	13	12	15	12	307	325	278	341	14.0	11.0	16.0	11.0	13.4
1982	10	11	10	11	307	316	341	342	15.7	15.0	6.9	4.5	11.9
1983	21	18	16	14	275	278	297	339	26.4	21.6	13.7	8.0	20.9
1984	22	19	15	18	272	286	304	286	30.3	18.0	12.4	24.2	24.8
Totals	3060	1100	1135	1046									
Averages	15	15	15	13	291	299	298	329	20.6	16.0	13.2	10.0	16.7

1) Net locations as follows: North - 1A, 1B, 1C, 2A, 2B; Central - 3A, 3B; W. Thumb - 4A, 4B; South - 6C, 7C.

Table 3. Gillnet catches of longnose sucker by site, Yellowstone Lake 1969-1972, 1974, 1976-1980, and 1982-1984¹⁾.

	Number per net ²⁾											Total
	1a	1b	1c	2a	2b	3a	3b	4a	4b	6c	7c	
1969	7	28	39	13	31	3)	3)	5	1	1	22	147
1970	13	3	4	23	16	3	1	4	3	0	1	71
1971	17	75	7	13	73	3)	3)	3)	3)	3)	3)	185
1972	4	4	0	3	2	0	0	3	2	5	5	28
1974	27	26	15	9	26	6	18	5	17	4	22	175
1976	13	30	13	26	13	8	14	13	14	0	16	160
1977	9	3	8	14	13	4	8	4	8	0	10	319
1978	4	18	7	11	13	6	3	5	9	1	2	398
1979	18	21	11	18	23	5	13	6	12	5	7	695
1980	5	12	9	15	13	2	15	5	17	6	11	548
1982	15	21	8	12	15	17	19	7	20	8	3	726
1983	14	24	8	11	16	11	8	7	13	7	4	625
1984	17	11	11	21	26	12	6	13	12	11	11	737

	Average total length (mm)											Average
	1a	1b	1c	2a	2b	3a	3b	4a	4b	6c	7c	
1969	431	319	411	394	323	3)	3)	368	425	360	358	365
1970	444	392	427	380	415	425	306	376	317	---	214	393
1971	432	267	433	410	312	3)	3)	3)	3)	3)	3)	316
1972	446	291	---	242	318	---	---	422	358	330	290	335
1974	401	340	428	401	345	392	355	385	358	369	356	370
1976	427	334	414	408	394	396	373	411	385	---	398	389
1977	440	408	434	407	413	380	361	400	431	---	409	401
1978	437	353	424	412	307	354	329	409	321	285	338	363
1979	435	342	429	413	334	396	325	397	345	285	362	371
1980	422	330	428	410	360	402	322	416	312	300	414	365
1982	438	363	432	400	323	374	316	414	289	261	401	356
1983	416	298	436	410	300	382	337	377	298	254	236	341
1984	407	311	410	339	283	382	385	340	361	266	443	349

	Average weight (g)											Average
	1a	1b	1c	2a	2b	3a	3b	4a	4b	6c	7c	
1969	938	415	855	825	434	3)	3)	621	860	614	592	635
1970	1076	971	970	773	883	1003	366	692	367	---	112	838
1971	963	273	935	869	413	3)	3)	3)	3)	3)	3)	459
1972	1012	260	---	167	575	---	---	961	600	457	286	519
1974	804	561	952	774	574	775	546	790	367	646	577	668
1976	930	527	951	834	560	765	651	876	720	---	806	759
1977	995	847	1047	840	898	716	656	810	529	---	889	833
1978	992	594	913	899	423	593	478	859	467	304	595	654
1979	986	567	964	864	563	791	484	810	552	339	689	699
1980	929	502	957	848	657	777	468	855	429	346	885	660
1982	970	662	931	852	478	701	451	911	324	249	928	631
1983	935	442	1042	898	415	743	524	759	361	211	234	596
1984	331	397	385	574	265	753	580	701	574	263	1077	500

1) Experimental gillnets (38.1 m long) set overnight (7.6 graduated mesh panels 19, 25, 32, 38, and 51 mm) in the 1.5-4.6 m depth interval.

2) From 1969-1976, only 1 set was made in each area at the specified depth interval; for 1977, the number represents an average of 4 sets, and 1978-1984 represents an average of 5 sets.

3) Areas not sampled.

APPENDIX B

RELATIONSHIP BETWEEN ANGLER AND
BEAR USE IN THE CLEAR CREEK
AREA OF YELLOWSTONE LAKE

The relationship between bear (*Ursus arctos horribilis* and *Ursus americanus*) and angler use in the Clear Creek area of Yellowstone National Park (YNP) for the years 1977-1983 was examined by Jones et al (1984). The 1984 analysis suggested two possible reasons for the increase in bear use of the area since 1980.

1.) Evidence suggested that high levels of angler use may have limited bear use of the area prior to 1980. This was supported in several ways.

An inverse relationship ($r=0.81$) existed between percent angler use and percent bear use of the Clear/Cub Creeks area for the years 1977-1983. As angler use of the area decreased after 1980 there was a corresponding increase in bear use.

In 1983, when the area was closed to all visitor use, bear use reached its highest level in seven years. The years with the highest number of spawners entering Clear Creek were also the years with the most anglers using the area. Although bears could be expected to follow the same pattern, bear use was lowest during the peak years of spawning numbers. This suggested that high levels of human use may have been responsible for displacing bears from the area.

2.) The second alternative suggested that the increase in bear use of the area since 1980 may have reflected a learned response to the presence of the weir, a reaction to the rich, highly concentrated, and an easily accessible food source and not a response to lower angler use. Cutthroat trout (*Salmo clarki*) are an important, high quality food source for some Park bears (Mealey 1975). When a food source of this quality is concentrated as at the weir, an increase in bear use might be expected as more bears became familiar with it.

This report updates the previous report with data collected in the 1984 field season.

METHODS

Bear use and related fisheries data were taken from trap log books kept at the Clear Creek weir. Bear use was measured as bear use days; one bear use day was recorded for each day that evidence of one or more bears was located in the vicinity of the Clear Creek weir. This included actual sightings as well as fresh tracks, scats, or other sign.

Since more than one bear probably used the weir on most nights, bear use measurements were only an absolute minimum estimate of use and were not a measure of intensity. In an effort to minimize the attraction of the weir to bears, cleanliness procedures were followed (Jones et al 1977). This included patrolling the stream from the weir to the mouth in order to collect and count all remains of dead trout. These procedures also insured that old bear sign was not recounted and that only new sign was found on a daily basis.

Angler use data was obtained from volunteer angler report (VAR) cards returned by anglers who fished in the Clear/Cub Creeks vicinity. This area was defined as a 1 km wide section of Yellowstone Lake shoreline that extended 2.6 km from Cub Creek to Elk Point. Angler use was measured in angler days; one angler day being recorded for each day that an angler fished in the Clear/Cub Creeks area. In 1983 and 1984 this area was closed to all visitor use during the trout spawning season. Some illegal use occurred in 1983 and a low level of administrative use occurred in all years.

RESULTS

Use of the weir by bears was concentrated in a period corresponding to the major portion of the downstream migration of cutthroat trout (Figure 1). Bear use began just prior to the peak of the downstream migration and continued until the weir was pulled. Approximately 87% of the bear use days for the years 1977-1984 fell within this time period. The starting and ending dates as well as the total length of this period varied from year to year. The length of this period ranged from 32 days (1983) to 52 days (1980), starting as early as June 22 (1977) and as late as July 13 (1984), and ending sometime between August 1 (1977) and August 17 (1978). To increase comparability of data, bear and angler use were both measured as a percentage of the total number of days in the major portion of the downstream migration.

Bear use of the Clear Creek area increased from 1980 to 1983 (Table 1) while during that same time period angler use and the number of spawning fish entering the creek decreased (Table 1, Figure 3). In 1984 angler use of the area reached its lowest level in 8 years. Bear use, however, also decreased in 1984 dropping 36% below 1983 levels (Table 1). The number of spawners entering Clear Creek in 1984 increased slightly for the first time in 5 years.

DISCUSSION

An inverse relationship ($r=0.77$) exists between percent angler use and percent bear use in the Clear/Cub Creeks area (Figure 2). During most years bear use increased as angler use decreased. A linear regression ($Y=MX+B$) of the data

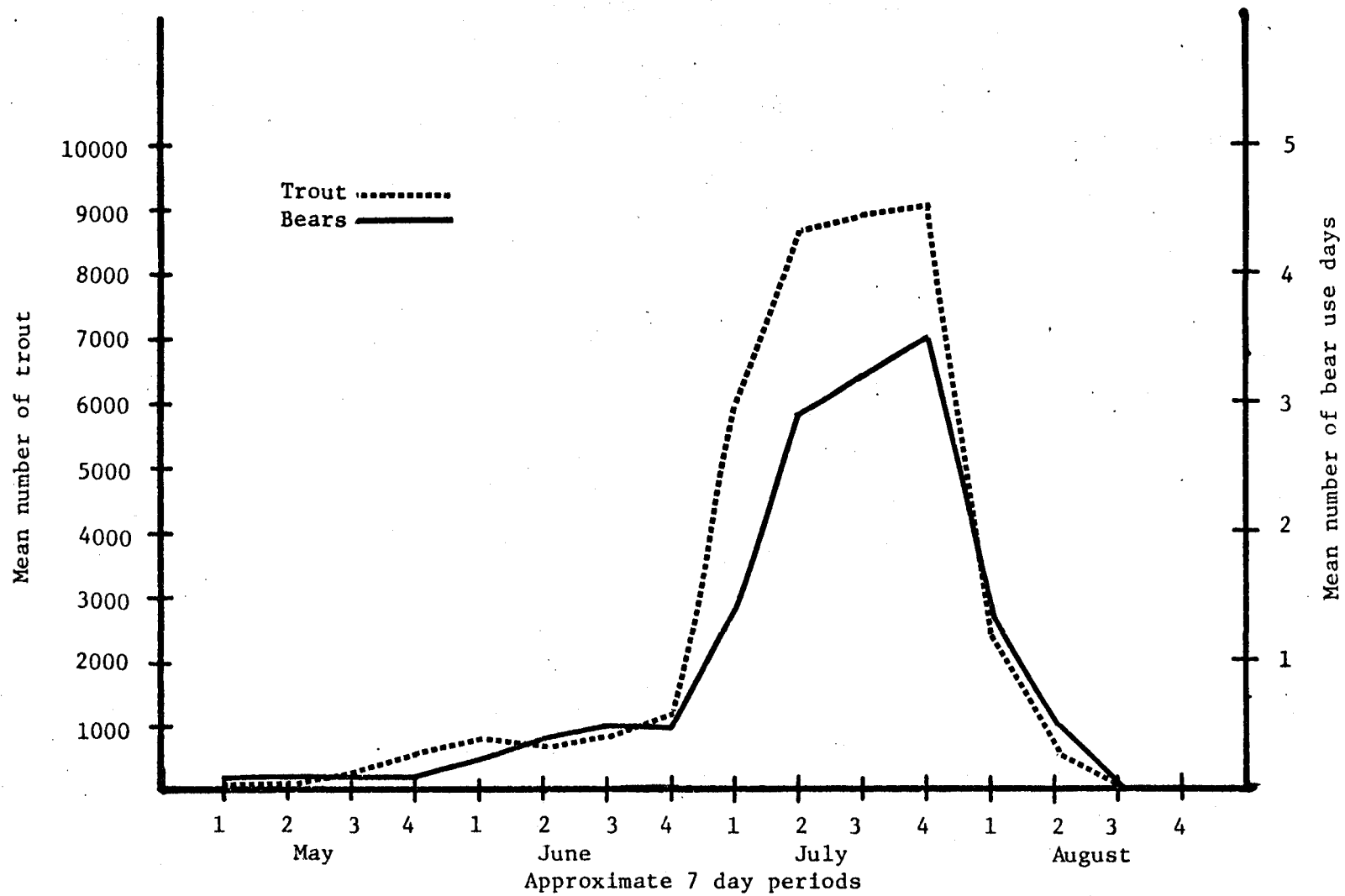


Figure 1. Relationship between mean number of downstream migrating trout and mean number of bear use days at the Clear Creek weir, YNP, 1977 - 1984.

Table 1. Comparison between bear and angler use of the Clear Creek area, YNP, during the period of the major portion of the downstream trout migration.

Year	Major portion of downstream migration		Bear use days	% Bear use ¹	Angler days	% Angler use ²
	Dates	Number of days				
1977	June 22 - August 1	41	11	27	17	42
1978	July 7 - August 17	42	3	7	39	93
1979	July 2 - August 3	33	0	0	29	88
1980	June 24 - August 14	52	7	14	24	46
1981 ³	July 1 - July 11	11	7	64	5	45
1982 ⁴	-	-	-	-	-	-
1983 ⁵	July 11 - August 11	32	30	94	6	19
1984 ⁶	July 13 - August 9	28	16	58	0	0

- 1) The percentage of bear use days out of the total number of days during the major portion of the downstream trout migration.
- 2) The percentage of angler days out of the total number of days during the major portion of the downstream trout migration.
- 3) Trapping operation shut down early due to continued use of the area by bears.
- 4) Weir pulled early due to high water levels.
- 5) Clear Creek area closed to visitor use from April 1 - August 12.
- 6) Clear Creek area closed to visitor use from April 1 - August 10.

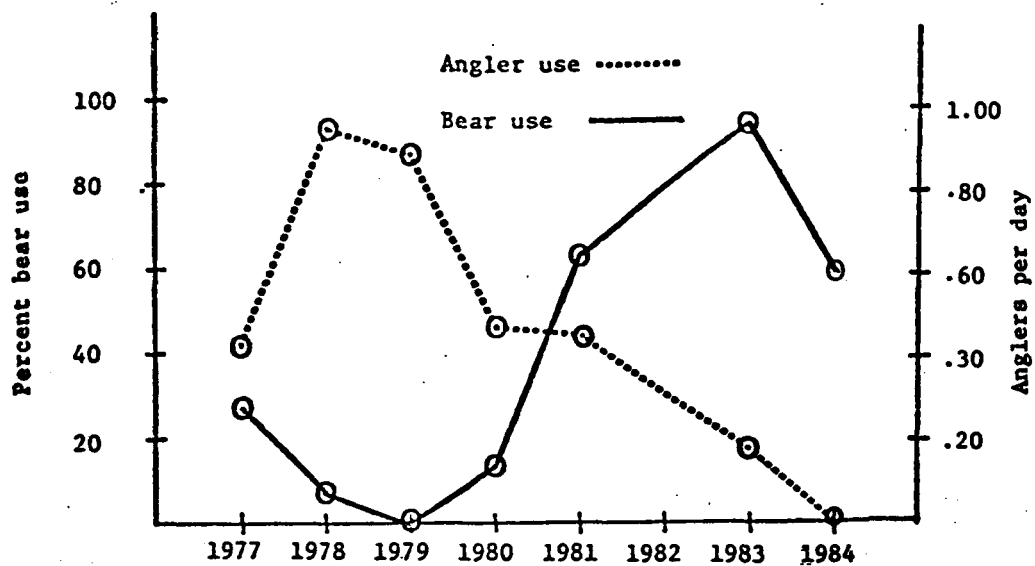


Figure 2. Relationship between anglers and bear use in the vicinity of the of the Clear Creek weir, YNP, 1977-1984 .

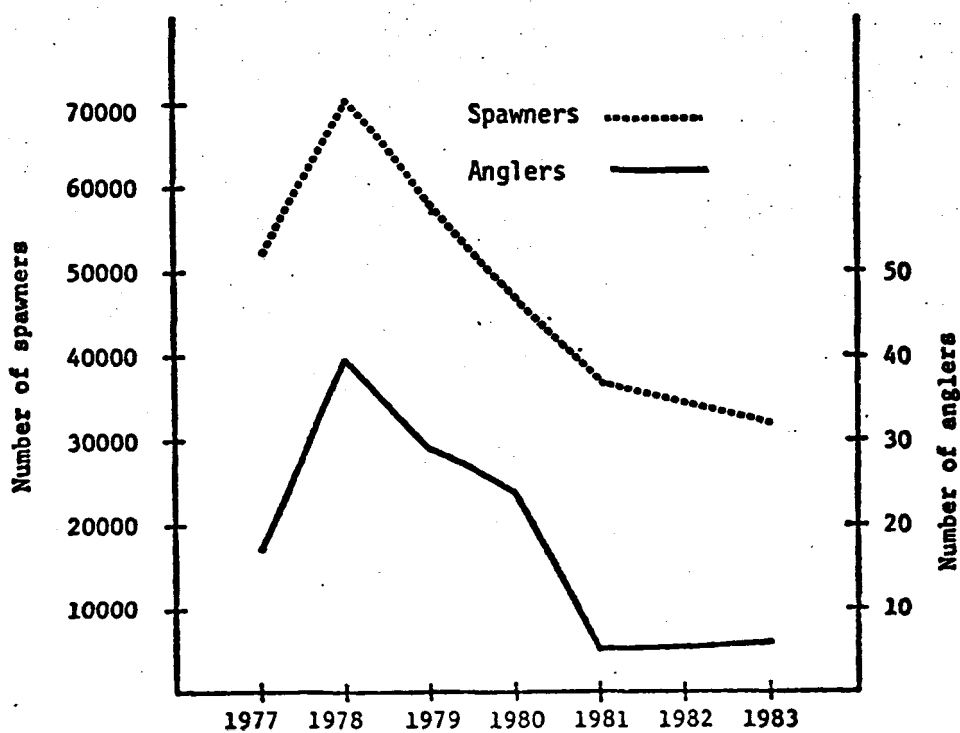


Figure 3. Relationship between number of anglers and number of spawners entering Clear Creek, YNP, 1977-1983. .

suggests that 60% of the variation in bear use is explained by the level of angler use. The years with the highest number of spawners entering the creek were also the years with the most anglers using the area (Figure 3). Although bears would be expected to follow the same pattern, bear use was lowest during the peak years of spawning numbers (Figures 2 & 3). This suggests that heavy human use may have played some part in displacing bears from the area.

In 1984 however, bear use of the Clear/Cub Creeks area decreased 36% from 1983 levels despite the area being closed to visitor use and having the lowest level of angler use in eight years (Table 1, Figure 2). If anglers had been responsible for displacing bears in previous years, bear use should have been similar in 1983 and 1984, the two years that the area was closed to visitor use. The decrease in bear use in 1984 may have been due to modifications made to the weir that year which were designed to make the post spawning trout less accessible to bears (Jones et al 1985). With these modifications the number of trout consumed by bears at the weir dropped 56% from at least 350 in 1983 to 156 in 1984. When trout were made less accessible, bears may have made less use of the immediate area. This supports the second hypothesis of the 1983 report which suggested that the increase in bear use of the area since 1980 reflected a learned response to the presence of the weir and not a response to lower angler use of the area.

RECOMMENDATIONS

Due to the small size of the study area in relation to the entire Clear Creek closure area as well as the apparent attraction of bears to the weir, the data collected in conjunction with fisheries research at Clear Creek may not be a valid way of evaluating the effectiveness of the 1983 and 1984 closures.

Since the data will be collected as long as the fish trap remains in operation and requires little time to analyze, it is recommended that this study be continued for several more years in order to monitor any long term effects of the Clear Creek closure.

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