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UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

Fishery Resources



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in

YELLOWSTONE NATIONAL PARK

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Cover photo: USFWS personnel picking gillnets.

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INTRODUCTION

In the Yellowstone National Park Establishment Act of 1872, the Park was "dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people and for the preservation, from injury or spoilation of all timber, mineral deposits, natural curiosities or wonders. . . , and their retention in their natural condition." Since that time, legislation and policies have further defined the purpose of the Park to prohibit hunting of all birds and mammals and to regulate fishing. The Park is currently managed as a natural area to perpetuate as a natural ecosystem the native fauna, flora, geology and scenic landscape. Fishing in Yellowstone National Park has, however, been a major visitor activity for over a century. After very liberal initial regulations, present restrictions have evolved (since the 1930's) to more closely reflect the Park's primary purpose. Specifically, the objectives of the fishing program are:

1. To manage fishing as an integral part of the Park's ecosystem.
2. To provide anglers with a high quality angling experience with wild trout under natural settings.
3. To preserve and restore native species and aquatic habitats.

A high quality angling experience has been defined as having the opportunity to fish for native species or wild trout in pristine waters where angler harvests do not exceed natural replenishment rates, or substantially reduce fish numbers, biomass, sizes and age groups from that which would occur in the absence of fishing. This management goal necessitates both a philosophical and literal distinction between catching fishes for recreation and removing fishes for consumption. This distinction is especially important since all maintenance stocking for harvest purposes ended in the early 1950's. Wild stocks, therefore, bear the pressure of increasing public interest. Management practices, consisting mainly of restrictive regulations, have had to be innovative to keep abreast of increasing trends of parkwide angler use, rapid increases in back-country visitation and growing interest in specialized fishing (such as fly fishing).

Regulations that attempt to restore or protect fishes and maintain high quality angling involve manipulating season dates, restricting baits, using creel and size limits and designating certain species or waters for catch and release fishing. Additionally, certain waters are closed to protect rare or endangered species, nesting birds or to provide vistas for viewing scenic landscapes and undisturbed wildlife (including fishes).

Yellowstone has one species of fish (the Montana grayling) and over a dozen waters restricted to catch and release fishing only. A number of other waters, including Yellowstone Lake, are partially catch and release as a result of

maximum or minimum length limits. These highly restrictive regulations have, by most measures of angling quality, improved populations and provided fishing superior to that found before the restrictions.

In 1981, the National Park Service issued an estimated 172,300 free fishing permits to fish Park waters. Permit holders comprised a composite group from all 50 states, all Canadian Provinces and numerous foreign countries (Table 1). The largest single group came from the local states of Montana, Wyoming and Idaho. Although Park anglers fish approximately 120 different lakes and streams, about 30 fisheries comprise most of the fishing pressure. Six fisheries are of such a quality to attract national attention. Several articles are published annually on National Park waters and are generally complimentary.

The fact that twelve states have fewer total licensed anglers than Yellowstone illustrates the national importance of Park fisheries. In 1976, the number of Park license-holders was greater than 80% of the total licenses issued by the state of Wyoming, over 70% of the total issued by Montana and 50% of the total by Idaho. Using values reported in the 1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation (USDI, Fish and Wildlife Service 1977), Yellowstone hosts about 1.1% of the national cold water anglers. Park fishermen have a substantial economic impact; it is estimated that they spend about 4 million dollars annually in and around the Park.

These facts are presented not only to show the widespread importance of the Park's fisheries but also to pinpoint the difficulties faced in the management of those fisheries. Angler use continued to increase in 1981 to the highest levels yet recorded in Yellowstone Park. Although there has been variation in annual angler use, the trend has been upward in the past decade concomitant with increases in total Park recreational visitation.

The format for the annual technical report was altered in 1981 in order to combine the various studies conducted on any given water into a single section. It is felt that this arrangement will provide a more logical organization and prevent confusion to the reader caused by excess fragmentation. The failure to replace two professional biologists who left the project staff necessitated a continued reduction in content in 1981; however, the position of assistant project leader was recently filled, and this action should greatly improve the situation beginning with the 1982 field season.

Despite the recommendation of several important regulation changes (Jones et al 1980), the statutes remained unchanged during 1981. Since we believe these changes are necessary to both protect native fishes and to 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, 1978, 1979, 1980 and 1981

States by geographical groups	Number interviewed at Entrance Station					Percentage of total interviewed				
	1976	1978	1979	1980	1981	1976	1978	1979	1980	1981
"Local states"										
Idaho	37	47	61	23	71	2.79	3.91	4.96	3.38	4.64
Montana	68	46	62	49	79	5.14	3.83	5.04	7.20	5.17
Utah	71	97	112	50	141	5.36	8.07	9.10	7.34	9.23
Wyoming	67	58	58	23	89	5.06	4.82	4.71	3.38	5.82
Total	243	248	293	145	380	18.35	25.48	23.80	21.29	24.87
West coast states										
California	225	158	222	102	228	16.99	13.15	18.03	14.98	14.92
Oregon	24	34	24	23	40	1.81	2.83	1.95	3.38	2.62
Washington	56	49	48	21	54	4.23	4.07	3.90	3.08	3.53
Total	305	241	294	146	322	23.03	20.05	23.88	21.44	21.07
Southwest states										
Arizona	18	28	26	22	41	1.36	2.33	2.11	3.23	2.68
Colorado	65	65	80	47	118	4.91	5.41	6.50	6.90	7.72
Nevada	7	4	10	4	12	0.53	0.33	0.81	0.59	0.79
New Mexico	9	8	9	6	16	0.68	0.67	0.73	0.88	1.05
Total	99	105	125	79	187	7.48	8.74	10.15	11.60	12.23
Central plains states										
Iowa	15	25	17	13	28	1.13	2.08	1.38	1.90	1.83
Kansas	14	12	8	7	26	1.06	1.00	0.65	1.03	1.70
Nebraska	18	15	21	10	22	1.36	1.24	1.71	1.47	1.44
North Dakota	10	12	2	8	10	0.76	1.00	0.16	1.17	0.65
Oklahoma	14	7	10	11	28	1.06	0.58	0.81	1.62	1.83
South Dakota	9	14	8	5	5	0.68	1.16	0.65	0.73	0.32
Texas	42	52	43	30	57	3.17	4.32	3.49	4.41	3.73
Total	122	137	109	84	176	9.22	11.38	8.89	12.33	11.52
North central states										
Illinois	70	48	40	26	56	5.29	4.00	3.25	3.82	3.66
Indiana	20	23	11	3	10	1.51	1.91	0.89	0.44	0.65
Michigan	58	61	47	13	42	4.38	5.07	3.82	1.91	2.75
Minnesota	64	44	31	17	44	4.83	3.66	2.52	2.50	2.88
Ohio	49	40	22	19	32	3.71	3.33	1.79	2.79	2.09
Wisconsin	40	37	31	23	44	3.02	3.08	2.52	3.38	2.88
Total	301	253	182	101	228	22.73	21.05	14.78	14.63	14.92
Southern states										
Alabama	3	3	1	2	2	0.23	0.24	0.08	0.29	0.13
Arkansas	1	4	6	3	5	0.08	0.33	0.49	0.44	0.33
Florida	22	14	20	12	23	1.66	1.16	1.62	1.76	1.50
Georgia	7	10	7	5	7	0.53	0.83	0.57	0.73	0.46
Kentucky	7	2	4	3	7	0.53	0.16	0.32	0.44	0.46
Louisiana	5	4	5	1	6	0.38	0.33	0.41	0.15	0.39
Mississippi	5	8	3	-	5	0.38	0.65	0.24	0.44	0.33
Missouri	19	19	23	12	11	1.44	1.58	1.87	1.76	0.72
North Carolina	9	9	6	2	3	0.68	0.79	0.49	0.29	0.20
South Carolina	5	4	3	1	3	0.38	0.33	0.24	0.15	0.20
Tennessee	7	1	4	0	4	0.53	0.08	0.32	0.00	0.26
Virginia	11	4	7	6	10	0.83	0.33	0.57	0.88	0.65
Washington, D.C.	1	0	0	0	0	0.08	0.00	0.00	0.00	0.00
West Virginia	4	4	1	2	3	0.30	0.33	0.08	0.29	0.20
Total	108	86	90	52	89	8.03	7.15	7.31	7.64	5.82
Northeast states										
Connecticut	10	11	13	7	3	0.76	0.95	1.06	1.03	0.20
Delaware	1	0	0	1	1	0.08	0.00	0.00	0.15	0.07
Maine	2	1	0	1	4	0.15	0.08	0.00	0.15	0.26
Maryland	14	9	9	7	8	1.06	0.74	0.73	1.03	0.52
Massachusetts	10	6	9	7	8	0.76	0.49	0.73	1.03	0.52
New Hampshire	3	2	2	2	2	0.23	0.16	0.16	0.29	0.13
New Jersey	14	12	17	10	17	1.06	1.00	1.38	1.47	1.11
New York	28	27	31	12	27	2.11	2.24	2.51	1.76	1.77
Pennsylvania	26	41	25	10	34	1.96	3.41	2.03	1.47	2.23
Rhode Island	1	0	1	0	3	0.08	0.00	0.08	0.00	0.20
Vermont	1	1	3	0	1	0.08	0.08	0.24	0.00	0.07
Total	110	110	110	57	108	8.33	9.15	8.94	8.37	7.07
Isolated states										
Alaska	3	1	1	1	2	0.23	0.08	0.08	0.15	0.13
Hawaii	2	1	1	2	0	0.15	0.08	0.08	0.29	0.00
Total	5	2	2	3	2	0.38	0.16	0.16	0.44	0.13
Canada	33	19	12	11	31	2.49	1.58	0.97	1.62	2.03
Foreign countries	0	0	14	3	5	0.00	0.00	1.14	0.44	0.33
GRAND TOTAL w/o Canada	1,291	1,182	1,205	667	1,492					
GRAND TOTAL w/ Canada	1,324	1,201	1,217	678	1,523					
GRAND TOTAL w/ Canada and Foreign countries	1,324	1,201	1,231	681	1,528					

1) Persons who obtained fishing permits.

PARKWIDE FISHING

In 1981, recreational visitation increased 26% from 1980, to over 2.5 million visitors (second only to the record of 2.6 million visitors in 1978). Although the estimated issuance of free angling permits declined in 1981, exit gate surveys suggest that this is related to much lower percentage of permittees which did not fish. After adjustments were made for nonanglers, the number of Park anglers was estimated to be 160,000 in 1981 (Table 2). This figure is the highest number reported since Parkwide estimates began in 1973 (Table 2).

The exit gate survey indicated that anglers spent an average of 1.9 days fishing in the Park and fished approximately 1.25 different waters per day. Computations utilizing these data (Jones et al 1977) yielded estimates of total use (383,400 angler days) and effort (923,000 angler hours). Both figures are the highest estimates since 1973 (Table 2).

An estimated 844,700 fish were landed and 110,800 creeled at a rate of 0.93 and 0.12 fish per hour, respectively (Table 3). Of the fish landed, 87% were released and 13% creeled.

The number of fish landed per average angler trip (2.41 hours) was 2.2, and the number creeled was 0.29 (Table 4). Anglers indicating satisfaction with their fishing trip landed 2.9 fish, whereas those that were unsatisfied landed only 1.1 fish. The average length of fish landed was also higher for satisfied anglers (345 mm or 13.6 inches) than unsatisfied fishermen (309 mm or 12.2 inches).

Species composition was indicated by anglers for 62,465 landed fish; 70.3% were reported as cutthroat trout, followed by rainbow trout (10.1%), brown trout (6.9%), brook trout (6.8%) and lake trout (1.9%). Small numbers of grayling, mountain whitefish, cutthroat x rainbow hybrid and nongame species were also caught.

The average size of landed fish (341 mm or 13.4 in) was unchanged from 1980. Of 61,007 fish, about 67% were greater than 305 mm (12 in) and 49% exceeded 356 mm (14 in). The average length of creeled fish was 318 mm (12.5 in). Lake trout were the largest fish landed (445 mm or 17.5 in) followed by cutthroat trout (360 mm or 14.2 in), brown trout (310 mm or 12.2 in), whitefish (331 mm or 13.0 in), cutthroat x rainbow hybrids (324 mm or 12.7 in) and brook trout (245 mm or 9.7 in).

The percentage of fishermen that reported satisfaction with their overall fishing experience were 73% in 1981. Satisfaction rates with numbers and sizes of fish landed were 65% and 66%, respectively (Table 3).

Table 2. Estimates of park recreational visitation, fishing permits issued, total parkwide anglers, total parkwide angler-days, Yellowstone National Park, 1972-1981

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Total Park Recreational Visitation:	2,246,827	2,061,537	1,973,915	2,233,483	2,511,224	2,481,433	2,618,390	1,992,938	2,000,273	2,521,831
Percent change from previous year:	—	-8.2%	-6.4%	+13.9%	+11.5%	-1.5%	+5.5%	-27.7%	+5.7%	+26.1%
Park Fishing Permits Issued:	—	169,103	164,600	191,350	213,200	217,000	219,000	195,100	184,200 ¹⁾	172,300
Percent change from previous year:	—	—	-2.7%	+16.4%	+11.3%	+1.8%	+0.5%	-10.5%	-5.6%	-6.5%
Total Parkwide Anglers:	—	121,898	116,518	134,332	151,730	154,581	155,700	139,100	130,830	160,000
Percent change from previous year:	—	—	-4.4%	+13.7%	+9.7%	+1.9%	+0.7%	-10.7%	-6.0%	+22.3%
Total Parkwide Angler-days:	—	230,100	270,200	257,300	284,200	311,300	333,800	291,300	311,300	363,400
Percent change from previous year:	—	—	+4.4%	+17.3%	+10.5%	+9.5%	+7.2%	-12.7%	+6.9%	+23.2%
95% Confidence limits:	—	225,500- 234,700	215,300- 274,300	248,400- 266,300	278,500- 289,900	304,000- 313,500	326,200- 341,300	274,500- 308,700	287,000- 334,600	363,400- 403,300

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

Table 3. Fisherman use, effort, success, and harvest for Yellowstone National Park, 1973-1981

Year	Angler days	$\bar{x}$ length angler day	Total hours fished	Landing rate	Total fish landed	Creel rate	Total fish creeled	Percent anglers satisfied with:			Average total length of fish landed (in.)	Mean expertise level (95% C.I.) ²⁾
								Overall experience	numbers caught	sizes caught		
1981	333,400	2.41	903,000	0.73	844,700	0.12	110,800	73	65	66	13.4	1.88 (1.87-1.89)
1980	311,300	2.44	798,000	0.96	725,300	0.13	101,000	73	66	68	13.4	1.87 (1.86-1.88)
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)
1978	333,800	2.23	744,400	0.99	736,900	0.17	126,500	73	66	68	13.4	1.86
1977	311,300	2.33	725,300	0.98	710,800	0.20	145,100	75	68	70	13.4	1.83
1976	284,200	2.36	670,700	1.02	684,100	0.20	134,100	74	69	69	13.2	1.90
1975	257,300	2.31	594,400	1.09	647,900	0.23	136,700	77	74	75	13.3	—
1974	220,000	2.42	531,300	0.86	496,900	0.19	101,000	—	—	—	—	—
1973	230,100	2.45	564,400	0.86	485,400	0.16	90,300	—	—	—	—	—

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, 1981.

	Mean number days fishing	Mean number hours fished/day	Landing rate (fish/hour)	Creel rate (fish/hour)	Fish landed/ angler day	Fish creeled/ angler day	Average length fish landed (in.)	Average ¹⁾ expertise	Sample anglers (n)
Satisfied anglers		2.53	1.15	0.15	2.9	0.38	13.6	1.01	4822
Unsatisfied anglers		2.28	0.50	0.07	1.1	0.16	12.2	1.85	2274 ²⁾
sum or $\bar{x}$	1.77	2.41	0.93	0.12	2.2	0.29	13.4	1.88	8345 ²⁾
Inexperienced Anglers	1.55	2.06	0.60	0.15	1.24	0.31	12.7	1.0	1501
Experienced anglers	1.82	2.45	0.95	0.13	2.33	0.32	13.4	2.0	4736
Expert Anglers	1.92	2.78	1.41	0.10	3.92	0.28	13.8	3.0	859 ²⁾
sum or $\bar{x}$	1.77	2.41	0.93	0.12	2.20	0.29	13.4	1.88	8345 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	0.7	0.8	0.7	0.3	0.3	0.4
Experienced anglers	1.1	1.2	1.1	0.4	0.4	0.7
Expert anglers	1.6	1.6	1.5	0.7	0.6	1.1
Creel Rate (Fish/hr)						
Inexperienced anglers	0.13	0.20	0.19	0.04	0.06	0.07
Experienced anglers	0.15	0.15	0.14	0.05	0.07	0.09
Expert anglers	0.10	0.10	0.10	0.06	0.07	0.10
Fish Size (Inches)						
Inexperienced anglers	12.7	12.7	13.1	13.3	13.1	11.3
Experienced anglers	13.4	13.4	13.8	12.6	12.8	11.6
Expert anglers	13.9	13.9	14.3	12.5	13.2	11.7

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.

On the VFR card, fishermen are asked to judge their own technical expertise level, and expertise is then estimated for each water by an arbitrary value whereby 1.0 is an inexperienced angler, 2.0 is experienced and 3.0 is an expert. In 1981, the mean expertise for 8,230 Park anglers was 1.88, a value indicating that most fishermen fall into the inexperienced to experienced category (Table 4).

In depth analysis of several fisheries including Yellowstone Lake, the catch and release section of the Yellowstone River, Indian Pond (Squaw Lake), Riddle Lake, Sylvan Lake, Hellroaring Creek, Pelican Creek and Soda Butte Creek were completed in 1981. Although it was not possible to expand these analyses to additional waters, data for over 30 lakes and streams that make up over 96% of the total Park angler use are given in tabular form (Tables 5, 6 and 7).

Table 5. fishery statistics from Yellowstone Park waters with over 40 angler-days in the sample and which comprise over 96% of the parkwide angler day use in 1981

Water	% of total parkwide angler days	Total reported angler days (VFR)	Estimates for the season							Average size fish landed (inches)	Average size fish creeled (inches)	Percent anglers landing 1 or more fish	% Anglers satisfied with:				
			Anglers	$\bar{x}$ length angler days (hours)	Angler days (trips)	Angler hours (effort)	Landing rate	Creel rate	Total fish landed				Total fish creeled	Average expertise	Overall experience	Numbers caught	fish sizes caught
Parkwide fisheries	100.00	14,764	159,995	2.41	363,361	923,039	0.93	0.12	844,667	110,842	13.4	12.5	66	1.88	73	65	66
Yellowstone Lake	41.40	6,112	57,326	2.42	158,698	383,217	0.83	0.16	305,533	62,101	14.6	12.5	62	1.75	73	54	69
Yellowstone River	16.23	2,396	24,809	2.55	62,205	158,450	1.04	0.04	161,500	6,270	14.8	12.7	67	1.99	80	73	84
Madison River	6.18	913	9,630	2.39	23,637	56,577	0.57	0.05	31,881	2,571	13.6	17.2	48	2.01	52	38	45
Firehole River	5.00	738	9,669	2.36	19,152	45,253	0.74	0.02	33,215	904	11.3	14.3	58	2.05	69	61	53
Gibbon River	4.15	613	8,877	1.85	15,507	23,429	0.96	0.03	28,241	2,384	9.8	11.5	61	1.98	60	51	40
Lewis Lake	3.10	458	4,736	2.94	11,882	34,936	0.47	0.18	16,562	6,234	13.8	14.7	50	1.88	65	54	65
Slough Creek	3.06	452	5,790	2.92	11,726	34,264	1.48	0.01	50,684	432	13.5	16.0	89	2.05	90	84	87
Shoshone Lake	2.34	346	2,607	3.60	8,574	32,281	0.58	0.13	18,662	4,157	18.2	18.1	47	1.89	57	46	70
Lamar River	1.89	279	3,451	2.35	7,234	16,951	1.40	0.06	23,765	1,068	11.7	10.9	83	1.98	80	75	73
Soda Butte Creek	1.81	267	3,010	2.06	6,922	14,222	1.27	0.34	17,838	4,773	10.3	11.3	81	1.88	86	62	73
Gardner River	1.35	199	2,665	1.97	5,156	10,177	1.28	0.28	12,992	2,818	9.6	9.7	82	1.99	74	68	45
Lewis River	1.04	153	2,416	2.02	3,962	8,002	1.04	0.06	8,337	514	10.4	14.7	66	1.93	63	56	35
Pelican Creek	0.91	134	1,936	2.55	3,469	8,849	2.25	0.01	19,315	118	14.5	17.0	96	2.06	89	90	93
Nez Perce Creek	0.84	124	2,071	1.81	3,209	5,801	0.68	0.13	3,932	772	10.3	11.0	53	1.80	53	47	45
Grebe Lake	0.80	118	1,456	2.33	3,053	7,118	1.27	0.10	9,053	694	11.1	12.9	87	2.11	84	75	83
Indian Creek	0.79	117	1,457	1.78	3,027	5,337	1.31	0.29	7,037	1,489	9.2	9.4	69	1.71	65	52	28
Falls River	0.62	91	1,438	2.27	2,352	5,346	1.10	0.16	5,871	845	10.0	5.9	67	1.71	69	50	25
Bechler River	0.58	85	1,054	2.44	2,196	5,350	1.23	0.12	6,563	628	10.5	11.5	73	1.98	57	50	25
Snake River	0.58	85	977	1.89	2,196	4,158	0.70	0.12	2,926	514	11.4	12.9	59	1.90	60	60	56
Gallatin River	0.52	77	339	2.60	1,988	5,174	0.77	0.14	3,976	719	12.1	12.6	71	1.94	66	61	63
Riddle Lake	0.47	70	578	1.83	1,307	3,402	0.82	0.26	2,779	898	12.2	11.8	71	1.73	78	63	78
Heart Lake	0.45	66	422	2.89	1,703	4,916	0.92	0.14	4,506	705	15.9	19.5	88	2.27	68	74	74
Obsidian Creek	0.38	56	605	1.74	1,443	2,514	1.44	0.29	3,620	734	9.1	9.2	72	1.68	65	65	32
Lewis-Shoshone Ch.	0.35	51	748	2.19	1,313	2,383	0.43	0.19	1,371	546	16.4	17.2	70	2.00	76	67	82
Sylvan Lake	0.33	48	844	1.82	1,235	2,250	1.59	0.03	3,573	70	10.2	11.7	95	1.91	88	86	67
Pebble Creek	0.29	43	554	1.95	1,106	2,160	1.53	0.21	3,300	443	10.4	11.1	86	1.95	91	95	64
Little Firehole River	0.28	42	671	1.49	1,080	1,610	1.46	0.49	2,345	736	10.0	11.3	82	1.89	100	90	83

Table 6. Fishery statistics from Yellowstone Park waters with less than 40 angler-days per year represented in the sample*, 1981

Water	% of total parkwide angler-days	Total reported angler-days (VFR)	Estimates for the season								$\bar{x}$ size fish landed (inches)	$\bar{x}$ length creeled (inches)	Percent of anglers landing one or more fish	% anglers satisfied with:			
			Anglers	$\bar{x}$ length angle days (hours)	Angler-days (trips)	Angler-hours (effort)	Landing rate	Creel rate	Total fish landed	Total fish creeled				Average expertise	Overall experience	Numbers caught	Fish sizes landed
Tower Creek	0.24	35	537	1.78	898	1,594	0.86	0.24	1,374	383	10.5	9.9	71	1.73	83	65	61
Cacho Creek	0.16	24	326	2.02	612	1,235	1.56	0.44	1,932	541	10.1	11.2	92	1.77	88	82	65
Hellroaring Creek*	—	95	234	2.21	491	1,085	1.62	0.32	1,754	347	9.9	10.6	91	2.02	82	82	65
Clear Creek*	—	85	288	2.02	439	886	2.85	0.20	2,532	181	14.6	13.7	95	1.88	92	92	76
Cascade Creek*	—	33	111	1.76	169	298	0.95	0.30	282	88	10.9	14.9	68	1.83	70	61	48

* Figures presented for these fisheries are an average value for 1977, 1978, 1979, 1980 and 1981 except for reported use which is the sum of those years.

Table 7. Fisherman use, effort, harvest and success estimates for Lewis Lake combined boat and shore fishery for 1963 and 1975 through 1981

Year	Angler days	Average length angler day	Angler hours	Landing rate	Total trout landed	Creel rate	Total trout creelcd	Weight harvest lbs/acre
1963	11,000	3.0	33,850	0.42	13,800	0.42	13,800	-
1975	5,400	2.3	12,400	0.66	11,000	0.29	4,400	-
1976	8,600	2.4	20,900	0.70	14,500	0.23	4,800	-
1977	3,300	2.3	19,600	0.53	10,300	0.23	4,600	1.85
1978	8,800	2.9	19,900	0.52	10,400	0.21	4,100	1.86
1979	9,300	3.2	29,600	0.56	16,600	0.17	5,100	2.47
1980	11,800	3.2	37,100	0.48	17,700	0.17	6,200	2.37
1981	11,900	2.9	34,900	0.48	16,600	0.18	6,300	2.38

Percentage of trout landed measuring over:

Average size:

Year	12 in	14 in	16 in	18 in	20 in	landed (n)	creelcd (n)
<u>Brown Trout</u>							
1973	70.4	32.0	15.2	0.8	0.8	13.2 (127)	-
1974	66.6	43.3	16.2	1.9	0.5	13.2 (208)	-
1975	80.6	48.3	10.6	2.0	1.1	13.8 (350)	-
1976	72.8	48.4	18.1	1.1	0.4	13.5 (684)	-
1977	71.1	47.0	15.7	4.0	0	13.4 (598)	14.6 (279)
1978	85.7	57.6	19.0	5.5	0.5	14.3 (559)	15.1 (218)
1979	81.4	58.7	27.1	2.9	0.2	14.2 (543)	15.3 (190)
1980	74.9	49.8	25.1	6.0	1.2	13.9 (681)	14.2 (225)
1981	63.5	49.7	23.1	9.2	3.9	13.6 (597)	14.2 (238)
<u>lake Trout</u>							
1973	100.0	100.0	30.8	30.8	0	16.2 (13)	-
1974	83.3	70.5	26.3	11.7	10.5	15.3 (85)	-
1975	94.8	79.0	57.9	34.2	6.6	16.5 (76)	-
1976	95.9	80.6	31.6	17.3	6.1	15.6 (98)	-
1977	95.2	87.7	62.6	23.4	3.1	16.4 (227)	16.7 (90)
1978	91.8	75.0	38.8	24.6	4.7	15.7 (232)	16.7 (113)
1979	96.0	90.6	56.0	15.2	2.9	16.2 (277)	17.3 (102)
1980	94.3	78.7	55.2	16.7	4.6	16.0 (174)	16.3 (91)
1981	84.8	74.4	53.6	24.0	4.0	15.7 (125)	16.5 (68)

YELLOWSTONE LAKE

Through the past century Yellowstone Lake has remained the most popular sport fishery in the Park. Despite its great size (35,400 ha or 87,450 acres) and once seemingly inexhaustable trout population, man has had and continues to have a significant impact on the Yellowstone Lake cutthroat trout fishery. Large scale spawn taking operations, commercial fishing and a 100 year history of almost unabated increases in sport fishery harvests have, both singly and in combination, altered historical trout stocks radically from the original state. Managers attempted to enhance and protect this, the largest inland cutthroat population in the world, and regulations restricting anglers date back to the 1880's. Between that time and 1968, periodic reductions in the creel limit failed to have lasting positive effects, however, and angling success and the condition of the trout stocks declined (Gresswell 1981).

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

In 1975, a 330 mm (13 inch) maximum size restriction was imposed in order to 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 theoretically resemble historic levels. This regulation has remained unchanged since 1975, and allows a daily limit of two cutthroat trout under 330 mm total length. It was not until 1978 that the regulation was applied to lake tributaries.

For over thirty years, fishery biologists have been investigating various aspects of the Yellowstone Lake ecosystem in order to assess human impacts. Since 1969, research has been aimed at evaluating the various regulations and their effect on both angling quality and the cutthroat trout population. In 1981, studies included a creel survey utilizing the VFR system (Jones et al 1977), the operation of two spawning traps, a monthly sampling of limnological parameters and two experimental gillnetting programs.

CREEL SURVEY

During 1981, angler use on Yellowstone Lake comprised 41% of the total parkwide fisherman use. An estimated 57,300 anglers spent 159,000 angler days and 383,000 angler hours fishing the lake (Table 8). Angler use rose over 20% and effort increased almost 40% from 1980 estimates. Although these values do

Table 8. Fishing statistics from Yellowstone Lake, 1981

Yellowstone Lake area:	% of lake total	Total VFR use reported	Predicted totals for season							% Anglers satisfied with:				
			Anglers	X 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 expertise
1 Shore	3.62	221	2,301	1.83	5,728	10,480	0.87	0.17	9,097	1,663	71	59	68	1.79
Boat	1.06	65	422	2.90	1,677	4,863	1.47	0.21	7,135	1,039	95	86	86	1.77
2 Shore	26.67	1,630	16,527	2.03	42,315	85,728	0.56	0.11	47,615	9,353	66	55	65	1.75
Boat	16.97	1,037	11,446	2.83	26,917	76,188	0.87	0.25	66,175	19,007	79	72	72	1.65
3 Shore	5.61	343	2,876	2.20	8,896	19,550	0.80	0.14	17,084	3,368	80	67	77	1.77
Boat	0.87	53	652	2.96	1,365	4,038	1.04	0.19	4,191	753	81	77	71	1.53
4 Shore	12.58	769	7,324	1.91	19,957	38,177	0.52	0.14	20,014	5,265	62	51	63	1.75
Boat	6.81	416	3,221	3.36	10,791	36,265	0.86	0.23	31,185	8,243	81	73	72	1.88
5 Shore	0.33	20	230	1.95	508	993	0.52	0.01	512	12	80	70	80	1.73
Boat	2.37	145	1,380	3.92	3,754	14,706	0.95	0.20	13,916	2,971	85	75	62	1.72
6 Shore	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Boat	2.90	177	1,208	4.10	4,585	18,774	2.57	0.13	48,311	2,350	92	88	83	1.98
7 Shore	0.46	28	115	1.44	716	1,029	1.13	0.26	1,162	263	67	67	100	1.83
Boat	1.55	95	556	3.28	2,456	8,053	1.21	0.14	9,770	1,118	81	81	93	1.83
Unknown	18.21	1,113	9,069	2.22	28,890	63,995	0.81	0.17	52,041	10,681	71	65	67	1.77
All boat	32.53	1,988	18,885	3.16	51,611	163,108	1.11	0.22	180,983	35,522	81	74	73	1.72
All shore	49.26	3,011	29,372	2.00	78,175	156,060	0.62	0.13	96,046	20,082	67	55	66	1.75
Entire lake	100.00	6,112	57,326	2.42	158,698	383,217	0.83	0.17	316,868	64,109	73	64	69	1.75

not approach records set in the 1960's (256,000 angler days and 543,100 hours), the current effort figure has only been surpassed once (1978) since 1970 (Figure 1).

Angler use continues 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 continue to sustain the lowest proportion of use (Table 8). From 1969 through 1974, an average of 86% (range: 84% - 88%) of the use occurred in areas with easy access, but since 1975, annual percentages have ranged from 89% to 94%, with a mean of 91%. The effect of the current regulation on this apparent shift in pressure is not clear. Although the accessible areas have smaller trout and thereby provide a greater chance of creeling a limit, rising energy prices may also affect this apparent shift in use patterns. Differences in survey techniques since 1975 may also confound such a comparison; however, regardless of the reason, it has been the more accessible areas which have been historically overfished.

Yellowstone Lake fishermen landed an estimated 316,900 trout and released 252,800. The total angler-caused mortality was estimated at 95,800 (64,100 creeled plus an estimated 31,700 which may have died of hooking wounds following release). Overall landing and creel rates were 0.83 and 0.17 trout/hour, respectively. Landing and creel rates from the boat segment (1.11 and 0.22 trout/hour, respectively) were substantially above those from the shoreline segment (0.62 and 0.13 trout/hour, respectively) (Table 8). Success by area continues to be inversely related to angling pressure; the more remote areas continue to sustain higher rates than the more heavily fished accessible areas. Seventy-nine percent of the lake's one-day anglers landed one or more trout, and 44% creeled one or more.

Based on length measurements of 20,054 trout reported from Yellowstone Lake, it is apparent that the age-size structure of the cutthroat population continues to improve (Table 9). The average size of trout landed in 1981 was 370 mm. Length frequencies continue to show general improvement indicating survival of proportionately more fish to older and larger size groups (Table 9). The percentage of trout landed exceeding 406 mm in total length (21.3%) continues substantially higher than before the regulation change. The percentage of landed trout measuring over 475 mm and 508 mm are among the highest yet reported.

The illegal harvest of trout over 330 mm is a continuing problem. An estimated 21,200 trout over 330 mm and 3,600 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

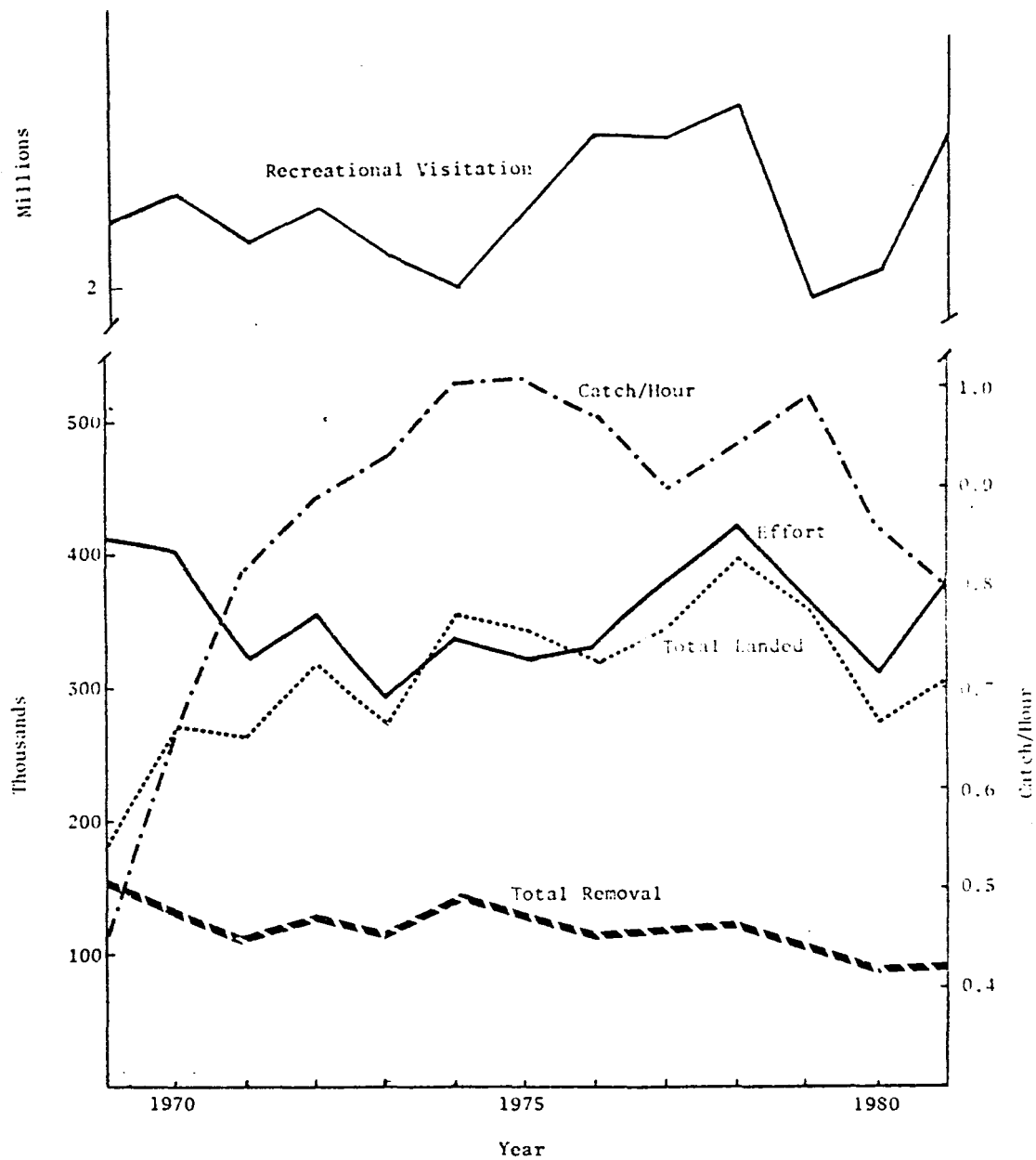


Figure 1 . Recreation visitation, catch per hour, total effort, total trout landed and total trout removed from Yellowstone Lake, 1969-1981.

Table 9. Average length and length frequencies of cutthroat trout landed and creeled from Yellowstone Lake, 1973-1981

		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:										
13"	1981	356	1,646	5,112	8,670	3,570	569	131	20,054	
max.	1980	295	1,500	5,418	8,855	3,268	699	212	20,217	
size	1979	781	2,463	7,042	13,193	5,308	912	237	29,936	
	1978	1,174	3,878	10,322	14,794	4,523	728	188	35,607	
	1977	645	3,029	10,068	11,778	3,619	613	228	29,980	
	1976	816	3,415	10,160	10,123	2,295	349	94	27,252	
	1975	686	2,634	8,654	8,366	1,571	155	44	22,110	
14"	1974	823	1,861	6,276	8,296	1,097	90	4	18,447	
min.	1973	131	364	1,204	1,521	268	9	0	3,497	
size										
Percentage of trout reported landed:										
13"	1981	1.8	8.2	25.5	43.2	17.8	2.8	0.7	20,054	
max.	1980	1.5	7.4	26.8	43.8	16.2	3.3	1.0	20,217	
size	1979	2.6	8.2	23.5	44.1	17.7	3.0	0.8	29,936	
	1978	3.3	10.9	29.0	41.5	12.7	2.0	0.5	35,607	
	1977	2.2	10.1	33.6	39.3	12.1	2.0	0.8	29,980	
	1976	3.0	12.5	37.3	37.1	8.4	1.3	0.3	27,252	
	1975	3.1	11.9	39.1	37.8	7.1	0.7	0.2	22,133	
14"	1974	4.5	10.1	34.0	45.0	5.9	0.5	0.02	18,447	
min.	1973	3.7	10.4	34.4	43.5	7.7	0.3	0	3,497	

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
13"	1981	90.0	64.5	21.3	3.5	0.7	14.6	370	12.5	316
max.	1980	91.1	64.3	20.5	4.4	1.0	14.6	371	12.6	320
size	1979	89.2	65.6	21.6	3.8	0.8	14.6	370	12.4	316
	1978	85.8	56.8	15.3	2.6	0.5	14.2	360	12.4	314
	1977	87.8	54.2	14.9	2.8	0.8	14.2	360	12.6	319
	1976	84.8	47.5	14.1	2.0	0.3	13.8	350	12.4	314
	1975	84.9	45.8	8.0	0.9	0.2	13.7	349	12.4	316
14"	1974	85.5	51.4	6.5	0.5	0.02	13.8	350	—	—
min.	1973	85.8	51.4	7.9	0.3	0	13.8	350	—	—
size										

public voice its concern over the level of violations, but the 21,200 illegal trout creel remains far above an acceptable level.

During 1981, the percentage of fishermen which reported satisfaction with their overall fishing experience was 73%; satisfaction with numbers and sizes landed was 64% and 69%, respectively (Table 5). The average expertise in 1981 was measured at 1.75 on the lake.

CLEAR CREEK CUTTHROAT SPAWNING RUN

From its source (2585 m above MSL) in the Absaroka Mountains, Clear Creek flows westward approximately 20.3 km before entering Yellowstone Lake along the east shore (Figure 2). The stream was utilized for spawn-taking activities almost annually from 1913 to 1950. Since that time, a fish trap, located approximately 400 m above the stream mouth, has been used to monitor the dynamics of the cutthroat trout spawning run in Clear Creek.

The information currently collected at the trap is diverse. Spawner counts and length measurements, some of which date back to 1945, provide an excellent data base for analyzing long-term changes in the cutthroat trout population. Additional information has been collected concerning run duration, instream mortality and age composition of the run. Investigation of the effects of density independent factors, such as water temperature and stream flow, also continues.

Methods

The upstream trap was installed at Clear Creek on May 4 and remained in operation until July 12. Although none of the weir grates were removed during peak runoff, the upstream trap could not be used for 11 days (May 31-June 1 and June 6-14) due to extreme high water conditions. The trap was open daily from 0800-2000 hours except for the high water periods. Ascending trout were passed upstream using dipnets until June 20, when a counting chute (Jones et al 1979) was installed.

A downstream trap was constructed below the weir on May 4 and was removed when trapping operations ceased on July 12. On days when the trap was not opened because of high water, downstream migrants were captured as they congregated above the weir. The downstream run was monitored from 0800 to 2400 hours daily throughout the trapping period.

Fish sampling procedures were identical for the upstream and downstream traps at Clear Creek. Weekly samples of 100 spawners were collected from

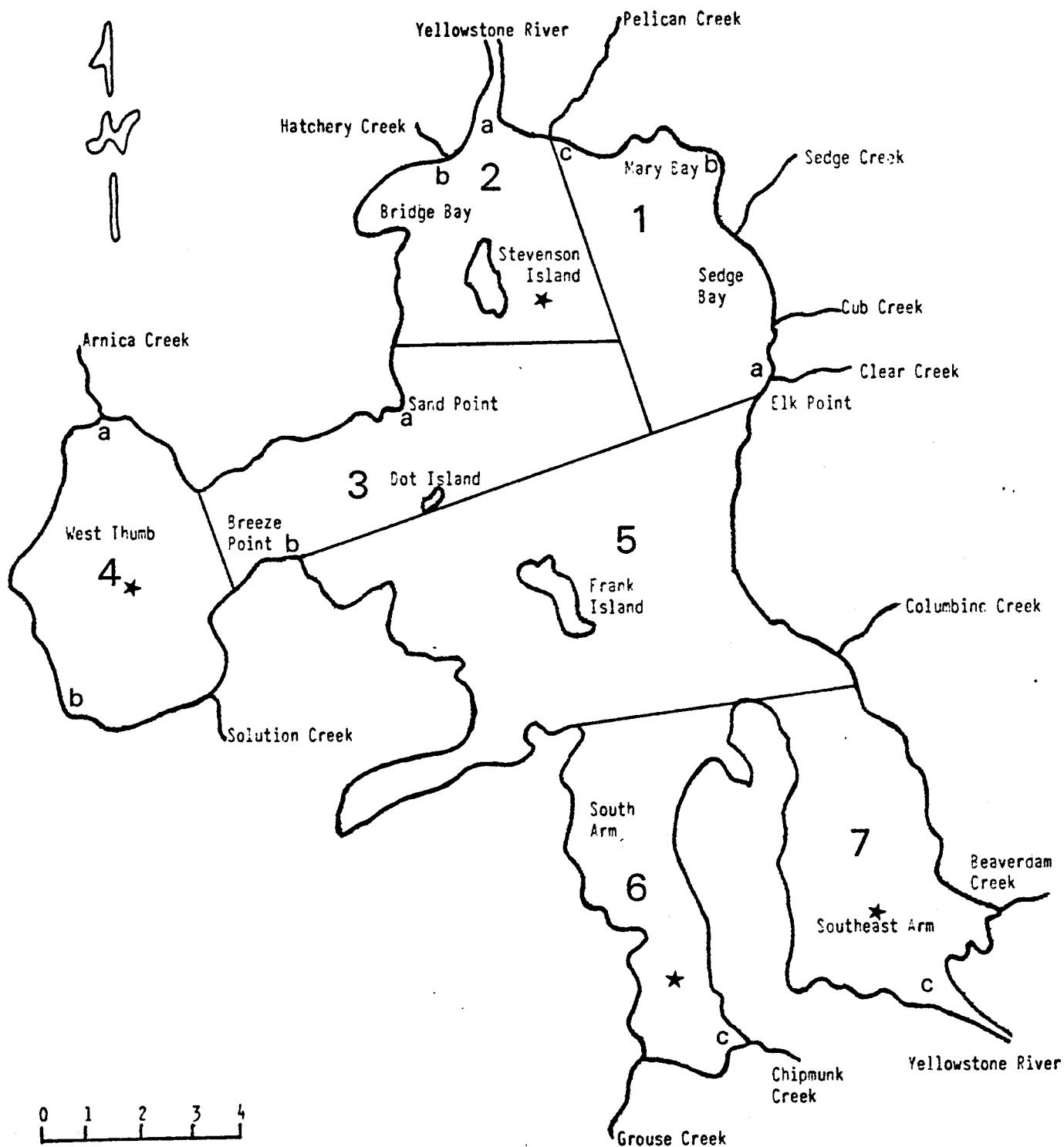


Figure 2. Creel survey, gillnetting, plankton sampling (★), and spawning trap sites, Yellowstone lake, 1981.

each trap for length and weight measurements. Scales from a subsample of 20 trout from each of these collections were used for age determination. Additional scale samples were taken as needed to provide data for the population extremes. Length frequency data (5 mm intervals) were collected from 75 trout daily. All sampled trout were inspected for fin clips.

Daily water temperatures were obtained with a hand thermometer. A staff gauge located approximately 400 m above the weir was used to monitor the pattern of stream discharge. Fifty flow measurements were taken at a transect near the gauge and these data were fitted to a level-flow prediction equation.

Bear activities were monitored daily at the trap. Campsites near the stream have been permanently removed to minimize the chance of visitor encounters with bears. Cleanliness procedures were strictly followed (Jones et al 1978).

Results

Upstream Migration

Grizzly bear activity at the weir necessitated the early removal of the trap on July 12. Although the upstream run was waning, the total count of 37,439 cutthroat trout is definitely a minimum estimate of the spawning run in 1981. The number of migrants fluctuated greatly during the first 50 days (May 4-June 21) varying from 545 (May 15) to 0 (May 31, June 1 and June 6-14) (Figure 3). Over 80% of the run (30,423) ascended from June 22 to July 6. Beginning July 7, the run dwindled rapidly, but was still averaging 170 trout per day during the five days (July 7-12) prior to removal.

During the downstream migration in 1979, the adipose fin was removed from 42,229 cutthroat trout at Clear Creek (Jones et al 1980). In 1981, 4,290 trout in the upstream run were inspected for clips, and 1,130 marks were reported. This suggests that 26.3% of the cutthroat trout entering Clear Creek were clipped, yielding 23.3% alternate-year return of 1979 spawners. Additionally, 13 adipose clips were found at Pelican Creek (0.3% of the run) indicating a 1.0% straying rate for those trout recaptured in 1981.

Mean daily temperatures increased throughout the season and ranged from near 0°C (May 7-8) to 12.5°C (July 5-6). Flow generally declined after reaching a peak discharge of 5.2 m³/sec on June 9. Rapid increases in the number of upstream migrants coincided with increasing temperatures and decreasing flow (Figure 3).

Mean total length and weight of upstream cutthroat trout were 394 mm and 524 g, respectively, and the average condition factor (K) was 0.84. The

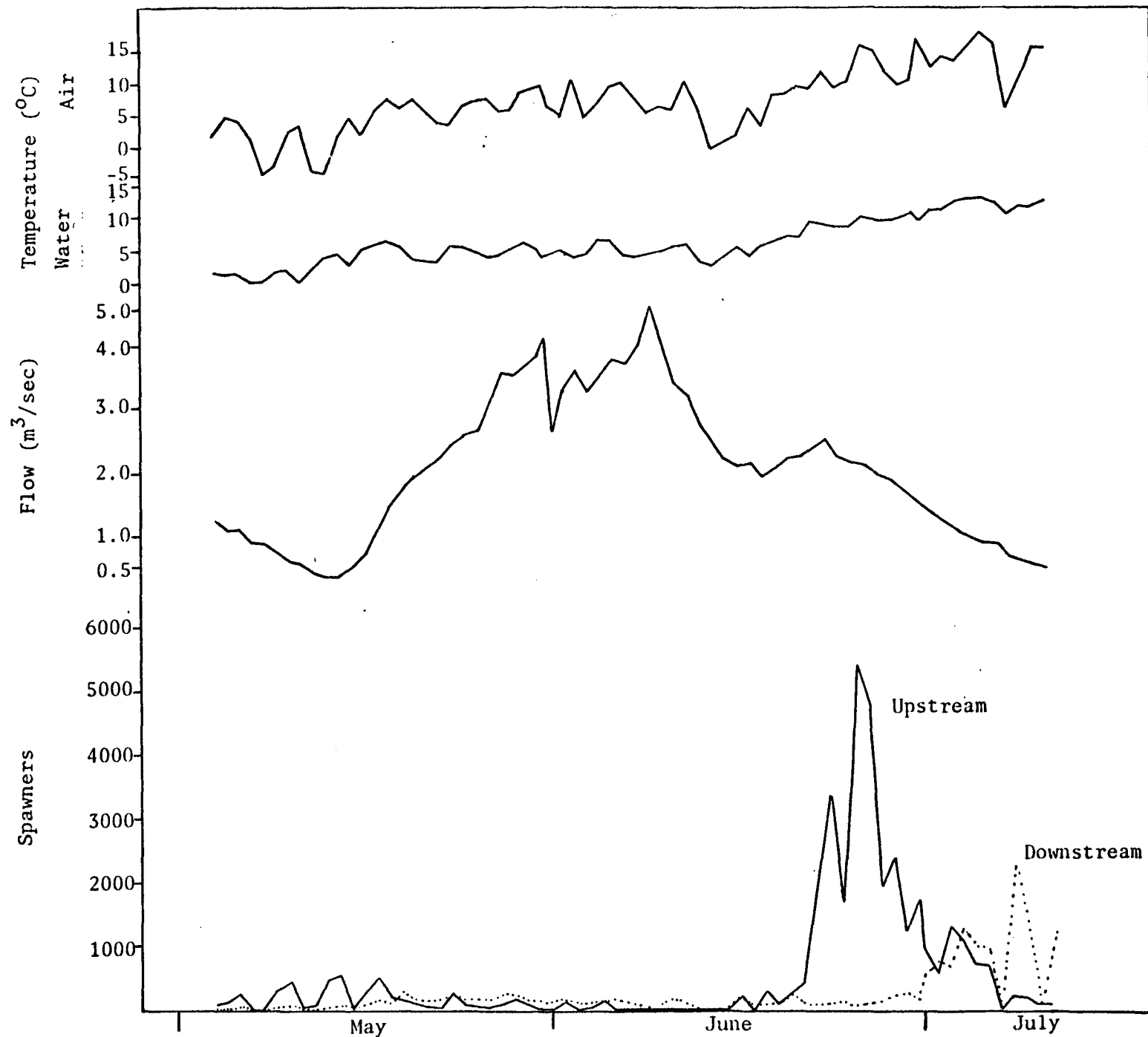


Figure 3. Pattern of daily temperature (air and water), flow and cutthroat spawning migration, Clear Creek, 1981.

male:female ratio was 0.53:1. Average total length and weight for males (402 mm and 538 g, respectively) were significantly greater than females (390 mm and 517 g, respectively). The weekly average of length, weight and K decreased significantly as the spawning migration progressed (Table 10).

Average total length of 3,160 unclipped trout was significantly greater than the length of 1,130 clipped trout (394 and 390 mm, respectively). When comparisons were made on a weekly basis, however, it appeared that unclipped trout were only larger during the first two sampling periods (Figure 4). As the run progressed, clipped trout displayed consistently greater mean length in these weekly samples.

Fingerling trout (presumed yearlings) were first observed near the weir on May 4. Young-of-the-year cutthroat were not seen until June 22. Occasionally somewhat larger trout (presumed age II+) were also found after July 1. Despite the occurrence of spawning longnose suckers near the mouth of Clear Creek and directly below the weir, none were captured in the traps.

Downstream Migration

Only 18,021 cutthroat trout were captured in the downstream trap prior to the removal of the weir. The premature cessation of trapping operations prevented the enumeration of the total run in 1981, and the pattern of movement illustrates that the downstream migration had just begun to increase at the time of trap removal (Figure 3).

Average total length and weight for the downstream migrants were 396 mm and 481 g, respectively (Table 11). The average K factor was 0.76, and the male:female ratio was 0.48:1. Males had a significantly greater mean total length (411 mm) and weight (562 g) than females (391 mm and 453 g, respectively). Mean length of unclipped cutthroat trout (398 mm) was significantly greater than that of clipped trout (390 mm).

Mean length of downstream migrants was significantly greater than upstream migrants (397 and 393 mm, respectively); however, both males and females in the downstream run displayed significantly lower weights and K factors. As in the upstream migration, there were significant decreases in weekly averages of length, weight and K factors during the study (Table 11).

Bear tracks and partially eaten fish were observed frequently along the stream in 1981. Despite substantial effort to prevent the attraction of bears to the weir, increasing numbers of downstream migrants above the weir were probably responsible for the presence of at least three different grizzly bears beginning on July 6. When it appeared these bears were becoming more successful at

Table 10. Weekly mean length, weight and condition factor of cutthroat trout spawners in the upstream trap in Clear Creek, May 4 - July 12, 1981¹⁾

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 4 - May 10	20	425	644	0.82	80	405	549	0.88	100	409	600	0.86	0.25:1
May 11 - May 17	34	413	599	0.83	66	400	571	0.88	100	405	580	0.86	0.51:1
May 18 - May 24 ²⁾	37	413	589	0.82	62	394	539	0.87	100	400	554	0.85	0.60:1
May 25 - May 31	16	414	584	0.81	38	383	500	0.88	54	392	525	0.86	0.42:1
June 1 - June 7	35	403	544	0.82	65	386	491	0.84	100	392	509	0.84	0.54:1
June 15 - June 21	51	395	508	0.82	49	397	509	0.57	100	391	509	0.85	1.04:1
June 22 - June 28	36	388	486	0.83	64	387	502	0.86	100	387	496	0.85	0.56:1
June 29 - July 5	35	391	494	0.81	65	381	467	0.84	100	385	475	0.83	0.59:1
July 6 - July 12	31	396	474	0.76	69	384	463	0.82	100	388	466	0.80	0.45:1
Composite	295	402	538	0.82	553	390	517	0.86	854	394	524	0.84	0.53:1

1) Based on daily samples of cutthroat trout which were both measured and weighed; from June 3 to June 14, no upstream trout were observed in the trap.

2) One trout on May 18 - May 24 was not separated by sex but was used in weekly totals.

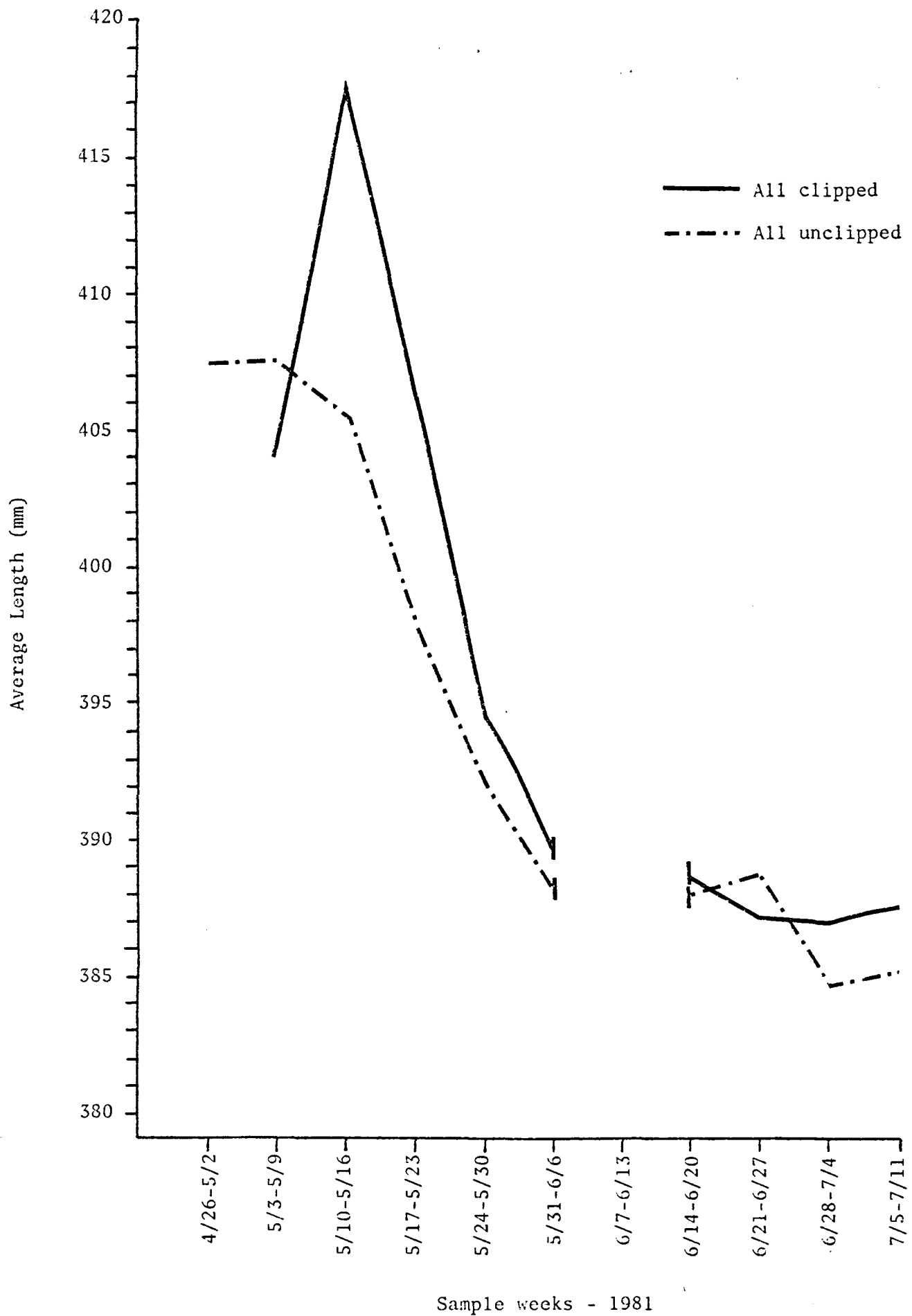


Figure 4. Average length of cutthroat trout (clipped and unclipped) in the upstream trap at Clear Creek, 1981.

Table 11. Weekly mean length, weight and condition factor of cutthroat trout spawners in the downstream trap in Clear Creek, May 18 - July 12, 1981¹⁾

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 18 - May 24	12	428	664	0.84	88	397	500	0.79	100	401	519	0.79	0.14:1
May 25 - May 31	47	412	583	0.82	53	395	496	0.78	100	403	532	0.80	0.89:1
June 1 - June 7	36	404	528	0.78	64	393	455	0.74	100	397	481	0.76	0.56:1
June 8 - June 14 ²⁾	42	426	632	0.81	57	393	465	0.77	100	397	481	0.76	0.75:1
June 15 - June 21	38	413	555	0.78	62	399	455	0.73	100	404	500	0.75	0.61:1
June 22 - June 28	40	413	559	0.78	60	387	429	0.74	100	397	481	0.75	0.67:1
June 29 - July 5	25	399	500	0.78	75	333	427	0.76	100	387	445	0.76	0.33:1
July 6 - July 12	17	386	439	0.76	83	382	403	0.72	100	383	409	0.73	0.20:1
Composite	257	411	562	0.79	542	391	453	0.75	800	396	481	0.76	0.48:1

1) Based on daily samples of cutthroat trout which were both measured and weighed.

2) One trout on June 8 - June 14 was not separated by sex but was used in weekly totals.

harvesting trout, the weir was removed on July 12 to prevent possible injury to project personnel or Park visitors. Other wildlife observed feeding in or near Clear Creek during the spawning season included family groups of mink, common loons, common mergansers, California gulls, as well as several ospreys, golden and bald eagles, great blue herons and white pelicans.

Discussion

Although there has been variation in the numbers of spawners entering Clear Creek since 1977, the dynamics of the run appear to be quite stable. Larger trout enter the stream first; mean length, weight and K factor gradually decrease during the season. Most males are ripe when they enter the stream, but females apparently ripen during the upstream migration.

The seasonal pattern is strongly influenced by stream flows and water temperatures (Figure 3). Since these factors are interrelated, it is difficult to separate their effects; however, numbers increase in June as flow decreases from its peak and water temperature rises above 10° C.

The daily pattern of upstream migration at Clear Creek also appears to be related to flow and water temperature. The number of trout increases from 1300-1700 hours as water temperature rises and flow decreases. As flow rises and temperature drops (1700-2100 hours), the number of spawners declines. Relatively few upstream migrants are seen after dark. This pattern resembles observations at Cub Creek and Pelican Creek in recent years. Although Bulkley (Pers. Com. 1978) reported nocturnal upstream migrations in these streams during the 1950's, all upstream movement has been during daylight hours in the past decade.

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

Since all spawners leave Clear Creek after spawning, and there are no residents other than a small number of yearling and age II+ cutthroat, the difference between accurate upstream and downstream counts provide an unbiased estimate of instream spawning mortality. Incomplete counts of downstream migrants in 1980 and 1981 prevented estimates of mortality; however, from 1977-1979, instream mortality ranged from 6.7% in 1977 to 18.5% in 1978. The mean estimate of 11.5% is much lower than the instream mortality estimate of 48.1% for five tributaries from 1949 to 1953 (Ball and Cope 1961). Only one estimate of 41.2% was made for Clear Creek during that period.

Figures were primarily calculated from tag return data, but in 1953, one estimate of 45.6% was based on total upstream and downstream counts in Arnica Creek. Although these earlier findings may be biased by tagging mortality and the use of artificially spawned trout in the estimates, significant changes in the population structure may have occurred due to intensive exploitation in the 1950's.

Ball and Cope (1961) estimated that only 1.22% of spawning trout were repeat spawners. Their estimates were based on the return of Petersen disc tags and logically supported by their instream mortality estimate (48.1%) for cutthroat spawners. Although they found a tagging mortality of 4-12% in Arnica Creek in 1952 and 1953, they were unable to determine whether this mortality continued after spawning. This extremely low estimate of repeat spawning was probably biased by high tagging mortality and/or a higher than expected fishing mortality.

Assuming that few trout required five years to attain sexual maturity, Bulkley (1961) speculated that the proportion of age V+ and VI+ trout (38.4 and 3.8%, respectively) in the Arnica Creek spawning run did not agree with the 1.22% return estimate of Ball and Cope (1961). The 3.8% of age VI+ trout is alone almost three times the 1.22% return of spawners. When Bulkley (1961) examined 58 trout of age V+ from the 1957 Arnica Creek spawning run for spawning checks (scars from resorption of scales during spawning which may later be distinguished from annuli), he found 25 trout (43%) had definitely spawned previously. Bulkley concluded that although some trout may spawn without scale deterioration (causing an underestimate of repeat spawners), the percentage of repeat spawners was much higher than previous tagging data suggested. Forty-three percent of the age V+ cutthroat trout would amount to 12.4% of the spawning run.

Clip returns from Clear Creek in 1980 and 1981, indicate that under current harvest levels, at least 23% of the cutthroat spawners clipped in 1979 survived to spawn again. Sample size of recent experiments far exceeds that of Ball and Cope (1961) and adds credibility to present estimates. Current instream mortality estimates are also indicative of a higher rate of repeat spawning.

Results from clip returns at Clear Creek in the past two years strongly support the hypothesis of alternate-year spawning for the majority of repeat spawners (Ball and Cope 1961). Although sample size was small, Bulkley (1961) found that among 25 repeat spawners from Arnica Creek (identified by the spawning checks), five times as many cutthroat trout spawned in consecutive years as alternate. It is possible, however, that the percentage of alternate and consecutive spawners may vary significantly between different tributaries. If Ball and Cope (1961) were correct in their hypothesis that alternate-year spawning was a physiological manifestation of the low productivity of

Yellowstone Lake, it is also possible that the number of consecutive and alternate-year spawners may vary slightly with changes in annual growth conditions.

The number of trout which were clipped at Clear Creek and later captured at Pelican Creek averaged approximately 1.15% for 1980-81. Ball (1955) found that approximately 2% of tagged fish which spawned repeatedly had strayed from the stream where they were originally captured. Since Clear Creek spawners may also stray into other streams tributary to Yellowstone Lake, especially those in the northern portion of the lake, current results suggest the estimate of 2% total straying may be reasonably accurate.

Comparison of 11 years of length frequency data collected since 1961 (Figure 5) has provided a means of monitoring the influence of angling during this period (Jones et al 1978). The continued shift towards larger trout in recent years has been interpreted as a positive response to increasingly restrictive regulations since 1969.

Although the current structure of the cutthroat trout population may still be far removed from historic levels, spawning migrations at Clear Creek in recent years indicate the potential of a native cutthroat trout population under protective regulations (Figure 6). Recent data from Clear Creek emphasize the disastrous effects of low spawner escapement, due both to egg-taking operations and overharvest, during the 1940's, 50's and 60's. The large variety of piscivorous birds and mammals currently associated with the spawning migration illustrates the importance of the cutthroat trout to the Yellowstone Lake ecosystem.

PELICAN CREEK SPAWNING RUN

Entering Yellowstone Lake along the north shore about 2.4 km east of Fishing Bridge (Figure 2), Pelican Creek is the largest tributary to the northern portion of the lake. Total stream length is about 160 km, and the drainage area has been estimated at 15,540 ha. Although late summer flows are low ($1 \text{ m}^3/\text{sec}$), peak flow may exceed $28 \text{ m}^3/\text{sec}$ (Ball and Cope 1961).

A fish trap (approximately 1.6 km above the mouth) was utilized for spawning activities in Pelican Creek from the early 1900's until 1953. Because of its potential value for monitoring the spawning population, the trap was not removed when hatchery operations ceased. The present trap, built in 1963, is located several hundred meters upstream of the old trap. Continued erosion problems at the trap have resulted in frequent alterations including the addition of a 12 m wide bypass weir (1978), a total reconstruction of the main weir apron (1979) and modification of the bypass weir (1980).

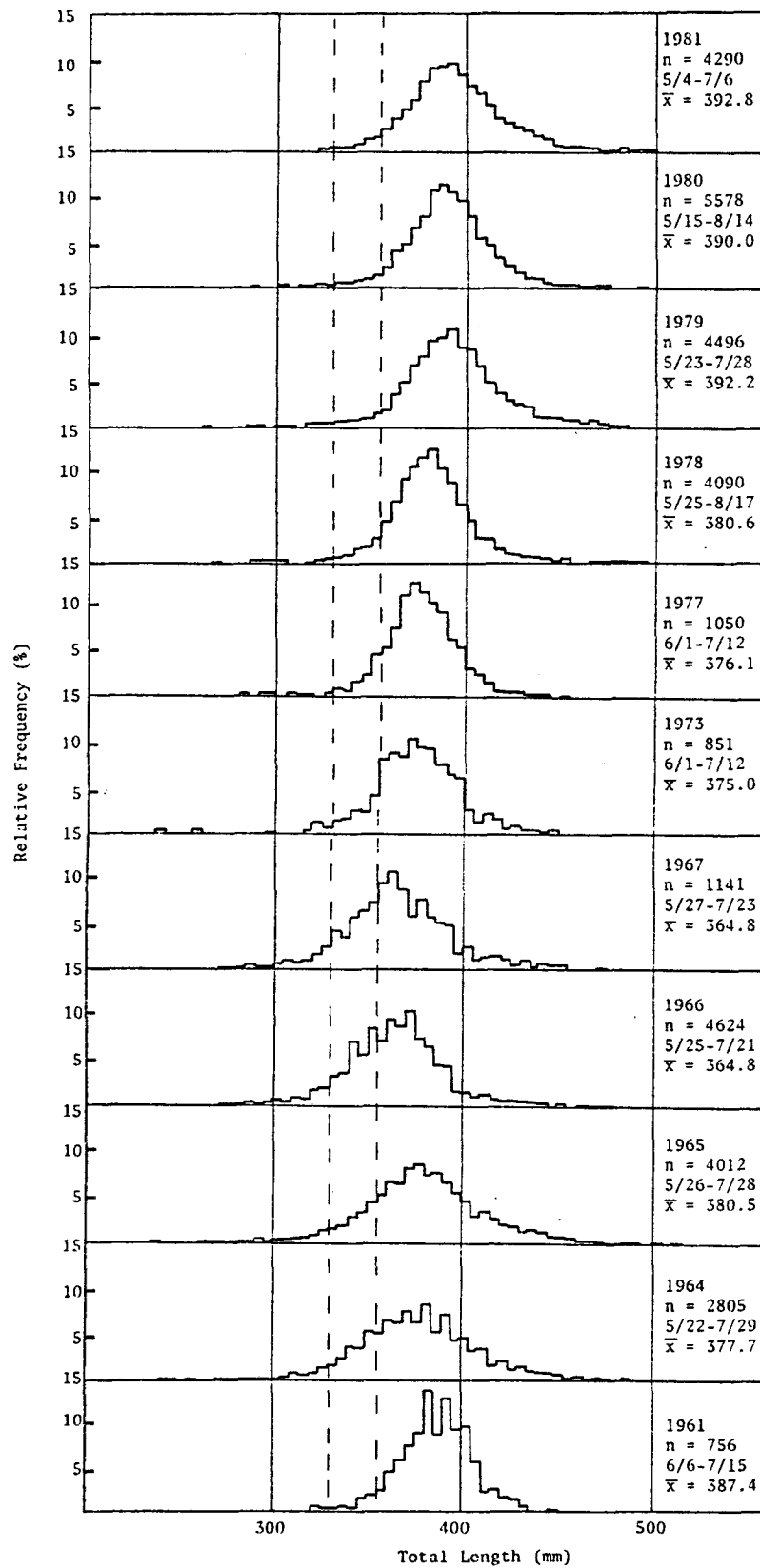


Figure 5. Length frequency of cutthroat trout in the upstream spawning migration in Clear Creek in recent years.

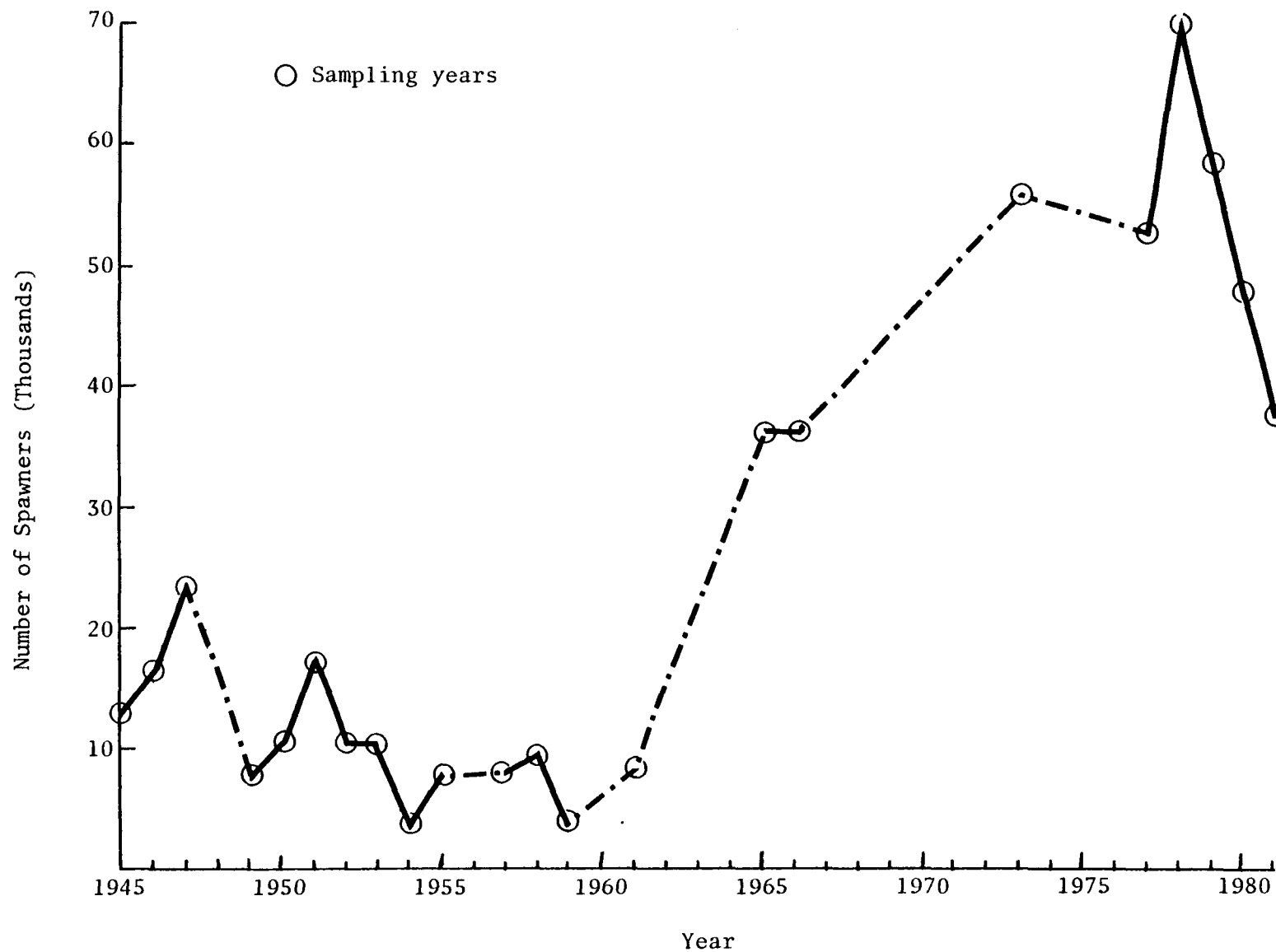


Figure 6. Number of cutthroat trout spawners entering Clear Creek during various sample years, 1945-1981.

Fishery information for the Pelican Creek spawning run, including spawner counts and length measurements, date back to 1945. The trap was operated annually from 1976-1979 for the continued collection of population data and the experimental destruction of the longnose sucker run (an exotic to the lake drainage). Since the discontinuation of the sucker removal program in 1980, emphasis of the trap operation has shifted to the description of the dynamics of the cutthroat trout spawning migration. In addition to spawner enumeration and trout size data, current investigations include determination of run duration, age composition and effects of density independent factors, such as water temperature and stream flow.

Methods

The upstream trap was installed on April 28 and remained in operation until July 27. Although weir grates were not removed during periods of peak runoff, high water prevented trap operation on June 4. The trap was generally open from 0800 to 1700-1800 hours except during the early portion of the run when it remained open until 2100-2200 hours. Ascending fish were counted as they passed through a counting chute (Jones et al 1979); however, high water and/or low numbers of fish sometimes precluded its use.

Until June 10, downstream migrants were netted over the weir as they congregated upstream. On that date the downstream trap was assembled on the east end of the weir. The trap was open from 0800 to 1700-1900 hours daily until it was removed on July 27.

Fish sampling procedures were similar for upstream and downstream traps. Weekly samples of 100 cutthroat spawners were collected from each trap for length and weight measurements. Scales from a subsample of 20 trout were used for age determination, and additional scale samples were taken as needed to provide data for population extremes. Length frequency data (5 mm intervals) were collected from 75 trout in each trap daily. Additionally, similar samples were taken from longnose suckers as their numbers increased in the latter part of the run. All sampled fish were inspected for fin clips, and both length and weight data were collected from all previously tagged trout and suckers.

Daily water temperature extremes were obtained from frequent observations with a hand thermometer. No attempt was made to measure water level in 1981. Bear activities were monitored daily, and cleanliness procedures were strictly followed (Jones et al 1978).

Results

Cutthroat Trout

Upstream migration. In 1981, 29,638 cutthroat trout were counted as they passed upstream at Pelican Creek. The number of migrants fluctuated greatly

throughout the major portion of the run (Figure 7). This unstable pattern appeared to be closely related to fluctuations in water temperature and stream flow caused by drastic changes in the weather during this period. The major portion of the run occurred between May 13-June 7 when 88% of the total run (25,995 trout) was counted; however, over 62% of the run (18,498) migrated in the nine day period between May 29-June 6. After June 7, the run diminished steadily to an average of only 4.5 trout/day during the final 30 days of operation.

Both adipose and pelvic fins were removed from 22,293 cutthroat trout migrating upstream in 1980 (Jones et al 1981). A total of 351 (8.8%) of the 4,003 trout inspected for clips in 1981 displayed such marks. These data indicate a 11.7% consecutive-year return of 1980 spawners. Six tagged trout were recaptured in 1981 representing approximately 1.5% of sampled trout. Expansion of these figures to a total of 44 tagged trout for the total run suggests a 14.9% alternate-year return of the trout tagged in 1979.

Mean daily water temperature generally increased throughout the run ranging from 2.2°C (April 28 and May 7) to 20°C (July 13). Water flow initially appeared to peak on May 28, but a second and apparently greater peak occurred on June 8. Increases in the number of migrants coincided with increasing temperatures and decreasing flows; however, the run was virtually complete by the time of the second discharge peak.

Mean total length and weight of upstream cutthroat trout were 384 mm and 468 g, respectively, and the average condition factor (K) was 0.82. The male:female ratio was 0.55:1. Average total length and weight of males (396 mm and 502 g, respectively) were significantly greater than females (379 mm and 457 g, respectively). The weekly average of length, weight and K factor decreased as the spawning migration progressed (Table 12).

Although there was a slight (2 mm) increase in mean length of trout clipped in 1980 (381 mm; n=3,731) and recaptured in 1981, mean length of 3,652 unclipped trout in the current sample was somewhat larger than the 351 clipped trout (385 mm and 383 mm, respectively)(Figure 8). The biological difference in these comparisons is questionable, and this lack of difference may be the most significant result of this comparison.

In 1980, 36 tagged trout displayed a mean increase of 11 mm in total length since time of tagging (376 mm and 387 mm, for 1979 and 1980, respectively). Although males were larger than females, both sexes displayed a similar difference in length (382 mm and 394 mm, respectively, for males and 371 mm and 381 mm, respectively for females).

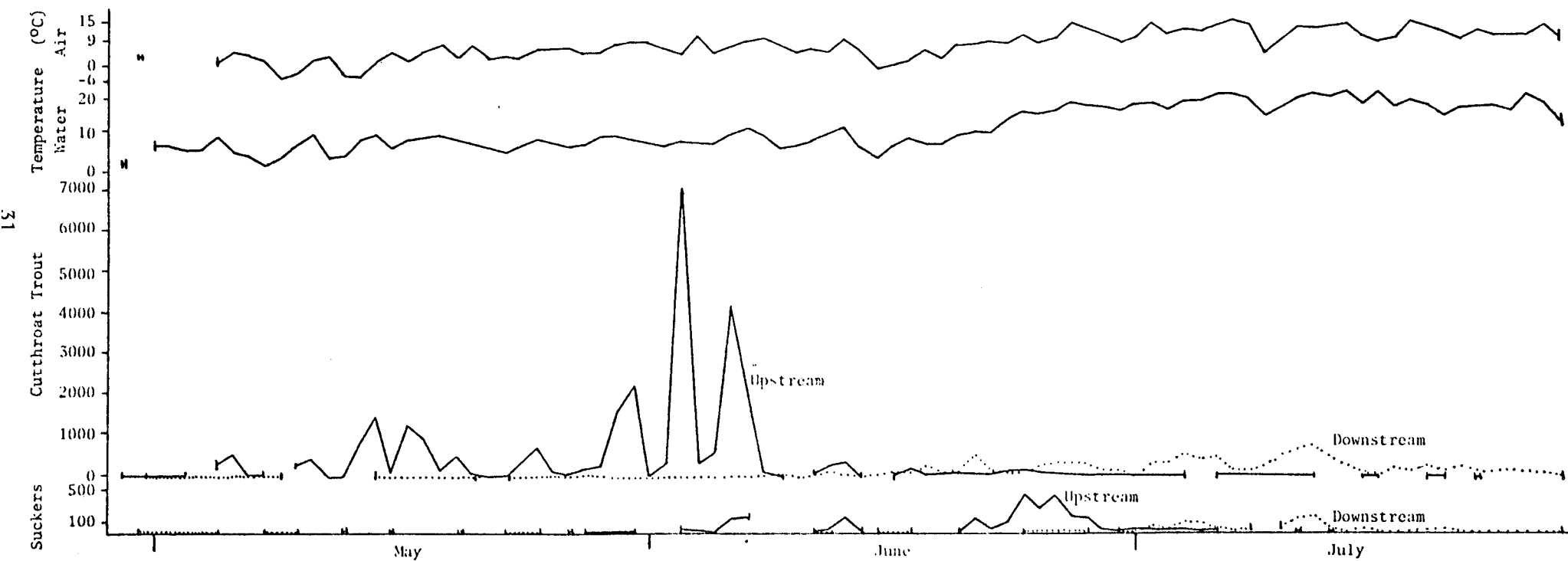


Figure 7. Pattern of daily temperature (air and water), and cutthroat trout and longnose sucker spawning migrations, Pelican creek, 1981.

Table 12 Weekly mean length, weight and condition factor of cutthroat trout spawners in the upstream trap in Pelican Creek, May 12 - July 20, 1981¹⁾

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 12 - May 18	45	403	559	0.83	55	370	509	0.85	100	396	531	0.84	0.82:1
May 19 - May 25	40	384	533	0.84	60	381	483	0.87	100	388	503	0.86	0.67:1
May 26 - June 1	38	397	530	0.83	62	387	485	0.88	100	388	509	0.86	0.61:1
June 2 - June 8 ²⁾	30	395	488	0.79	69	380	469	0.85	100	384	473	0.83	0.43:1
June 16 - June 22	42	389	472	0.80	58	377	466	0.87	100	382	468	0.84	0.72:1
June 23 - June 29 ²⁾	23	395	464	0.75	71	386	473	0.79	100	376	421	0.78	0.32:1
June 30 - July 6 ²⁾	11	411	526	0.77	35	389	510	0.77	47	377	410	0.76	0.31:1
July 7 - July 13 ²⁾	20	389	416	0.71	47	370	386	0.76	73	371	385	0.75	0.42:1
July 14 - July 20	4	370	334	0.66	0	—	—	—	4	370	334	0.66	4.00:0
Composite	253	395	502	0.80	457	379	467	0.83	724	384	468	0.82	0.55:1

1) Based on daily samples of cutthroat trout which were both measured and weighed; from June 1 to June 15, no upstream trout were observed in the trap.

2) One trout on June 2 - June 8, six on June 16 - June 22, one on June 23 - July 6 and six on July 7 - July 13 were not separated by sex but were used in weekly totals.



Figure 8. Average length of cutthroat trout (clipped and unclipped) in the upstream trap at Pelican Creek, 1981.

Mean length for six tagged trout recaptured in 1981 increased from 379 mm at time of tagging (1979) to 404 mm two years later. Three males displayed a much greater difference (388 mm and 420 mm for 1979 and 1981, respectively) than did females (370 mm and 389 mm, respectively). One male which had been recaptured in both years increased in length from 398 mm (1979) to 403 mm in 1980, and to 412 mm in 1981.

Downstream migration. Only 11,545 were passed downstream at Pelican Creek in 1981. During the first 43 days, lakeward migration was low and varied from 0 (April 28-29, May 9-13) to 79 (May 27). There was never a substantial peak of downstream migrants and the number remained fairly constant. The trap was removed on July 27 (Figure 7). Average total length and weight were 382 mm and 403 g, respectively. The average K factor was 0.71, and the male:female ratio was 0.52:1. Males had a significantly greater mean total length (397 mm) and weight (447 g) than females (376 mm and 384 g, respectively)(Table 13).

Because weekly samples of clipped trout in the downstream run were so small, length frequency data were included in the comparison, and all samples were combined over time. Mean length of 221 clipped trout was significantly greater than that of 3,729 unclipped trout (383 mm and 378 mm, respectively). Results from clipping studies conducted at Pelican Creek in 1980 (Jones et al 1980), indicated that these comparisons are probably confounded by the presence of immature trout in the unclipped sample.

The complex nature of the downstream migration also restricts comparisons between upstream and downstream runs. When only clipped trout were considered, there were no significant differences between runs, but if unclipped trout are included the interpretation becomes confounded by immature trout. As the prior analyses of clipped and unclipped trout indicated (Jones et al 1981), the downstream run displays a lower mean length when immatures are included. Regardless of combination, weights and K factors were significantly lower for lakeward migrants. Unlike the upstream migration, however, mean length, weight and K factor did not decline through time (Table 13).

On June 10, a black bear was sighted near the weir, but although bear tracks and partially eaten trout were found on numerous occasions after July 7, no other bears were observed. Other wildlife forms were numerous. Piscivorous animals included otters, ospreys, belted kingfishers, bald eagles and great blue herons. Moose were abundant throughout the season in the large meadow area of the Pelican Creek flood plain, but bison were observed mainly in the earlier portion of the season. Other animals associated with the aquatic system included muskrats, widgeons, scaup and beaver.

Table 13 Weekly mean length, weight and condition factor of cutthroat trout in the downstream trap in Pelican Creek, June 8 - July 26, 1981¹⁾

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	
June 8 - June 18	23	388	441	0.81	77	375	407	0.76	100	379	424	0.77	0.30:1
June 15 - June 21	25	404	448	0.74	75	380	368	0.72	100	386	421	0.73	0.33:1
June 22 - June 28	33	405	491	0.73	67	383	401	0.73	100	388	450	0.73	0.49:1
June 29 - July 5 ²⁾	40	398	467	0.73	59	379	397	0.72	100	386	423	0.73	0.68:1
July 6 - July 12 ²⁾	40	394	395	0.64	62	381	380	0.69	105	379	367	0.68	0.64:1
July 13 - July 19 ²⁾	40	400	445	0.69	58	375	370	0.70	100	383	397	0.70	0.69:1
July 20 - July 26 ²⁾	37	388	391	0.66	62	381	343	0.67	100	376	358	0.67	0.66:1
Composite	238	397	447	0.71	460	376	384	0.72	705	382	403	0.71	0.52:1

1) Based on daily samples of cutthroat trout which were both measured and weighed.

2) One trout on June 29 - July 5, three on July 6 - July 12, two on July 13 - July 19 and one on July 20 - July 26 were not separated by sex but were used in weekly totals.

Longnose Suckers

A total of 2,904 longnose suckers were passed upstream. Numbers peaked in late June as the upstream trout run decreased and the downstream migration was increasing (Figure 7). The upstream sucker run began as water temperature rose above 14°C and flows decreased well below peak.

Mean length for 948 suckers was 390 mm. Females had a significantly greater mean length than males (406 mm and 369 mm, respectively). Male:female ratio was 0.73:1.

A total of 15 tagged suckers were recaptured. Mean length and weight for tagged suckers were 443 mm and 979 g, respectively; mean K factor was 1.12. Only two females were recovered, but mean length and weight were significantly greater for females (482 mm and 1,352 g, respectively) than for males (438 mm and 931 g, respectively).

A total of 1,306 longnose suckers were counted during the downstream migration. Average length for 911 suckers (147 clipped; 764 unclipped) was 400 mm. Females were larger than males (413 mm and 386 mm, respectively). Male:female ratio was 0.80:1. Average length for downstream migrants was significantly greater than upstream, although differences were greater for males. Clipped suckers had a significantly greater mean length than unclipped suckers (405 mm and 400 mm, respectively).

Discussion

The cutthroat trout spawning migration at Pelican Creek began much earlier than Clear Creek again in 1981. Larger trout entered the stream first; mean length, weight and K factors decreased during the season. Most males were ripe when they entered the stream, but females apparently ripened during the upstream migration. The number of spawners increased as water flow decreased from its peak and temperature began to rise toward 10°C.

Daily migration patterns were similar to Clear Creek. Very few fish moved upstream in the morning, but by 1200-1300 hours, large numbers were entering the trap. Most upstream movement ceased at about 1700-1800 hours daily. It would appear that temperature was a significant factor for triggering daily upstream movement, and combined with increasing flows in the late afternoon, probably influences the daily decline in numbers. Although the majority of downstream movement also occurred in the afternoon, this pattern may have been influenced by trap operational procedures (hours of operation).

Because of the complex pattern of downstream movement in Pelican Creek (Jones et al 1981), it is impossible to obtain an unbiased estimate of instream

mortality. The appearance of immature trout and adult trout which are believed to have overwintered in Pelican Creek, also confounded analysis of tag return data. Since all trout tagged in 1979 came from the downstream trap, it is highly probable that the sample was comprised of trout in various stages of sexual maturity. Tag return data which indicates a 13.5% consecutive-year return and a 14.9% alternate-year return should therefore be scrutinized carefully. Although an 11.5% consecutive-year return of trout clipped in the upstream run in 1980 appears to support the tagging data, more definite conclusions await future returns of clipped trout.

Comparison of mean length of clipped trout between time of marking and time of recapture, suggested only 2 mm growth in the past year. Conclusions utilizing these data are inconclusive, however, due to the inability to identify individual fish. Actual growth of the return spawners may be much greater than analyses indicate. Tag return data is more meaningful in this instance since individual identity is retained. The consecutive-year sample displayed an 11 mm average growth, and the smaller alternate-year sample indicated a 25 mm increase or 12.5 mm annually. The one individual captured in both years displayed a 5 mm increase the first year and a 9 mm increase the second. It is currently difficult to form conclusions from these small samples, but these data do give some preliminary estimates of growth for adult spawners and emphasize the need to expand this program in the future.

Comparison of six years of length frequency data since 1960 (Figure 9) provides a means of monitoring the influence of angling during this period (Jones et al 1978). The shift towards larger size in recent years suggests a positive response to increasingly restrictive regulations since 1969.

The low number of suckers entering the upstream trap in 1981 again reflects the intensive efforts to destroy the run from 1976 to 1979. During that period, 39,391 suckers were removed from Pelican Creek. Both increases in numbers and size over 1980 is interpreted to be a response to the curtailment of the sucker removal program.

SUMMER GILLNETTING

A fall largemouth gillnetting program was initiated in 1969, to monitor relative abundance and population structure of the cutthroat trout and longnose sucker in Yellowstone Lake. In addition, gonad weights of cutthroat trout were recorded during the 1979 and 1980 operations to provide insight into the annual cycle of sexual maturation. Results from these studies have suggested the need to expand the gillnetting program to investigate seasonal distribution and gain additional knowledge concerning the maturation cycle. Information

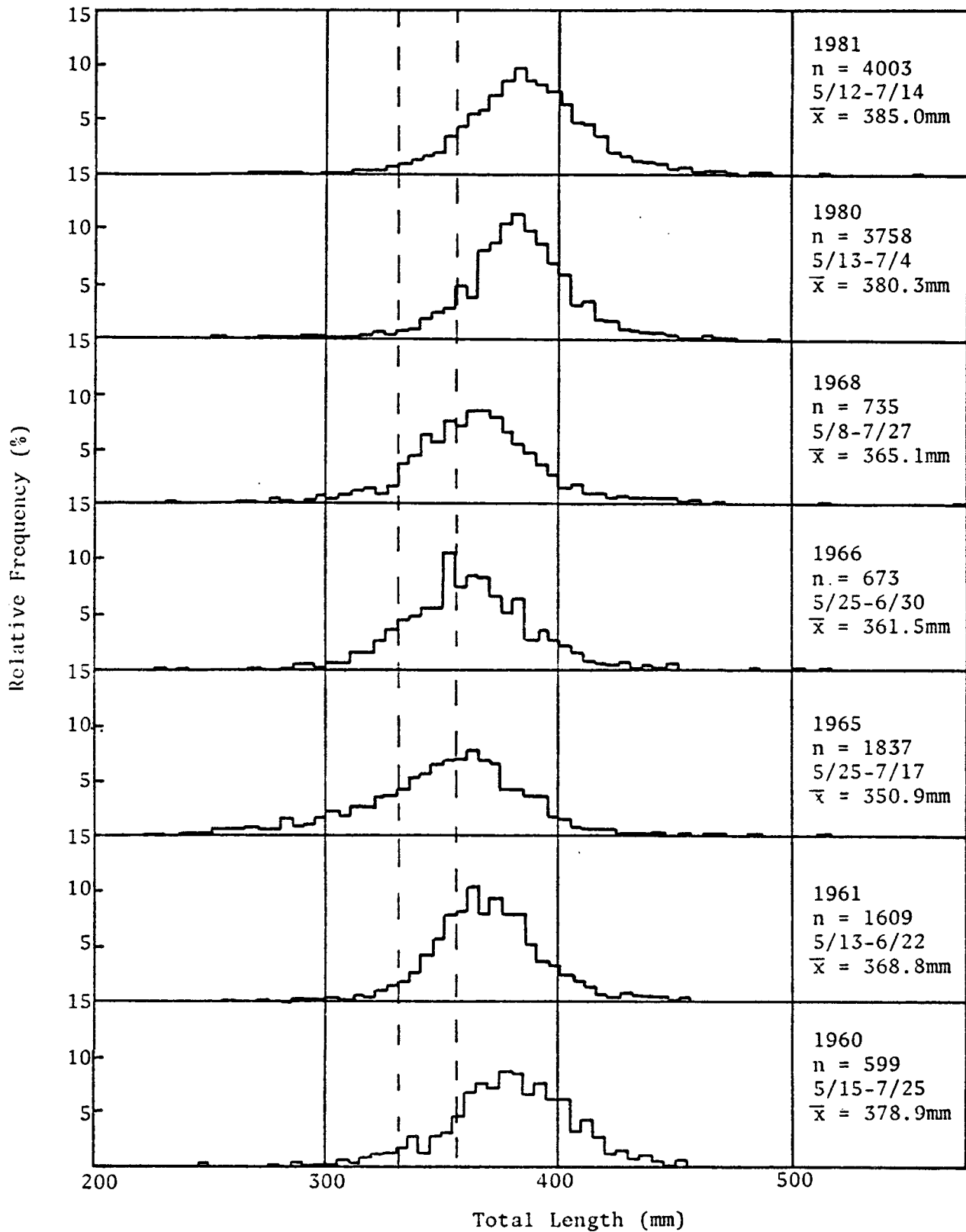


Figure 9. Length frequency of cutthroat trout in the upstream spawning migration in Pelican Creek in recent years.

was also needed to test comparability of new experimental gillnets (purchased in 1981) and the older Swedish gillnets which have been used since the fall operations began.

In order to obtain data needed to supplement the fall program, largemouth gillnets were set throughout the summer of 1981. The specific objectives of the program were to investigate changes in seasonal distribution and sexual maturation and to compare catchability and size selectivity of the new gillnets.

Methods

From June 15 to September 4, a total of 35 gillnets were set overnight (5 nets per night) near the old boathouse at Lake Village (site 2b) (Figure 2). Sampling dates were June 15, 28, July 14, 23, August 11, 24, and September 3. All sets were made at the 1.5-4.6 m depth interval. Measurement of length and weight, scale collection and determination of sex and stage of maturity followed established procedures (Dean et al 1975 and Jones et al 1978). Gonad samples were not obtained on June 15 or July 23, but trout from the fall gillnetting were included to aid in data analysis. The entire gonad was removed and weighed (to the nearest 0.05 g) on a balanced beam scale.

Results

A total of 898 cutthroat trout (25.6 per net) and 599 longnose suckers (17.2 per net) were captured during the summer gillnetting (Table 14). Of the five clipped trout captured during this study, four were originally clipped at Pelican Creek and one was marked at Clear Creek. Although the number of cutthroat trout captured per net varied from 20.4 per net (June 28) to 30.8 per net (July 14), differences were not statistically significant, and a trend in number captured was not evident (Figure 10). The number of longnose suckers captured did vary significantly from a low of 4.0 per net (June 28) to a high of 26.6 per net (August 12). Sucker numbers increased during the third sampling period (July 15) and remained above 20 per net thereafter (Figure 10).

The number of cutthroat trout captured in new nets (636; 30.3 trout per net) was significantly greater than the number in the old nets (262; 18.7 trout per net). Although differences in the number of suckers captured by the two net types was not statistically significant, new nets captured approximately 32% more suckers overall (Table 14).

Mean length of cutthroat trout decreased significantly from June to September (Table 15). Decreases were greatest during the first two sample periods, after which mean length remained fairly stable (Figure 11). Length frequency analysis indicates a slight reduction in trout over 330 mm, but what appears to

Table 14. Number of cutthroat trout and longnose suckers captured in largemesh gillnets, site 2b, Yellowstone Lake, June-September, 1981

Week	Cutthroat Trout							Longnose Suckers						
	Old Nets		New Nets			Sum	Mean	Old Nets		New Nets			Sum	Mean
6/16	14	16	32	28	33	123	24.6	14	8	11	11	3	47	9.4
6/28	16	13	24	26	23	102	20.4	10	3	1	0	6	46	4.0
7/15	20	30	36	38	30	154	30.8	14	14	19	29	11	87	17.4
7/24	27	17	19	31	18	112	22.4	16	20	22	19	23	100	20.0
8/12	19	16	47	34	27	143	28.6	18	18	46	27	24	133	26.6
8/25	15	22	31	27	28	123	24.6	20	15	15	23	30	103	20.6
9/4	23	14	24	29	51	141	28.2	17	14	42	17	19	109	21.8
Sum	134	128	213	213	210	909		109	92	156	126	116	602	
Mean	19.14	18.29	30.43	30.43	30.00		25.65	15.57	13.14	22.29	18.00	16.57		17.2

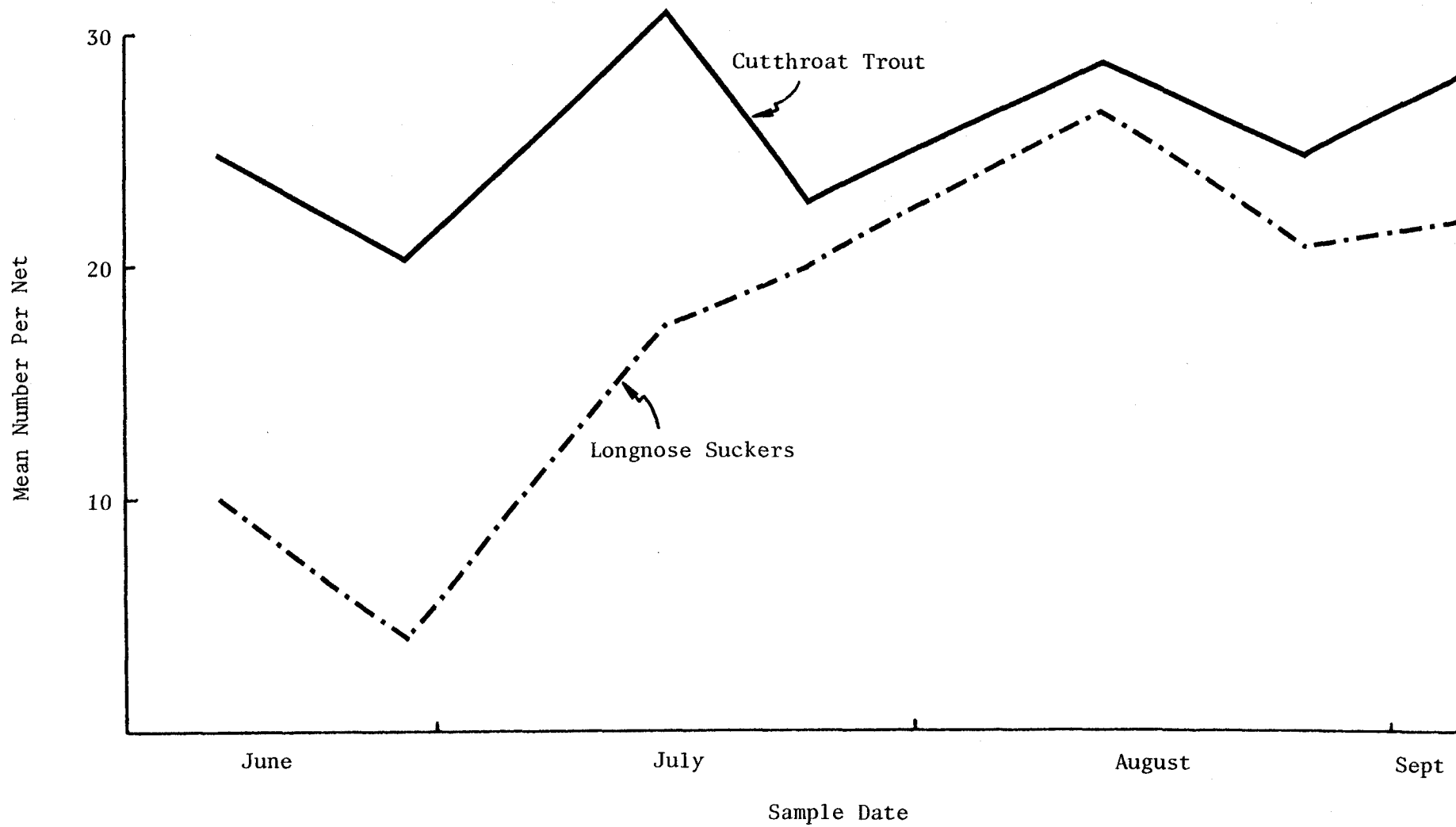


Figure 10. Mean number of cutthroat trout and longnose suckers captured per net, site 2B, Yellowstone Lake, June-September, 1981.

Table 15. Mean total length of cutthroat trout captured in largemesh gillnets, site 2B, Yellowstone Lake, June-September, 1981

Week	Mean Length	Number	Mean Weight	Mean Condition Factor (K)	Number
6/16	357.3	123	430.1	0.92	123
6/29	341.6	102	397.7	0.95	101
7/15	289.8	154	255.7	0.88	154
7/24	277.4	112	224.6	0.88	112
8/12	278.4	143	225.3	0.88	143
8/25	297.8	123	272.2	0.92	123
9/4	279.7	141	236.7	0.89	141

Table . Mean total length of longnose suckers captured in largemesh gillnets, site 2B, Yellowstone Lake, June-September, 1981

Week	Mean Length	Number	Mean Weight	Mean Condition Factor (K)	Number
6/16	367.3	47	714.3	1.24	47
6/29	388.5	20	815.0	1.24	20
7/15	383.1	87	726.7	1.15	87
7/24	411.0	100	850.8	1.16	100
8/12	347.3	133	447.3	1.08	133
8/25	335.1	103	519.8	1.17	103
9/4	326.0	109	453.3	1.15	109

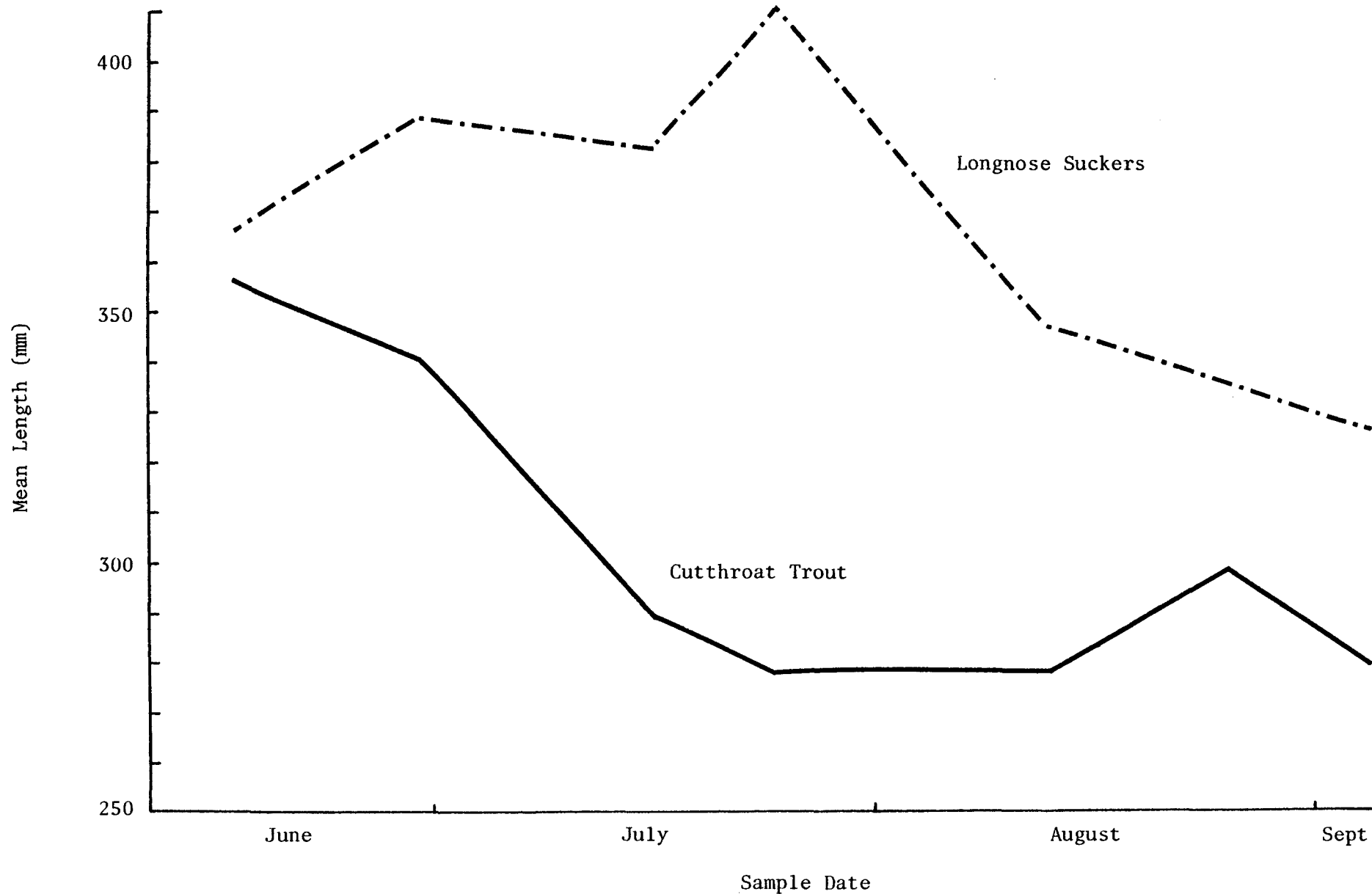


Figure 11. Mean length of cutthroat trout and longnose suckers captured in gillnets, site 2B, Yellowstone Lake, June-September, 1981.

be of greater significance is the increase in the percentage of trout less than 300 mm (Figures 12 and 13). Stage of maturity analysis indicates a sharp increase in immature cutthroat trout after the second sampling period, although decreases of mature trout are also evident (Figure 14).

Mean length of longnose suckers increased through July, but then displayed significant decreases during the last three periods (Figure 11). This decrease appears to be related to a sharp decline in suckers over 304 mm total length (Figure 15). The surge in sucker numbers during the fifth sample (August 11) coincides with a sharp increase in suckers less than 210 mm total length during that period.

Net type also affected the mean total length of fish captured. Length of cutthroat trout captured in new nets was 310 mm and length of trout in old nets was 279 mm (Figure 16). Since differences between new and old nets were not significant when comparisons were restricted to adult trout (365 mm and 368 mm, respectively) and prespawners (362 mm and 366 mm, respectively), it would appear that immature trout were captured in greater proportion in old nets. Length frequency analysis clearly illustrates that old nets captured a much higher proportion of trout less than 300 mm (Figure 15). Differences in mean length for longnose suckers between old nets (358 mm) and new nets (361 mm) were not statistically significant.

Gonadal-somatic indices (GSI) (LeCren 1951) were calculated for 192 cutthroat trout including 28 from the fall largemouth gillnetting. Ripe trout, prespawners and postspawners were grouped by sex. Trout which had never spawned and lacked gonadal development were considered immature. Although the nonrandom collection of samples may limit comparisons with future collections, these data provide an adequate means of evaluating changes in the annual cycle of sexual maturation.

GSI values for females were high during the latter part of June, but dropped drastically by the middle of July (Figure 17). Values increased gradually throughout the remainder of the study reaching a maximum of 2.85 by the final sample (September 24). Males began with much lower GSI values but surpassed females by the middle of August and remained higher than females during the final samples. Despite a slight increase in mean values during July and August, immatures remain below 0.2.

Discussion

The number of cutthroat trout captured during this study was substantially higher than longnose suckers, and although variation between sample dates was great, there was no evidence of either increasing or decreasing numbers of trout during the period. Number per net was much higher than those

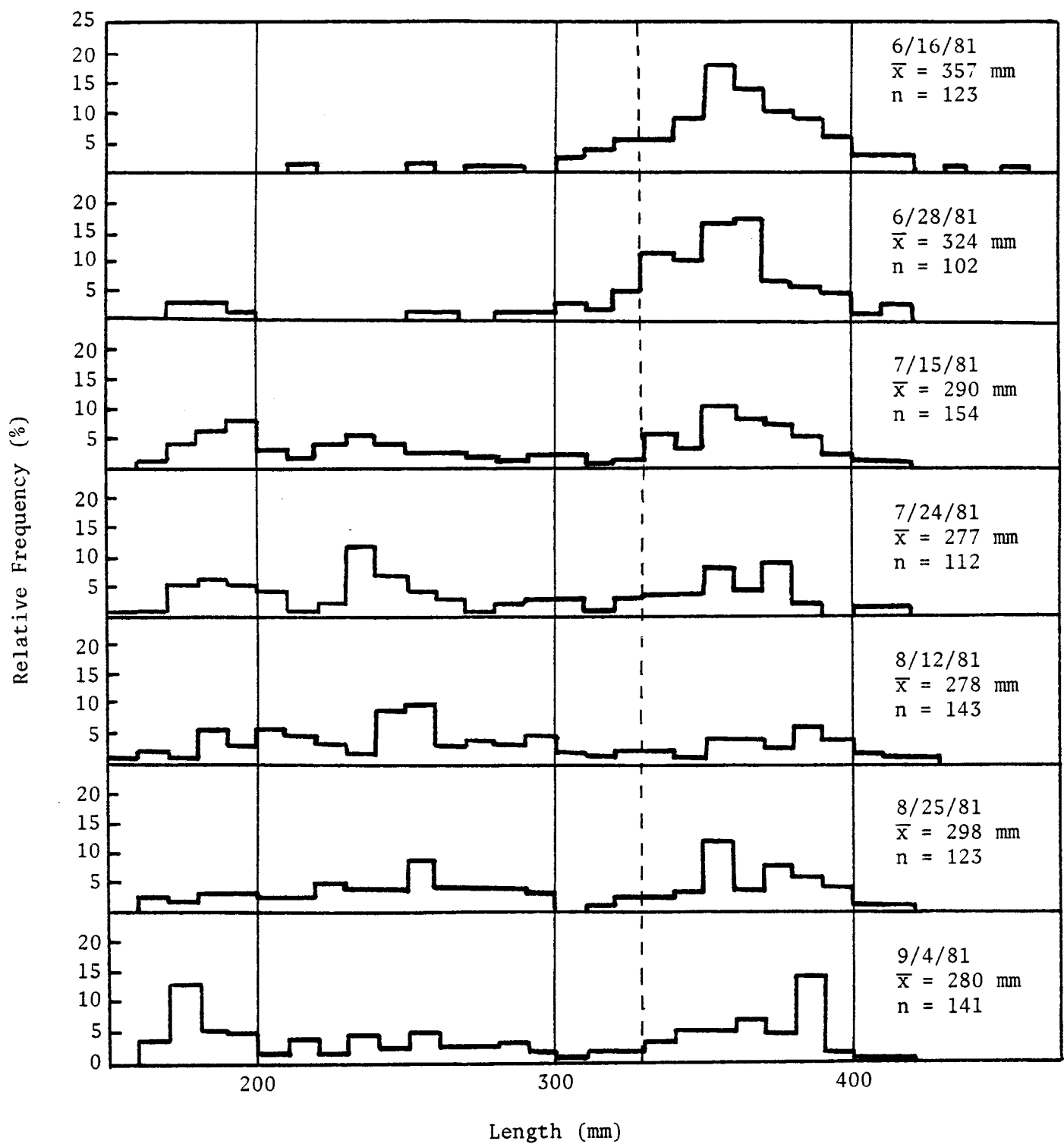


Figure 12. Length frequency analysis of cutthroat trout captured in largemesh gillnets, site 2B, Yellowstone Lake, June-September, 1981.

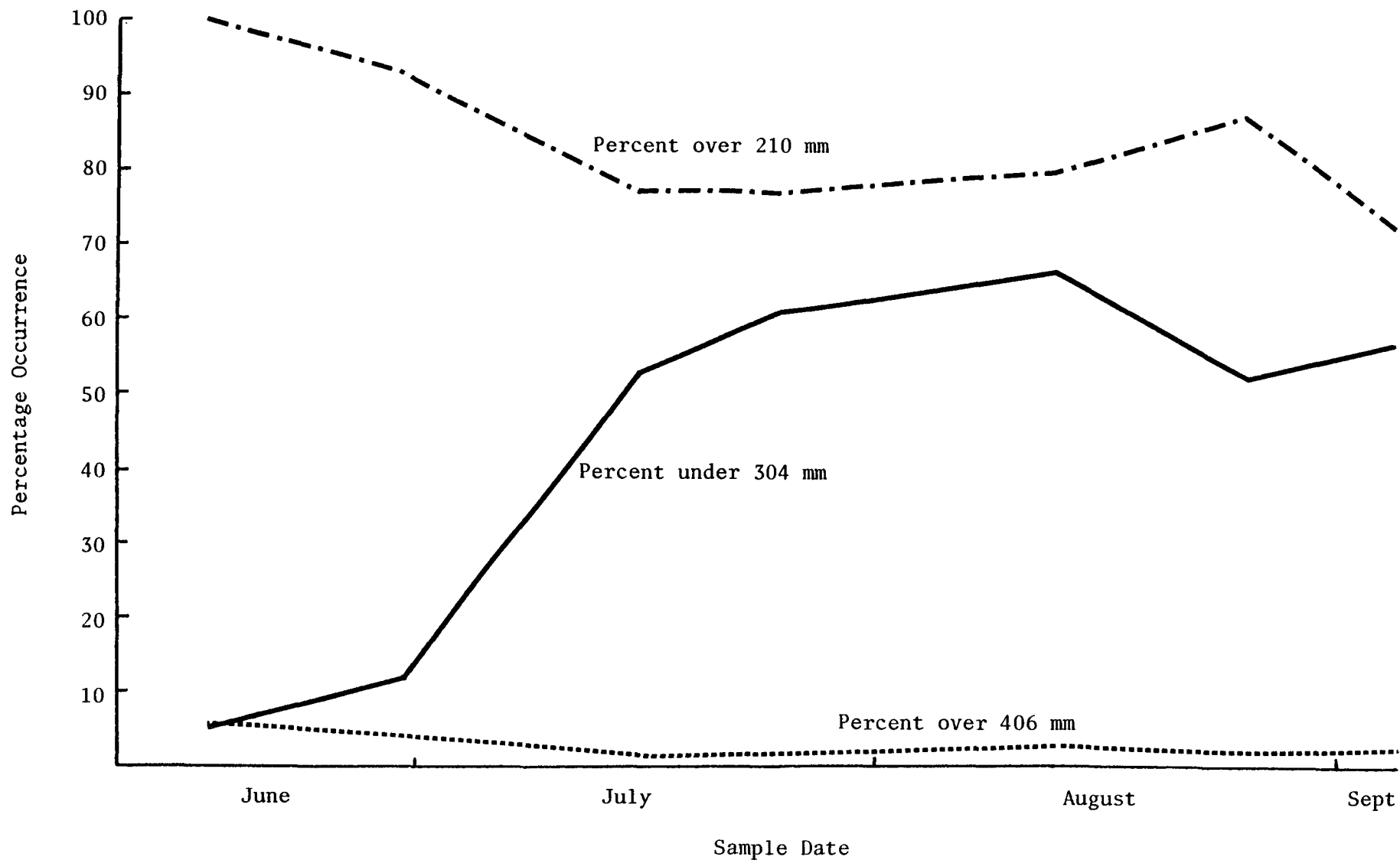


Figure 13. Percentage of cutthroat trout over 210 and 406 mm, and under 304 mm total length, captured in largemesh gillnets, site 2B, Yellowstone Lake, June-September, 1981.

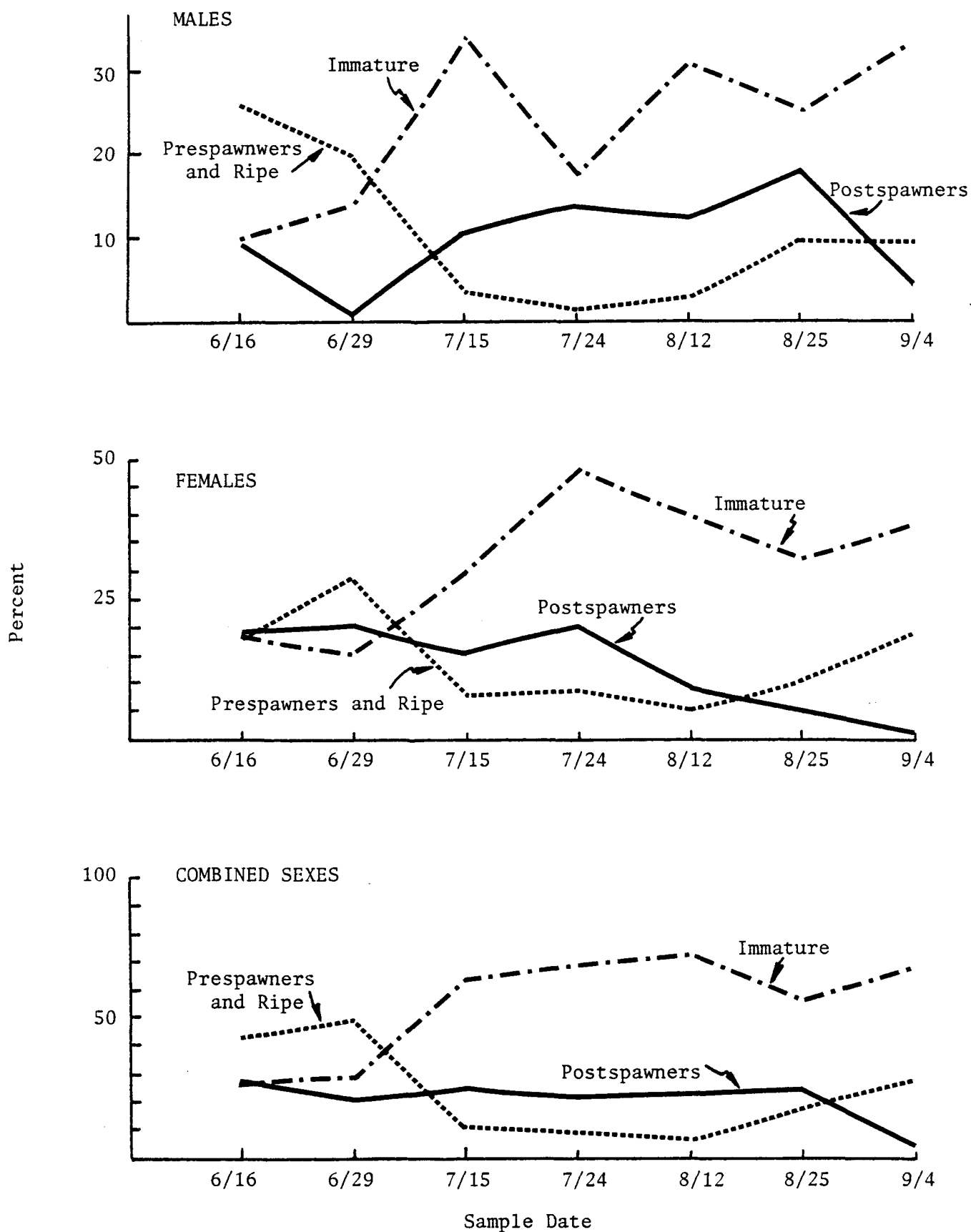


Figure 14. Percentage of trout in various maturity categories, captured in largemesh gillnets, site 2B, Yellowstone Lake, June-September, 1981.

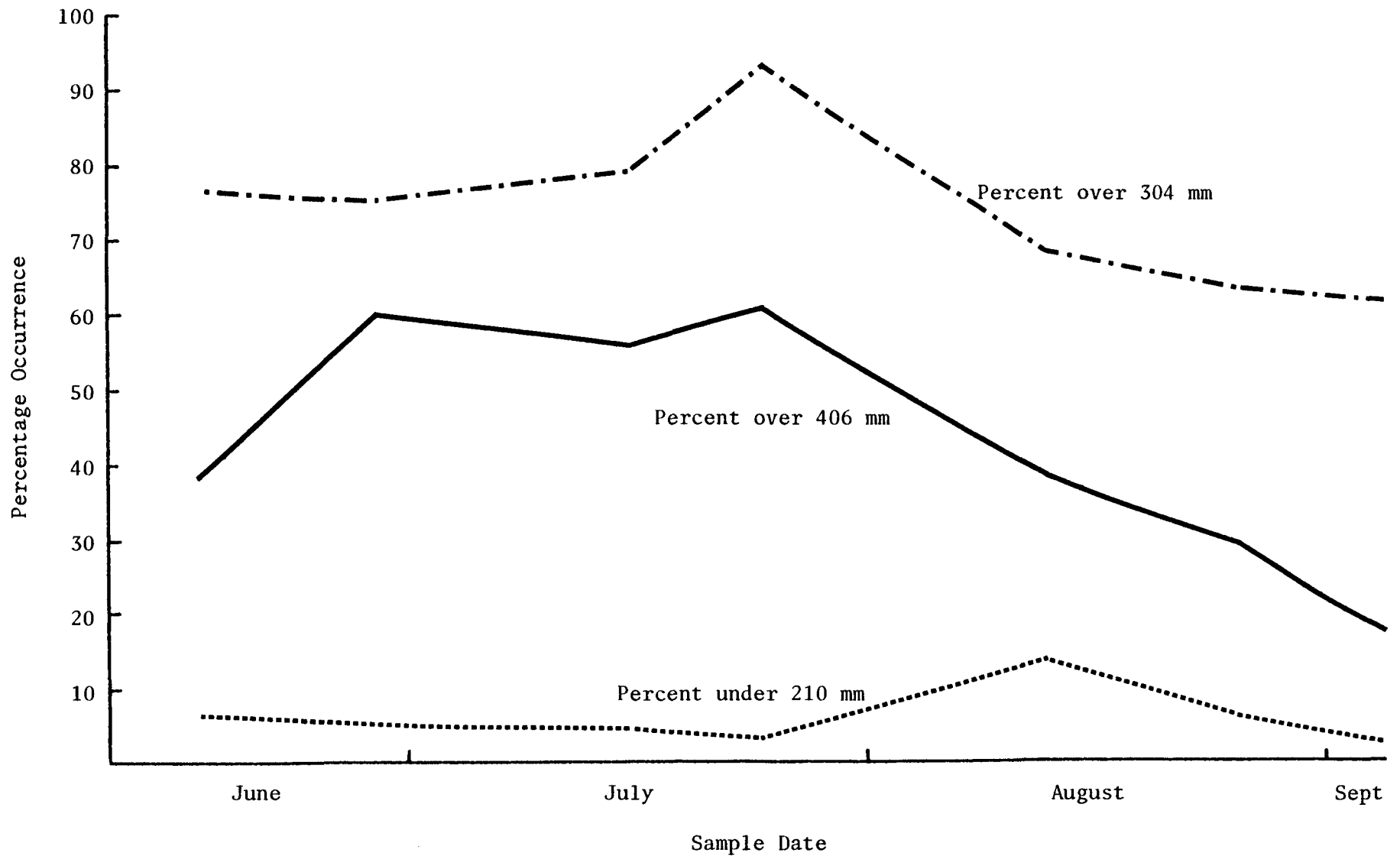


Figure 15. Percentage of longnose suckers under 210 mm and over 304 and 406 mm total length, captured in largemesh gillnets, site 2B, Yellowstone Lake, June-September, 1981.

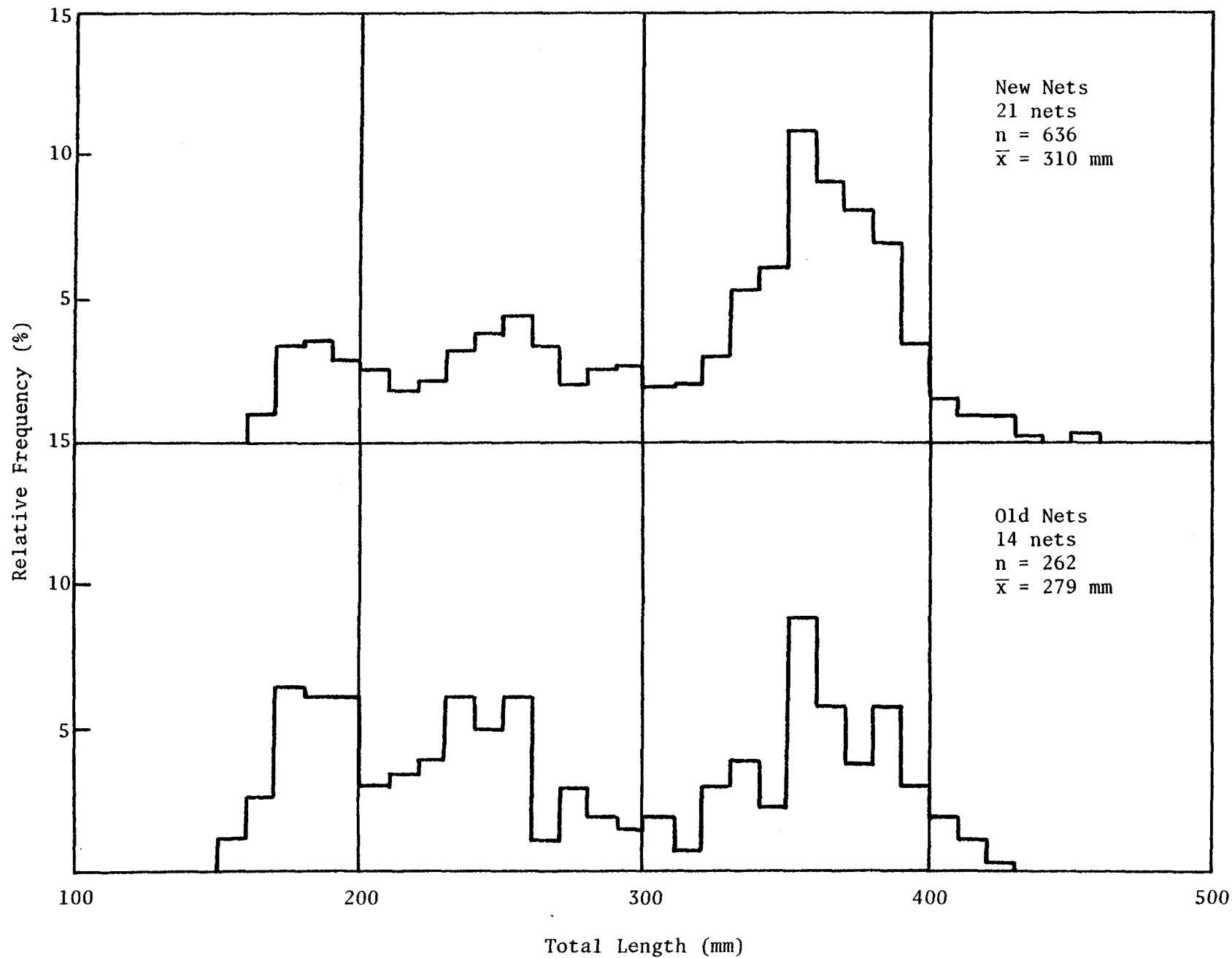


Figure 16. Comparative length frequencies of cutthroat trout captured in new and old gillnets, site 2B, Yellowstone Lake, June-September, 1981.

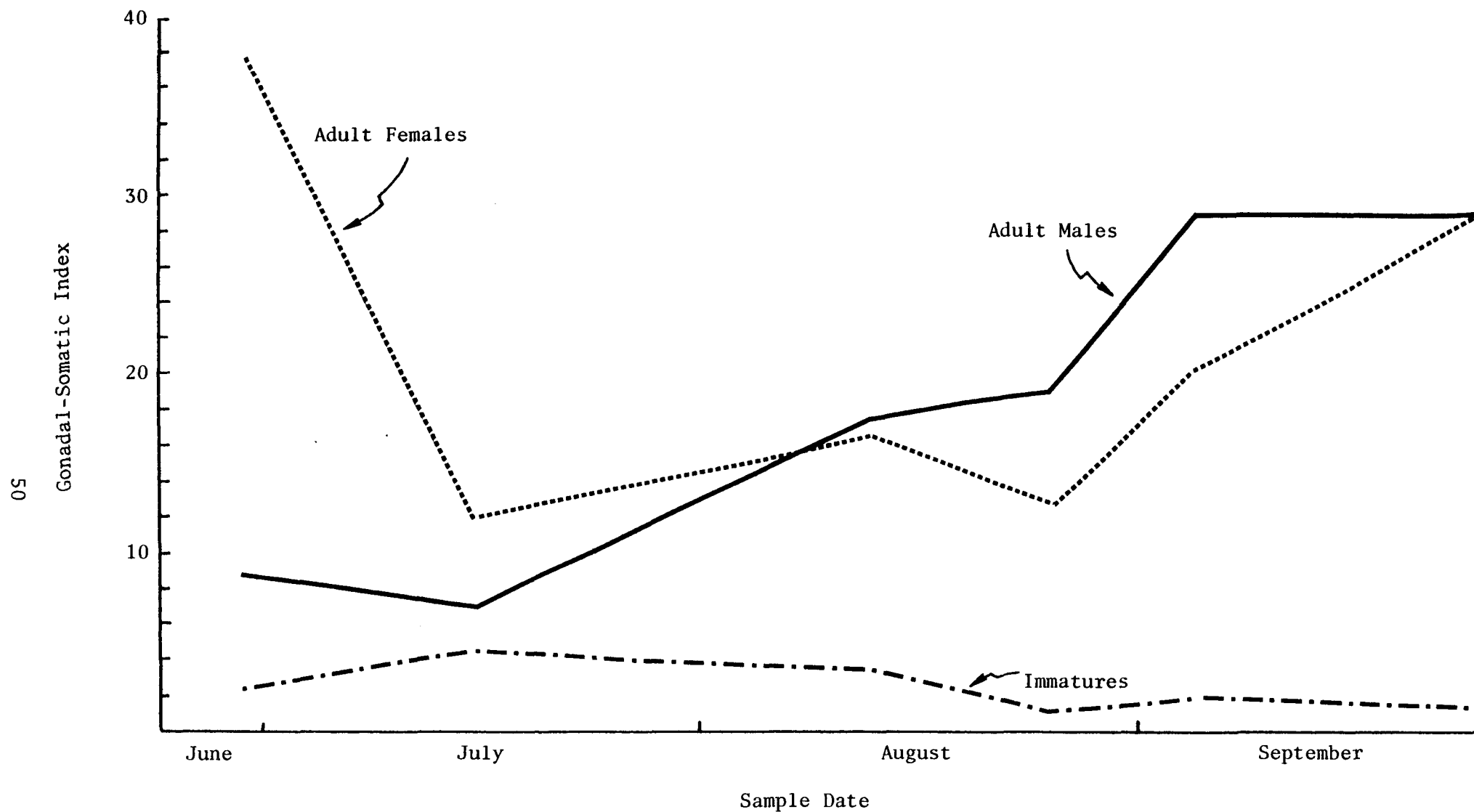


Figure 17. Gonadal-somatic index values for cutthroat trout captured in largemouth gillnets, site 2B, Yellowstone Lake, June-September, 1981.

reported for fall studies since 1969 (Table 16), but the use of new nets during the summer program definitely confounds these comparisons. If old nets alone are utilized for this analysis, current data are within range of numbers found at site 2b since 1969.

Decreases in mean length indicate a shift in distribution at site 2b during the sampling period. The rapid decline in the percentage of ripe adults and the increase in the proportion of immatures appears to explain this size decrease. Length frequency analysis supports this hypothesis. The presence of larger trout during June is probably associated with cutthroat spawning activities at that time. Since differences in mean length between net types appear to be related to the proportion of immature trout captured, unbiased comparisons can be made by examining adult trout only.

Longnose sucker numbers displayed a sharp increase after June 29. Changes in mean length suggest an increase in larger suckers during late June and July are responsible for initial increases. During August and early September, sucker numbers were supported at higher levels by increases in smaller suckers as larger individuals declined. Although the early scarcity of suckers is presently unexplained, it may be linked to lower water temperatures early in the study. Later changes appear to be influenced by sucker spawning migrations. Since differences in number and sizes of suckers captured in old and new nets is minimal, current data remains comparable with results since 1969.

Analysis of the GSI data for cutthroat trout indicates that many adult females were still spawning during the initial sample, but most males had spawned by that time. Increases in GSI values for both sexes from mid-July through September illustrate the sexual development throughout the summer. It appears that females recover much more gradually than males, but are approaching spawning levels by late September. Continued study with emphasis on quantitative comparability is necessary to increase our understanding of the annual maturity cycle.

LARGEMESH GILLNETTING

The objective of the largemesh gillnetting program is to monitor relative abundance and population structure of cutthroat trout and longnose suckers in Yellowstone Lake. In order to reduce variability and enhance the interpretation of data, the experimental design has been altered since the program was initiated in 1969. Despite changes, data has remained comparable for the eleven years in which studies have been conducted. Jones et al (1977, 1978, 1979, 1980 and 1981) provide summaries of previous results.

Table 16. Gillnet catches of cutthroat trout by areas, Yellowstone lake, 1969, 1970, 1971, 1972, 1974, 1976, 1977, 1978, 1979, 1980 and 1981¹⁾

Area	Number per net ²⁾											Average total length (mm)											Average weight (g)										
	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981 ³⁾	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981 ³⁾	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981 ³⁾
1A	3	1	15	15	11	19	10	14	12	7	11	277	290	291	297	249	315	301	286	276	279	319	213	311	249	269	167	322	273	254	222	357	325
1B	19	19	5	13	12	9	23	9	18	21	35	293	308	363	295	330	322	261	327	281	302	326	272	279	363	276	341	337	214	360	245	302	324
1C	5	10	23	21	25	22	15	15	12	17	34	322	327	306	262	304	306	305	281	312	310	340	317	348	267	331	267	260	292	235	316	316	373
2A	17	11	21	16	21	11	16	10	10	6	11	328	365	326	329	300	337	290	313	372	344	341	359	450	318	350	269	363	268	336	339	418	374
2B	5	15	8	12	26	21	21	17	9	14	26	378	279	379	321	266	291	286	298	306	309	317	527	223	452	352	200	267	258	232	360	314	310
3A	4)	20	4)	17	6	19	19	16	19	12	31	4)	352	4)	296	264	302	265	293	286	308	304	4)	382	4)	262	253	285	219	283	239	369	286
3B	4)	9	4)	3	12	15	12	14	12	12	14	4)	352	4)	368	311	324	341	319	306	341	345	4)	390	4)	410	290	322	339	337	304	410	390
4A	4)	2	4)	9	19	13	7	15	16	13	16	360	352	4)	358	290	331	283	286	288	268	322	411	320	4)	405	265	331	256	260	255	217	326
4B	23	32	4)	19	12	10	15	18	18	18	32	290	280	4)	334	301	324	269	302	294	286	303	261	249	4)	358	235	306	215	260	280	255	235
5C	14	7	4)	8	6	12	12	13	12	15	40	341	364	4)	349	349	330	344	342	374	339	310	403	438	4)	459	361	353	430	416	517	430	301
7C	16	1	4)	17	20	14	22	13	10	9	13	300	224	4)	329	324	337	292	365	335	345	296	249	108	4)	349	309	358	270	467	400	414	250
Totals	110	135	72	150	170	165	682	766	748	715	1311																						
Averages												311	315	321	313	298	317	290	308	303	309	319	312	320	305	320	266	314	271	316	301	329	318

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 for 1978, 1979, 1980 and 1981, represents an average of 5 sets.

3) New experimental gillnets were utilized in 1981; numbers, lengths and weights are not strictly comparable (see text).

4) Areas not sampled.

Methods

In 1981, experimental gillnets were set September 21-25, at eleven sites in Yellowstone Lake (Figure 2). Although new gillnets utilized in 1981 were manufactured by a different company, overall dimensions and mesh sizes were the same as the old Swedish nets (Jones et al 1977). Since prior studies indicated significant differences in the efficiency of the two net types (see Summer Gillnetting this report), six old nets were set during the fall survey to improve comparability with past data.

Gonad weights were collected from 28 of the cutthroat trout sampled. All other sampling procedures, including terms used to describe stage of maturity have remained unchanged since 1978 (Jones et al 1979).

Results

Cutthroat Trout 1981

A total of 1,311 cutthroat trout (23.8 trout per net) were captured. Average length and weight were 319 mm and 318 g, respectively (Table 17). Average condition factor (K) was 0.89.

The number of cutthroat trout captured per net was significantly greater for new nets. Although problems with sets at site 7c eliminated those nets from comparison, mean number per net for the remaining five sites were 15.6 trout per old net and 28.5 trout per new net (Table 18). These figures yielded a ratio for new:old nets of 1.8:1. When this number was divided into the mean catch for all 49 new nets (25.2 trout per net), the adjusted catch for new nets was 13.81 trout per net and the adjusted catch for all 55 nets was 13.75 trout per net.

Mean length (314 mm) of 631 trout captured in new nets was significantly greater than the mean (294 mm) for 79 trout captured in old nets. Length frequency analysis indicates the main difference between nets was a greater proportion of trout under 200 mm in the old nets (Figure 18). When comparisons were limited to prespawners, differences between mean length of trout from old and new nets (363 mm and 369 mm, respectively) were not significant.

A total of 17 clipped and 2 tagged trout were captured during the survey. Of the clipped trout, 11 were originally marked at Pelican Creek (1980) and 6 were clipped at Clear Creek (1979). The two tagged trout were originally marked at LeHardy's Rapids on the Yellowstone River (one each in 1980 and 1981). Clipped trout were found at eight of the eleven sample sites; however, Pelican Creek trout were most often captured in the northern portion of the lake

Table 17. Length frequency distribution, average lengths and weights, and condition factors of prespawning and nonspawning cutthroat trout and longnose suckers captured in largemouth gillnets, 1.5-4.6 m depth interval, Yellowstone Lake, 1981

Species	Maturity category ¹⁾	152	178	203	229	254	279	305	330	356	381	406	432	457	483	508	533	Total number	Average total length (mm)	Average weight (g)	Average condition factor (K)
Cutthroat Trout	Nonspawners	11	56	48	121	179	112	80	93	58	59	17						869	292	245	0.89
	Prespawning males			1	2	2	2	8	26	66	89	15	5		1			197	375	473	0.88
	Prespawning females					4	3	11	48	106	61	12						245	367	454	0.91
	TOTALS and AVERAGES	11	56	49	123	185	117	99	167	270	189	39	5		1			1,311	319	318	0.89
Longnose Sucker	Nonspawners	15	11	7	14	7	21	15	9	3	1			1				102	264	248	1.14
	Prespawning males			1			4	12	18	17	45	56	38	2				193	397	802	1.25
	Prespawning females						1		9	9	14	35	61	47	23	3	2	204	442	997	1.14
	TOTALS and AVERAGES	15	11	8	14	7	26	27	36	29	60	91	99	50	23	3	2	499	368	768	1.10

1) Prespawning fish defined as those judged to have sufficient gonadal development to spawn in 1982; nonspawners includes immature, and mature fish which were judged to lack sufficient gonadal development to spawn in 1982.

Table 18. Number of cutthroat trout captured in two types¹⁾ of largemouth gillnets, Yellowstone Lake, September 21-25, 1981

Site ²⁾	New Nets						Old Nets
	1	2	3	4	Sum	Mean	
2a	10	7	19	15	51	12.8	6
3a	29	32	30	44	135	33.8	19
3b	15	15	19	16	65	16.3	7
4b	15	43	39	45	142	35.5	20
6c	55	43	49	29	176	44.0	26
Sum					569		78
Mean						28.5	15.6

1) Experimental gillnets were 38.1 m long and 1.8 m deep with five 7.6 m panels of 19, 25, 32, 38 and 41 mm bar mesh. Old nets were Swedish nets purchased in 1969-1971; new nets (purchased from a different company in 1980) differed in float and leadline construction and monofilament twine diameter.

2) Site 7c was deleted because of problems in setting three of the nets.

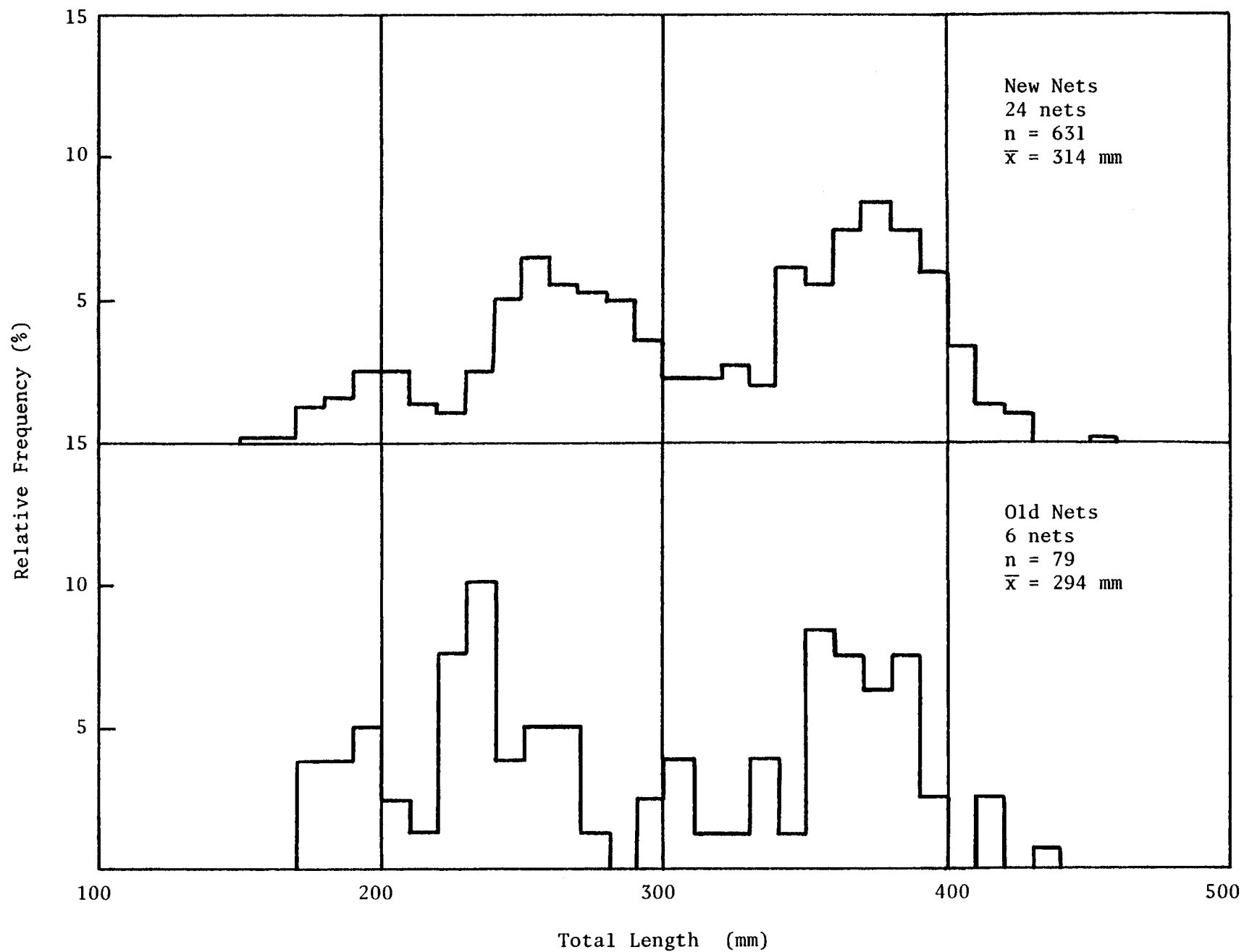


Figure 18. Comparative length frequencies of cutthroat trout captured in new and old gillnets, sites 2a, 3a, b, 4b, 6c and 7c, Yellowstone Lake, September 21-25, 1981.

(sites 1b, 1c, 2a and 2b), and Clear Creek trout were most often found in the Central zone (sites 3a and 3b). Both tagged trout were recovered in the North zone (1b and 2a).

Comparison of length and stage of maturity indicates that most trout less than 305 mm were nonspawners (Table 17). The percentage of nonspawners was greater than 40% up to 330 mm. Male prespawners were larger than female prespawners and dominated all size-groups above 381 mm.

The number of trout captured differed significantly among the 11 netting sites. Sites 6c, 1c and 4b had the greatest catch per net (40.4, 33.6 and 32.4, respectively) and sites 1a, 2a and 7c had the lowest (11.0, 11.4 and 12.6, respectively) (Table 16). Since comparisons are confounded by net types, data were reanalyzed using only new nets. Although most means changed, relative abundance was similar except for a shift upwards of 1b and a shift downwards of 1c. Sites 6c, 4b and 1b yielded the highest catch per net (44.0, 35.5 and 34.8, respectively) and 1a, 2a and 7c had the lowest (11.0, 12.75 and 15.5, respectively).

When net catches, old and new nets combined, were compared between four lake zones (North: 1a, 1b, 1c, 2a, 2b; Central: 3a, 3b; West Thumb: 4a, 4b; and South: 6c, 7c), differences between zones were not statistically significant. South had the greatest mean number per net while Central had the lowest (26.5 and 22.6, respectively) (Table 19). When comparisons were limited to new nets, South again had the greatest number per net, but North had the lowest (24).

Average total length of trout differed significantly among the 11 net sites. Sites 3b, 2a and 1c had significantly larger trout than all other sites (Table 16). Since mean length was also influenced by net types, comparisons were made using only new nets. Mean length changed in most cases, but relationships between sites remained virtually unchanged.

Differences between sites in the length of prespawners were significant, and trout at site 3b were again the largest. Although differences in length of prespawners was not significantly altered by net types, site comparisons were also made with new nets alone, and results were essentially the same.

Length comparisons by zone revealed that cutthroat from the North were significantly larger than those from the other zones. Relationships were unchanged by excluding old nets. Prespawners were also compared by zone, and results were quite different. Cutthroat trout from Central had significantly greater length than trout from West Thumb (374 mm and 359 mm, respectively), but South and North were just slightly smaller (372.4 mm and 372.1 mm, respectively). Deleting old nets had little effect on this comparison.

Table 19. Gillnet catches of cutthroat trout by general area, Yellowstone Lake, 1969, 1970, 1971, 1972, 1974, 1976, 1977, 1978, 1979, 1980 and 1981¹⁾

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
1981 ²⁾	23	23	24	27	329	317	309	307	3.1	9.3	9.2	7.9	6.3
Totals	2310	870	967	879									
Averages	14	16	17	15	306	309	295	328	13.0	12.9	12.9	7.5	12.0

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

2) New nets set in 1981 bias yearly comparisons (both number per net and average length).

A gonadal-somatic index (GSI) (LeCren 1951) was calculated for 28 cutthroat trout. Nonspawning cutthroat greater than 304 mm (TL) had significantly lower GSI values (0.06 and 0.81 for males and females, respectively) than cutthroat prespawners (3.19 and 3.28 for males and females, respectively). As expected, females had greater GSI values in both maturity categories.

Longnose Suckers 1981

The average length and weight were 388 mm and 768 g, respectively, for the 499 longnose suckers captured (Table 17). The average K factor was 1.18. Differences between old nets and new nets in number per net (5.4 and 12.2, respectively) and mean length (402 mm and 391 mm, respectively) were not statistically significant.

Approximately 96% of suckers over 305 mm were categorized as prespawners (Table 17). Males were judged prespawners at a smaller size, and females dominated size classes over 432 mm. These results are consistent with previous studies (Jones et al 1978, 1979, 1980 and 1981).

Discussion

Cutthroat Trout 1969-1981

Average number per net. The use of new gillnets in 1981 has definitely confounded comparisons of number per net with previous years. The adjusted estimate of 13.75 trout per net suggests a substantial increase over 1980. Although the credibility of this number might be questionable, results from the Summer Gillnetting program revealed a similar relationship of number per net between old and new nets. Regardless of the exact estimate, it is safe to assume that there was no major decline in number per net in 1981.

Because of the high degree of variability inherent with the gillnetting results, differences in mean number per net since the program began in 1969 are not statistically significant (Table 20). Interpretation of general trends, however, may provide insight into the observed differences. Although the early increase in number per net (1970-1978) may be confounded by variation caused by density independent variables, it appears to be a response to increasingly restrictive regulations beginning in 1969. After initial increases in numbers, density decreased somewhat beginning in 1978. This decrease is assumed to be associated with a shift in biomass toward larger trout under the influence of the 330 maximum size limit. Since 1978, densities appear to be relatively stable, and fluctuations are apparently due to variation in density independent factors (Jones et al 1981).

Table 20. Comparative largemouth gillnetting results, cutthroat trout, 1.52-4.57 m depth interval, Yellowstone Lake, 1969, 1970, 1971, 1972, 1974, 1976, 1977, 1978, 1979, 1980 and 1981

Category	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981
Number of gillnets set ¹⁾	9	11	5	11	11	11	44	55	55	55	55
Average number of trout caught per net	12.22	12.27	14.4	13.63	15.45	15.0	15.55	13.93	13.6	13.0	13.75 ³⁾
95% confidence interval of number of trout caught per net	±6.71	±5.90	±8.76	±3.57	±4.75	±3.06	±1.98	±1.06	±1.27	±1.53	—
Percentage of trout over 356 mm (TL)	29.1	26.7	37.5	32.7	34.7	37.6	33.0	37.5	32.3	40.6	38.4
Percentage of trout over 406 mm (TL)	1.8	3.0	1.4	3.3	0.6	2.4	4.7	5.4	7.4	7.1	3.8
Percentage of trout over 457 mm (TL)	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.1	0.3	0.2
Percentage of prespawning trout ²⁾	53.6	45.6	54.3	39.8	56.4	48.6	75.6	65.7	59.0	50.1	56.4
Ratio of prespawning males to females	1.06	1.73	1.50	0.52	1.00	1.43	0.98	1.06	0.91	1.05	0.80
Average length (mm) of prespawning males	353	359	360	358	349	370	376	383	387	389	375
Average length (mm) of prespawning females	346	351	348	349	359	365	362	372	374	376	367
Condition factor K	0.924	0.917	0.853	0.937	0.859	0.877	0.892	0.923	0.915	0.884	0.889

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.

3) New monofilament nets were used in 1981, new nets averaged 28.5/net, old nets averaged 15.6/net for five sites; figure given is adjusted for comparative purposes.

When data from the ten years of gillnetting were combined, differences in the number of trout between sites were significant. The relationship between site and number of trout captured has changed since 1977; however sites 1a, 2a, 3b and 4a continued to be among the lowest, and site 4b has remained the highest.

Although the relationships between lake zone and the number of trout has varied annually, there was little difference between zones when data from ten years were combined (Table 19). Biological interpretation of these results is confounded by the high degree of variation and absence of observable trends.

Average size. The mean total length of cutthroat trout captured in gillnets has varied significantly since 1969. Similar results were observed when data were combined over years and compared by site and zone (Tables 16 and 19 and Figure 19). Biological interpretation of these results is confounded by the high degree of variation and absence of observable trends.

It has been suggested that differences in the length of trout captured since 1969 are due mostly to fluctuations in the proportion of smaller fish in the sample (Jones et al 1978). The yearly fluctuations in the proportion of smaller trout, and thus the mean length of the entire sample, may be caused by differences in population distribution or may reflect year-class fluctuations of the smaller trout prior to entry into the fishery. Additionally, current data indicate that differences in mean length of trout captured in old nets and new nets are due to differential efficiency in the capture of small trout. Since the mean length of prespawners is not affected by changes in the proportion of smaller trout, comparisons of prespawners may provide an effective means of detecting changes in mature trout, and these comparisons do not appear to be confounded by net type.

Differences in the length of prespawners between sample years were significant. The mean length of prespawners decreased in 1981, for the first time since 1974. Although the increasing trend reported by Jones et al (1981) could not be expected to continue unabated, the reasons for the current decline is unclear. It is assumed, however, that the decreases are not harvest related and are a response to natural regulating factors.

When prespawners were separated by sex, both males and females displayed significant differences in mean length between years. The response of prespawners to structure changes has been most pronounced in prespawning males (Figure 20). Since most large cutthroat are males, such a response could be expected. Although earlier changes can be attributed to difference in harvest regimes under various regulations, harvest levels have remained stable since 1975, supporting the assumption that current decreases are not related to harvest.

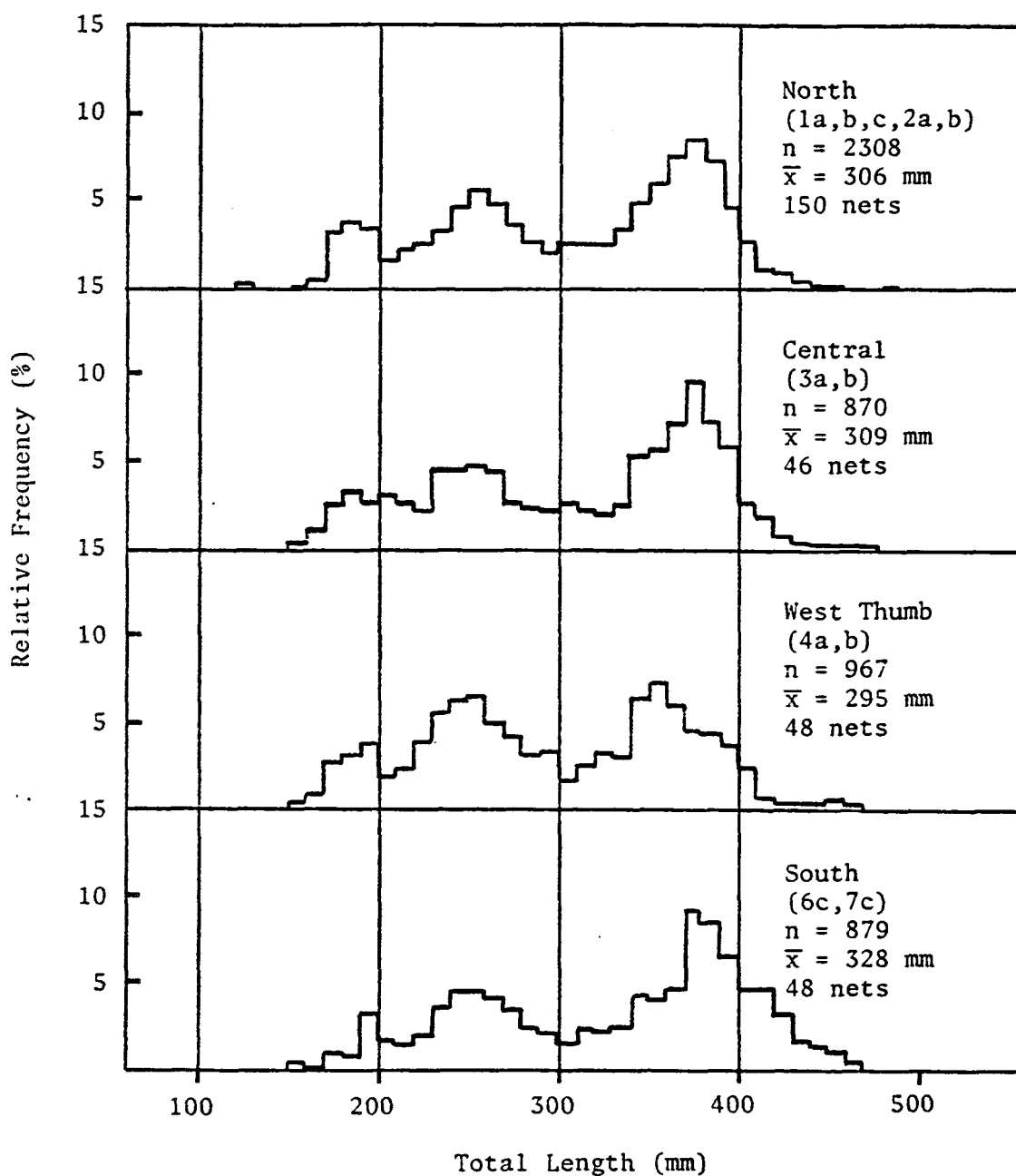


Figure 19. Length frequencies of cutthroat trout captured in largemesh gillnets at the 1.5-4.6 m depth interval in Yellowstone Lake, 1969-1981.

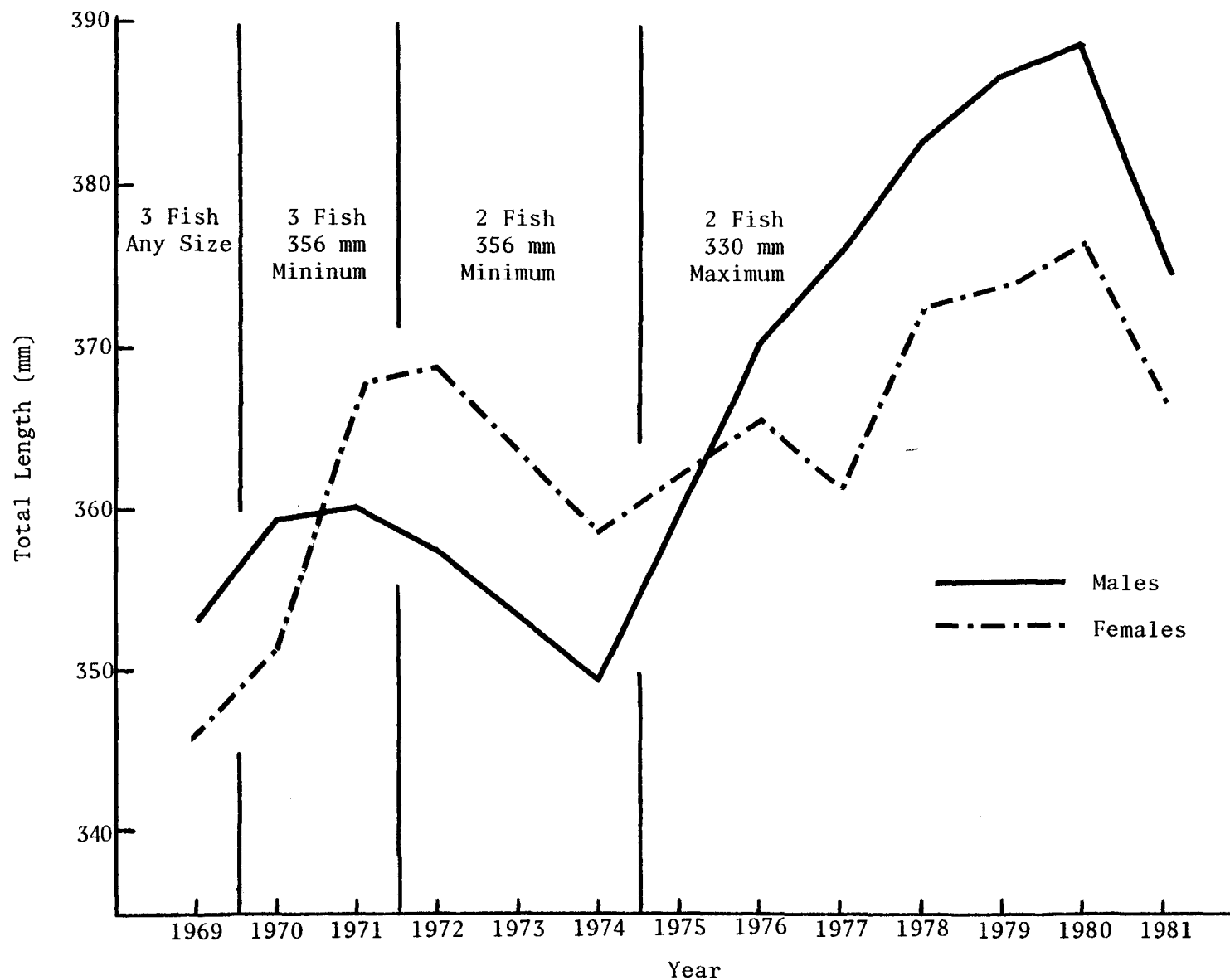


Figure 20. Mean total length of prespawning cutthroat trout captured in largemesh gillnets, Yellowstone Lake, 1969-1981.

Differences in length of prespawning trout from the four lake zones were also significant. Prespawners from the South (383 mm) were the largest and West Thumb prespawners (361 mm) were the smallest. Although prespawners from the North and Central zones (371 mm and 373 mm, respectively) differed from the other two zones, there was little difference between them.

Length frequency. A comparison of length frequency data from ten survey years illustrates several interesting trends (Figure 21). Since the 330 mm maximum size limit was imposed in 1975, there has been a shift towards larger fish in both the 330-400 mm and 400-500 mm groups. This is best illustrated by dividing the data into pre- and post-regulation groups (Figure 22). Aside from the general shift toward larger trout, another important change has been a depression in the length frequency curve between 300 mm and 340 mm since 1975.

In 1981, the proportion of trout over 356 mm was the second highest reported; however, there was a precipitous decline in the percentage of trout over 406 mm. These data were definitely reflected in prespawner lengths. The proportion of trout over 456 mm remained within the range reported since 1977. Although there may be several explanations for these results, interpretation is confounded by the use of new nets in 1981. Comparison of old and new nets from the same sites suggest the new nets may be more efficient in the range between 345 mm and 406 mm although differences are not statistically significant.

Although previous attempts at interpreting annual changes in length frequency distributions have provided insight into trends (Jones et al 1981), it appears that assignment of year-class has been erroneous. Current data indicate that the majority of trout less than 210 mm total length are I+ instead of II+ as previously indicated, and therefore, year-classes mentioned in prior reports (Jones et al 1981) have been increased by one year.

In 1977, a large pulse of trout less than 210 mm suggested that the 1976 year-class was very strong. In 1978, the increased frequency of trout in the 200-270 mm group was interpreted as growth of this year-class (Figure 21). When the majority of this year-class entered the fishery during 1979, the previously reported depression between 270-340 mm (Jones et al 1979) was dampened considerably. In 1980, the 1976 year-class progressed to the right, making a substantial addition to the proportion of trout over 330 mm. Continued growth of the 1976 year-class may partially explain the large percentage of trout between 356 mm and 406 mm in 1981.

The extreme paucity of trout less than 210 mm in 1978 (the 1977 year-class) may partially explain a decrease in numbers in 1980. The weak 1977 year-class was definitely evident in the 1981 Clear Creek spawning run as predicted by Jones et al (1981), and undoubtedly contributed to poor catch rate in 1981

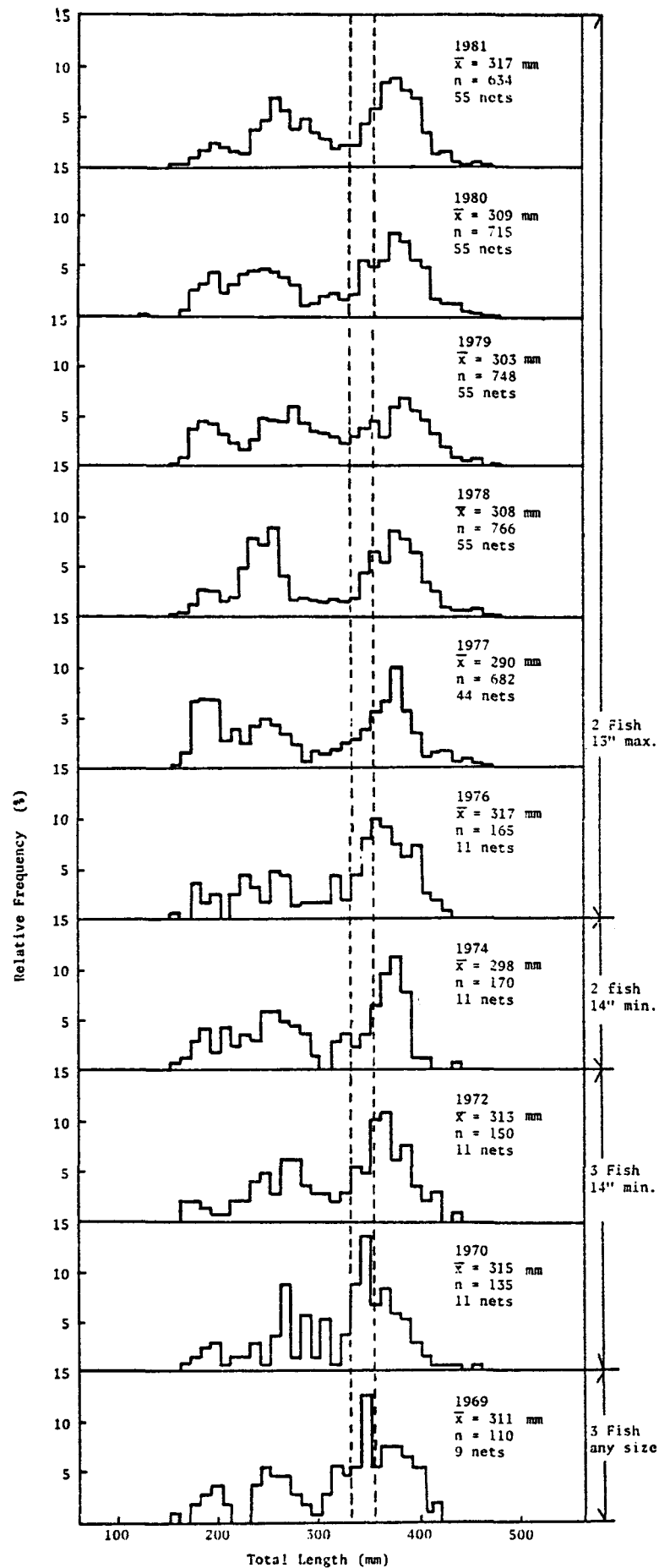


Figure 21 Length frequencies of cutthroat trout captured in largemouth gillnets at the 1.5-4.6 m depth interval, Yellowstone Lake, 1969-1981.

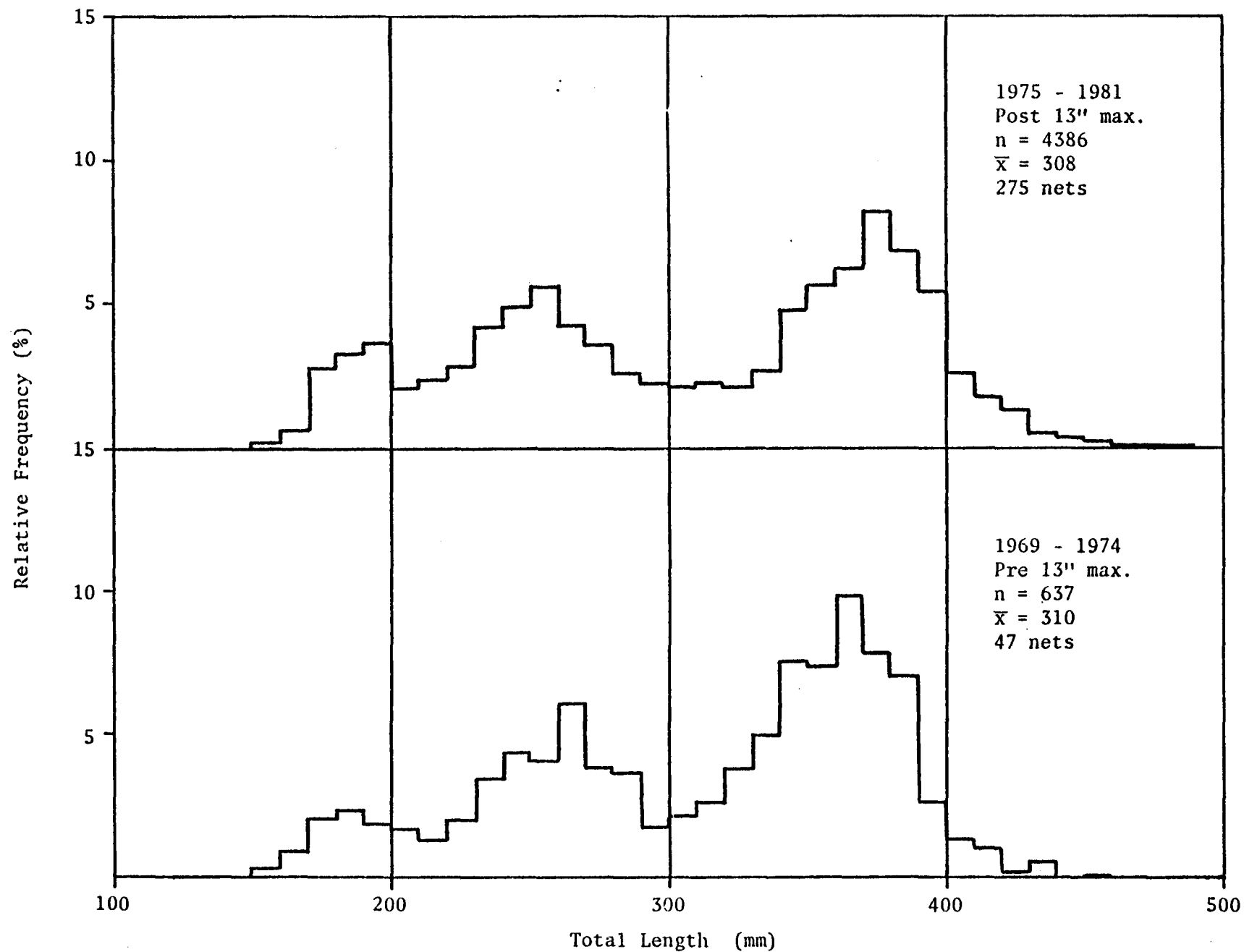


Figure 22. Length frequencies of cutthroat trout captured in largemouth gillnets at the 1.5-4.6 m depth interval in Yellowstone Lake, 1969-1981.

fishery. This extremely weak year-class is assumed to be the result of abnormally low runoff in 1977. Lake level data reveal that 1977 was the poorest water year since 1940.

Average or slightly above average year-classes are indicated by length frequency 1978 and 1979, which should halt the trend of decreasing numbers in the next several years. Depressed frequency of trout less than 210 mm in 1981 may suggest another weak year-class in 1980; however, new gillnets are significantly less efficient for trout less than 210 mm and therefore confound comparisons. Analysis of both summer and fall data indicates that new nets may underestimate trout less than 210 mm by almost 50 percent.

GSI values were compared to those collected in April, 1978 (Jones et al 1979) and those from the 1979 and 1980 fall gillnetting. Values for nonspawners over 304 mm appear almost identical in all samples. Although there were differences between the fall samples, females had higher values than males for all years, and spring values were at least 3 times greater for females. Fall GSI values for males were similar in the past three years, but were greater than estimates for spring males (1.90). Further replication of spring samples is needed to aid interpretation; however, these results suggest the existence of either early spring or late fall spawners in the cutthroat population.

Longnose Suckers 1969-1981

Average number per net. Although differences between years in the number of suckers captured are significant, reasons for these changes remain unidentified. It is doubtful these differences are due to population fluctuations since the longnose sucker is believed to be longlived in Yellowstone Lake (Jones et al 1977). These fluctuations may be partially due to schooling behavior; such behavior would intensify variation in gillnet catch. Although it was speculated that the sucker eradication project at Pelican Creek had contributed to the lower sucker catches in 1977 and 1978, the sharp increase in the number per net in 1979 suggests that variability continues to confound comparisons (Table 21).

Average size. Comparisons between years (Table 22) yields 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 (TL) ($r=0.94$) (Jones et al 1981). Since the latter two factors are probably related to distribution, annual variations affecting numbers captured may also affect variation in mean length.

The largemesh gillnetting program has provided only minimal information concerning the longnose sucker. If methods of ageing this species can be verified, they may provide a means of evaluating yearly fluctuations.

Table 21 Gillnet catches of longnose sucker by areas, Yellowstone Lake, 1969, 1970, 1971, 1972, 1974, 1976, 1977, 1978, 1979, 1980 and 1981¹⁾

Area	Number per net ²⁾											Average total length (mm)											Average weight (g)											
	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981 ³⁾	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981 ³⁾	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981	
1A	7	13	17	4	27	13	9	4	13	5	7	431	444	432	446	401	427	440	437	435	422	444	938	1076	963	1012	804	930	955	932	916	929	1023	
1B	28	3	75	4	26	30	3	19	21	12	4	319	392	267	291	340	334	408	353	442	330	344	415	791	273	260	561	527	647	594	567	502	500	
1C	39	4	7	0	15	13	8	7	11	9	6	411	427	433	—	428	414	434	424	429	428	420	855	670	935	—	952	951	1047	913	964	957	926	
2A	13	23	13	3	9	26	14	11	18	15	21	394	380	410	242	401	468	407	412	413	410	410	825	773	869	167	774	934	840	639	664	648	655	
2B	31	16	73	2	26	13	13	13	23	13	11	323	413	312	318	345	394	413	307	334	360	341	434	883	413	575	574	590	695	423	363	657	576	
3A	4)	3	4)	0	6	8	4	6	5	2	12	4)	425	4)	—	392	396	380	354	346	402	360	4)	1995	4)	—	775	765	716	593	751	777	629	
3B	4)	1	4)	0	18	14	8	3	13	15	12	4)	306	4)	—	355	373	361	329	325	322	379	4)	366	4)	—	546	651	656	478	484	466	703	
4A	5	4	4)	3	5	13	4	5	6	5	5	358	346	4)	422	385	411	409	409	397	416	418	621	692	4)	961	790	876	810	859	810	855	953	
4B	1	3	4)	2	17	14	8	9	12	17	8	425	317	4)	358	358	395	431	321	345	312	356	860	367	4)	600	637	720	529	467	502	420	527	
6C	1	0	4)	5	4	0	0	1	5	6	2	360	—	4)	330	369	—	—	285	285	300	217	614	—	4)	457	616	—	—	304	339	340	147	
7C	22	1	4)	5	22	16	10	2	7	11	13	398	214	4)	290	356	398	409	358	362	414	428	592	112	4)	286	577	816	949	595	669	685	345	
Totals	147	71	185	28	175	160	319	398	695	548	499																							
Averages												365	398	316	335	370	369	401	363	371	365	388		635	838	456	519	663	756	833	654	639	660	762

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 for 1978, 1979, 1980 and 1981, represents an average of 5 sets.

³⁾ New experimental gillnets were utilized in 1981; numbers, lengths and weights are not strictly comparable (see text).

4) Areas not sampled.

Table 22. Comparative largemouth gillnetting results, longnose suckers, 1.5-4.6 m depth interval, Yellowstone Lake, 1969, 1970, 1971, 1972, 1974, 1976, 1977, 1978, 1979, 1980 and 1981

Category	1969	1970	1971	1972	1974	1976	1977	1978	1979	1980	1981
Number of gillnets set ¹⁾	9	11	5	11	11	11	44	55	55	55	55
Average number of suckers caught per net	16.33	6.45	37.0	2.54	15.91	14.55	7.25	7.25	12.64	9.98	4.24 ³⁾
95% confidence interval of number of suckers caught per net	±10.65	±5.01	±42.17	±1.29	±5.92	±5.36	±1.83	±1.99	±2.07	±1.82	—
Percentage of suckers over 356 mm (TL)	66.0	83.1	34.0	42.9	69.7	80.6	80.9	58.3	62.6	59.3	71.5
Percentage of suckers over 406 mm (TL)	29.2	59.2	17.8	28.6	29.1	44.4	55.5	38.9	45.2	39.4	54.7
Percentage of suckers over 457 mm (TL)	6.1	12.7	2.7	7.1	5.7	7.5	14.7	11.1	13.0	12.6	16.0
Percentage of prespawning suckers ²⁾	92.1	100	100	88.2	100	95.2	100	92.5	87.8	78.1	80.0
Ratio of prespawning males to females	1.28	0.80	2.00	2.00	1.28	1.07	1.48	1.13	0.99	1.12	0.95
Average length (mm) of prespawning males	382	386	357	378	372	387	390	385	399	370	397
Average length (mm) of prespawning females	419	440	417	428	415	425	441	435	440	432	442
Condition factor K	1.207	1.235	1.207	1.205	1.215	1.227	1.229	1.187	1.197	1.171	1.179

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.

3) New monofilament nets were used in 1981; new nets averaged 9.51/net, old nets averaged 5.4/net for 5 sets; figure given is adjusted for comparative purposes.

Conclusions

Thus far, it would appear 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 eleven age groups prior to modern angler exploitation. It is doubtful, however, that the cutthroat population could reach historic levels under the current regulation. Ricker (1963) warns that exploitation as low as 5% annually may significantly alter a pristine population.

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 20, 23 and 24).

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 mechanisms of the 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 inches) and are beyond the legal limit within one growth 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-only) 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 would satisfy all but the most greedy anglers. Currently five large trout (356-457 mm or 14-18 inches) 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.

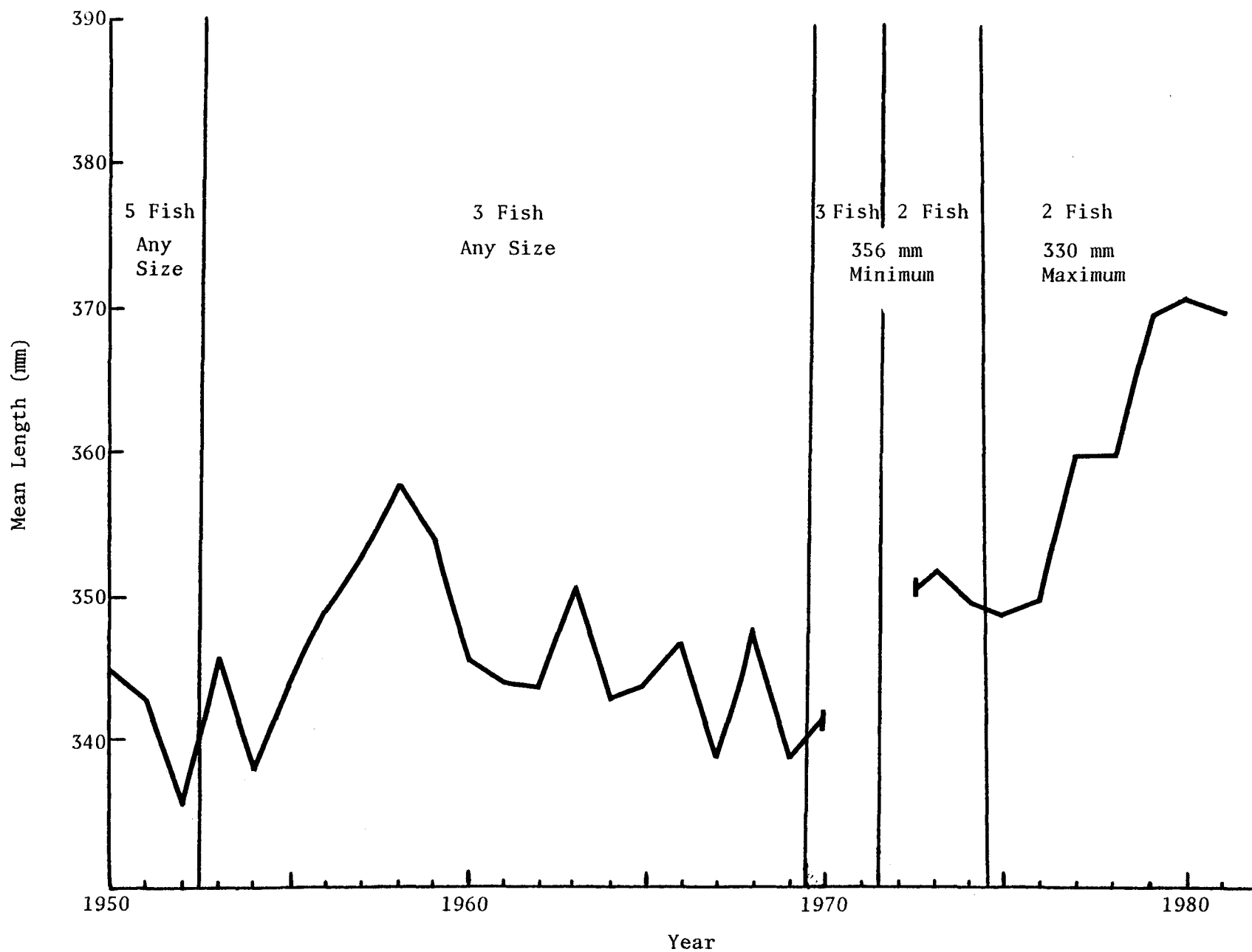


Figure 23. Mean length of cutthroat trout captured in the fishery measured at boatdocks (1950-1962) and shoreline-boatdocks combined 1963-1981.

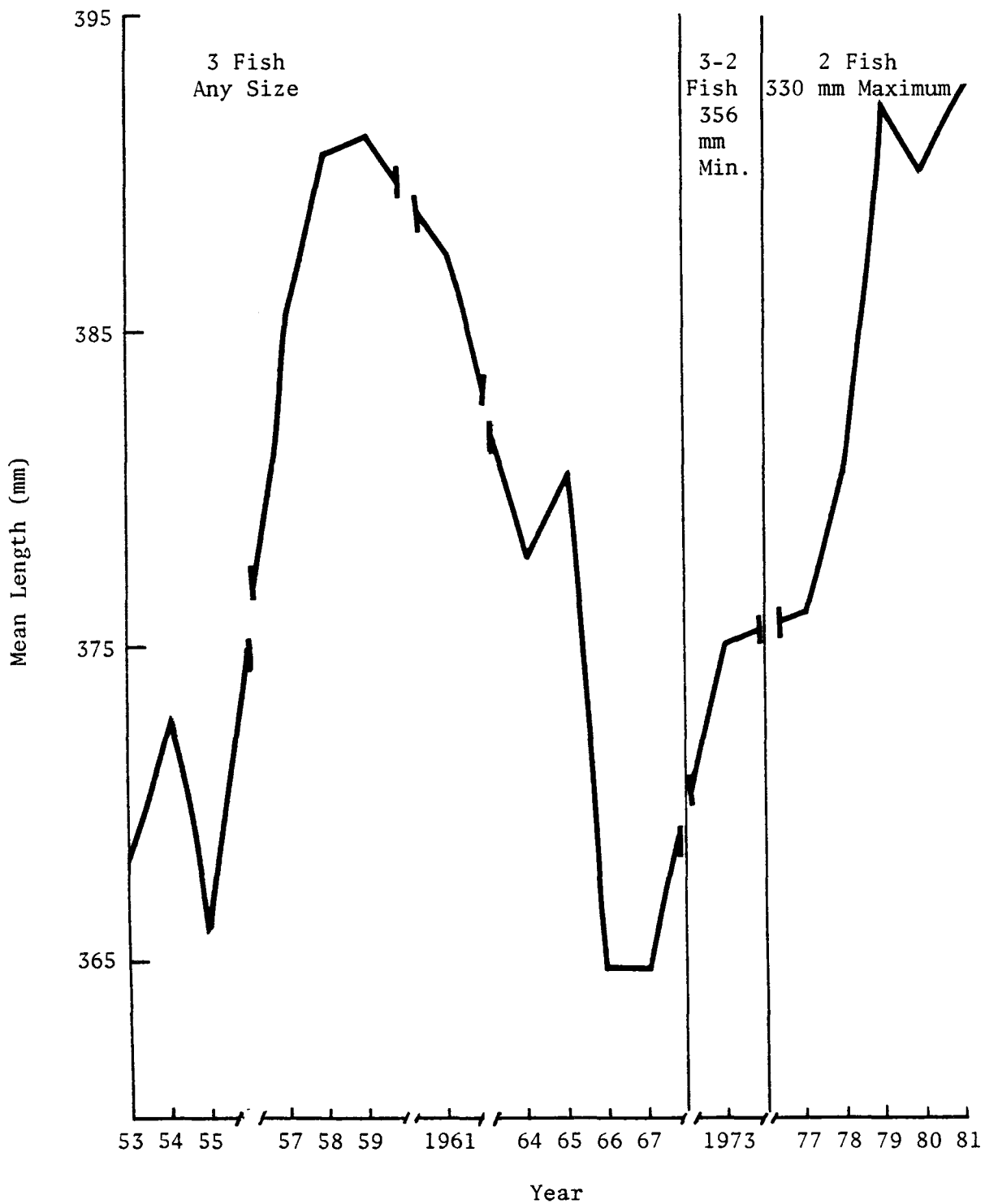


Figure 24. Mean length of cutthroat trout spawners entering Clear Creek, 1952-1981.

Results from Yellowstone Lake fishery during the first seven 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. The number of years required to evaluate such a regulation is unknown, but the decrease of larger fish after the first several years of the 356 mm minimum size limit and the continuing changes associated with the 330 mm maximum size limit underscore the necessity of long term research. Continued increases in angler use may have a profound effect on the cutthroat trout population despite the protection afforded under the current regulation.

YELLOWSTONE RIVER (CATCH AND RELEASE AREA)

Since the 14.0 km (8.7 mile) catch and release section of the Yellowstone River supports over 75% of the total use on the river (114 km or 71 miles in the park) and because this section alone is the second most popular fishery in the park, it will be treated as a separate fishery in this report. Although there may be some interaction with cutthroat trout from Yellowstone Lake, this portion of the Yellowstone River is also separated ecologically from the remainder of the river.

The catch and release area is divided by a 10.2 km (6.4 mile) section of river (Sulphur Caldron to Alum Creek) in Hayden Valley which has been closed to angling since 1965. The first 1.6 km (1 mile) below the Yellowstone Lake outlet is also closed, leaving 9.8 km (6.1 miles) of fishable water in the upper portion of the catch and release area. The lower portion (Alum Creek to the Upper Falls) is 4.2 km (2.6 miles) in length.

Fishery research on the Yellowstone River between the lake and the falls dates back to 1950 (Moore, Cope and Beckwith 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 1981, studies included a creel survey utilizing the VFR system (Jones et al 1977), continued sampling of spawning trout at LeHardy's Rapids and a fall electrofishing operation.

CREEL SURVEY

In 1981, the catch and release segment of the Yellowstone River supported the highest level of use yet reported (48,800 angler days). An estimated 19,000 anglers spent 126,800 hours and captured 127,100 cutthroat trout. Approximately 1,800 of these trout were illegally creeled. Despite the high level of use, catch rate was 1.00 trout per hour (Table 23).

When the upper and lower portions of the catch and release area were examined separately, the upper section alone (9.8 km) sustained 95% of the use for the entire area (46,500 angler days). A total of 17,800 anglers captured 123,800 trout while expending 122,200 angler hours. Catch rate was 1.01 trout per hour.

Only 2,200 angler days were reported by 1,150 anglers in the lower section. Despite lower effort (4,600 angler hours), catch rate (0.73 trout per hour) was significantly lower than the upper section. Expanded results indicate that of 3,300 trout landed, 180 were illegally creeled.

Table 23 Creel survey summary, Yellowstone River between Fishing Bridge and Chittenden Bridge, 1951-55, 1957-68, 1970 and 72, and 1973 through 1981¹⁾

	4.2 fish creel limit ⁴⁾ No size limit Bait fishing permitted	3 fish creel limit No size limit Bait fishing permitted	3 fish creel limit 14" minimum size limit Bait fishing prohibited	Catch and release fishing only Lures and flies only Bait fishing prohibited								
	1951 to 1955 $\bar{x}$	1967 to 1968 $\bar{x}$	1970 and 1972 $\bar{x}$	1973	1974	1975	1976	1977 ⁶⁾	1978	1979	1980	1981
Angler days (trips) ¹⁾	45,430	44,300	45,120	25,000	23,900	27,900	30,900	26,900	26,300	28,900	34,900	48,800
$\bar{x}$ length angler trip (hrs)	1.97	2.00	1.87	2.35	2.31	2.46	2.45	2.44	2.50	2.60	2.44	2.60
Total hours fished	89,500	88,625	84,400	58,250	55,200	69,200	75,700	65,600	65,700	75,300	85,100	126,800
Landing rate (trout/hr)	2)	2)	0.74	1.74	2.25	2.04	1.43	1.43	1.23	1.10	1.06	1.00
Total trout landed	2)	2)	62,550	102,200	124,700	141,100	108,200	93,900	80,800	82,800	88,700	127,100
Creel rate (trout/hr)	0.41	0.43	0.18	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01
Total trout creeled	36,700	38,100	14,425	590	550	690	980	1,300	1,100	1,500	2,000	1,800
Angler days per mile ⁸⁾	2,800	4,600	4,700	2,900	2,700	3,200	3,600	3,100	3,000	3,300	4,000	5,600
Angler days per acre ⁸⁾	63	105	107	63	60	70	78	68	66	72	87	122
Angler hours per acre ⁸⁾	123	209	199	147	138	173	189	164	164	188	213	317
Mean angler expertise ⁷⁾	-	-	-	-	-	-	2.00	1.98	1.99	2.02	2.04	2.01
% trout landed and released	2)	2)	76.2	99.4	99.9	99.5	99.8	99.6	99.6	99.3	99.0	98.6
$\bar{x}$ length trout creeled ⁵⁾	3)	13.5"	14.7"	3)	3)	3)	3)	14.3"	13.3"	13.2"	13.5"	13.1"
$\bar{x}$ length trout landed	3)	3)	3)	14.3"	14.4"	14.5"	14.7"	14.7"	15.1"	15.3"	15.3"	15.4"

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

2) Trout landed and released were not measured during this period.

3) Not measured.

4) Three years of 5 fish creel limit plus two years of 3 fish creel limit.

5) Illegal beginning in 1973.

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

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

8) Yellowstone River between Fishing Bridge and Chittenden Bridge is 16 mi long and averages 1.3 acres. Area open to fishing was 9.7 mi and 265 acres between 1965 and 1972. Beginning in 1973, the open area was 8.7 mi and 235 acres.

Average size of cutthroat trout landed rose to a record high of 392 mm (15.4 inches). Trout from the upper portion were significantly larger than those from the lower section (392 mm and 377 mm, respectively). Creeled trout were also larger in the upper segment (356 mm and 302 mm, for upper and lower sections, respectively) and therefore influenced the mean length of creeled trout for the entire catch and release area (332 mm).

Satisfaction indicies indicated 81% of the anglers were satisfied by their overall experience, with 75% satisfied with number and 86% with sizes. The proportion of single day anglers landing one or more trout was 67%. Although these figures have declined somewhat in recent years, they remain above the park mean. Average expertise remains high at 2.01.

LE HARDY'S RAPIDS

Annual monitoring of the cutthroat spawning run at LeHardy's Rapids was initiated in 1974 in order to provide an alternate means of evaluating the catch and release-only regulation on the Yellowstone River (Fishing Bridge to Upper Falls). This program has provided valuable data concerning the cutthroat population structure, independent of the VFR system. During 1981, collections were made weekly from June 1 through July 20. Established sampling procedures (Varley et al 1976) remained unchanged except that all captured trout were tagged with numbered internal anchor tags (Dell 1968) prior to release.

Results

The scarcity of trout during the initial collections indicated that the main portion of the run had not yet commenced. Numbers increased between June 11 and July 6, and 100 trout were collected each week. After July 6, numbers dwindled rapidly for the remainder of the study.

A total of 571 cutthroat trout adults and 7 subadults were captured in 1981, but no other fish species were observed. Mean length (394 mm) for 383 males was significantly greater than mean length (373 mm) for 188 females (Table 24). There were no significant changes in mean length during the study period.

Mean length of males, females and all adults increased slightly from 1980, and mean length for females and all adults were the highest reported since the program began (Figure 25). The percentage of adult trout over 406 mm increased from 1980. Although the annual proportion of trout over 406 mm may be influenced by sampling procedures, there has been a significant increase since 1974 (Figure 26).

The male:female ratio rose to a record high of 2.0:1 in 1981. Since 1974 and 1975, when M:F ratios were 0.72:1 and 0.79:1, respectively, males have

Table 24 Total number and average length, weight, and condition factor of cutthroat trout for each year sampled at LeHardy's Rapids, Yellowstone River, 1974 - 1981

Year	Adult Males				Adult Females				All Adults				Immatures & Subadults			
	Number captured	Avg length (mm)	Avg weight (g)	Avg K factor	Number captured	Avg length (mm)	Avg weight (g)	Avg K factor	Number captured	Avg length (mm)	Avg weight (g)	Avg K factor	Number captured	Avg length (mm)	Avg weight (g)	Avg K factor
1974 ¹⁾	177	375	394	0.75	244	352	339	0.73	463	362	363	0.76	43	177	60	0.84
1975	338	385	451	0.78	476	359	363	0.73	725	370	401	0.78	40	205	116	1.04
1976 ¹⁾	531	384	431	0.75	423	362	360	0.75	954	375	399	0.75	29	173	71	1.04
1977 ¹⁾	133	382	429	0.77	111	362	370	0.73	244	373	402	0.77	2	250	139	0.87
1978	399	386	458	0.78	353	364	413	0.75	752	376	437	0.81	68	169	67	0.96
1979	334	394	514	0.83	232	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	0.81	133	373	440	0.84	521	387	478	0.82	7	308	286	0.89

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.

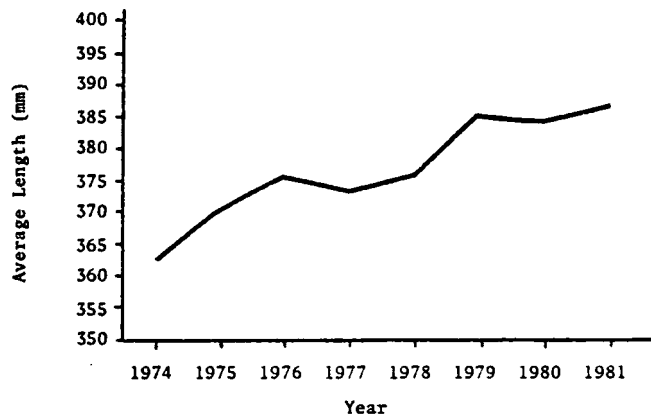


Figure 25. Average lengths for the entire season for all adults, LeHardy's Rapids, 1974-1981.

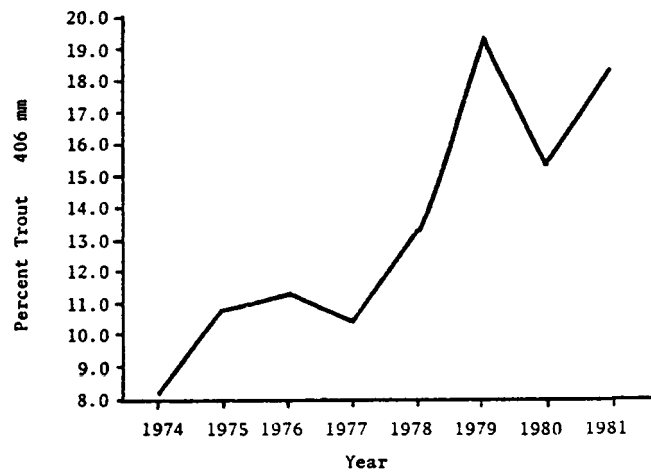


Figure 26. Percentage of adult trout greater than 406 mm captured at LeHardy's Rapids, 1974-1981.

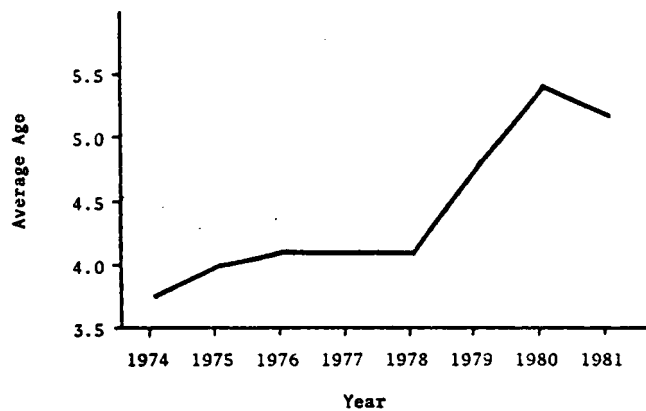


Figure 27. Average age of all adult trout captured at LeHardy's Rapids, 1974-1981.

dominated all collections (Table 24). This situation appears quite anomalous, since M:F ratios from tributaries to Yellowstone Lake such as Clear, Cub and Pelican Creeks have been significantly lower (0.59 - 0.74:1) since 1945 (Jones et al 1981, Ball and Cope 1961). Although none of the various size and creel limit regulations implemented on Yellowstone Lake since 1945 have appreciably changed the M:F ratio, the change in M:F ratio at LeHardy's Rapids is apparently associated with the elimination of harvest under the catch and release-only regulation.

A total of 74 cutthroat trout were aged using the scale method (Bagenal and Tesch 1978). Expanded age estimates for the entire sample were calculated using an age-length key (Westerheim and Ricker 1978). Mean age of males, females and all adults were 5.5, 5.0 and 5.2 years, respectively. Although mean age declined somewhat from 1980, a definite trend of increased age since 1974 is evident (Figure 27). Age VII+ trout comprised approximately 9% of the sample, and age VIII+ trout (3% of the sample) were observed for the first time in 1981.

YELLOWSTONE RIVER ELECTROFISHING

For the past two years, personnel of this project have assisted researchers evaluating hooking mortality on the upper part (Fishing Bridge to Sulphur Caldron) of the catch and release portion of the Yellowstone River. In 1981, a section of stream in the vicinity of the cable car (3.2 km below Fishing Bridge) was electrofished in a joint operation which included personnel from this project, Idaho State University and Idaho Fish and Game. The objectives of this project were to obtain a population estimate of cutthroat trout for comparisons with snorkel counts, and obtain length, weight and age data from the captured trout.

Methods

Two electrofishing boats were utilized to sample a 300 m section of the Yellowstone River on September 29, 1981. All trout captured were marked with a caudal clip, enumerated and released. On September 30, both boats worked the area again during a recapture run. All captured trout were inspected for marks, measured (total length to nearest mm) and weighed (to the nearest 2 g). Sex was determined for each trout and scales were collected from the first 100 trout captured.

Population estimates for the study section utilized the adjusted Petersen technique (Ricker 1975). Procedures developed by Robson and Regier (1964) provided evaluation of statistical bias, and fiducial limits were calculated from Ricker (1975). Age was determined by the scale method (Bagenal and Tesch 1978); estimates were expanded for the entire sample using an age-length key (Westerheim and Ricker 1978).

Results

A total of 103 cutthroat trout were marked and released on September 29. The next day, three marked trout were reported in the recapture sample of 145 trout. Additionally, one marked trout was found dead and therefore subtracted from total of marked fish. The resulting estimate was 3,760 cutthroat trout in the 300 m section with confidence limits of 1,709 to 25,063. Statistical bias due to the low number of marked trout in the recapture sample indicates an underestimation of the population by at least 2%.

Mean length and weight of 145 cutthroat trout in the recapture run were 397 mm and 594 g, respectively, and the male:female ratio was 0.41:1. There was no significant difference in mean length for males (399 mm) and females (396 mm). Comparisons of mean length of trout with hooking scars (397 mm) and those without scars (397 mm) also failed to yield significant differences.

Estimated ages for 66 of the captured trout ranged from III+ to VI+. The mean age expanded for 140 trout was 4.8 years. Average age for males (5.2 years) was somewhat higher than females (4.7 years).

Discussion

Although statistical bias indicated in the population estimate would lead to an underestimate, the calculated density is over twice as high as the expanded snorkeling counts for this section. Physical characteristics of the section probably induced error in electrofishing attempts by allowing disturbed fish to move freely into or out of the study section. Gear inefficiency undoubtedly compounded this problem by distressing the trout without actually incapacitating them and thereby stimulating movement out of the area. Although section characteristics might hamper snorkel counts in the same manner, very little disturbance of this censused trout was noted. It would appear, therefore, that the snorkel estimate (1,376 cutthroat trout) more accurately reflects the population in this section.

The mean length of cutthroat trout in this sample is slightly larger than mean lengths from LeHardy's Rapids and the creel survey, but all three samples illustrate the significant increase in size since catch and release regulations were implemented in 1973 (Table 25). Although one prior experiment indicated a difference in mean length of trout with and without hook scars (Jones et al 1981), lengths from the two groups were equal in the current study. Lack of significant size differences between sexes and the low M:F ratio also differed from previous studies. Reasons for these apparent anomalies are unknown, but gear efficiency and time of year undoubtedly confounded such comparisons.

Mean age of the sampled trout was lower than similar determinations for spawners at LeHardy's Rapids. Such a discrepancy might be expected,

Table 25. Percentage of trout in various length categories, Catch and Release Section, Yellowstone River, 1973-1981

Year	305 mm	356 mm	406 mm	457 mm	508 mm
1981	88.2	71.0	30.8	6.2	0.9
1980	93.8	77.8	37.6	9.2	1.2
1979	92.5	77.5	35.9	8.7	1.0
1978	91.1	71.6	33.2	9.0	1.8
1977	89.2	68.7	26.2	5.3	0.9
1976	90.0	67.7	24.3	4.4	0.7
1975	92.7	60.4	15.4	2.6	0.3
1974	89.5	63.3	26.6	6.6	1.2
1973	86.3	62.5	17.3	3.1	0.7

since the spawning run is comprised of mature individuals only. As expected, average age was greater for males. Since age is closely related to length, average age is also influenced by gear selectivity. Despite discrepancies, however, these data help to substantiate the increase in age since the implementation of the catch and release regulation.

Conclusion

Angler use and effort have increased steadily since catch and release regulations were implemented in 1973, with a sharp increase (40% over 1980) in 1981. Despite a precipitous decline in use after this regulation was initiated current levels are the highest yet recorded (Table 23). In terms of fishable water these figures equate to 4,980 angler days per km (5,600 angler days per mile), or 301 angler days per hectare (122 angler days per acre). On this basis, the catch and release portion of the Yellowstone River sustains the highest levels of use in the park and is probably one of the most intensively fished wild trout fisheries in North America.

As might be expected, 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 per hour in 1974. As effort continued to rise, landing rates gradually declined. What is most significant, however, is that despite record levels of effort, the landing rate remains at 1.00 trout per hour.

Despite 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's Rapids reveals a definite shift towards larger trout (Figure 28) and mean length of trout captured in this study has risen significantly since 1973 (Table 25). Length frequency and mean length of cutthroat trout landed by anglers also indicates a substantial increase in larger trout (Table 26). These findings are strongly supported by measurements of trout captured during the fall electrofishing operation. A general increase in average age has accompanied the increase in size at LeHardy's Rapids.

Although there is an inverse relationship between effort and landing rate, changes in population structure have also influenced this measurement of angler success. It must be remembered that as biomass shifts toward older and larger trout, the actual number of trout will probably decrease (Nikolskii 1969). The interaction of these two factors (increases in effort and shifts in structure) may continue to gradually lower landing rates in the future.

Two variables which are critical to the success of the catch and release regulation are hooking mortality and recatchability. Although hooking

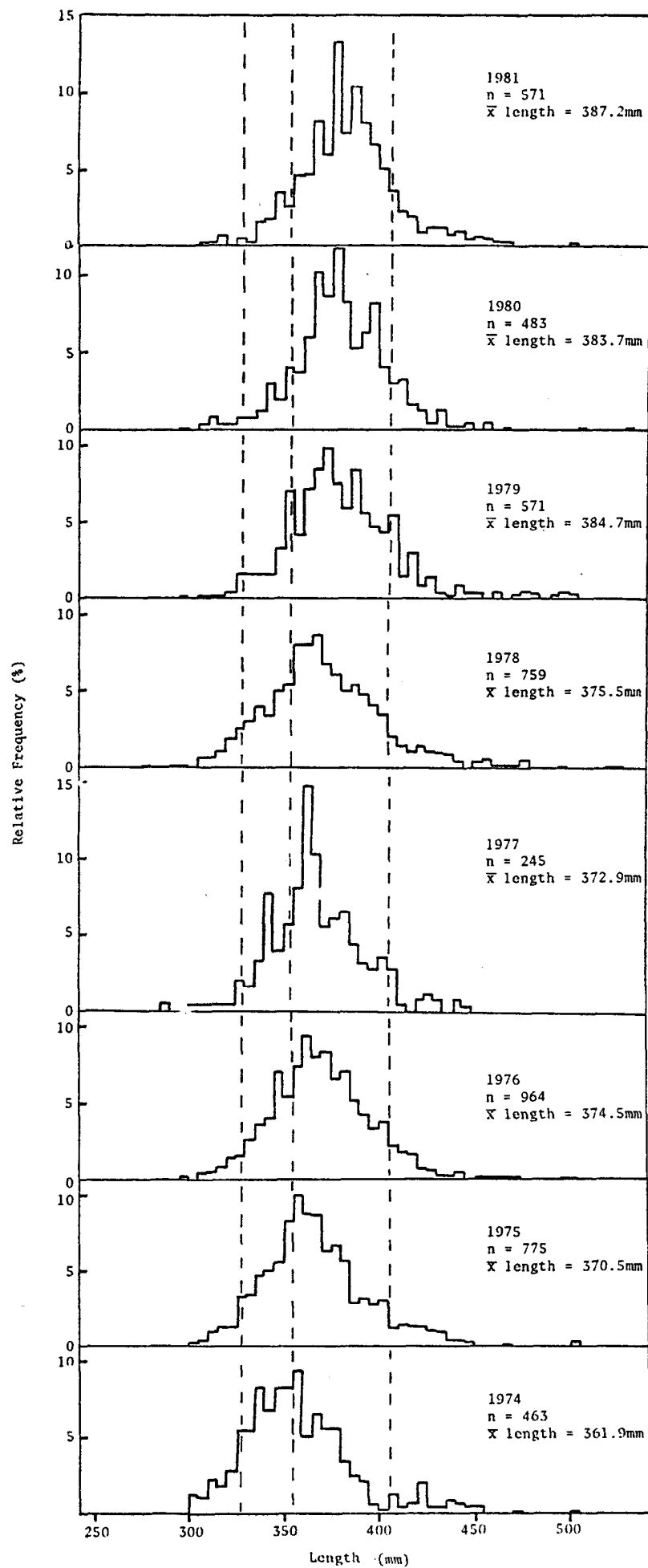


Figure 28 Length frequency of all adult cutthroat trout, Lellardy's Rapids, 1974-1981.

Table 26. Mean total lengths of cutthroat trout captured in the Yellowstone River, 1952-1981

Regulations	Year	Mean total length in mm (inches)				Sample size	Area	Source
		Dip net	Electrofishing	Hook and line	Creel			
5 fish bag limit, no size limit	1952 ¹⁾	368 (14.5)				382	LeHardy's Rapids	Cope 1953
	1952				330 (13.0)	107	Above Upper falls	Cope 1953
3 fish bag limit, no size limit	1967		345 (13.6)			346	Excluding Hayden Valley	Unpublished data
	1967				338 (13.3)	127	Excluding Hayden Valley	Dean and Varley 1973
	1968		351 (13.8)			351	Excluding Hayden Valley	Unpublished data
	1968				348 (13.7)	487	Excluding Hayden Valley	Dean and Varley 1973
3 fish bag limit, 14 inch min. size limit	1970				378 (14.9)	43	Excluding Hayden Valley	Dean and Mills 1971
	1970			424 (16.7)		17	Hayden Valley	Dean 1972
	1971		447 (17.6)			309	Hayden Valley	Dean 1972
	1971		361 (14.2)			378	Fishing Bridge	Dean 1972
	1972				368 (14.5)	125	Excluding Hayden Valley	Dean and Varley 1973
	1973				363 (14.3)	2,798	Above falls, excluding Hayden Valley	Jones et al 1976
Catch and release	1974 ¹⁾	362 (14.3)				463	LeHardy's Rapids	Dean et al 1975
	1974				372 (14.6)	3,926	Excluding Hayden Valley	Dean et al 1975
	1975 ¹⁾	370 (14.6)				775	LeHardy's Rapids	Varley et al 1976
	1975				366 (14.4)	10,540	Above falls, excluding Hayden Valley	Varley et al 1976
	1976 ¹⁾	375 (14.8)				964	LeHardy's Rapids	Jones et al 1977
	1976				373 (14.7)	11,062	Above falls, excluding Hayden Valley	Jones et al 1980
	1977 ¹⁾	373 (14.7)				245	LeHardy's Rapids	Jones et al 1978
	1977				373 (14.7)	10,239	Above falls, excluding Hayden Valley	Jones et al 1980
	1978 ¹⁾	376 (14.8)				759	LeHardy's Rapids	Jones et al 1979
	1978				382 (15.1)	8,350	Above falls, excluding Hayden Valley	Jones et al 1980
	1979 ¹⁾	385 (15.2)				571	LeHardy's Rapids	Jones et al 1980
	1979				387 (15.2)	3,495	Above falls, excluding Hayden Valley	Jones et al 1980
	1980 ¹⁾	384 (15.1)				483	LeHardy's Rapids	Jones et al 1981
	1980				390 (15.3)	7,769	Above falls, excluding Hayden Valley	Jones et al 1981
	1981 ¹⁾	387 (15.2)				571	LeHardy's Rapids	Current Report
	1981				392 (15.4)	9,904	Above falls, excluding Hayden Valley	Current Report
	1981		397 (15.6)			148	Cable Car Area	Current Report

1) All adults only.

mortality studies on this section are incomplete, researchers report that mortality may be less than 0.5% on a per capture basis, or 3% of the total population (Schill personal communication). 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 per 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 why such a regulation can support high levels of effort on cutthroat trout.

Although it is possible that effort may rise to a point that catch and release regulations 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 these factors are closely related to the species and the habitat involved. The high recatchability of the cutthroat trout and the 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 1964, data describing the basic physical, chemical and biological parameters of 111 Park lakes has been collected in conjunction with the lake survey program. The objective of this program has been the fundamental inventory of lacustrine systems to provide baseline data necessary to assess changes through time. Analysis of angler impact has been an integral part of this program and has been utilized to monitor the effects of various angling regulations. In 1981, aquatic surveys were conducted on three lakes.

Although field collection techniques have varied somewhat during the past 17 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 have been collected for many of the lakes surveyed prior to 1974.

Plankton samples have been collected with a Wisconsin plankton net, and a single 9.1 m oblique tow, or its equivalent, was made in each lake 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. The 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.

INDIAN POND (SQUAW LAKE)

Indian Pond is located approximately 4.5 km from Fishing Bridge Junction along the East Entrance Road. Since there are no natural barriers to fish movement in the short (300 m) outlet stream, cutthroat trout from Yellowstone Lake probably gained entry historically during periods of high water. The lake was stocked almost annually from 1923 to 1955 with cutthroat trout (Varley 1981), and during this period over 4 million fry and fingerling were planted in an attempt to support a trout fishery. The lake chub (Couesius plumbeus), an exotic to Yellowstone Lake drainage, was first collected from Indian Pond in 1957. Two years later (May, 1959), the lake was chemically treated to prevent this species from entering Yellowstone Lake. No official attempts to restock the lake have been documented since that time.

In 1966, Arnold and Sharpe (1967) conducted a basic survey of the physical, chemical and biological parameters of Indian Pond. They captured four large cutthroat trout (430-568 mm) and 53 salamanders (Ambystoma sp.). Dean (1972) collected 10 cutthroat trout, 61 lake chub and one longnose sucker during the 1971 gillnet sampling.

On July 15, 16 and 18, 1981, the lake was resurveyed in order to document the current status of the fish community and to supplement data gathered during the previous studies. Additionally, an updated bathymetric map was developed by the Park Geologist, Rick Hutchinson, from a survey conducted through the ice cover during January and February, 1982 (Figure 29).

Physical

The extremely small drainage area of Indian Pond (16 ha) consists solely of an ancient hydrothermal explosion crater (Christiansen and Blank, Jr. 1975). Surficial deposits of sandy lake sediments (Richmond 1977) are generally vegetated by sagebrush (Artemisia tridentata) and mixed grasses. A 10-20 meter wide band of sedges borders most of the lake; however, a stand of lodgepole pine occurs along the southeast shore. Numerous angler trails descend from the campground which is situated among the trees.

The green colored water of Indian Pond was visually turbid during the survey, and secchi disc visibility was only 3.2 m on a calm, sunny day (Table 27). Water temperature varied from 17.8 °C at the surface to 14.4 °C at the bottom (22 m). These temperatures were identical to those recorded by Arnold and Sharpe (1967). Although the lake was not completely stratified, there was evidence of surface warming. A thermocline occurred between 4.3 m and 5.6 m.

The lack of shoreline erosion indicated a moderate degree of wind protection by the lodgepole pine trees on the southwestern shore and the steep slopes of

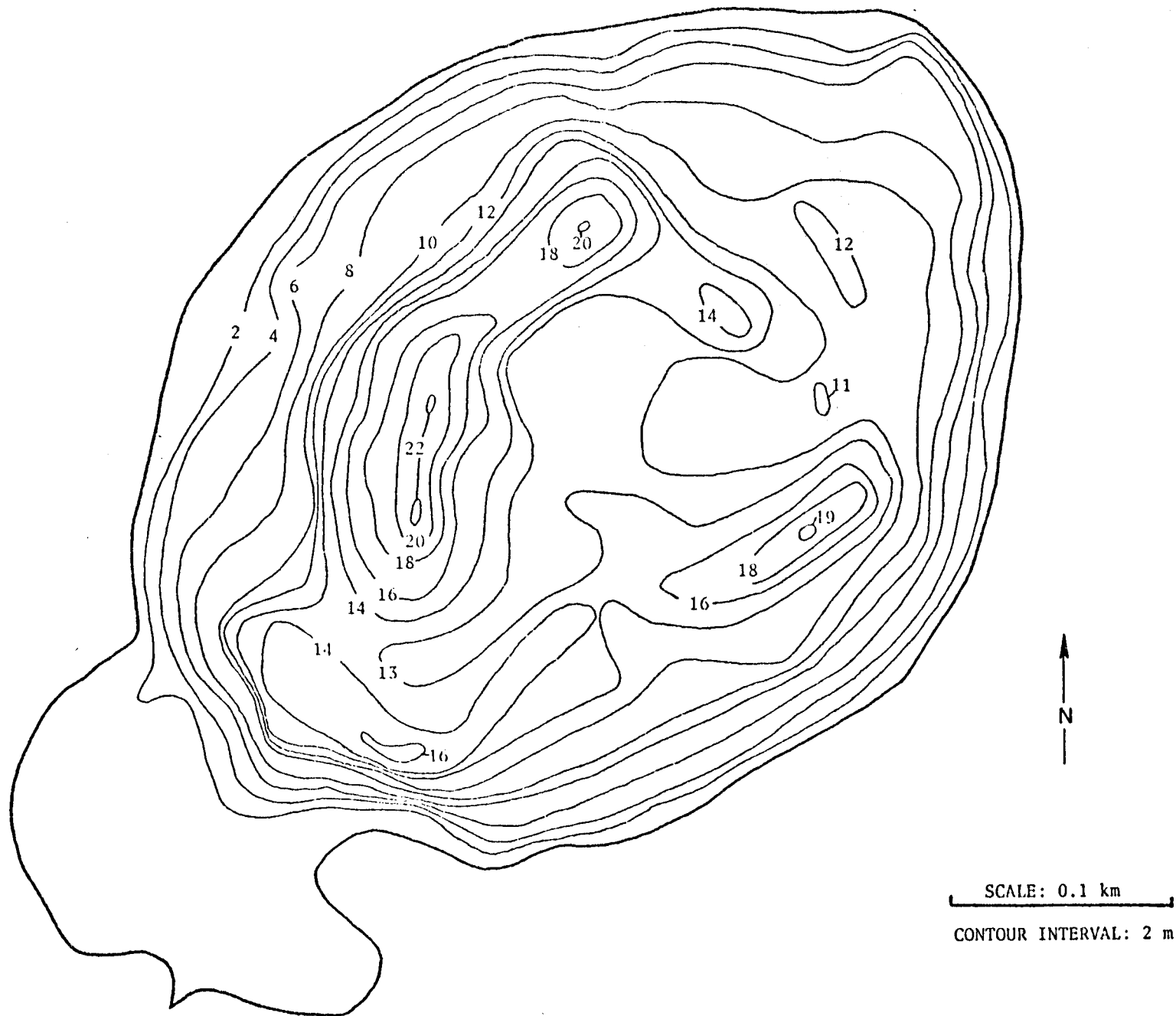


Figure 29. Indian Pond (Squaw Lake), Yellowstone National Park, 1981.

Table 27. Physical characteristics of back-country lakes surveyed in Yellowstone Park, 1981

Table 27. Physical characteristics of back-country lakes surveyed in Yellowstone Park, 1961																	
Lakes	Location ¹⁾	Elevation		Drainage Area ²⁾		Surface Area		Maximum Depth		Average Depth		Capacity		Secchi Visibility		Tributary to:	Major Drainage
		meters	feet	hectares	acres	hectares	acres	meters	feet	meters	feet	m ³	acre ft.	meters	feet		
Riddle	536.0E 4911.5N	2412	7913	754	1863	110.8	274 ³⁾	7.9	26	2.5	8.2 ⁴⁾	2,771,989	2247.	3.0	10	Solution Creek	Yellowstone River
Indian Pond (Square)	553.7E 4934.0N	2362	7750	16	39	9.8	24.3 ⁵⁾	22.0	72	9.0	29.0	867,533	719.3	3.2	10.5	#0069	Yellowstone River
Sylvan	566.8E 4925.5N	2563	8410	176	435 ⁶⁾	11.4	28.2 ⁶⁾	6.7	22	2.3	7.4 ⁶⁾	257,461	208.7 ⁶⁾	6.1	20	#0096	Yellowstone River

¹⁾ Coordinates utilizing Universal Transverse Mercator 1000 meter Grid System on USGS map, Yellowstone National Park, N4400-W10948/59x82, 1961.

²⁾ As calculated from USGS maps, Wyoming-Yellowstone National Park, 15 min. series, 1:62,500.

³⁾ Reported by Dean (1972).

⁴⁾ Estimated from bathymetric map in Dean et al (1975).

⁵⁾ Reported by Arnold and Sharpe (1967).

⁶⁾ Reported by Jones et al (1979).

Table 28. Mean calculated length at annulus for cutthroat trout captured in Indian Pond, 1966, 1971 and 1981

Source	Year	Number	Mean calculated length at annulus					
			I	II	III	IV	V	VI
Arnold and Sharpe (1967)	1966	3	110	227	358	446		
Dean (1972)	1971	10	66	130	269	366		
Current study	1981	10	63	153	277	344	421	555

the crater in which the lake lies. Water fluctuation appeared to be minor (approximately 0.15 m), and the circular shape of Indian Pond yielded a poor shoreline development (Lagler 1956). Shoal substrate was mostly gravel and rubble covering obsidian sand. Sedimentary deposits of conglomerate-limestone (Arnold and Sharpe 1967) form precipitous subaqueous cliffs along the southern shore. Profundal sediments were fine clay-silt muck covered with a fine layer of organic detritus.

Groundwater is the primary water source. Seepage was common in the sedge covered areas near the shore, and two small springs located on the northwest and southeast also drained into the lake. Several gravel areas in the shallow water displayed evidence of subaqueous springs. Much of the inflowing waters were warm, and areas near the northeast shore are free of ice throughout the winter.

The outlet stream (#0089) flows approximately 300 m before entering Yellowstone Lake. Although very little water was flowing in the narrow (0.6 m) channel at the time of survey, there are no barriers to fish movement. During spring runoff, movement between the two lakes could be easily accomplished in this low gradient (5%) stream. Substrates closest to the lake outlet were comprised of detritus silt, and only limited amounts of sand and gravel suitable for spawning were observed in the stream.

Chemical

Indian Pond was classified as a sodium-chloride type lake. Only two other lakes in the Park have received this classification, and all three lakes have high nutrient levels. Total dissolved solids for Indian Pond have varied from 687 ppm in 1979 to 714 ppm in the present study. These levels are almost three times the mean level for 59 non-dilute Park lakes ($\text{TDS} > 50 \text{ ppm}$).

Almost all chemical parameters were well above the Park mean for sodium-chloride lakes, which as a group have higher than average nutrient levels. Nutrients which are considered important to lake productivity such as silica, phosphate and bicarbonates were abundant (Table 29). Nitrate level was slightly below the Park mean and may be limiting in Indian Pond; however, Kjeldahl nitrogen was slightly above average.

Groundwater inputs have a decided impact on the chemical parameters. According to Hem (1970) most natural waters are low in chlorides with the exception of those affected by high chloride groundwater usually associated with hot springs and volcanic gasses. Additionally, waters in which chloride is the predominant anion most often have sodium as the dominant cation (Hem 1970). Groundwater is also associated with elevated levels of CO_2 and bicarbonates, and Hutchinson (1975) reports that most silica is the result of the solution of rocks in the presence of CO_2 .

Table 29. Chemical characteristics of back-country lakes and streams surveyed in Yellowstone National Park, 1981

	Riddle Lake	Indian Pond (Snow Lake)	Sylvan Lake	Arpitheater Creek	Cougar Creek	Hellroaring Creek	Little Firehole Creek	Tetble Creek	Pelican Creek	Soda Butte Creek	Spring at old Trout Cr. Dump
	2 m 9/1-2/81	2 m 7/14/81	2 m 8/7-8/81	9/31/81	7/14/81	7/28-30/81	8/4/81	8/31/81	7/1/81	8/18-20/81	8/31/81
Water Temp. °C *	13.8	17.7	16.9	9.44		16.1		8.89		8.33	
Spec. Cond. µhos *	40	1100	80	89		85		175		190	
pH *	6.75	8.0	7.4**	7.4		7.8		8.4	7.4	8.0	
Dissolved O ₂ *	5.8	8.0	7.4								
Pheno alk.	0	0	0	0	0	0	0	0	0	0	0
Total alk.	12	102	48	46	16	42	60	108	36	96	156
Ca hardness	12	36	48	30	20	30	30	72	18	72	60
Total diss. solids	34	714	66	50	75	65	74	160	52	130	470
Carbonate alk.	0	0	0	0	0	0	0	0	0	0	0
Bicarbonate alk.	12	102	48	48	16	42	60	108	36	96	156
Carbonates	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates	14.6	124	59	50	20	51	73	132	44	117	190
Hydroxides	0	0	0	0	0	0	0	0	0	0	0
Carbon dioxide	2.4	26	3.9	1.6	5.3	6.8	3.1	1.4	15	3.1	63.6
Chloride	0.9	292	3	1.2	1	3	3	1	1	9.4	1
Sulfate	15	7	4	0.6	2.2	5.5	8	1.1	6	13	130
Fluoride	0.28	7.8	0.12	0.16	2.9	0.1	3.6	0.16	0.52	0.005	0.93
Phosphate	0.12	2.2	0.09	0.37	0.09	0.16	0.65	0.34	0.28	0.16	1.7
Potassium	0.07	11	1	1.8	1	1.6	2.9	1.2	1	1	1.7
Mg hardness	2	18	18	12	1	12	30	1	9	24	54
Calcium	4.8	14	19	12	8	12	12	29	7.2	29	24
Magnesium	0.5	4.4	4.4	2.9	0.2	2.9	7.3	0.1	2.2	5.8	13.1
Sodium	0.6	201	2.7	2.4	6.2	1.3	7.2	0.9	4.5	4.5	9.9
Iron	0.24	0.15	0.01	0.02	0.01	0.02	0.03	0.02	0.25	0.1	78.8
Manganese	0.05	0.05	0.05	0.1	0.05	0.05	0.05	0.15	0.05	0.05	23.5
Copper	0.03	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Silica	0.1	37	1.8	2.5	17	17	5.2	2.5	7	0.5	15
Color (PCU)	30	0	0	0	0	0	0	0	0	0	—
Turbidity (NTU)	0.7	2.9	0.69	0.49	4.3	0.56	1.3	0.25	1.3	2.3	707
TOC	8.6	8.0	4.9	1.9	0.97	0.5	1.6	1.9	6.2	1.6	5.3
Ortho-phosphate	0.09	2.2	0.09	0.12	0.09	0.09	0.12	0.08	0.19	0.12	0.09
Kjeldahl N	0.84	0.83	0.12	0.47	0.2	0.02	0.08	0.17	0.25	0.04	8.4
Nitrate N	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02

* Field measurements, all others made by commercial laboratory.

** Laboratory measurement.

Aquatic Vegetation

Most of the aquatic macrophytes were hardwater forms commonly found in nutrient rich waters (Table 30). Water-milfoil (Myriophyllum spicatum) was limited to the area near the outlet where the substrate had a greater amount of organic matter. This species is well adapted to life in shallow water often susceptible to dessication (Hutchinson 1975) which characterized this portion of the lake. Fennel-leaved pondweed (Potamogeton pectinatus) dominated the flora in Indian Pond and was common in the sand-gravel shoal area. Broken pieces of horned pondweed (Zannichellia palustris) were numerous along the windward (northern) shore. Although horned pondweed can reproduce sexually utilizing water-borne pollen, it also has the ability to spread by rhizomes and is usually associated with sandy substrates (Hutchinson 1975). Spiked rush (Elcocharis sp.) was also common in the shallow water along the windward shore. Rosulate forms such as the spiked rush have evolved to survive in areas with significant wave action (Hutchinson 1975). Aquatic mosses are dependent on CO₂ as a carbon source which undoubtedly explains their collection near the seeps surrounding the lake. Horsetails (Equisetum arvense) were observed among the sedges in moist areas along the shore.

Limnoplankton

Phytoplankton diversity (4 genera) was about average for Park lakes, and crustacean diversity (6 species) was almost three times the Park mean; however, the total lack of rotifers in the sample is quite uncommon (Table 31). Despite the absence of rotifers, overall plankton diversity (10 forms) was slightly above average for 77 lakes (9 forms). Phytoplankton densities were slightly low for a lake with "bloom" species, but zooplankton densities were the highest yet reported in Park waters. Since phytoplankton usually dominate plankton density, slightly depressed phytoplankton numbers in Indian Pond caused overall plankton densities to also be slightly below average.

The phytoplankton were dominated by blue-green algae which is typical for nutrient rich water (Hutchinson 1967). Melosira, a diatom, is also a eutrophic form. These phytoplankton forms are often found in association in nutrient enriched temperate lakes during warmer periods (Wetzel 1975). Although physical and chemical factors undoubtedly influence the composition of this phytoplankton community, it may also reflect the effects of grazing by the extremely dense zooplankton populations (Moss 1980).

The total absence of rotifers from the plankton sample is difficult to explain, but according to Hutchinson (1967), rotifers are most often limited by abundance and quality of food. Since rotifers appear to have a competitive advantage in the presence of intense piscine predation (Hutchinson 1967, Wetzel 1975), the lack of rotifers coupled with the abundance of larger crustacean zooplankton

Table 30 Qualitative checklist of terrestrial and aquatic plants collected during lake and stream surveys, Yellowstone National Park, 1981

	Hellroaring Creek			Pelican Creek			Soda Butte Creek			Indian Pond (Squaw Lake)
Name	Sta. 1	Sta. 2	Sta. 3	Sta. 1	Sta. 2	Sta. 3	Sta. 1	Sta. 2	Sta. 3	
Terrestrial plants:										
<u>Alnus incana</u> (L.)	X	X	X					X	X	
<u>Alopecurus alpinus</u> J.E. Smith				X	X	X				
<u>Aster</u> sp.	X						X			
<u>Astragalus eucomus</u> Robins.									X	
<u>Carex aquatilis</u> Wahl.				X	X	X	X			
<u>Carex microptera</u> Mack.					X					
<u>Carex praticola</u> Rydb.						X				
<u>Carex</u> sp.	X			X						
<u>Equisatum arvense</u> L.		X	X		X			X		
<u>Lonicera involucrata</u> (rich.) Banks								X		
<u>Luzula campestris</u> (L.) DC				X						
<u>Melica spectabilis</u> Schribn.					X					
<u>Phleum alpinum</u> L.						X				
<u>Polygonum bistortoides</u> Pursh.				X						
<u>Populus angustifolia</u> James							X			
<u>Populus tremuloides</u> Michx.									X	
<u>Rumex salicifolius</u> Weinm.							X			
<u>Shepherdia canadensis</u> (L.) Nutt.						X				
Willows:										
<u>Salix bebbiana</u> Sarg.	X			X						
<u>Salix drummondiana</u> Barratt									X	
<u>Salix eastwoodii</u> Cocherell ex. Heller			X		X					
<u>Salix fluviatilis</u> Nutt.							X			
<u>Salix glauca</u> L.				X						
<u>Salix lasiandra</u> Benth.	X	X					X			
<u>Salix phylicifolia</u> L.									X	
<u>Salix scouleriana</u> Barratt		X	X							
<u>Salix wolfii</u> Bebb.	X		X	X	X	X		X	X	
<u>Salix</u> sp.			X							

continued on next page

Table 30. continued

Hellroaring Creek			
Name	Sta. 1	Sta. 2	Sta. 3
Aquatic plants:			
<u>Alopecurus alpinus</u> J.E. Smith			
<u>Callitriche</u> sp.			
<u>Eleocharis paulustris</u> (L.) R. & E.			
<u>Eleocharis</u> sp.			
<u>Equisetum arvense</u> L.		X	
Gramineae			
<u>Myriophyllum spicatum</u> L.			
<u>Mimulus guttatus</u> DC			
<u>Poa</u> sp.			
<u>Potamogeton filiformis</u> Pers.			
<u>Potamogeton pectinatus</u> L.			
<u>Potamogeton richardsonii</u> (Bennett) Rydb.			
<u>Ranunculus aquatilis</u> L.			
<u>Rorippa nasturtium-aquaticum</u> (L.) Schinz. & Thell.			
<u>Saxifraga arguta</u> D. Don			
<u>Zannichellia palustris</u> L.			

Pelican Creek			Soda Butte Creek			Indian Pond (Squaw Lake)
Sta. 1	Sta. 2	Sta. 3	Sta. 1	Sta. 2	Sta. 3	
	X	X				
		X	X			X
						X
	X		X			X
						X
		X	X			
		X				X
X		X				
	X					
				X		
						X

Table 31. Occurrence and density (number per liter) of common net plankton from Yellowstone Park, 1981

Genera		Riddle Lake	Indian Pond	Sylvan Lake
Division	Chrysophyta (Yellow-green algae)			
	<u>Asterionella</u>	119		1700
	<u>Melosira</u>	338	984	4890
	<u>Surirella</u>	89		
	<u>Synedra</u>	179		
	<u>Tabellaria</u>	4682		
Division	Cyanophyta (Blue-green algae)			
	<u>Anabaena</u>	5994	447	417
	<u>Gomphosphaeria</u>		239	
	<u>Nostoc</u>		4324	
Division	Chlorophyta (Green algae)			
	<u>Staurostrum</u>	179		
Class	Rotatoria (Rotifers)			
	<u>Asplanchna</u>	37		1
	<u>Conochilus unicornis</u>	15		6
	<u>Kellicottia longispina</u>	1		8
	<u>Keratella cochlearis</u>	13		1
	<u>Polyarthra</u>	32		
Order	Cladocera (Water fleas)			
	<u>Alona rectangula</u>	1	1	
	<u>Ceriodaphnia pulchella</u>	1	1	
	<u>Daphnia pulex</u>		5	
	<u>Daphnia rosea</u>	16		
	<u>Daphnia schødleri</u>		28	
	<u>Daphnia sp.</u>	19		
	<u>Holopedium gibberum</u>	1		
Order	Copepoda (Copepods)			
	<u>Cyclops bicuspidatus thomasi</u>	34	28	
	<u>Diaptomus ashlandi</u>		255	
	<u>Diaptomus shoshone</u>	6		
	<u>Nauplii</u>	P		P
Total Phytoplankton/liter		11630	5994	7007
Total Zooplankton/liter		170	324	89
Total Plankters/liter		11800	6318	7096
Number genera/lake		10	19	10

P = Present in sample, not enumerated.

indicates that fish are not utilizing this food resource extensively in Indian Pond. Both predation by larger crustaceans and competition for quality food source may partially explain the lack of rotifers.

Littoral and Benthic Organisms

Macroinvertebrate diversity (5 taxa) was much lower than the Park mean (11 taxa) (Table 32). Scuds (Gammarus lacustris) dominated the littoral sample and shallow water benthic samples, and scud densities appeared high. Arnold and Sharp (1967) estimated scud numbers to be approximately 6,460 per m² (expanded from 600 per ft²) along the northeast shore at a depth of about 4 m. Snails (Physa sp.) and leeches (Hirudinea) were also abundant in the current littoral samples. Although backswimmers were reported in the 1966 survey (Arnold and Sharpe 1967), none were collected in 1981. One snail and one clam (Pelecypoda) were found in profundal benthic samples, but chironomids and leeches dominated these collections.

Aquatic Vertebrates

A total of 13 cutthroat trout, 6 longnose suckers (Catostomus catostomus) and 375 redbreast shiners (Richardsonius balteatus) were captured in one small mesh and two largemesh experimental gillnets set overnight. No salamanders were collected or observed, but one large cutthroat trout was seen in the shallow water near shore.

Cutthroat Trout

Average total length and weight of the cutthroat trout were 242 mm and 423 g, respectively, and mean condition factor (K) was 1.07. Total length ranged from 115 mm to 585 mm, five trout were less than 150 mm, four were between 180 and 250 mm and three trout were greater than 400 mm.

Nine of the trout were aged by the scale method and only one exhibited a retarded scale pattern (failure to form annulus at age I) (Laakso and Cope 1956). An age length key (Westerheim and Ricker 1978) was used to estimate the average age of 11 trout. Average age was 2.3, and only three trout were four years and older. Back-calculated lengths were 63, 153, 277, 344, 421 and 555 mm for ages I-VI, respectively (Table 28).

Although trout densities may have increased somewhat since 1966, there appears to have been little change in the past decade. Numbers increased from four in 1966 to 10 in 1971, and 13 were captured in 1981. The appearance of smaller trout in the current sample indicates that some trout reproduction may occur in the outlet stream, but it is impossible to determine whether the spawners come from Yellowstone Lake or Indian Pond. One large female captured in 1981 had resorbing eggs, and Arnold and Sharpe (1967) also reported reproductive failure. Two of the large males in the current sample displayed well developed testes.

Table 32. Aquatic invertebrates collected from Hellroaring, Pelican and Soda Butte Creeks and Squaw Lake, 1981

Taxon (common name)	Hellroaring Creek				Pelican Creek				Soda Butte Creek				Indian Pond (Squaw Lake)
	Sta. 1 Surber	Sta. 2 Surber	Sta. 3 Surber	Drift	Sta. 1 Surber	Sta. 2 Surber	Sta. 3 Surber	Drift	Sta. 1 Surber	Sta. 2 Surber	Sta. 3 Surber	Drift	
Hirudinea (leeches)						X							X
Crustacea													
Amphipoda (Scuds)													
<u>Gammarus lacustris</u>													X
Insecta													
Ephemeroptera (mayflies)													
Baetidae													
<u>Baetis bicaudatus</u>						X	X			X			X
<u>Baetis tricaudatus</u>	X	X	X	X				X	X				X
Ephemerellidae													
<u>Ephemerella coloradensis</u>	X	X	X	X	X	X			X	X	X	X	
<u>Ephemerella grandis-nigerus</u>						X							
<u>Ephemerella infrequens</u>						X		X					
<u>Ephemerella tibialis</u>				X					X		X	X	
Heptageniidae													
<u>Cinygmula sp.</u>	X	X	X	X	X			X	X	X			X
<u>Epeorus albertae</u>											X		X
<u>Epeorus deceptivus</u>				X					X	X	X		X
<u>Epeorus longimanus</u>	X		X	X		X		X	X				X
<u>Rithrogena sp.</u>									X				
<u>Rithrogena hageni</u>	X		X	X									
Siphonuridae													
<u>Ameletus sp.</u>				X				X		X			X
Odonata													
Plecoptera (stoneflies)													
Chloroperlidae													
Chloroperlinae		X	X	X				X					
<u>Paraperla frontalis</u>									X				X
Nemouridae													
<u>Malenka sp.</u>				X									
<u>Zapada sp.</u>					X					X	X	X	
Perlidae										X			
<u>Doroneuria theodora</u>				X									
Perlodidae													
<u>Kogotus sp.</u>				X				X			X	X	

Continued on next page

Table 32. continued

Taxon (common name)	Hellroaring Creek				Pelican Creek				Soda Butte Creek				Indian Pond (Squaw Lake)
	Sta. 1 Surber	Sta. 2 Surber	Sta. 3 Surber	Drift	Sta. 1 Surber	Sta. 2 Surber	Sta. 3 Surber	Drift	Sta. 1 Surber	Sta. 2 Surber	Sta. 3 Surber	Drift	
Trichoptera (caddisflies)													
Arctopsychidae													
<u>Arctopsyche grandis</u>									X		X	X	
Brachycentridae													
<u>Brachycentrus</u> sp.						X			X		X		
Glossosomatidae													
<u>Glossosoma</u> sp.						X	X				X		
Hydropsychidae				X									
Lepidostomatidae				X									
<u>Lepidostoma</u> sp.						X							
Limnephilidae													
<u>Farula</u> sp.													
Rhyacophilidae		X		X									
<u>Rhyacophila</u> sp.										X		X	
Coleoptera (beetles)													
Elmidae													
<u>Cleptelmis ornata</u>								X					
<u>Stenelmis</u> sp.							X	X					
Diptera													
Chironomidae						X							X
Deuterophlebiidae													
<u>Deuterophlebia</u> sp.				X									
Syrphidae	X			X									
Tipulidae													
<u>Ilexatoma</u> sp.			X	X			X						
Gastropoda (snails)													
<u>Physa</u> sp.													X
Pelecypoda (clams)													X
NUMBER TAXONOMIC GROUPS	6	5	7	18	3	10	4	9	10	8	9	13	5
TOTAL NUMBER OF GROUPS PER WATER		18				19				18			5

Back-calculated growth is also quite similar in the two most recent surveys but has apparently decreased since 1966 (Table 28). Arnold and Sharpe (1967) reported all captured trout (3) were age IV+, and Dean (1971) found one age III+ and nine age IV+. In 1981, there were four age I+, five age II+, one age V+ and one age VI+ trout. Although sample sizes are small and therefore more susceptible to error due to the subjectivity of the scale method, there is evidence of limited trout reproduction in Indian Pond and an indication that longevity may have increased.

Longnose Suckers

Average length and weight for the six suckers was 381 mm and 825 g, respectively. Mean K factor was 1.33. Total length ranged from 188 mm to 433 mm, but only one sucker was less than 400 mm. None of the suckers were aged in 1981.

Longnose sucker numbers were somewhat greater in 1981, but studies on Yellowstone Lake have indicated that gillnet data for longnose suckers display great variation. It does appear, however, that this species was not present in 1966. The predominance of large suckers suggest this species also reproduces poorly in Indian Pond, and the population may be supported by migrants from Yellowstone Lake. The preponderance of larger suckers also suggests that the sucker population is not increasing rapidly.

Redside Shiners

Total length for 317 of the shiners ranged from 60 mm to 160 mm with a mean of 103 mm. Total weight for the 375 shiners captured was 4.7 kg or a mean weight of 12 g per shiner. None of the shiners were aged.

The redside shiner is currently the dominant fish species in Indian Pond. Length frequency indicates substantial annual reproduction, and it is undoubtedly this factor which has allowed the rapid increase of this species since 1971. The redside shiner has been reported to spawn in the shallow portions of lakes (Brown 1971), a fact which provides reproductive advantage in Indian Pond.

Absence of lake chub in the current sample is curious. Although the possibility for misidentification of the redside shiners exists, it appears that the shiner has replaced the lake chub in Indian Pond. The lake chub was introduced into Yellowstone Lake before 1949 (Benson and Bulkley 1963), but this species has never increased substantially; however, the shiner, which was discovered in the lake during the late 1950's (Cope 1958), has spread throughout the littoral zone. It is unknown whether niche limitation or competition with redside shiners has prevented the spread of chubs, but the

same factors may also influence species composition of Indian Pond. Since the lake chub is a stream spawner like the cutthroat trout and longnose sucker, the reproductive advantage would definitely favor the shiner.

Angler Use

Although angling success is extremely low, the roadside location of Indian Pond makes it attractive to the passing visitor. Arnold and Sharpe (1967) did not have accurate records but estimated annual use of 1,500 angler days. Current data is confounded by the low number of VFR cards returned; however, angler use since 1974 has varied from 118 to 490 angler days with a mean of approximately 250 angler days annually. Observations during the current survey indicate this may be underestimated, and low success rates may influence a disproportionate return of cards.

Landing rate has varied considerably since 1973, but the average of 0.27 trout per hour may be fairly representative. There are reports of seasonal employees in the Lake Village area who capture a few trout annually. Average length of trout landed in 1981 was less than 254 mm.

Discussion

Groundwater inputs and low outflow definitely contribute to the nutrient rich quality of Indian Pond. The enriched character of this small lake was reflected by eutrophic forms of phytoplankton and elevated zooplankton diversity and density. Low nitrogen levels obviously favored blue-green algae which possess the ability for nitrogen fixation. The absence of rotifers is probably related to reduced food quality and availability, which may in turn be affected by high densities of larger zooplankton grazers. Current zooplankton community composition and density suggest a low level of piscine predation.

Despite the productive nature of Indian Pond, trout densities are low. The morphoedaphic index (MSI) (Ryder et al 1974) was 78.5, one of the highest values obtained for Park lakes, and the subsequent hypothetical fish yield was 8.55 kg/ha. It appears that lack of sufficient reproductive habitat limits both the cutthroat trout and longnose sucker populations in this otherwise suitable habitat.

Arnold and Sharpe (1967) speculated that high CO₂ levels might also be limiting in Indian Pond. Current values for CO₂ (22 ppm in 1979, 26 ppm in 1981) are lower than they reported (75 ppm), and since prior samples were analyzed in the field, present values are assumed to be more accurate. Although current CO₂ levels might still be considered high, excellent growth of all species and apparent spawning success of redbreasted shiners suggest that concentrations are not limiting.

Cutthroat trout densities apparently increased somewhat between 1966 and 1971, but appear to be rather stable at present. The disappearance of larval salamanders since 1966 supports this supposition. A decrease in growth since 1966 also indicates increased densities; however, competition by exotic species may also affect growth rates. The presence of larger zooplankton forms and the absence of rotifers is indicative of low trout densities. There have been reports of local summer residents "stocking" Indian Pond, but the presence of young trout suggests that population numbers are supported by occasional reproductive success.

Longnose suckers have probably entered Indian Pond from the outlet stream. Numbers may have increased somewhat since 1971, but the failure of consistent successful reproduction is suggested by predominance of large suckers.

The redbside shiner has apparently expanded its range into Indian Pond also. The ability to spawn in lake shoals has allowed the dominance of this species in the lake. The primarily insectivorous food habits of the redbside shiner (Brown 1971), in conjunction with littoral habitat preference, probably explain the low levels of zooplankton predation indicated by the present samples, despite high shiner densities.

Since Indian Pond can not support a naturally reproducing cutthroat trout fishery, there is no reason to chemically rehabilitate the lake to remove the exotic species. Future study of this lake may provide insight into the coexistence of these species in Yellowstone Lake. Resampling of Indian Pond to substantiate the identification of the redbside shiner will be conducted in 1982.

RIDDLE LAKE

With a surface area of 110.9 ha, Riddle Lake is a moderate size back-country lake. A well marked trail (3.6 km long) provides easy access from the trailhead located approximately 4 km south of Grant Village along the south entrance road. It is an extremely popular day-use area and the four campsites along the lake shore are occupied throughout most of the summer season.

Cutthroat trout are native to Riddle Lake and were the only species present historically. Currently, both the redbside shiner and the longnose sucker also inhabit the lake. It is assumed that the native cutthroat and both of the exotic species gained entry from Yellowstone Lake via Solution Creek.

Lake surveys conducted in 1970 and 1971 described the physical and chemical properties of the lake and presented data concerning the fish population under the 2 fish, 356 mm minimum size 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 which had been initiated on Yellowstone Lake.

On September 1-2, 1981 the lake was resurveyed to assess the current status of the cutthroat trout population after six years under the 330 mm maximum size regulation.

Physical

At an elevation of 2,212 m, Riddle Lake has a drainage area of approximately 754 ha (Table 27). Glacial deposits consisting mostly of rhyolitic till form the major portion of the geological substrate within the drainage (Richmond 1973 and Christiansen 1974). Thick stands of lodgepole pine cover these deposits as well as the rhyolitic lava of the Aster Creek flow which occurs in the eastern portion of the drainage, north of Solution Creek. Large wet meadows of mixed grasses and sedges cover alluvial deposits to the west and south of the lake. Smaller areas of similar composition are found in several places along the east shore including the outlet.

Although a complete bathymetry was not conducted on Riddle Lake, the maximum observed depth (7.9 m) resembled previous studies (8.2 m: Dean 1972 and 8.5 m: Dean 1975). Water temperature was uniform from surface to bottom. Since both prior studies described a stratified condition, current findings suggest that autumnal turnover was in progress at the time of survey. The secchi disc visibility in the tea-brown water was 3.0 m; however, the presence of an algal bloom and strong surface winds may have affected the reading.

Wave erosion along the sand and gravel eulittoral zone of the northern shore indicated the lack of substantial wind protection, but lake level fluctuations appear to be minimal (0.3 m). Above average shoreline development was due to the irregular shape of the shallow, lily-covered western portion of the lake (Figure 30). Substrate materials varied from gravel and rubble along the northern shore to sand and gravel on the eastern shore. Organic detritus increased near the stands of lilies and dominated the substrate along much of the southern shore and the entire western shore. Profundal sediments were composed of decaying organic debris.

Although Dean (1972) reported at least six intermittent tributaries, only one small tributary draining the wet meadow to the northeast was evident in 1974 (Dean et al 1975). Both reports conclude, however, that groundwater appears to be the major water source. Dean et al (1975) indicated that spawning habitat was limited to the outlet stream (Solution Creek) at least 4.8 km below the lake.

Chemical

On the basis of the 2 m water sample (TDS: 34 ppm), Riddle Lake was classified as a dilute lake (TDS less than or equal to 50 ppm). The predominant ions were calcium and sulfate (Table 29). Although several chemical constituents were above average for dilute waters in the calcium-sulfate group, only TDS, sulfate, iron and Kjeldahl nitrogen levels appeared significantly greater than the mean for all dilute Park waters (n=53). Silica concentration was virtually undetectable using current methods and represents one of the lowest levels yet sampled in the Park.

Comparison with past water samples from Riddle Lake reveals a great variation in major ions. Such changes have occurred often among samples from dilute Park waters and are believed to be manifestations of differences in physical and biological conditions at the time of sampling. Thus far, all three of the major cations found in natural waters (calcium, magnesium and sodium) have predominated in at least one Riddle Lake sample, but, except for the current study, bicarbonate has always been the dominant anion.

Although temporal variations in sulfate concentrations are not uncommon, Hutchinson (1975) reported that the reasons for such changes remain unexplained. The rhyolitic nature of the Riddle Lake watershed probably limits the amount of sulfates introduced by groundwater. Since sulfate in precipitation provides a major sulfur source in some areas (Hem 1970), the presence of several large forest fires in the vicinity of Riddle Lake in 1981, may have influenced sample concentrations. The bog nature of this dystrophic lake, however, may provide the most plausible explanation. According to Wetzel (1975), the change in predominance from calcium and bicarbonates to sulfate and hydrogen ions is

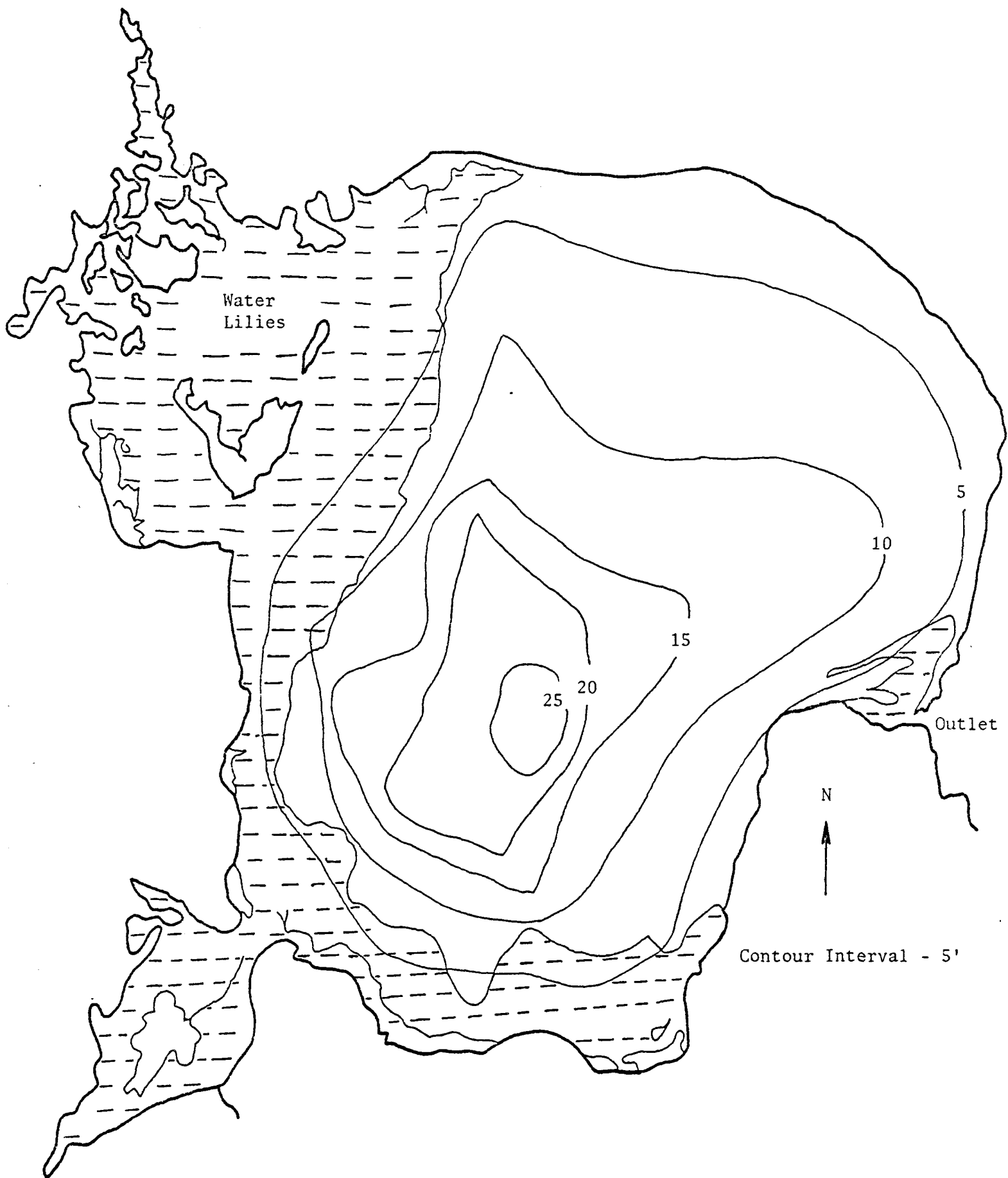


Figure 30. Riddle Lake, Yellowstone National Park,
(adapted from Dean et al 1975).

a significant feature of these waters. It is possible that lack of stratification and strong surface winds produced a thorough mixing of waters high in sulfur from the decomposition of abundant organic debris throughout the summer.

Aquatic Vegetation

Pond lilies (Nuphar polysepalum) were abundant along the western and southern shoreline extending at least 30 m into the lake in most places. Lilies also covered the marsh areas to the west and south, and a smaller cluster was located in the protected area near the outlet. Extensive development of littoral flora, in this case a bog species, is a definitive characteristic of dystrophic lakes, and such flora constitute the primary source of organic matter in these lakes (Wetzel 1975).

The specific location of lilies in Riddle Lake appears to be limited by water depth (usually less than 2.5 m) and protection from the wind. These characteristics are common for Park lakes in which this species is found.

Although other submerged and emergent littoral vegetative species undoubtedly occur in Riddle Lake, a comprehensive collection has not been made to date. In addition to pond lilies, Dean (1972) reported the collection of pondweed (Potamogeton sp.) in some areas at depths of 2-2.5 m. Sedges (Carex sp.) dominated the wet meadow areas around the lake.

Limnoplankton

Despite the nutrient paucity of Riddle Lake, phytoplankton diversity (7 genera), crustacean diversity (7 genera) and rotifer diversity (5 genera) were much greater than the means for a sample of 77 Park lakes. Total number of plankton genera (19) is far above the Park mean (9 genera) and is the highest yet reported from Park back-country lakes. Plankton densities were also high (Table 31), and the number of plankters per liter was above the Park mean in all categories. Although changes in methods of plankton identification and enumeration may confound comparisons with prior data, evaluation of trends should remain valid.

The plankton sample collected from Riddle Lake in 1981 displayed a high degree of similarity with results reported by Dean et al (1975) despite a difference in sampling date of approximately one month. In both samples Anabaena (a blue-green algae) and a diatom species were in bloom proportions. Three more diatom species were collected in 1981, including Melosira, which has never been reported in Park waters. A desmid, Staurastrum, was reported in moderate numbers in both years. Kirchneriella, a green alga often found in fertile ponds (Hutchinson 1967), was reported in 1974 but was absent in the current sample.

Rotifers dominated the zooplankton from Riddle Lake again in 1981, but despite a much greater diversity, densities were considerably lower. Cladoceran densities were also slightly lower in 1981, and two species of Daphnia dominated the five species collected. Of the two copepods in the current sample, Cyclops bicuspidatus thomasi outnumbered Diaptomus shoshone, the only copepod reported in 1974.

The bloom of Anabaena was not surprising since it may often dominate the phytoplankton community in nutrient poor water because of its nitrogen fixing ability (Hutchinson 1967). According to Wetzel (1975), a large bloom of Anabaena may cause a rise in organic nitrogen, and this may partially explain the large difference between nitrate nitrogen and Kjeldahl nitrogen in the current water sample. A rise in organic nitrogen may also be related to the autumnal diatom bloom observed in both Riddle Lake samples. The dependence of diatoms on silica is evident in the greatly depressed level of this essential nutrient during the observed diatom bloom.

Desmids, such as Staurostrum, are often associated with dystrophic, bog type lakes and frequently dominate the phytoplankton of these lakes (Wetzel 1975). Although this species was only found in moderate numbers in the Riddle Lake samples, its presence undoubtedly is linked to the dystrophic qualities of the lake. It is possible that desmids were the predominant form in Riddle Lake prior to the Anabaena bloom.

Although rotifers are quite cosmopolitan and appear to be limited primarily by food supply (Hutchinson 1967), rotifer numbers are usually correlated positively with fish densities (Wetzel 1975). Since this phenomenon is believed to be related to the small size of this form, the prominence of rotifers in the zooplankton and the small size of the remaining forms are both indicative of intensive piscine predation of plankters in Riddle Lake.

Littoral and Benthic Organisms

Since significant changes in the littoral and benthic forms collected by Dean (1972) and Dean et al (1975) were not expected, samples were not obtained in 1981. Dean et al (1975) reported 12 taxa which is about average for Park lakes, and most of the forms reported are quite common.

Aquatic Vertebrates

Two largemouth and one smallmouth experimental gillnets captured 35 cutthroat trout and 140 longnose suckers.

Cutthroat Trout

Average length and weight for 29 of the trout were 139 mm and 79 g, respectively, and mean condition factor (K) was 0.90. Total length of trout ranged from 75 to 282 mm.

Comparison with data collected in 1970, 1971 and 1974 indicates that both density and average size of cutthroat trout have decreased since 1970. Although the number of largemouth and smallmouth nets has varied somewhat between samples, net types have not changed. Mean number per net has decreased from almost 17 in 1970 to approximately 12 in 1981 (Figure 31) and mean length of trout captured has decreased over 100 mm since 1970 (Figure 32). Length frequency analysis indicates a substantial decrease in larger trout by 1981 (Figure 33). The percentage of trout over 330 mm has dropped from 60% (1970) to 0% (1981) during this period.

Longnose Suckers

Mean total length of 139 suckers was 286 mm, ranging from 105 to 448 mm. Only 66 of the suckers were weighed; mean length and weight for this subsample was 316 mm and 386 g, respectively. Mean K factor was 1.14.

Trends in the longnose sucker population appear to be the inverse of those observed for the cutthroat trout. The mean number of suckers captured per net has risen from 5 per net (1970) to 47 per net (1981). Mean total length has varied significantly between 1970 (238 mm), 1974 (161 mm) and 1981 (288 mm), but a consistent trend was not observed. It is evident, however, that the mean size of gillnetted suckers was the greatest yet reported from Riddle Lake.

Redside Shiners

Although redside shiners have been previously collected in Riddle Lake, none were captured during the 1981 survey. Numbers captured by Dean (1972) and Dean et al (1975) were low (1 and 3 shiners for 1971 and 1974, respectively), and this population does not appear to be expanding. Since this species has spread throughout the littoral habitat of Yellowstone Lake, it is curious that it has not expanded in Riddle Lake. Apparently, lack of niche separation from the indigenous cutthroat trout in this nutrient poor and rather unproductive lake has prevented the firm establishment of the redside shiner. Recent declines in the trout population, if not reversed in the near future, have the potential of allowing the future expansion of this exotic species in Riddle Lake.

Angler Use

Angler use information for Riddle Lake is provided by the Volunteer Fisherman Report (VFR) system. Although angler use estimates could not be obtained for 1973 and 1974, all other parameters were available since 1973. Despite possible bias due to low sample sizes in 1973-1975 and 1978, several important trends are evident.

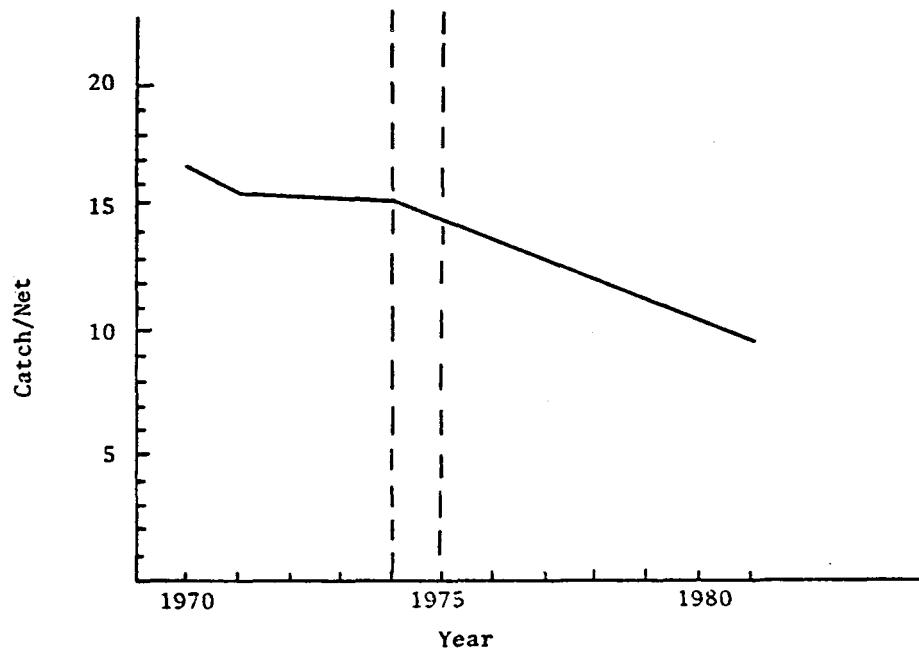


Figure 31. Mean number of cutthroat trout captured per net in experimental gillnets, Riddle Lake, 1970-1981.

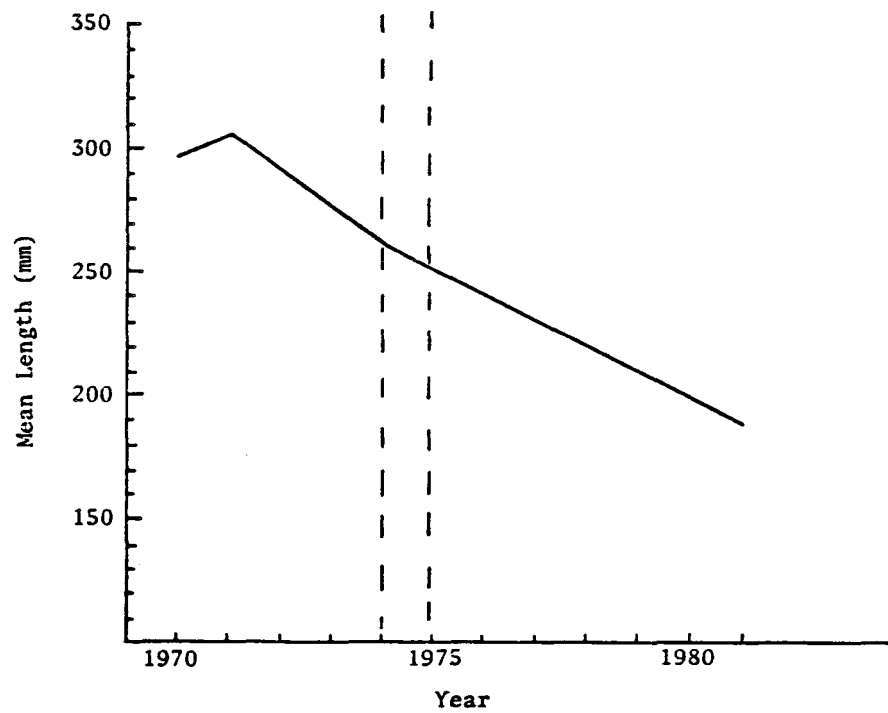


Figure 32. Mean length of cutthroat trout captured in gillnets, Riddle Lake, 1970-1981.

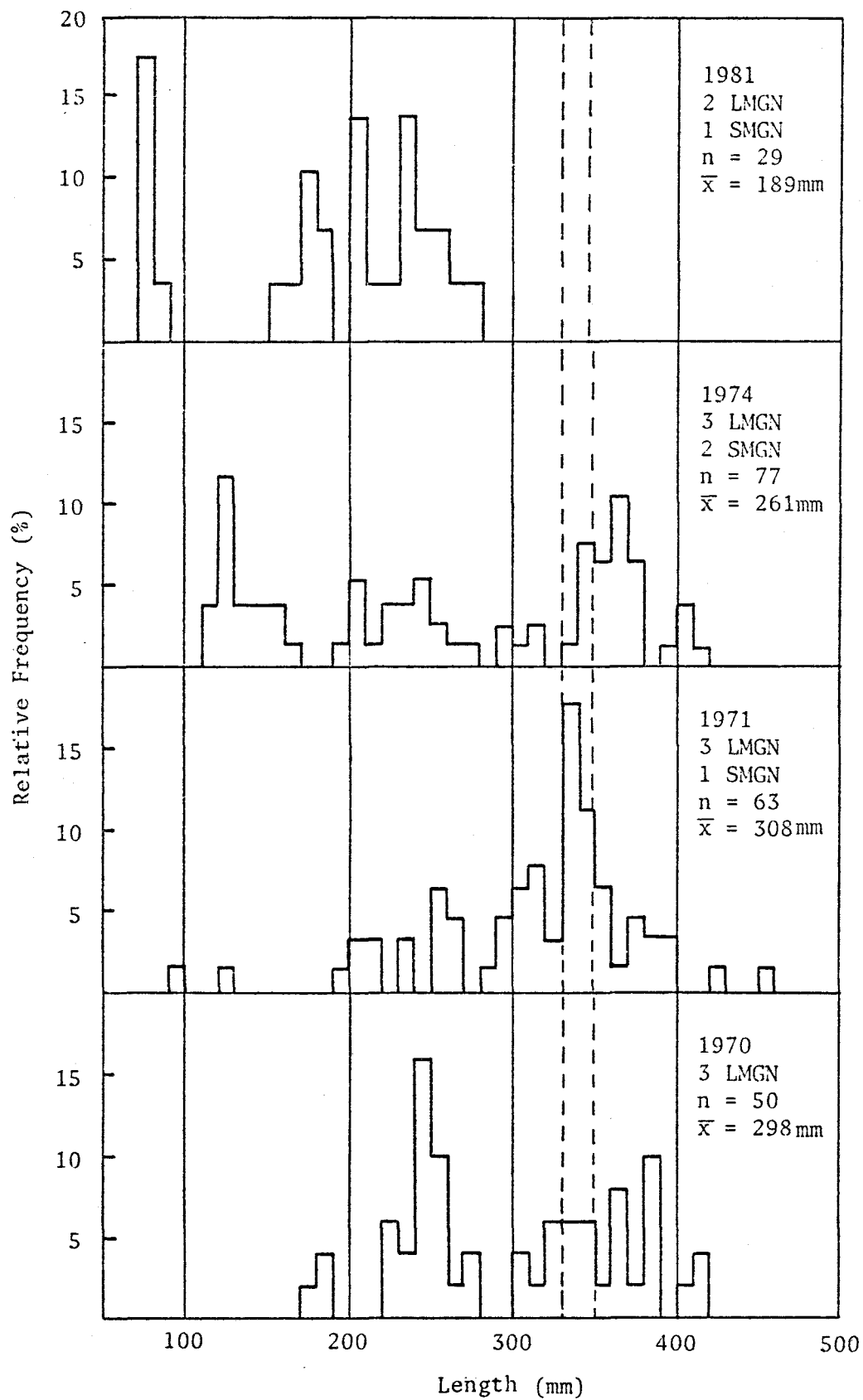


Figure 33. Length frequency of cutthroat trout captured in experimental gillnets, Riddle Lake, 1970-1981.

Since 1975, angler use has more than doubled from less than 500 to over 1,200 angler days (Figure 34). Landing rates have fluctuated since 1973 and a definite trend is difficult to interpret (Figure 35), however, the mean landing rate for this period (0.71 trout per hour) is poor for a Park lake containing cutthroat trout.

Perhaps the most significant result of the VFR analysis is the drastic plunge in the average length of landed trout (Figure 36). Despite the initial increase to 378 mm in 1977, mean length is currently only 309 mm. Length frequency analysis indicates that over two thirds of the trout landed in 1981 could have been harvested. These data appear to substantiate the results of the gillnetting comparisons.

Discussion

The dystrophic condition of Riddle Lake is manifested in various physical, chemical and biological factors. Accumulation of large amounts of decaying plant matter has produced humic acids which are responsible for the brown color and acidic pH. The pond lilies which dominate the littoral zone, provide the major source of organic matter in this system. The lack of flowing tributaries contributes to the reduced level of nutrients and severely limits the reproductive success of the native cutthroat trout.

Phytoplankton samples were dominated by forms well adapted to existence under nutrient poor conditions. Bloom proportions of Anabaena, a blue-green alga, attest to low levels of nitrate, and diatom numbers undoubtedly contribute to the extremely low levels of silica. The presence of the desmid, Staurastrum, is also common in dystrophic waters.

The effects of intensive piscine predation were evident in the zooplankton. Rotifers dominated the samples, and remaining forms were also small. It is possible the competition among the three fish species for this apparently limited food resource may be responsible for the reduced numbers of reidside shiners.

Analyzes of both gillnetting and VFR data indicate that the 330 mm maximum size limit has failed to provide adequate protection for the cutthroat trout in Riddle Lake. The reasons for failure of this regulation are probably linked to the slow growth and great susceptibility to angling of trout in this relatively unproductive environment. It is possible that low mean length due to reduced growth has allowed excess harvest of valuable spawning stocks. Although a causal relationship has not been established, apparent increases in the longnose sucker population may be linked to reduced trout densities.

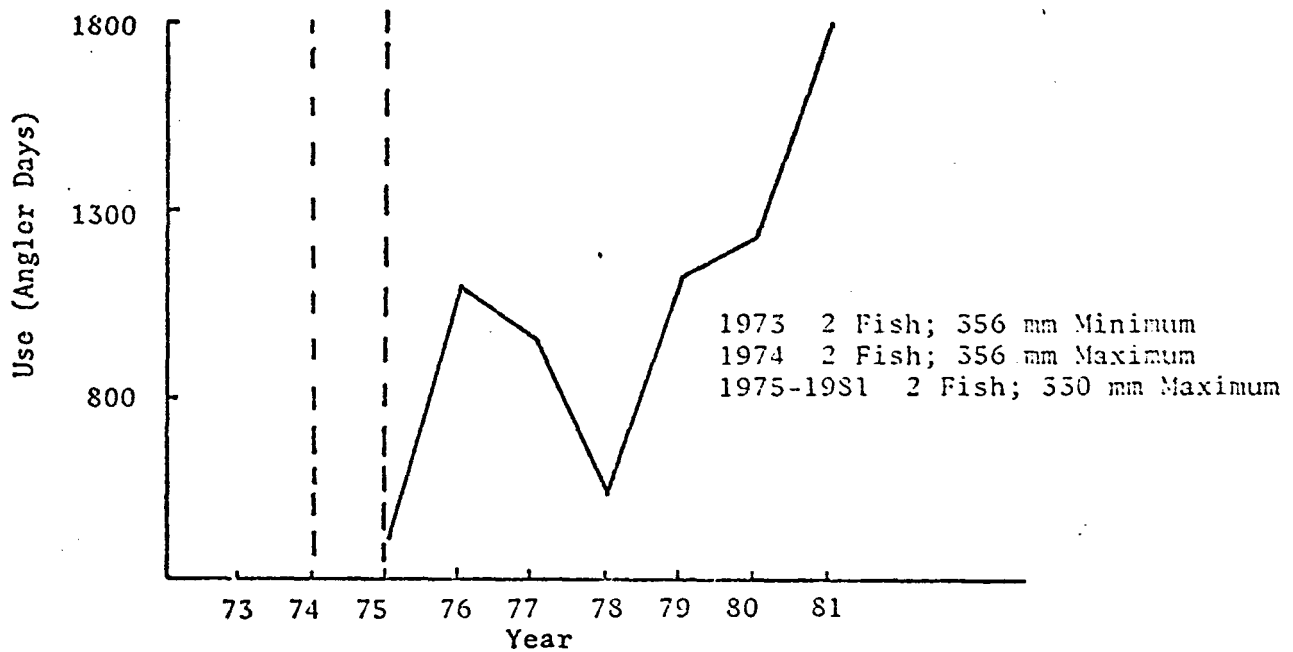


Figure 34. Angler use estimates for Riddle Lake, 1973-1981.

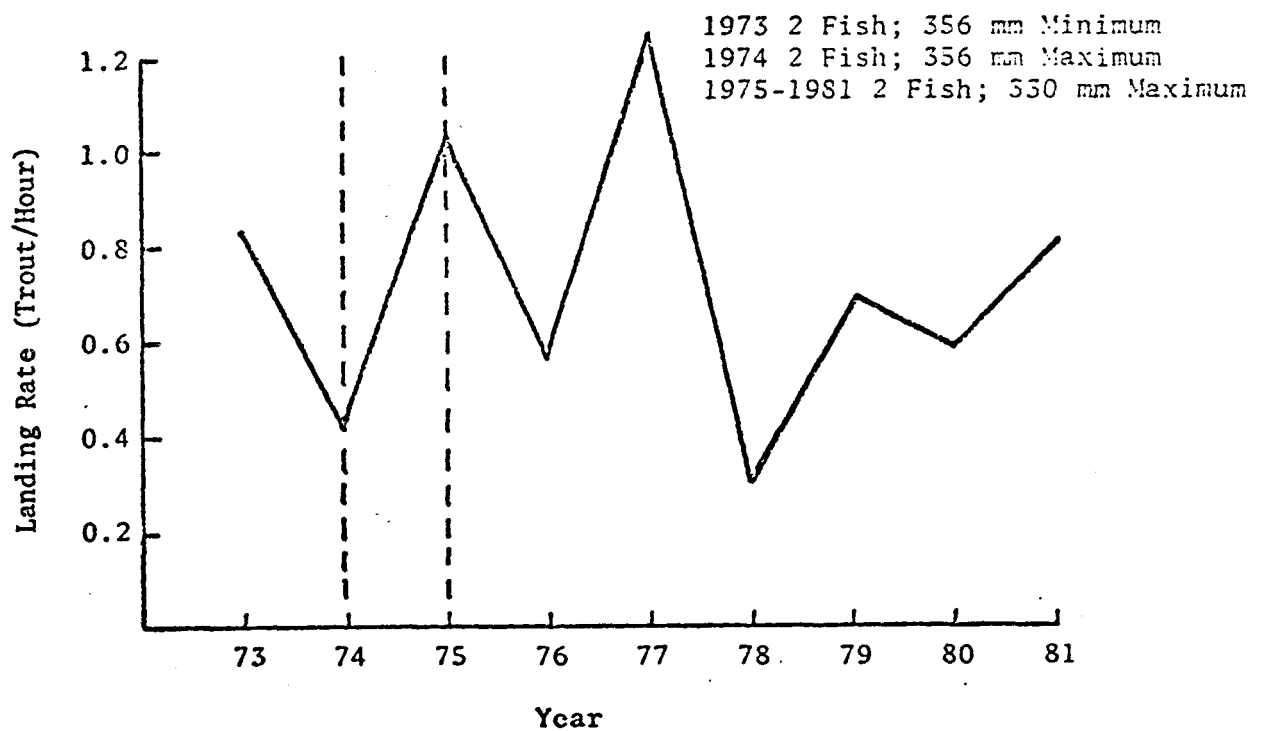


Figure 35. Landing rate estimates for Riddle Lake, 1973-1981.

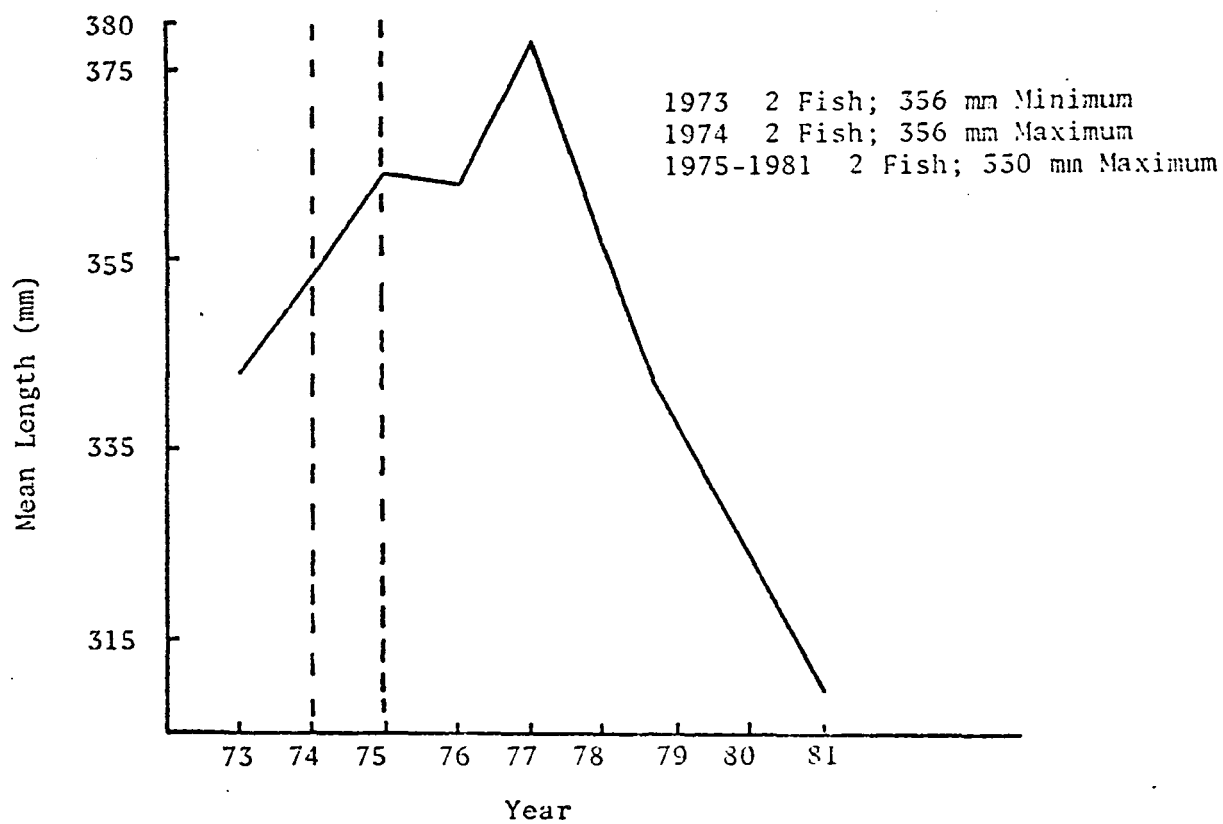


Figure 36. Mean length of trout landed by anglers at Riddle Lake, 1973-1981.

The current status of the cutthroat fishery in Riddle Lake warrants immediate attention, and restrictions are necessary to prevent further degradation of this once viable native population. Acute decreases in catch per effort and average size of trout in both lake survey collections and VFR data along with increases in the number and sizes of the exotic longnose sucker emphasize the need for immediate response. We therefore recommend that Riddle Lake be placed under catch and release-only regulations in 1982. If it appears that such a change can not be accomplished in time for the 1982 fishing season, we recommend that Riddle Lake be closed to sports angling until the catch and release regulation can be implemented.

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. It has been the ease of access which has historically contributed to excessive 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-only 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 a basic survey of Sylvan Lake in 1966. In 1978, the lake was resurveyed to provide baseline data necessary for continued evaluation of the catch and release-only regulation. In order to investigate the effects of the regulation after the first four years, an abbreviated lake survey was conducted on July 7-8, 1981. Additional information concerning the status of the longnose sucker population in Sylvan Lake was also collected during this survey.

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 6.1 m through dark green-brown waters on a calm, sunny day (Table 27). Water temperature varied from 16.9° C at the surface to 10.0° C at the bottom (6.7 m). Surface warming was evident to 4.1 m, but temperature dropped rapidly (1.9° C/m) from that point.

Chemical

The nutrient concentration (TDS: 66 ppm) of this calcium-bicarbonate water appeared to be slightly higher than during the last survey (Jones et al 1979). Despite a rise in TDS of 16 ppm, nitrate and silica, nutrients often limiting in oligotrophic lakes during the summer, were lower than in 1978. Slight variation in water samples are undoubtedly manifestations of changes in

physical and biological factors due to differences in sampling date. Of greatest significance, however, is the fact that levels of most chemical constituents (Table 29) are below the mean for calcium-bicarbonate Park lakes.

Limnoplankton

As expected, slight differences between the current sample and the 1978 sample (Jones et al 1979) were noted. Since plankton are sensitive to extremely small changes in the physical and chemical environment (Wetzel 1975), such apparent discrepancies are common. Recent changes in methods of plankton analysis may also influence these comparisons.

Phytoplankton diversity (3 genera) declined and was below average for Park lakes. Both crustacean and rotifer diversity (4 forms each) increased slightly, but total diversity was somewhat lower than in 1978. Plankton densities increased substantially overall and were above the mean for Park lakes with a "bloom" in process. Phytoplankton estimates were responsible for this increase, however, and zooplankton densities actually declined.

Generally, the phytoplankton community reflects a neutral to slightly alkaline, nutrient poor lake (Wetzel 1975). Although Melosira, a diatom appearing in bloom proportions, is often associated with eutrophic waters, Wetzel (1975) indicates that some species are found in oligotrophic lakes in conjunction with Asterionella. The latter was also present in large numbers in Sylvan Lake (Table 31). The blue-green algae Anabaena is also found in sterile environments where its nitrogen fixing capabilities often provide a competitive advantage.

The presence of four different genera of rotifers attests to an abundance of food. These small zooplankters are common when piscine predation is significant (Hutchinson 1967). Larger crustacean plankters were either absent or in reduced numbers. Adult copepods were conspicuously absent in 1978, and only one adult was enumerated in the current study.

Aquatic Vertebrates

One smallmesh and two largemesh experimental gillnets yielded 200 cutthroat trout and 123 longnose suckers. No other aquatic vertebrates were captured.

Cutthroat Trout

Only 190 of the cutthroat trout could be measured for length, and mean total length was 167 mm (range: 75-307 mm). A subsample of 96 trout which were also weighed had a mean length of 204 mm and mean weight of 81 g. Mean

condition factor (K) was 0.83 and male:female ratio was 1.09:1. These fish frequently harbored the parasitic copepod Salmincola sp.

Age was determined for 42 of the cutthroat trout using the scale method, and only two displayed a retarded pattern of growth (failure to form an annulus at age I) (Laakso and Cope 1956). Ages were expanded for 161 of the trout using an age-length key (Westerheim and Ricker 1975). Approximately 97% of the cutthroat trout were age I-III, and mean age was only 1.9 years. Back-calculated lengths at annulus formation were 58, 144, 201, 229 and 283 for ages I-V, respectively.

Although differences in number of smallmesh and largemesh nets used during the two surveys confounded comparisons, there appears to have been a decline in the number of trout per net. This comparison is further confounded, however, by a drastic increase of the number of suckers, which in itself would cause a relative decline of cutthroat trout in the gillnet samples.

Differences in mean length of trout captured in 1978 and 1981 (162 mm and 167 mm, respectively) were not statistically significant. When comparisons were limited to adult trout, mean lengths were virtually identical (225 mm and 226 mm for 1978 and 1981, respectively). Length frequency analysis reveals a greater percentage of trout in the 200-300 mm class in 1981, but slightly more trout were larger than 300 mm in 1978.

Mean age for both of the samples was 1.9 years. Back-calculated lengths for ages I-V were virtually identical except for annulus I and annulus II. There was one age VI+ trout in the 1978 sample, but since few trout in Sylvan Lake appear to live past five years, the greatly reduced sample size in 1981 may explain the lack of age VI trout in the current study.

Longnose Suckers

Total length was measured for 118 of the longnose suckers, and mean length was 253 mm. Mean length and weight in a subsample for which both measurements were obtained was 293 mm and 321 g, respectively. Mean K factor was 1.12 and male:female ratio was 1.19:1.

Sucker numbers have risen sharply since 1978 when only 46 were captured (Jones et al 1979). The size structure of the current sample has also changed significantly. In 1978, the range of lengths was only 29 mm (173 mm-212 mm), but lengths ranged from 125 mm to 360 mm in 1981. Mean length was significantly greater in 1981 (194 mm and 253 mm, for 1978 and 1981, respectively). Many of the larger suckers were sexually mature, and the size variation suggests that suckers are now reproducing successfully in Sylvan Lake.

Angler Use

The Volunteer Fisherman Report (VFR) system 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 500-1000 angler days. Current data indicates 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). Since 1978, there has been a steady increase in angler use to a record high of 1235 angler days in 1981 (Figure 37).

Landing rate appeared fairly stable but low (mean=0.59 trout per hour) during the four years preceding the catch and release restriction (Figure 38). Since that time, landing rates have risen to 1.57 trout per hour, a value unprecedented for Sylvan Lake. These improvements have occurred despite rising levels of use.

Although mean length of landed trout has been fairly stable, the size increased from 253 mm for the four years prior to the regulation to 265 mm since 1978. Mean length was greatest in 1978 (274 mm) but has gradually declined to 259 mm for the past two years. The reason for these changes is unclear; however, the mean length of illegally creeled trout in 1981 (296 mm) suggests that many of the larger trout may be unlawfully removed from the population.

Discussion

Although nutrient levels are low in Sylvan Lake, it may be its location at an elevation of over 2500 m which limits fish 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.

Despite a rather drastic decline in the number of cutthroat trout captured in gillnets, it appears that the trout population has remained quite stable since 1978. Mean length from gillnet samples and growth estimates for 1981 are virtually identical with the preceding survey. The decline in trout numbers is assumed to be only a relative decrease caused by the sharp rise in the density of longnose suckers.

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

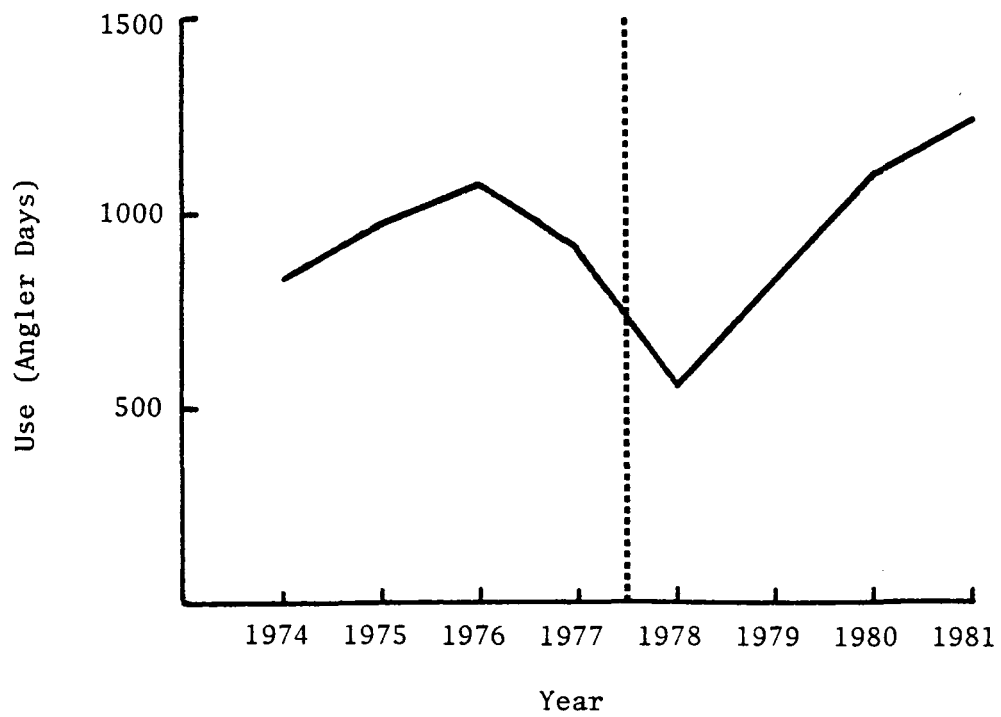


Figure 37. Angler use estimates for Sylvan Lake, 1974-1981.

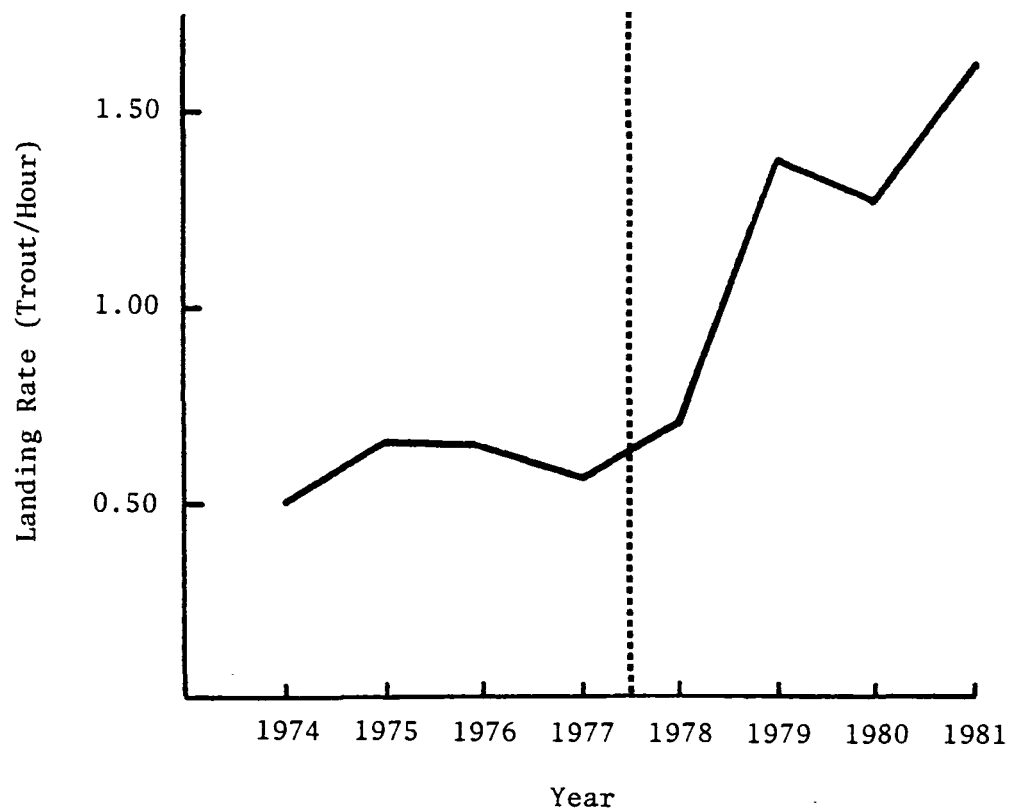


Figure 38. Landing rate estimates for Sylvan Lake, 1974-1981.

The catch and release-only regulation has significantly improved the annual landing rate despite rapid increases in angler use since 1978. Minor changes in the mean length of landed trout supports the stability suggested by the gillnetting data. Although extensive population monitoring will be necessary to verify future trends, the high recatchability of the cutthroat trout undoubtedly is important to the success of this regulation. Apparently, slow growth in this subalpine environment may be limiting the average length of trout, and size increases which have been documented in other "no harvest" waters may not occur in Sylvan Lake.

The extent of possible competition between the cutthroat trout and longnose sucker in Sylvan Lake is unknown, but thus far, there have been no observable effects on the trout population. If competition for a limited resource does occur between these two species, it seems logical that the effects of this interaction would be readily evident in this unproductive lake. Since a robust cutthroat trout population is probably the best defense against adverse effects, the protection of the current catch and release-only regulation may be significant. Continued monitoring is necessary to determine future population trends of these two species and to evaluate the effects of this restrictive angling regulation.

STREAM SURVEYS

Investigations on the Park's extensive stream resources continued in 1981 with the completion of the survey begun in 1980 on Hellroaring Creek and the initial survey of two more streams, Pelican Creek and Soda Butte Creek. Methods used followed the same procedures as in previous years (Jones et al 1979 and 1980).

HELLROARING CREEK

Hellroaring Creek originates outside the northern Park boundary in Gallatin National Forest and only the lower third (14.5 km) is situated in the Park. In 1980, (Jones et al 1981) a reconnaissance survey was conducted on the Park portion of this stream. A habitat inventory and an electrofishing operation were conducted July 28-31, 1981 to gain additional data on this fishery. Information reported herein will refer only to that portion of Hellroaring Creek that is within Park boundaries.

Habitat Inventory

Three stations were set up and sampled on Hellroaring Creek, each being representative of a portion of the stream habitat. Station 1, located 1.7 km upstream from the mouth and representing 47% of the creek and Station 2, located 3.7 km upstream from the mouth and representing 35% of the creek, are situated in very similar terrain with generally open hills of big sagebrush and Idaho fescue influenced by infrequent stands of Douglas fir and lodgepole pine (Jones et al 1981). Approximately 50% of direct sunlight reaches the stream on a clear, sunny day.

Station 3, located 6.5 km upstream from the mouth, represents 18% of the creek. In this section, Hellroaring Creek flows south from the Park boundary through a dense Douglas fir/pinegrass forest interspersed with large open areas of big sagebrush with Idaho fescue (Jones et al 1981). Approximately 35% of direct sunlight reaches the stream here on a clear, sunny day.

The mean flow and depth for Hellroaring Creek varied from 2.64 m³/sec and 0.30 m, respectively, at Station 1 to 1.67 m³/sec and 0.27 m, respectively, at Station 3. For the entire stream, average flow and depth were estimated at 2.20 m³/sec and 0.9 m, respectively (Table 33). Mean width was 21.40 m.

Optimum habitat rating for Hellroaring Creek was 40.5% (Table 33). Although this is not an excellent rating, it is the highest yet obtained for Park streams. There does not seem to be much variation between stations, with a high of 44.1% at Station 3 and a low of 38.7% at Station 2. Stable stream bottoms and

Table 33. Station means and optimum habitat ratings for Hellroaring, Pelican and Soda Butte Creeks, 1981

	Hellroaring Creek				Pelican Creek				Soda Butte Creek			
	Sta. 1	Sta. 2	Sta. 3	weighted avg. survey area	Sta. 1	Sta. 2	Sta. 3	weighted avg. survey area	Sta. 1	Sta. 2	Sta. 3	weighted avg. survey area
Pool measure (%)	22.7	30.7	44.0	29.3	17.6	44.9	7.2	11.0	0	16.3	0	3.8
Pool structure (%)	0	5.0	0	1.7	17.6	0	0	4.6	0	0	0	0
Stream bottom (%)	69.0	44.0	61.0	58.8	92.0	62.0	41.0	54.9	95.0	84.0	94.0	92.1
Environment (%)	70.0	75.0	71.3	72.0	37.5	78.8	25.0	29.9	25.0	82.5	32.5	41.0
Bottom structure (%)												
Bedrock	0	0	0	--	0	2.0	0	--	0	0	0	--
Boulder	25.6	49.0	35.0	--	1.0	10.0	0	--	0	4.0	0	--
Rubble	61.0	38.0	49.0	--	76.0	44.0	5.0	--	75.0	47.0	62.0	--
Gravel	8.0	6.0	12.0	--	16.0	18.0	36.0	--	20.0	37.0	32.0	--
Sand	4.4	6.0	4.0	--	6.0	23.0	32.0	--	0	8.0	3.0	--
Silt	1.0	1.0	0	--	1.0	3.0	27.0	--	5.0	4.0	3.0	--
Other	0	0	0	--	0	0	0	--	0	0	0	--
Mean width (m)	23.10	19.38	20.94	21.40	3.08	8.56	17.31	13.35	12.93	13.35	10.12	12.01
Pool (%)	11.3	15.3	22.0	--	8.8	24.6	63.6	--	0	8.2	20.0	--
Run/Riffle (%)	88.7	84.7	78.0	--	91.2	75.4	36.4	--	100.0	91.8	80.0	--
Mean depth (m)	0.30	0.27	0.27	0.27	0.15	0.18	0.43 ¹⁾	0.37	0.27	0.21	0.18	0.21
Mean velocity (m/sec)	0.46	0.55	0.27	--	0.24	0.24	0.33	--	0.58	0.55	0.21	--
Flow (m ³ /sec)	2.64	1.89	1.67	2.20	0.09	0.27	1.23	0.90	1.41	1.10	0.29	0.92
% of the habitat represented by each station	47	35	18	100	26	3	71	100	40	23	37	100
Optimum Habitat Rating (%)	40.4	35.7	44.1	40.5	41.2	46.4	13.3	25.1	30.0	45.7	31.6	34.2

1) See text.

banks contribute to consistently high ratings in stream bottom structure and environment. Pool structure and pool rating, however, were very low at all three stations. Likewise, pool rating was also low.

Hellroaring Creek was rated good (55.6) under the Channel Stability Rating System (U.S. Forest Service 1975)(Table 34). The upper banks of Stations 1 and 2 showed no evidence of past or any potential for future mass wasting into the channel. Upper banks at Station 3 were only slightly less stable with infrequent wasting. Debris was present at all three stations with moderate frequency and sizes. Vegetative bank protection was good at all three stations, adding to the bank stability. Lower banks also appear to be quite stable. Stations 1 and 2 had 40-65% rock content and Station 3 had greater than 65% rock content with a higher frequency of boulders 305 mm in diameter and greater.

Obstructions to flow and sediment traps were not firmly embedded and had little or no depositing; neither were common in Hellroaring Creek. Stations 1 and 2 had no bank cutting while Station 3 had only slightly more at outcurves and constrictions. Stream bottom consisted of 80-100% stable materials at all three stations. Although the stream bottom was extremely slippery with algae and mosses at all three stations, vascular aquatic vegetation was rare (Table 30). This paucity of aquatic macrophytes could be caused by extremely fast water during spring runoff not allowing the vegetation to develop adequate root masses in the stream channel; however, lower flows throughout the summer and fall are suitable for algae and moss growth.

Chemical

A water sample was taken at Station 2 and sent to a commercial laboratory for chemical analysis (Table 29). Hellroaring Creek was classified as a calcium-bicarbonate stream. The pH varied from 7.6 at Station 3 to 7.8 at Stations 1 and 2. Several of the chemical parameters were low for Park streams, including sodium, iron, silica, potassium, total organic carbon, total Kjeldahl nitrogen, nitrate nitrogen and ortho-phosphate. Total hardness and calcium were both slightly higher than average for Park waters.

Aquatic Invertebrates

Two surber samples were collected at each station. A total of 9 taxonomic groups were represented with mayflies (5 genera) being the most common (Table 32). Cinygmula sp. was the only invertebrate found abundantly at all three stations. Stoneflies (1 genera), caddisflies (1 genera) and crane flies (2 genera) were rare at all three stations.

An overnight (11.75 hours) drift net sample was taken at Station 2. A total of 18 taxonomic groups were represented in this sample (Table 32), including

Table 34. Stream reach inventory and channel stability evaluation, Hellroaring, Pelican and Soda Butte Creeks, 1981

	Station 1				Station 2				Station 3			
	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
<u>Hellroaring Creek</u>												
Upper banks	3	10	6	0	5	6	6	0	0	16	6	0
Lower banks	10	6	0	0	8	10	0	0	6	12	3	0
Stream bottom	14	2	0	0	6	18	0	0	12	6	0	0
TOTALS	27	18	6	0	19	34	6	0	18	34	9	0
Station Stability Score:	51				59				61			
Stream Stability Score: ¹⁾ (weighted average)	55.6											
<u>Pelican Creek</u>												
Upper banks	2	10	9	0	3	0	21	0	0	0	21	12
Lower banks	0	4	33	0	0	8	24	4	0	0	9	40
Stream bottom	0	2	42	0	1	26	3	0	0	2	33	12
TOTALS	2	16	84	0	4	34	48	4	0	2	63	64
Station Stability Score:	102				90				129			
Stream Stability Score: ¹⁾ (weighted average)	120.8											
<u>Soda Butte Creek</u>												
Upper banks	2	10	9	0	3	0	21	0	0	10	15	0
Lower banks	0	4	33	0	0	8	27	0	0	4	30	4
Stream bottom	10	10	0	0	0	26	6	0	0	0	42	4
TOTALS	12	24	42	0	3	34	54	0	0	14	87	8
Station Stability Score:	78				91				109			
Stream Stability Score: ¹⁾ (weighted average)	92.5											

¹⁾ Ratings: Excellent = 0-38; Good = 39-76; Fair = 77-114; Poor = 115+.

those identified in the surber sample. Baetis tricaudatus was the most common invertebrate in the drift sample. Of the 435 invertebrates collected in this sample, mayflies represented 92.6% or 2.69 individuals per cubic meter of water; stoneflies 4.1% or 0.12 per cubic meter of water and caddisflies and crane flies 0.02% or 0.05 per cubic meter of water each.

Aquatic Vertebrates

An adjusted Petersen technique (Ricker 1975) was used for the population estimate in Station 1. A total of 13 trout were marked with fin clips on July 29. During the recapture run on August 27, length and weight measurements were obtained from all trout captured and scales were collected from 30 trout for age determination. Ages were estimated by the scale method (Bagenal and Tesch 1978), and expansions for the entire sample were calculated using an age-length key (Westerheim and Ricker 1978).

Clipped trout ranged from 81 to 217 mm total length (Figure 39), and therefore only trout within this size range were inspected for marks during the recapture run for inclusion in the population estimates. Mean length for the 75 trout in this group was 127 mm and mean weight was 32 g; mean K factor was 1.17 (Table 36). Additionally, 147 young-of-the-year trout were captured. Mean length of these small trout was only 37 mm and they were not included in the estimates.

The trout utilized in the population estimates ranged from age I-V, and mean age for 51 trout was 1.8 years. Back-calculated length at annulus formation were 42, 100, 164, 222 and 278 mm for ages I-V, respectively (Table 35). Eight of the 26 trout for which age could be determined displayed a retarded growth pattern (Laakso and Cope 1956).

The total estimate for the 244 m section was 177 cutthroat trout (confidence limits 91-665) over 80 mm total length. This figure equates to 725 trout/km or 314 trout/ha. Biomass estimates were 23.2 kg/km or 10.0 kg/ha (Table 37). Although the inclusion of young-of-the-year cutthroat trout would greatly increase the abundance estimates, biomass would not be increased significantly by the addition of these fry.

Angler Use and Pressure

Volunteer Fisherman Reports (VFR) for Hellroaring Creek are severely hampered by low sample size (Figures 40 and 41). Combining data from 1977-1980, use estimates average 405 angler days per year with a mean catch rate of 1.37 fish per hour. Although these figures do not indicate severe problems, the inability to separate the returns into the various sections of stream may bias the results positively causing overestimateion. The decrease in mean length of trout landed is significant and suggests overharvest may be occurring at least on portions of the stream (Figure 42).

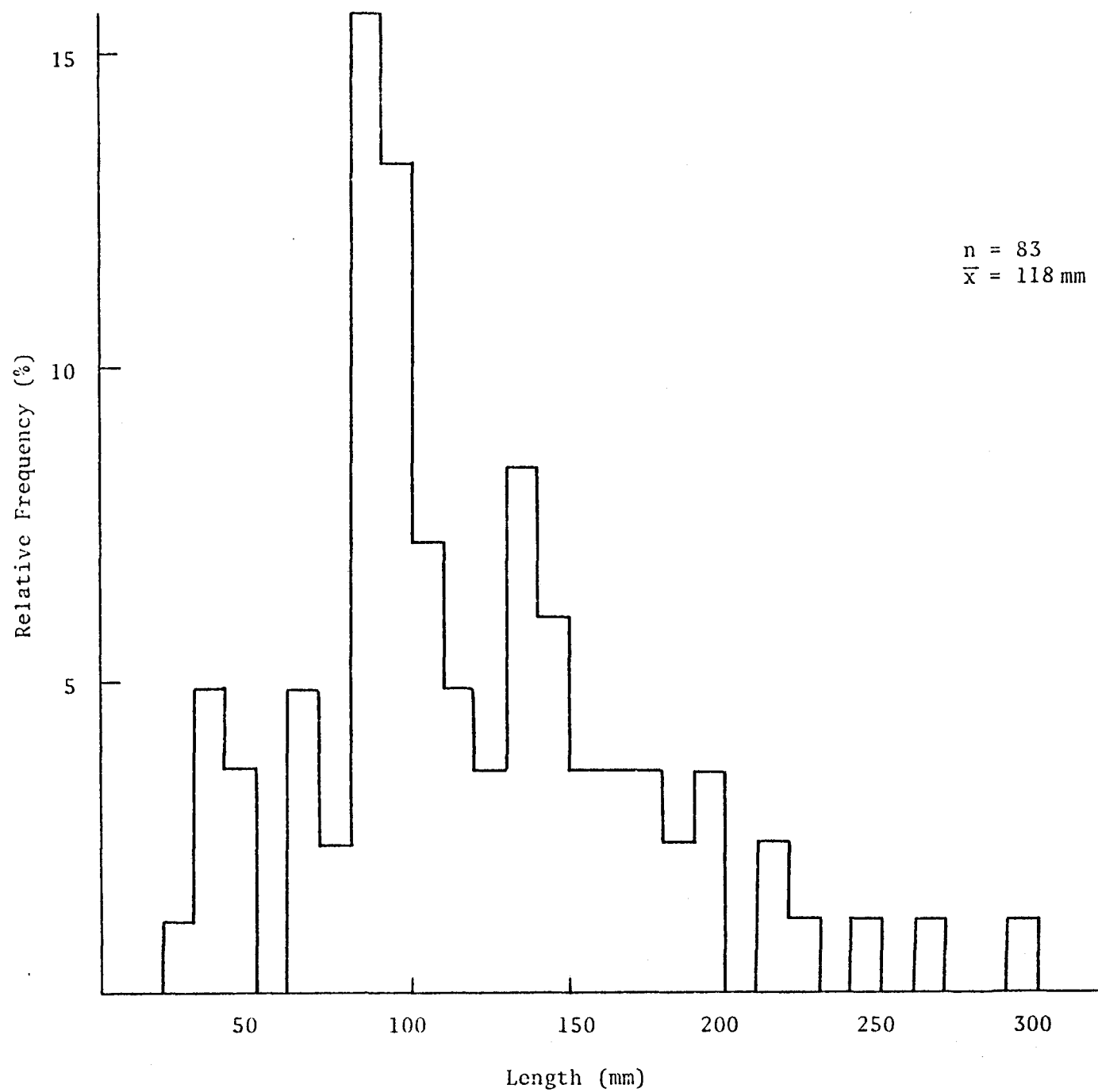


Figure 39. Length of introgressed cutthroat captured by electrofishing gear, Hellroaring Creek, August 27, 1981.

Table 35. Mean calculated length (mm) at annulus formation of introgressed cutthroat trout populations sampled during stream surveys, 1981

Location	Sample Size	Annulus				
		I	II	III	IV	V
Hellroaring Creek	26	42	100	164	222	278
Soda Butte Creek						
Station 1	36	47	109	186	251	326
Station 2	17	49	101	177	220	
Station 3	14	62	122	192	258	

Table 36. Mean length, weight and condition factor for introgressed cutthroat trout populations sampled during stream surveys, 1981

Location	Mean Length (mm)	Number	Mean Weight (g)	Mean K Factor	Number
Hellroaring Creek	127	75	32	1.17	74
Soda Butte Creek					
Station 1	155	114	90	1.20	63
Station 2	122	150	23	1.11	58
Station 3	201	22	129	1.07	22

Table 37. Population and biomass estimates for introgressed cutthroat trout populations sampled during stream surveys, 1981

Location	Trout/km	Trout/ha	kg/km	kg/ha
Hellroaring Creek	725	314	23	10
Soda Butte Creek				
Station 1	679	523	61	47
Station 2	1004	752	23	17
Station 3	138	136	17	17

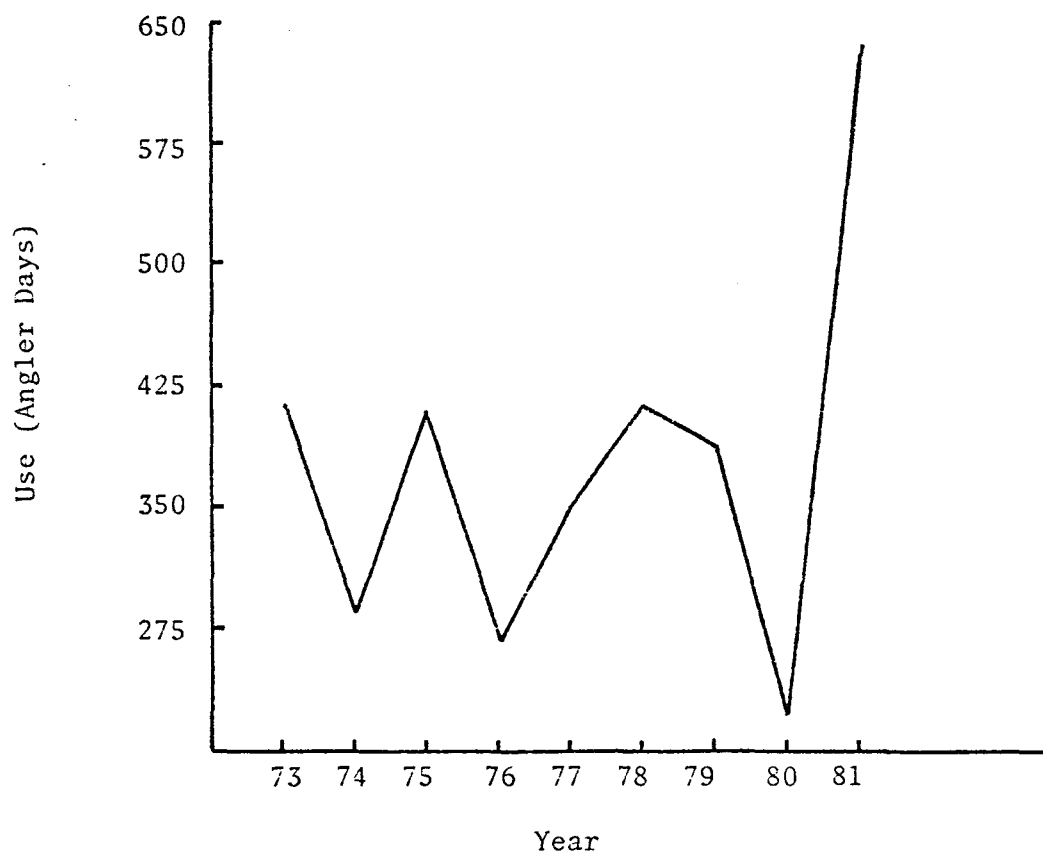


Figure 40. Angler use estimates for Hellroaring Creek, 1973-1981.

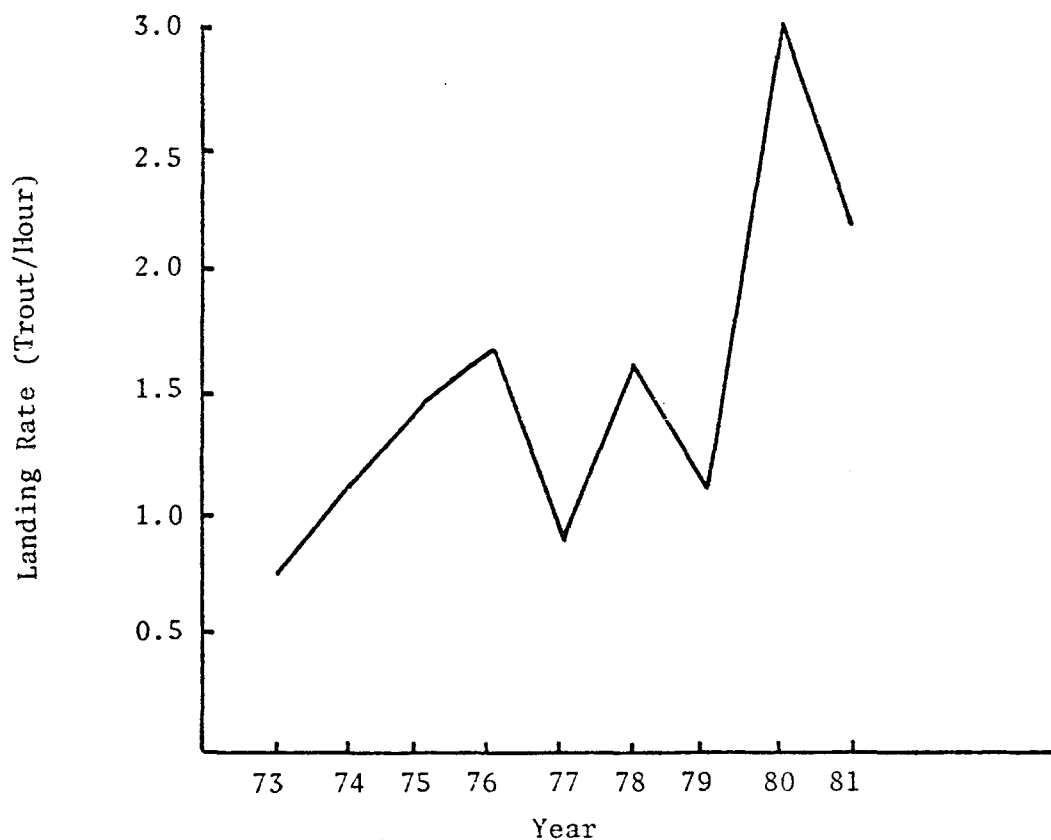


Figure 41. Landing rate estimates for Hellroaring Creek, 1973-1981.

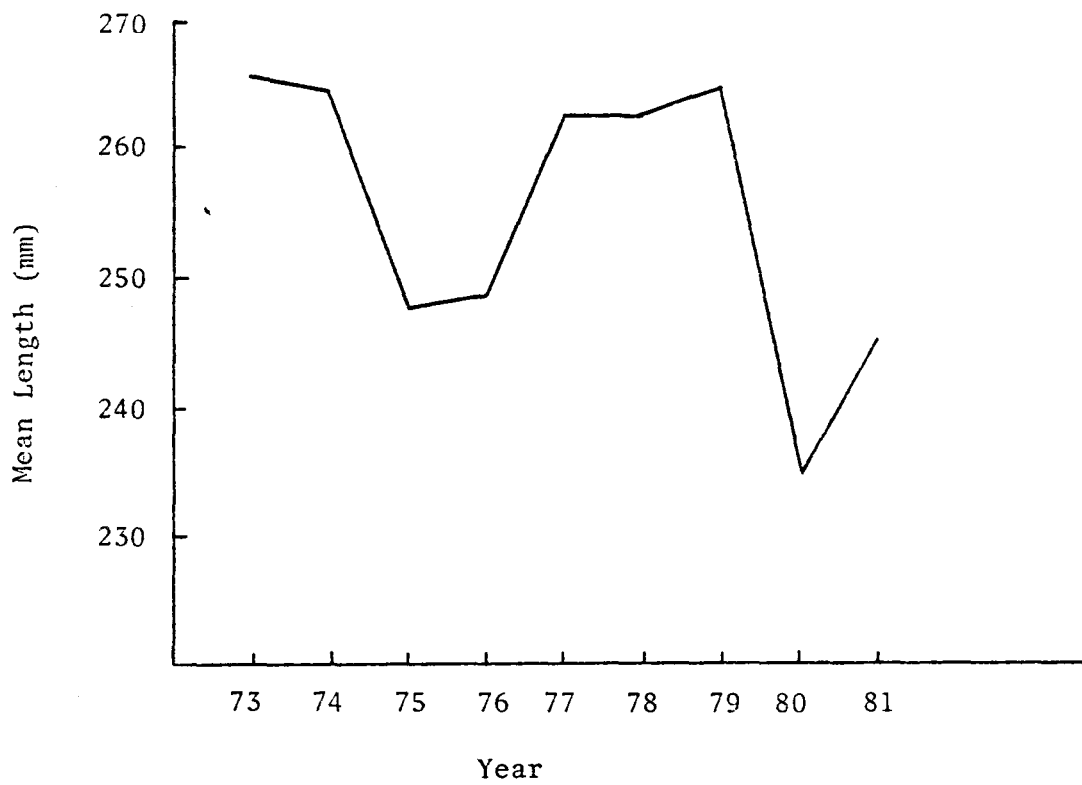


Figure 42 . Mean length of trout landed by anglers at Hellroaring Creek, 1973-1981.

Discussion

Habitat inventory on Hellroaring Creek in 1981 revealed a good habitat by Park standards, and yet, population estimates were only 314 trout per acre. Fish size was extremely small, averaging only 127 mm, and biomass was only about 10.0 kg/ha. Since the current population estimates were limited to the lower portion of the creek, where angler use is highest, it is reasonable to assume that number and sizes of cutthroat may be greater in upper portions of the creek. If this is the case, however, it only emphasizes the effect of angling on the cutthroat population in Hellroaring Creek.

Despite the lack of overwhelming evidence of overharvest by VFR returns, stream survey analysis indicates definite problems in the lower portion of the stream. As a matter of comparison, Soda Butte Creek, which is of similar size, has a lower habitat rating, yet biomass estimates are from 2 to 4 times greater than Hellroaring Creek. The increase of reports by concerned anglers concerning the deterioration of angling condition supports the current findings. We recommend, therefore, that Hellroaring Creek be placed under catch and release regulations in 1982.

PELICAN CREEK

Pelican Creek, second only to the upper Yellowstone River as the largest tributary to Yellowstone Lake, originates in the high meadow areas just south of the Mirror Plateau. A reconnaissance and habitat survey was conducted on this creek June 30-July 3, 1981. Although the only wildlife observed during this survey were sandhill cranes, great blue herons and several moose, this area supports a diverse fauna including grizzly bear, bison, elk, beaver, weasel, muskrat, great gray owl and several species of waterfowl.

The East Entrance Road passes over Pelican Creek near its mouth providing easy access to the lower portion of the stream. Upper portions can also be easily reached on foot or with stock by a well maintained pack trail which follows the creek nearly its entire length.

Historic Documents and Fish Stocking Records

Historically, only cutthroat trout and longnose dace (Rhinichthys cataractae) were found in Pelican Creek. A fish trap (located approximately 1.4 km above the mouth) was used for spawn-taking activities, and from 1914-1944, over 106.5 million cutthroat trout eggs were collected for fish cultural purposes (Superintendent's Annual Reports 1914-1944). The current fish trap, built in 1963, is utilized to monitor annual spawning runs and collect data on Yellowstone Lake fish populations (see Yellowstone Lake, Pelican Creek Spawning Run, this report). Approximately 23.1 million cutthroat trout were stocked in Pelican Creek between 1913 and 1952 (Varley 1981). Present species composition consists of cutthroat trout, longnose suckers, redbreast shiners and longnose dace (Dean 1971).

Physical and Chemical Characteristics

Pelican Creek originates at an elevation of 2,682 m in the high meadow area southwest of the Mirror Plateau (Figure 43). It derives its main water supply from snowmelt and springs. The creek's mainstem flows approximately 49.6 km where it empties into the northern portion of Yellowstone Lake. The entire stream system contains almost 160 km of fluvial water and drains approximately 15,540 ha (Ball and Cope 1961). The upper portion of Pelican Creek (above Raven Creek) flows at a moderate gradient of 12 m/km, but from Raven Creek to its mouth, Pelican Creek flows at a much lower gradient of 2 m/km.

From its source to approximately 7.0 km downstream, Pelican Creek meanders through a hilled meadow area with many small seeps and springs. The meadow narrows and the upper banks become forested with Engelmann spruce, Douglas fir and lodgepole pine for the next 4.5 km. Here the meadow again opens up

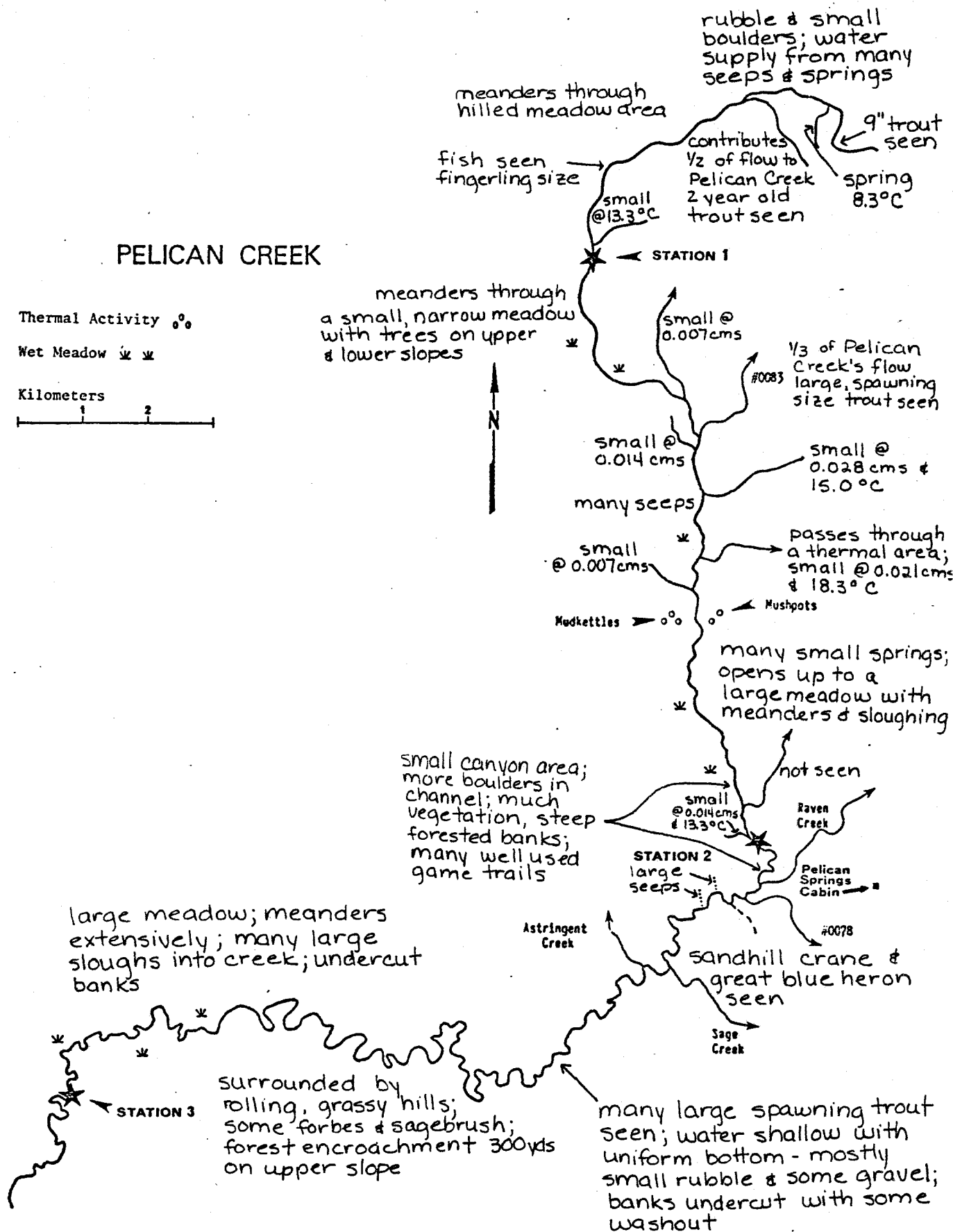


Figure 43. Pelican Creek, Yellowstone National Park, 1961.

and Pelican Creek meanders for another 7.6 km. Thermal features in this section have only a minimal input into the water flow. From here Pelican Creek enters a small canyon area (2 km) with steep banks dominated by lodgepole pine interspersed with Engelmann spruce and Douglas fir. Vegetation and small boulders occur much more frequently in the stream here. The lower 26.5 km of Pelican Creek meanders through another very wide meadow area with grasses and some willows and sedges. Here the creek flows at a very low gradient with sparse stream vegetation consisting only of algae and mosses.

Pelican Creek has several tributaries and many small springs and seeps particularly in the upper portions. Flows, water temperature and pH were taken on five of its more important tributaries: Raven Creek, Sage Creek, Astringent Creek and two unnamed streams (#0078 and #0083)(Figure 40). Flows varied from 0.49 m³/sec to 0.08 m³/sec (Table 38). Raven Creek contributes approximately one half of Pelican Creek's volume at their confluence. Astringent Creek's temperature and pH were measured at 21.7° C and 6.8, respectively. Temperature and pH on the other four tributaries ranged from 12.8° C to 17.8° C and 7.2 to 7.4, respectively. The high temperature and acidic pH of Astringent Creek are probably due to thermal inputs.

Geologically the main course of the creek meanders through alluvium and glaciofluvial deposits of the Pleistocene and Holocene eras. The upper eastern slopes of Pelican Creek are heavily influenced by the Langford Formation of andesitic breccias of the Eocene era with intermittent areas of Lava Creek Tuff (rhyolitic ash-flow)(Pleistocene). The upper western slopes are also heavily influenced by the Lava Creek Tuff of rhyolitic ash-flow (Christiansen et al 1975).

A water sample was taken at Station 2 and Pelican Creek was found to be a calcium-bicarbonate water. The pH varied from 7.1 in the canyon area to 7.4 in the headwaters area. Most measured chemical parameters were average for Park streams except for slightly low measures of total dissolved solids, chloride, sulfate, fluoride, calcium, sodium and silica.

Habitat Inventory

Three stations were selected and analyzed on Pelican Creek (Figure 43). Station 1 was located in the high meadow area (42.6 km upstream from the mouth) and represented 26% of the entire creek. Representing 3% of the creek, Station 2 (27.5 km upstream from the mouth) was situated in a small canyon section. The major portion of the creek (71%), meandering through a wide, open valley, is represented by Station 3 (3.7 km upstream from the mouth).

The average flow and depth for Stations 1, 2 and 3 varied from 0.09 m³/sec and 0.15 m at Station 1 to 1.23 m³/sec and 0.43 m, respectively, at Station 3, yielding

Table 38. Major tributaries to streams surveyed, 1981

	Flow (m ³ /sec) ¹⁾	Width (m)
Pelican Creek		
Astringent Creek	0.10	4.2
Raven Creek	0.36	6.4
Sage Creek	0.13	3.4
#0078	0.49	6.0
#0083	0.08	1.7
Soda Butte Creek		
Amphitheater Creek	0.03	3.1
Pebble Creek	0.25	6.5
Warm Creek	-	-

1) All flows were taken near the confluence.

pH	Water Temperature ($^{\circ}\text{C}$)	Conductivity μ mhos
6.8	21.7	-
7.2	17.8	-
7.3	12.8	-
7.2	13.3	-
7.4	17.2	-
7.4	9.4	89
8.4	8.9	195
8.2	5.6	300

a weighted average for the entire creek of $0.90 \text{ m}^3/\text{sec}$ and 0.37 m , respectively (Table 33). Widths varied from 2.13 m at Station 1 to 22.34 m at Station 3.

The overall habitat rating for Pelican Creek was low (25.1). This is attributable to the extremely low rating (18.3) at Station 3, which represented almost three fourths of the entire creek. Station 3's pool rating and structure were very low, while environment and stream bottom were only slightly better (Table 33). Massive sloughing and bank undercutting were abundant throughout the entire station.

Station 1 and 2 rated much higher, (41.2 and 46.4, respectively), but because of the low percentage of the creek these two stations represented, they had little effect on the overall rating. Station 1 had an excellent bottom rating due to a high percentage of rubble and gravel in the substrate. Station 2 rated good in both environment and stream bottom.

Upper slopes of Pelican Valley were dominated by lodgepole pine at all three stations interspersed with stands of Engelmann spruce and Douglas fir. Lower slopes were similar at all three stations, supporting lodgepole pine, grasses and some willows. The riparian zone was dominated by grasses at all three stations. Stations 1 and 3 also had willows and some sedges and Station 2 had some lodgepole pine. Stations 1, 2 and 3 receive approximately 80%, 30% and 70% direct sunlight, respectively, on a clear, sunny day.

Pelican Creek rated poor (120.8) under the Channel Stability Rating System (U.S. Forest Service 1975) (Table 34). Station 1, rated fair (102), had a moderate frequency and size of bank sloughing into the channel and very little debris in the channel area, and vegetation density on upper banks was 70-90%. Lower banks here indicated occasional overbank flooding with rock content being only 20-40%. Some obstructions to flow were present causing erosive cross currents and minor pool filling with significant bank cutting and sloughing. Approximately 20-50% of the bottom appears stable. Clinging aquatic vegetation was present but spotty, mostly in back water areas.

Station 2 rated slightly better (90) having more vigorous bank protection, and vegetation density over 90% with a deep dense root mass. Channel capacity appeared inadequate with overbank flooding common. There was also an increase in bottom stability (50-80% stable materials) over Station 1. Vegetation was absent with 15-25% of the bottom covered.

Station 3 had the worst rating (129) of the three stations. This was primarily due to a much higher frequency of bank undercuts and sloughing into the stream, extensive deposition of fine particles and accelerated bar development. The only vegetation present here was algae and mosses.

Aquatic Invertebrates

Two surber samples were taken at each station (Table 32). Species diversity and abundance was low at both Stations 1 and 3. At Station 1, mayflies (2 genera) and stoneflies (1 genera) were collected only rarely. Station 3 was only slightly higher in abundance and diversity. Mayflies (1 species), caddisflies (1 genera), crane flies (1 genera) and riffle beetles (1 genera) were represented in the sample. Mayflies and stoneflies occurred rarely and crane flies commonly at Station 3. At Station 2, 10 different taxonomic groups were found. Two species of mayflies occurred abundantly and two genera of caddisflies were common in the sample. All other groups including mayflies, caddisflies, crane flies and riffle beetles, were rare.

An overnight (13.85 hours) drift sample was taken at Station 1 on Pelican Creek. Nine taxonomic groups were represented in this sample, and the mayfly, *Baetis tricaudatus*, occurred most abundantly (70.4%) (Table 32). Total mayflies represented 88% of the sample or 0.18 individuals per cubic meter of water. Riffle beetles (7.4%) and stoneflies (4.4%) were the only other invertebrates collected, and each represented 0.01 individuals per cubic meter of water.

Aquatic Vertebrates

Pelican Creek is an important spawning stream for the native cutthroat trout and the exotic longnose sucker and redbreasted sunfish. Longnose dace, another native species, have also been captured in Pelican Creek near its mouth (Dean 1971). This stream also sustains a resident cutthroat trout population (Jones et al 1979). (See Yellowstone Lake, Pelican Creek Spawning Run, this report). During the survey, trout were observed throughout the entire stream and spawners were seen in several of the Pelican Creek tributaries. One longnose sucker was seen at Station 2.

Angler Use and Pressure

Fishing regulations on Pelican Creek were changed to catch and release-only in 1978. The season does not open until July 15 and the lower 3.2 km remains closed year round. Most of the fishing occurs below Raven Creek and is done by back-country campers or day use anglers (Jones et al 1978).

According to 1981 VFR data this fishery ranked thirteenth Parkwide in popularity where an estimated 1,936 anglers spent 3,469 angler days and 8,849 angler hours fishing (Table 5). Approximately 19,915 trout were landed and 118 illegally creel. Mean length of trout landed was 356 mm and of trout illegally creel 432 mm (Figure 44). Pelican Creek has an excellent landing rate of 2.25 fish per hour (Figure 45). This far exceeds the reported

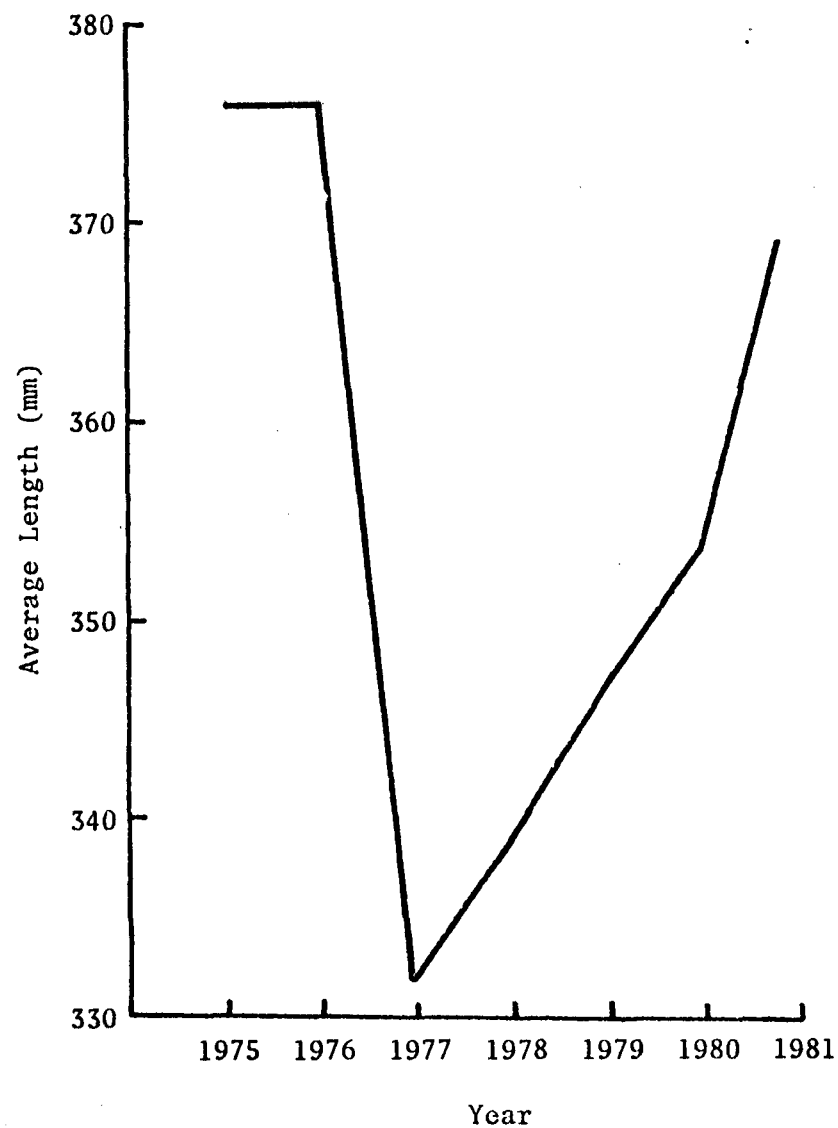


Figure 44. Mean length of trout landed, Pelican Creek, 1975-1981.

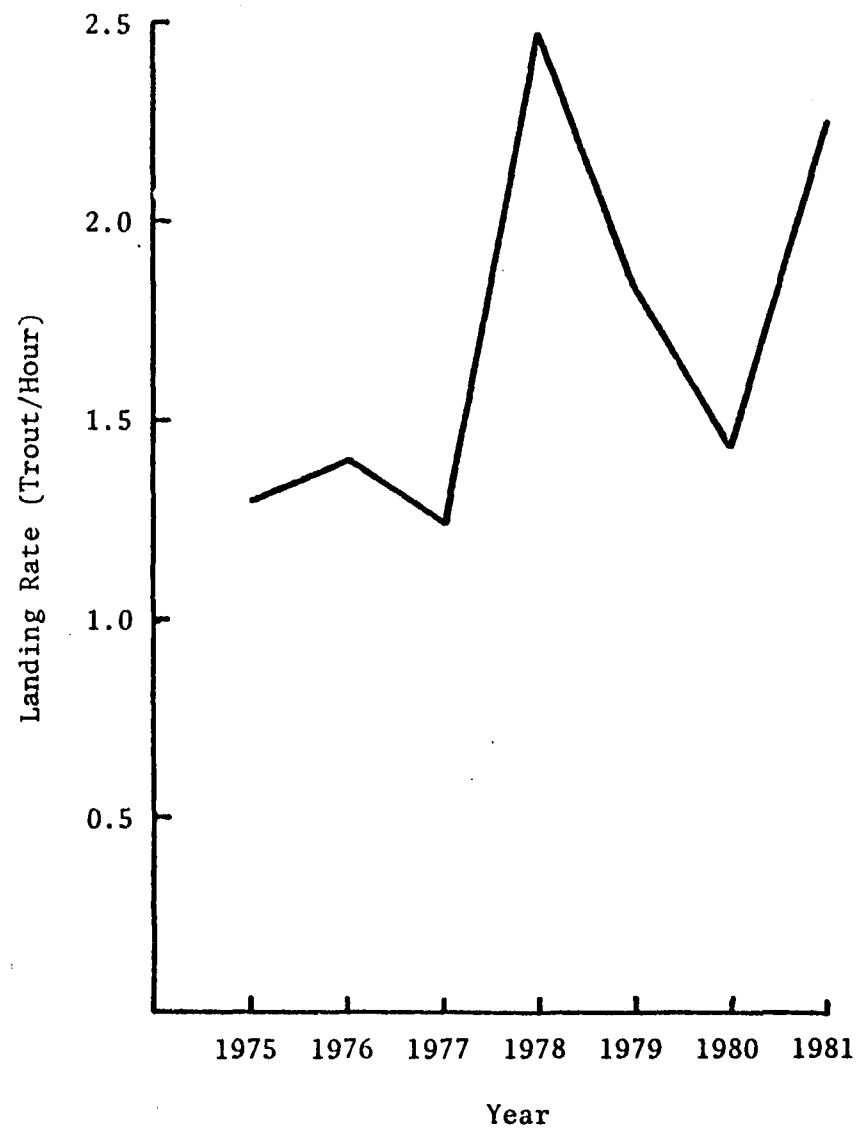


Figure 45. Landing rate estimates for Pelican Creek, 1975-1981.

landing rate of any other water in the Park. The percentage of anglers satisfied with their overall experience, the numbers landed and the sizes of fish landed were also exceptionally high (89%, 90% and 93%, respectively). After being placed on the catch and release-only regulation in 1978, Pelican Creek suffered an initial reduction in angling pressure, but at least partially because of its excellent landing rates, pressure has been steadily increasing since 1979.

The mean landing rate (1.34) of the five years prior to the regulation change (1973-1977) increased 49% over the mean landing rate (2.00) of the four years following the change (1978-1981). Sizes also appear to be increasing but variations in sample sizes may affect results. It is suggested that although Pelican Creek supports a high quality resident fishery, extremely high landing rates, as in 1981, are substantially boosted by Yellowstone Lake spawners (Figure 7). For example, in 1981 29,638 trout were passed upstream through the fish trap while only 11,545 returned downstream through the fish trap (see Yellowstone Lake, Pelican Creek Spawning Run, this report). Factors controlling the movement of spawners out of Pelican Creek are unknown.

Discussion

Although Pelican Creek does have some excellent trout habitat, stream survey results showed poor pool structure, frequent bank undercutting and massive bank sloughing into the channel throughout the major portion of the creek.

Despite these findings, Pelican Creek is able to support an excellent trout fishery. It appears the spawning run of cutthroat trout from Yellowstone Lake contribute significantly to the angling success on Pelican Creek; however, this contribution varies greatly from year to year.

Since implementation of the catch and release-only regulation, angling quality has remained high with occasional occurrences of extremely high quality. These extremely high occurrences are assumed to be caused by the influence of the spawning run. Years when the spawning run has little effect on the Pelican Creek fishery, the resident trout population must carry the full load of angling pressure. Therefore, this regulation not only protects the Yellowstone Lake spawning trout but also gives needed protection to the resident population, when because of the spawners' absence, they are most vulnerable.

Further study needs to be made of the complex interactions of the resident and non-resident cutthroat trout in Pelican Creek.

SODA BUTTE CREEK

Recent concerns and inquiries involving angling quality and recommended catch and release regulations in Soda Butte Creek prompted a more intensive stream survey in 1981. This includes additional hydrographic and hydrochemical data as well as fish population estimates. These data will provide information for future monitoring and comparison with past studies.

Historic Documents and Fish Stocking Records

Soda Butte Creek was stocked with cutthroat fry and fingerling almost annually from 1920 to 1943. Additionally, plants of adult cutthroat trout from Trout Lake were made in 1937 and 1938, and approximately 106,000 rainbow trout fry were introduced into Soda Butte Creek in 1937. Yellowstone Lake and Trout Lake were the predominant egg sources for the 4.6 million cutthroat trout planted in the stream, and the rainbow trout came from Ennis Hatchery stocks (Varley 1981).

Loudenslager and Gall (1981) classified the present trout population in Soda Butte Creek as introgressed. Apparently past hybridization has allowed the entry of rainbow trout alleles into the gene pool, but rainbow trout and F_1 hybrids of the two species do not occur. He observed a frequency of backcross hybrids between 10 and 30 percent.

Fishermen also report brook trout from the tributaries of upper Soda Butte Creek and a few are reported in the creek within the park boundary. This stream may also be vulnerable to immigration of brown trout introduced earlier into the Yellowstone River.

Mill Tailings Pollution

Tailings from a mining operation in the upper part of Soda Butte Creek have had a detrimental effect on aquatic life in that part of the stream (Mills and Sharpe 1968). The McLaren mine and mill was located just east of Cooke City on the north bank of Soda Butte Creek at its confluence with Miller Creek. This mine operated continually from 1933 to January 1, 1953. Gold was the principle ore mined, but some copper and silver were also found. This was once the largest operating gold mine in Montana.

Large quantities of mill tailings remained after the operation ceased. A cyanide process was used in recovering gold at the mill, but arsenic may have also been employed in this recovery process. These materials and high levels of iron were contained in the tailings and were eroded badly by precipitation into Miller Creek prior to entering Soda Butte Creek.

Efforts by the National Park Service prompted the mine owners, the Bear Creek Mining Company (Subsidiary of Kennicott Corporation), to take steps

to eliminate pollution from the tailings in 1969. The stream was rechanneled around the tailings which were covered with 2 feet of soil and sown with grass. The problem of ferrous oxide precipitates remained unsolved.

In 1970, reductions in siltation were observed in Soda Butte Creek as a result of the rehabilitation, but no decreases in iron, copper or zinc were reported by the Environmental Protection Agency. Seepage continues to bleed toxic materials from these buried tailings into the stream.

A general deterioration of Soda Butte Creek and its fishery occurred with erosion of the mill tailings. Local sources indicated that it was once possible to catch cutthroat trout immediately behind Cooke City and to observe fish spawning in the area before the mining operation. No fish were observed in 1967 above the park boundary.

Fishermen from Silver Gate area now report catching some cutthroat trout above the park boundary, but the numbers are very low. In the Park, Soda Butte Creek is showing some signs of recovery, but these trends are being confounded by increased fishing pressure, domestic sewage pollution from Cooke City and apparent periodic surges of pollutants from the mill tailings.

Physical Description

Soda Butte Creek originates at an elevation of 2,347 m as the outlet to a small, unnamed lake above Cooke City, Montana, and flows a total of 33.6 km southwest into Yellowstone National Park and into the Lamar River, a major tributary of the Yellowstone River. Only the lower 26 km of Soda Butte Creek are within Park boundaries and will be considered in this report. The entire drainage (26,020 ha) is steep with several peaks over 3,050 m in elevation bordering the stream basin. Gradient varies considerably with an average drop of 11.7 m/km and total drop of 396 m from its origin to its confluence with the Lamar River.

From its entry into the Park to Icebox Canyon (11.7 km), Soda Butte Creek generally flows through a densely forested area with a few interspersed small meadows (Figure 46). A small canyon (0.8 km) exists beginning 4.8 km within the Park boundary and a large meadow area occurs just above Icebox Canyon. Forested areas consist of lodgepole pine and Engelmann spruce with some willows and cottonwood. Icebox Canyon (3 km) consists of very steep walls of conglomerate rock. Soda Butte Creek travels at a moderate to high gradient through the canyon passing over three fish barriers. The first is approximately 6 m high and consists of a double waterfall with a very steep cascade passing around the falls. The second, approximately 61 m in length, is a velocity chute/cascade. The third barrier, another combination of falls and cascades, is approximately 5 m high. While all three of these provide at

SODA BUTTE CREEK

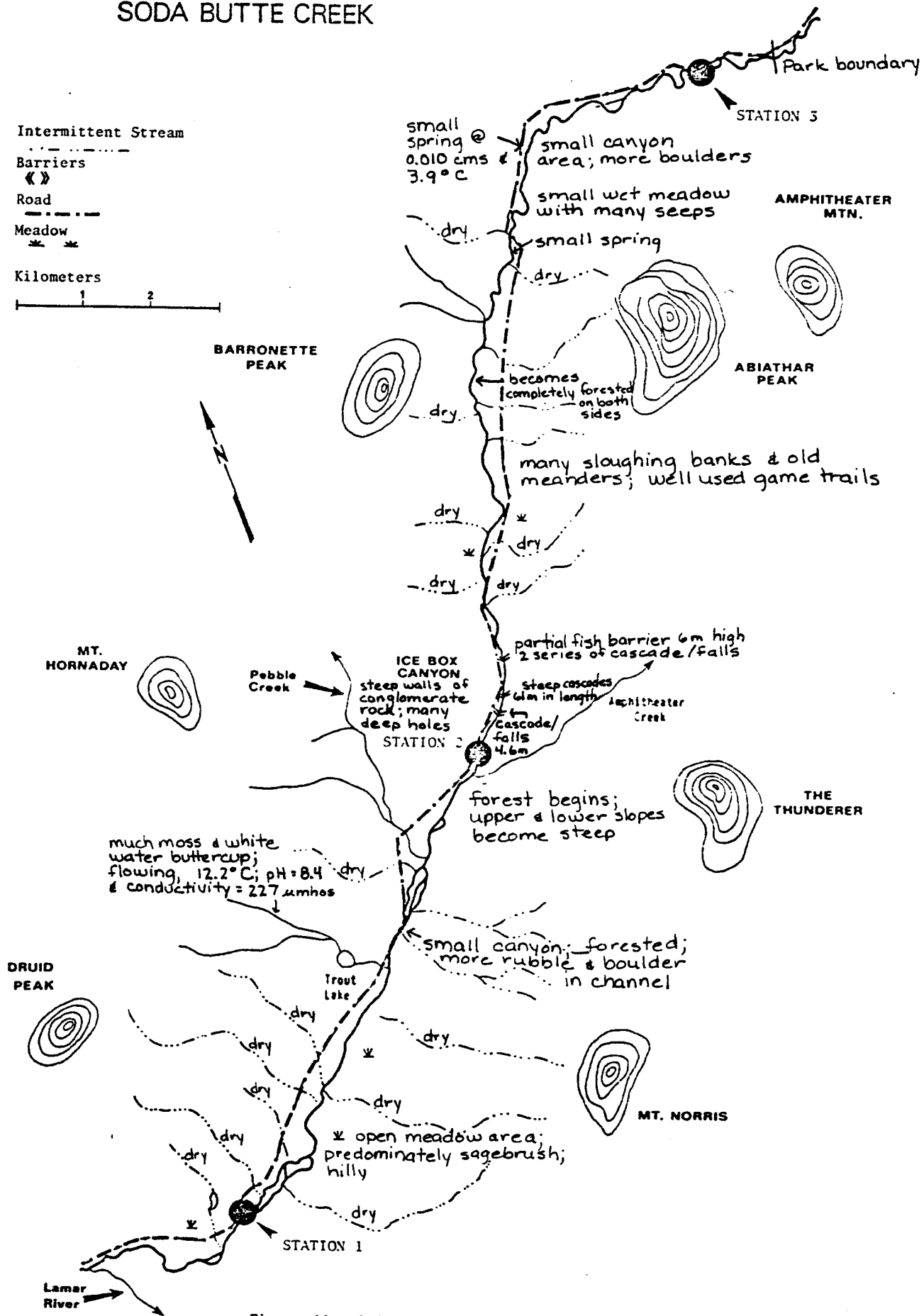


Figure 46. Soda Butte Creek, Yellowstone National Park, 1981.

least a partial barrier to fish movement, none are believed to be complete. There are several deep pools throughout the canyon. During the survey over 30 adult trout were observed in one of these pools.

Below Icebox Canyon, Soda Butte Creek begins to meander through a large open meadow (2.5 km) with frequent bank sloughing and many old stream channels. The creek then enters a small canyon section (1 km) with the forest closing in to its banks and the substrate consisting of a higher percentage of rubble and boulder. The last 7.5 km of Soda Butte Creek wanders through a wide open meadow. Upper slopes support aspen, lodgepole pine, sagebrush and some Douglas fir while the lower slopes are primarily sagebrush and grasses. Along with these, willows and sedges occur in the riparian zone. The channel is braided in this section with bank sloughing and undercutting.

The major tributaries of Soda Butte Creek inside the Park are Pebble and Amphitheater Creeks. Flows, water temperature and pH were taken on both of these creeks near their mouths (Table 38).

Geologically the lower slopes of Soda Butte Creek consist mainly of alluvium and glaciofluvial deposits of the Holocene and Pleistocene eras. Upper slopes are heavily influenced by alluvial-facies, volcanic conglomerate, sandstone, tuff and well sorted breccia (Christiansen et al 1975).

Chemical Description

Based on water samples collected August 18-20, 1981, Soda Butte Creek can be characterized as a calcium-bicarbonate system (Table 29). Besides calcium, Soda Butte Creek is also relatively high in magnesium and sodium ions. Total dissolved solids are the highest of any stream surveyed in the Park in 1981, except for Pebble Creek, which probably contributes substantially to the mineral content of Soda Butte Creek below their confluence. Concurrently, specific conductance is highest in Pebble Creek (195) and Soda Butte Creek (190).

Seasonal fluctuation of ions in Soda Butte Creek appear normal except for dissolved iron. Water samples from near the Northeast Entrance and the Lamar Trail Bridge show large fluctuations in this cation (Figures 47 and 48). This phenomenon may be related to rain or snowmelt-induced freshets through the McLaren mill tailings; however, it is unlikely that iron would remain in solution for more than a mile or so below the tailings, especially in a well-oxygenated stream like Soda Butte Creek. Usually iron in the absence of oxygen exists as a ferrous ion. If dissolved oxygen is present, oxidation to insoluble ferric hydroxide takes place. Ferric hydroxide precipitates almost instantly as a rust brown flocculate very soon after the ferrous ion comes in contact with dissolved oxygen, and therefore, does not explain the dramatic fluctuation in iron seen some distance below the mill tailings.

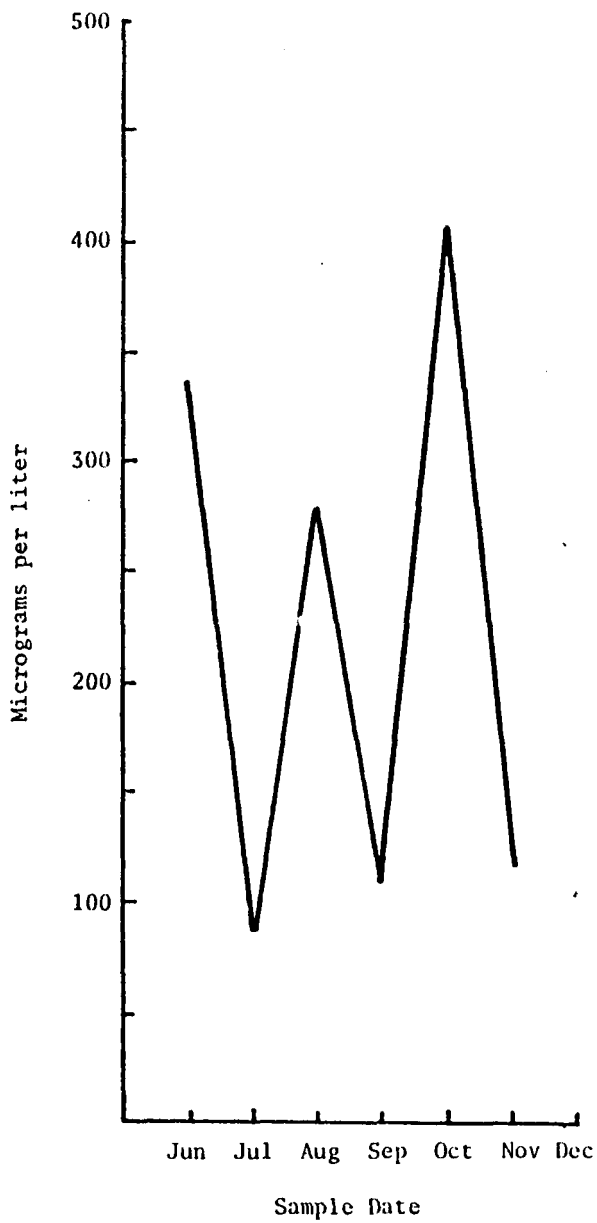


Figure 47. Dissolved iron content at the Northeast Entrance of Soda Butte Creek, June-December 1981.

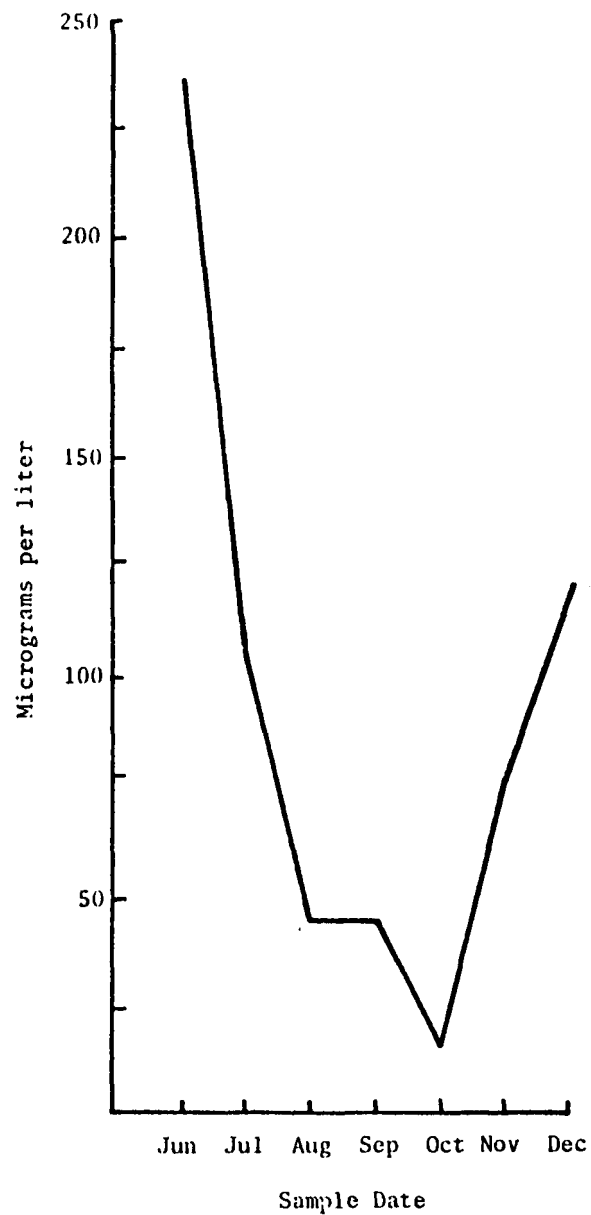


Figure 48. Dissolved iron content at the footbridge of Soda Butte Creek, June-September 1981.

Measurable quantities of iron could be reaching the lower areas of Soda Butte Creek tied in colloids. Colloidally dissolved humates will incorporate iron and become transported for considerable distances downstream so that dissolved iron can exist in the presence of oxygen; however, this usually occurs in more acid waters, a condition unlikely in Soda Butte Creek with a pH of 8.0.

Apparently, a local source of iron seems to be contributing to the iron impulses observed in Soda Butte Creek. Several tributaries flowing through a variety of formations in the basin might be contributing this cation to the stream. Future investigation is required to locate the source of this iron and determine if the McLaren mill tailings are contributing.

Habitat Inventory

Three stations were surveyed on Soda Butte Creek. Station 1, 3 km upstream from the confluence with the Lamar River, was located in a wide meadow area with sagebrush and grasses dominating the riparian zone. Some willows and sedges were also present. Lower slopes were also predominantly sagebrush and grasses and upper slopes supported aspen and lodgepole pine with some sagebrush and Douglas fir. This station represents 40% of the stream. On a clear, sunny day approximately 90% direct sunlight reaches the creek.

Station 2, located in the foot of Icebox Canyon, represents 23% of the creek. The riparian zone and lower slopes of Station 2 were dominated by alders, willows and Engelmann spruce with some grasses. Slopes were very steep and approximately only 33% direct sunling reaches the stream on a clear, sunny day.

Located in a forested area 25 km upstream from the mouth, Station 3 represents 37% of the creek. Lodgepole pine and Engelmann spruce dominated the upper and lower slopes with some willows, cottonwoods and grasses. The riparian zone was made up of approximately 40% grasses, 30% deciduous shrubs and trees, 10% conifers, 5% sedges and 15% bare ground. On a clear, sunny day approximately 70% direct sunlight reaches the creek.

Under the Channel Stability Rating System (U.S. Forest Service 1975), Soda Butte Creek rated fair (Table 34). This stability evaluation revealed that the Soda Butte Creek channel became progressively more stable in a downstream direction. Observations indicate that the riparian zone of Soda Butte Creek is occupied by large numbers of elk and some bison. Their activity probably contributes to this instability, but the major cause appears to be the nature of the stream itself. In 1965, Sharpe observed that "...flooding and consequent shifting of stream bottom materials..." in Soda Butte Creek probably accounted for heavy natural mortality of trout. A comparison of old topographic maps with recent aerial photographs supports this observation; the maps show the stream was once more braided than is indicated by recent photographs and field observations.

Fish habitat was evaluated for the three previously described stations of Soda Butte Creek (Table 33) using the methods of Dunham and Collotzi (1975) and Duff and Cooper (1976). Optimum habitat rating (%) ranged from 30.0 for Station 1 to 45.7 for Station 2. Overall habitat rating for Soda Butte Creek was 34.2. The most critical limiting factor in Soda Butte Creek is an apparent lack of pools (Table 33). Two of the three stations sampled encompassed no pools. It is estimated that these two stations represent 77 % of the stream habitat.

During the survey, mean depth and flow ranged from 0.27 m and 1.41 m³/sec at Station 1 to 0.18 m and 0.29 m³/sec at Station 3.

Macrophytic vegetation was uncommon throughout the survey, algae was spotty at all three stations and mosses present only at Station 2. As at Hellroaring Creek, this is probably due to the high water velocities during spring runoff which prevent vascular plants from developing an adequate root mass.

Aquatic Invertebrates

Surber and drift nets were used to sample the invertebrate population of Soda Butte Creek. Two surber samples were taken at each station and one drift sample was taken at Station 2.

Ten taxonomic groups were collected at Station 1 (Table 32). Mayflies were found most commonly (5 genera) but stoneflies and caddisflies were also represented (1 species and 2 genera, respectively; all rarely).

Station 2 had slightly lower diversity and higher densities. The mayflies Ephemerella coloradensis and Cinygmula sp. were both found abundantly. Three more genera of mayflies and two taxonomic groups of stoneflies were also found but only rarely. One genus of caddisflies was found commonly.

At Station 3, caddisflies were most abundant (2 genera common and 1 genera abundant). Two genera of mayflies and 2 genera of stoneflies were also collected.

An overnight (11.5 hours) drift sample was taken at Station 2. The mayfly, Baetis bicaudatus, was the single most common invertebrate representing 32.9% of the entire sample or 0.19 individuals per cubic meter of water (Table 32). Total mayflies made up 83.6% of the sample or 0.50 individuals per cubic meter of water. Stoneflies (12.9%) and caddisflies (3.6%) represented 0.08 and 0.02 individuals per cubic meter of water, respectively.

In 1965 and 1967, surber samples were collected on Soda Butte Creek but complete quantitative analysis was not done in either of these studies. Results are similar, however; a slight increase in the abundance of mayflies and

decrease in Diptera does appear to exist. This could be indicative of higher quality water or just reflect differences in sampling.

Aquatic Vertebrates

A capture-removal method (Zippin 1958) was used to estimate population abundance of cutthroat trout in the three study sections of Soda Butte Creek. Stations 1 and 3 were the same as those previously described for habitat inventory, but Station 2 was relocated to 1 km below Pebble Creek Campground for the vertebrate samples. A minimum of three electrofishing passes were made in each 305 mm section and captured trout were removed and placed in holding nets. All fish were measured to the nearest mm and a subsample was weighed to the nearest 2 g. Scale samples were collected from 40 trout at Station 1 and 20 trout at Stations 2 and 3 for age determination. Ages were estimated by the scale method (Bagenal and Tesch 1978); results were expanded for the entire sample using an age-length key (Westerheim and Ricker 1978). After processing, trout were returned to the stream unharmed. As a basis for comparison, an underwater census (Northcote and Wilkie 1963) of the cutthroat trout in Station 1 was conducted by two divers prior to the electrofishing estimate.

Trout abundance in Soda Butte Creek varied from 752 trout per hectare (Station 2) to 136 trout per hectare (Station 3) (Table 37). Close agreement between the population estimate for Station 1 (523 per hectare) and the under water census in that area (558 per hectare) suggests that the capture-removal method provided reasonable estimates in Soda Butte Creek. Average length varied significantly between stations and appeared to be inversely related to abundance. Trout from Station 3 (201 mm) were almost 80 mm larger than those captured at Station 2 while trout from Station 1 (155 mm) were intermediate between the two extremes (Table 36). Biomass estimates at the three stations reflected the combined factors of abundance and size (Table 37). Despite great differences in numbers and mean lengths between Station 2 and Station 3, biomass in these two areas was quite similar (17.3 and 17.5 kg per hectare, respectively). Biomass at Station 1 (47.1 kg per hectare) was greater than the other two stations combined.

Evaluation utilizing back-calculated lengths indicate that growth of cutthroat trout in Soda Butte Creek is about average for streams of this size in Yellowstone Park. As expected, however, growth was correlated to population abundance. Trout growth at Station 2, where numbers were the greatest and mean size the smallest, was much slower than the other stations. Trout captured at Station 3 displayed the fastest growth, although after age II there was little difference when compared to Station 1. The relative increase in growth after age II at Station 1 may indicate the lessening of density dependent effects with increased age; however, low mortality of older trout at Station 3 might also produce this effect.

Angler Use and Pressure

Regulations on Soda Butte Creek allow the creeling of two fish of any size. Current Volunteer Fisherman Report (VFR) card data indicate that angling has improved since 1973, despite increased use since 1975 (Figures 49, 50 and 51). When the stream is separated into segments above and below Icebox Canyon, however, it appears since 1977 most use increases have been above the canyon and landing rates have shown a subsequent decline in that area (Figures 52, 53 and 54). Below the canyon there has been a slight decrease in use with an increase in catch per effort (Figures 55 and 56). Mean length of trout landed by anglers has increased substantially (Figure 57).

Although it is currently impossible to separate the effects completely, it appears that the observed improvements are associated with both a partial reduction in pollution input from the McLaren mill tailings and the catch and release regulation on the Lamar River implemented in 1973. Decreases already observed above Icebox Canyon indicate that these improvements can not be expected to continue for long. Easy accessibility along the entire 26 km of stream within the Park virtually assures a continued increase in angler use and harvest on this vulnerable species.

Discussion

Stream survey work in 1981 revealed some interesting features. Despite a rather small average size, the population structure at Station 1 (near the Lamar River Trail bridge) was the best observed in Soda Butte Creek (Figure 58). Population estimates indicated a population of 523 trout per hectare and a resulting biomass of 47.1 kg per hectare. In terms of habitat this was the poorest section of stream, but it was also the closest to the Lamar River. At Station 2 (just below Pebble Creek) population estimates rose to 752 trout per hectare but biomass dropped to only 17.3 kg per hectare. Average size was less than 127 mm and no fish over 305 mm were captured (Figure 59). The lack of older and larger individuals in this section appears to be directly attributable to over-harvest in the vicinity of Pebble Creek Campground. Station 3 (near the Park boundary) yielded the largest cutthroat trout (averaging 201 mm), but population estimates dropped to 136 trout per hectare. Biomass was just over 17.5 kg per hectare. It is difficult to explain this situation, but it appears that reproduction is marginal in this section (closest to the pollution source). Angler harvest is also probably quite low due to the sparse population.

Two complexing factors for current fisheries management are the existence of brook trout in Soda Butte Creek above the mine tailings in Cooke City and the continued addition of chemical effluents from the mill site. Although the Astra

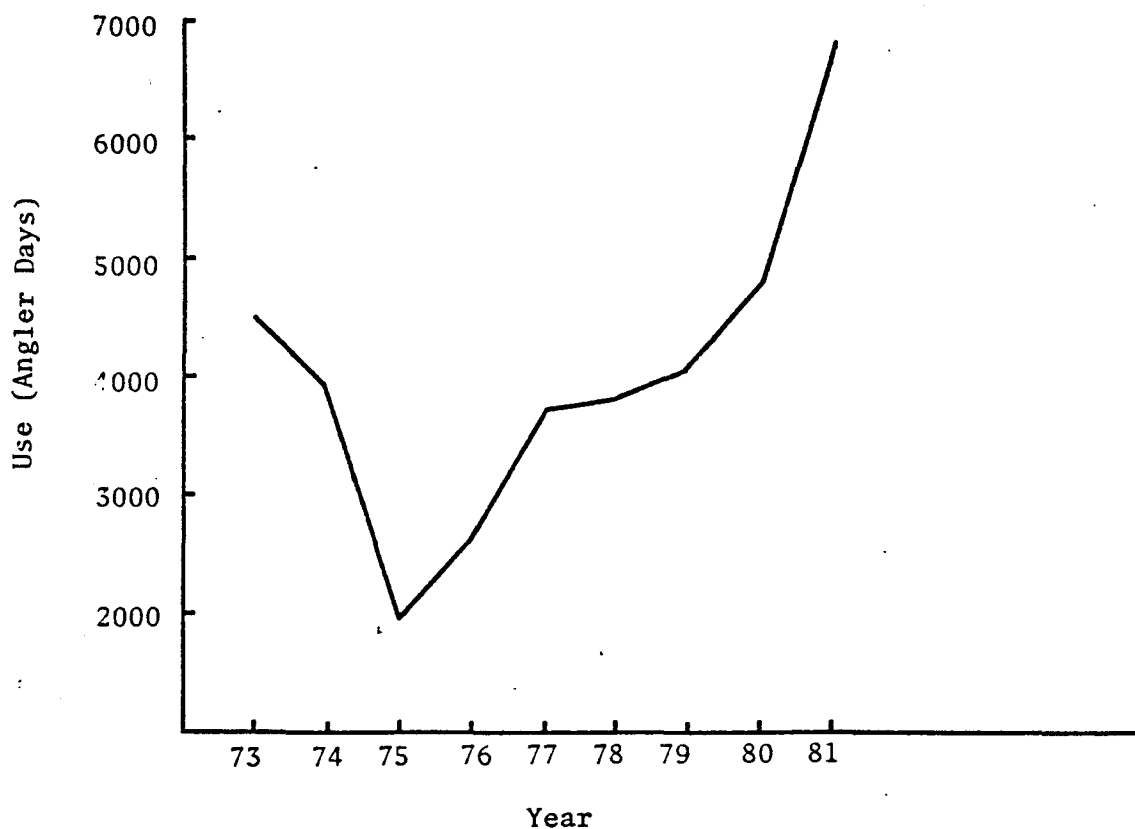


Figure 49. Angler use estimates for Soda Butte Creek, 1973-1981.

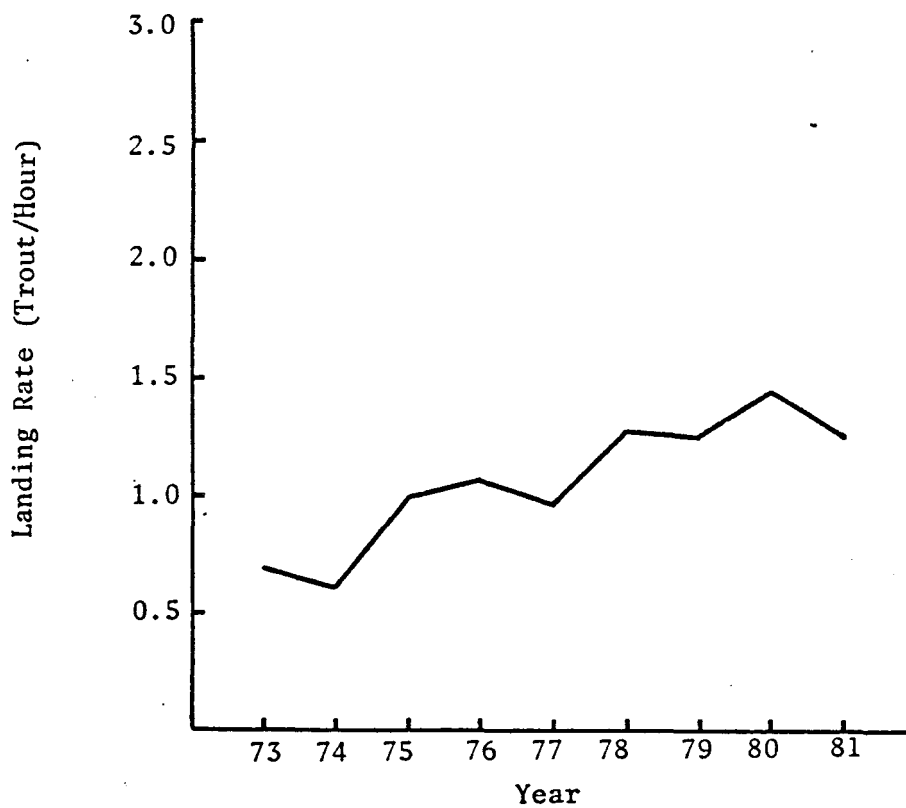


Figure 50. Landing rate estimates for Soda Butte Creek, 1973-1981.

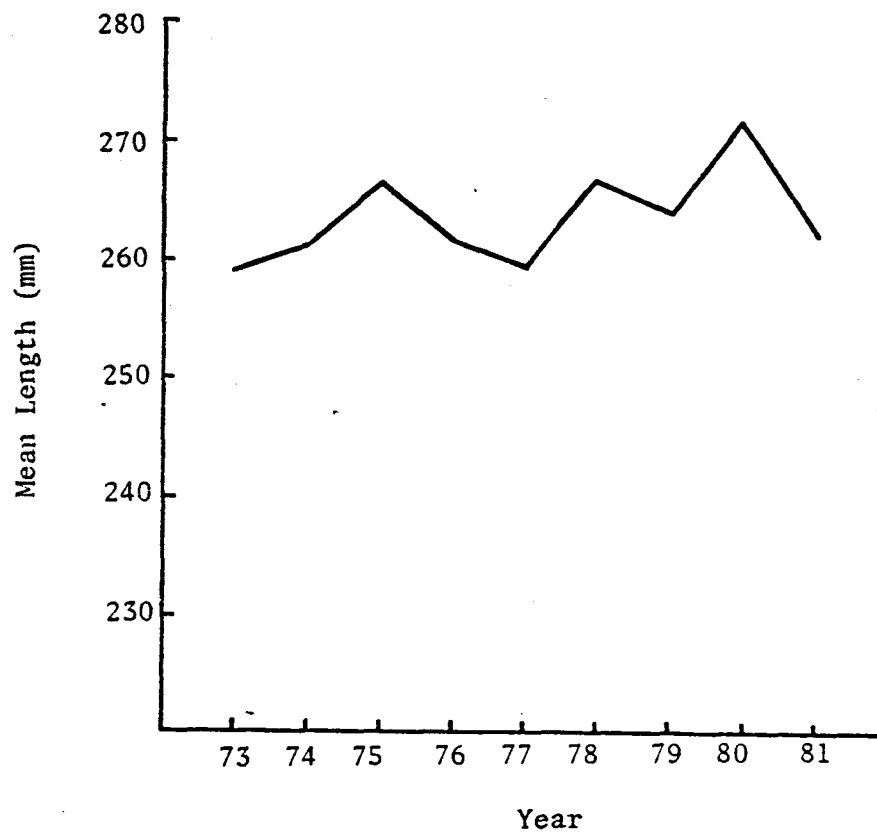


Figure 51. Mean length of trout landed by anglers at Soda Butte Creek, 1973-1981.

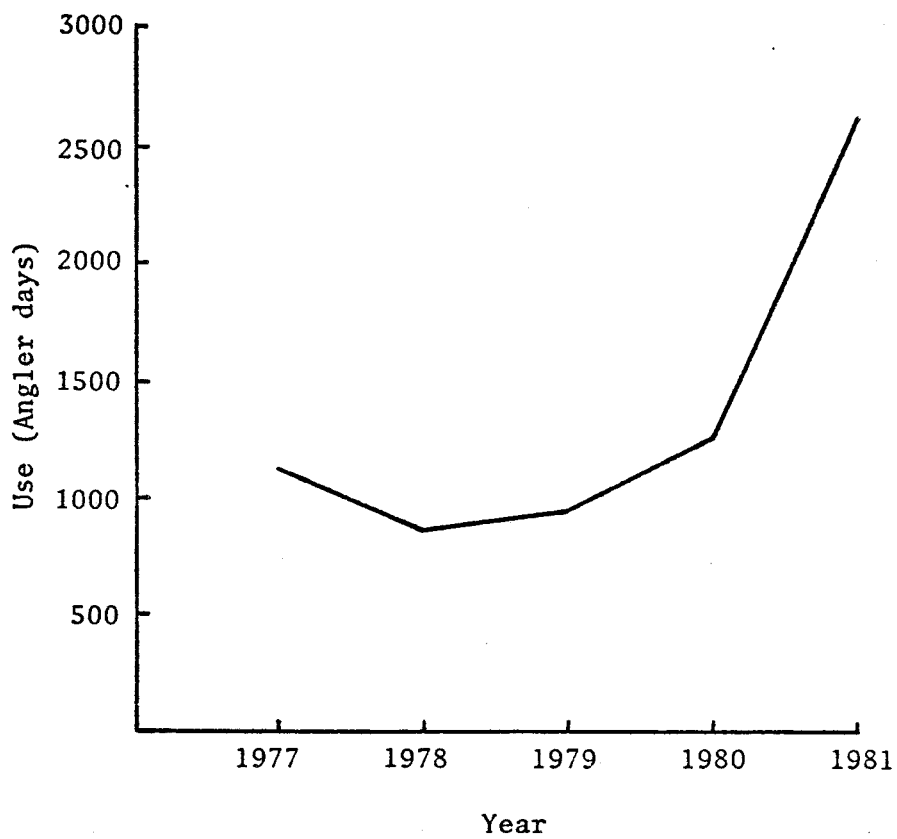


Figure 52. Angler use estimates for Soda Butte Creek above Icebox Canyon, 1979-1981.

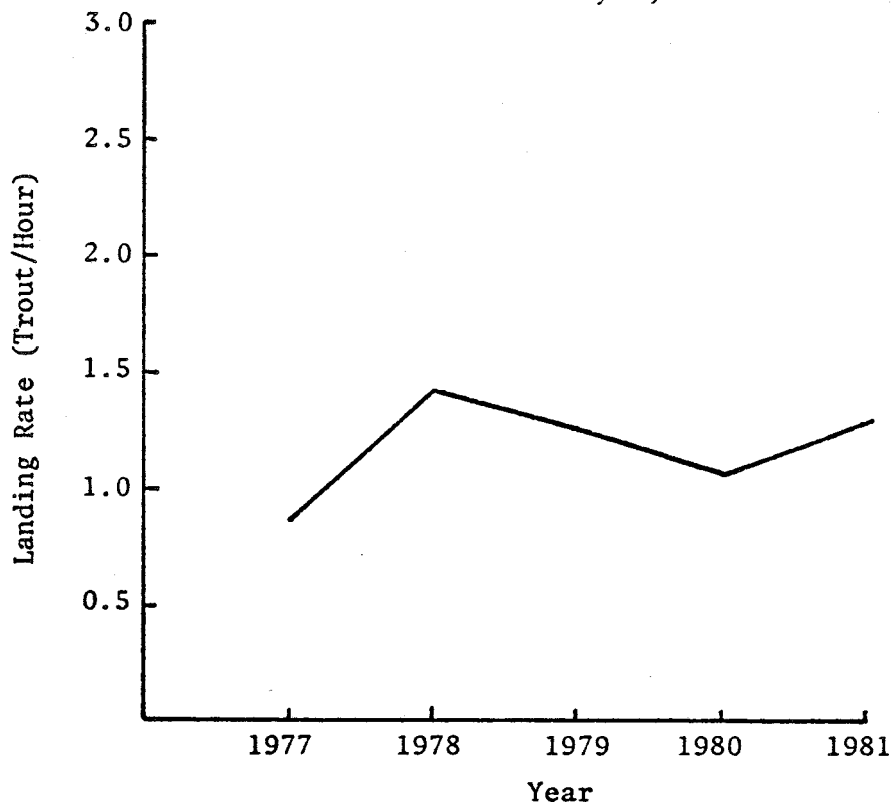


Figure 53. Landing rate estimates for Soda Butte Creek above Icebox Canyon, 1977-1981.

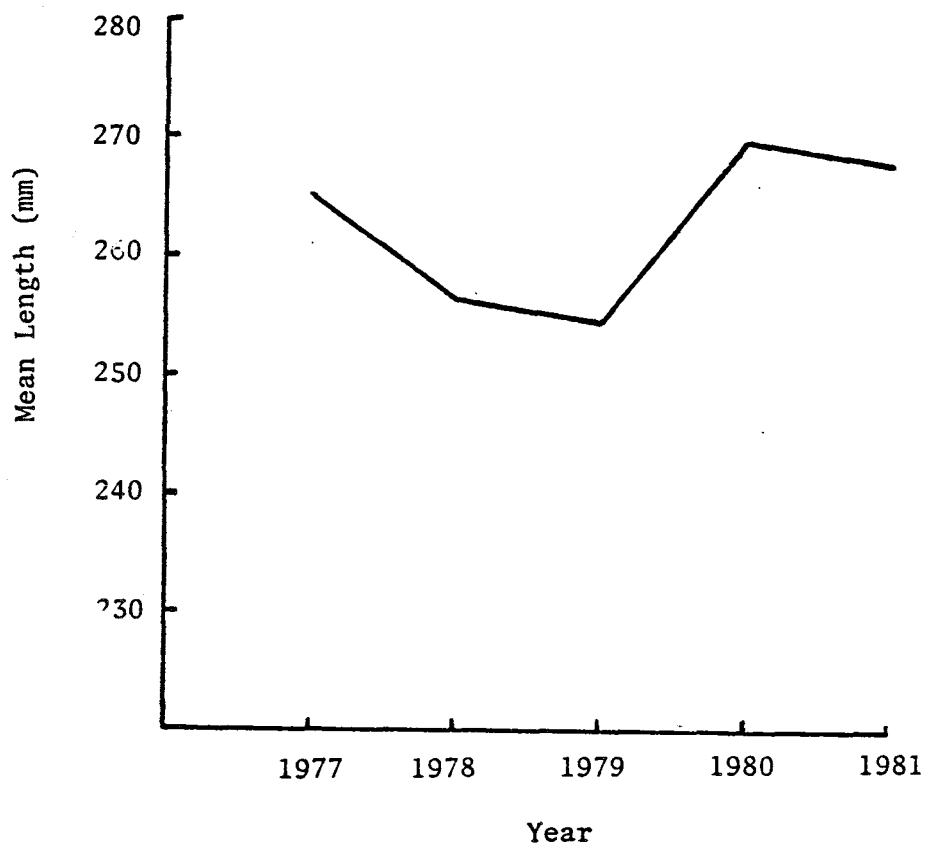


Figure 54. Mean length of trout landed at Soda Butte Creek above Icebox Canyon, 1977-1981.

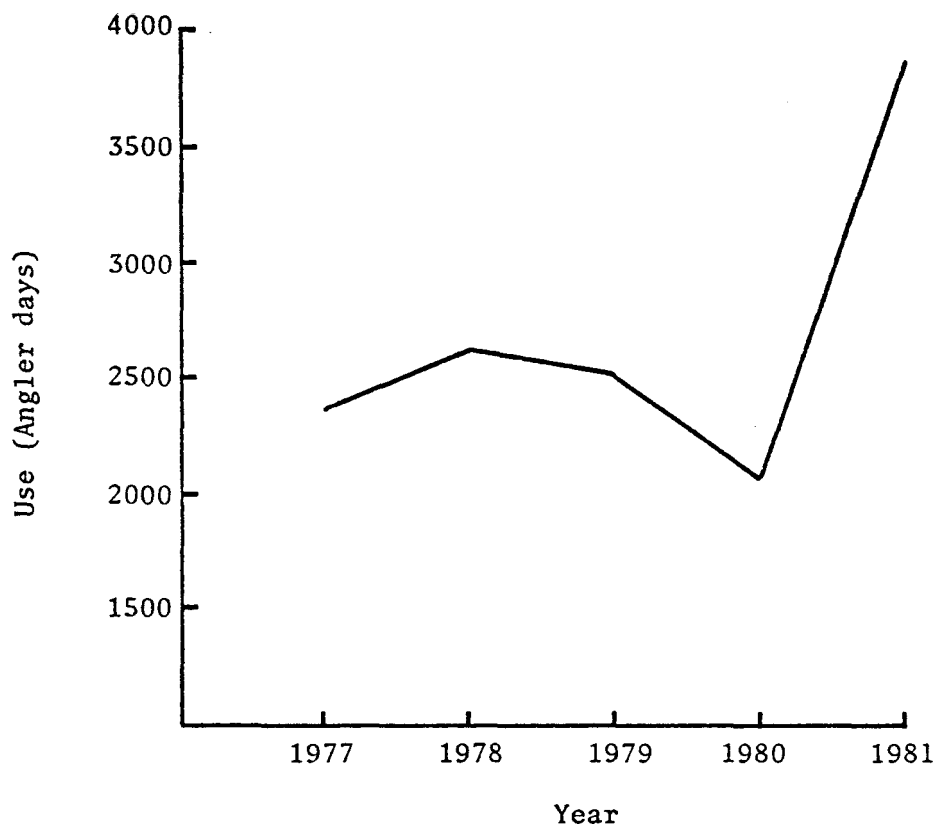


Figure 55. Angler use estimates for Soda Butte Creek below Icebox Canyon, 1977-1981.

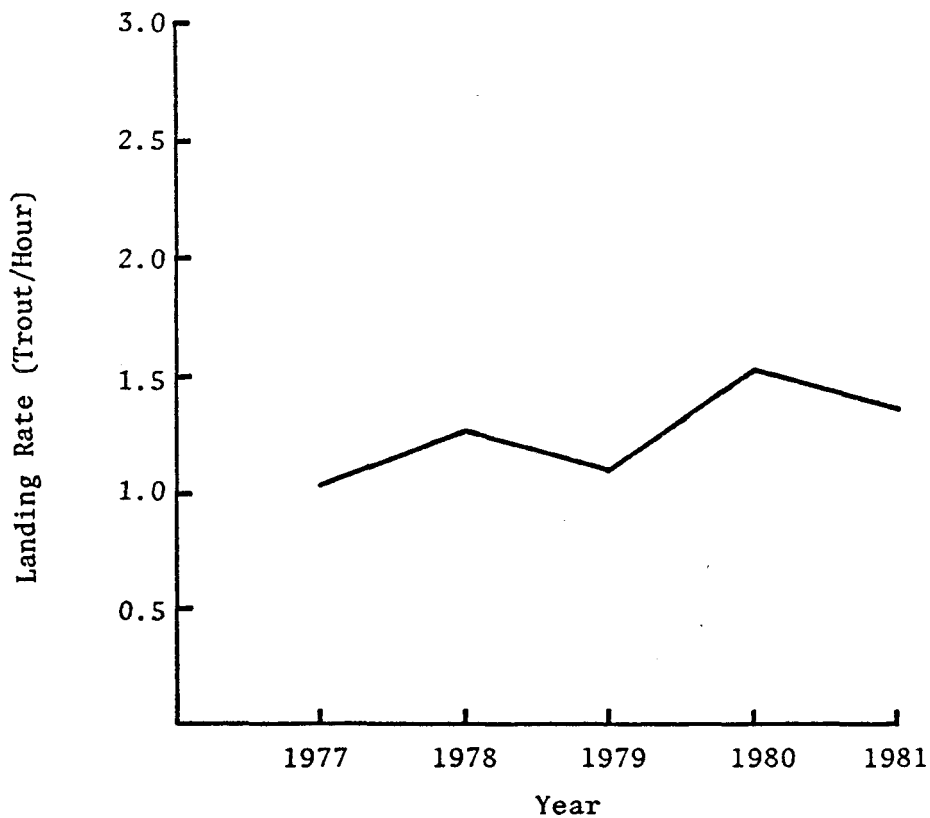


Figure 56. Landing rate estimates for Soda Butte Creek below Icebox Canyon, 1977-1981.

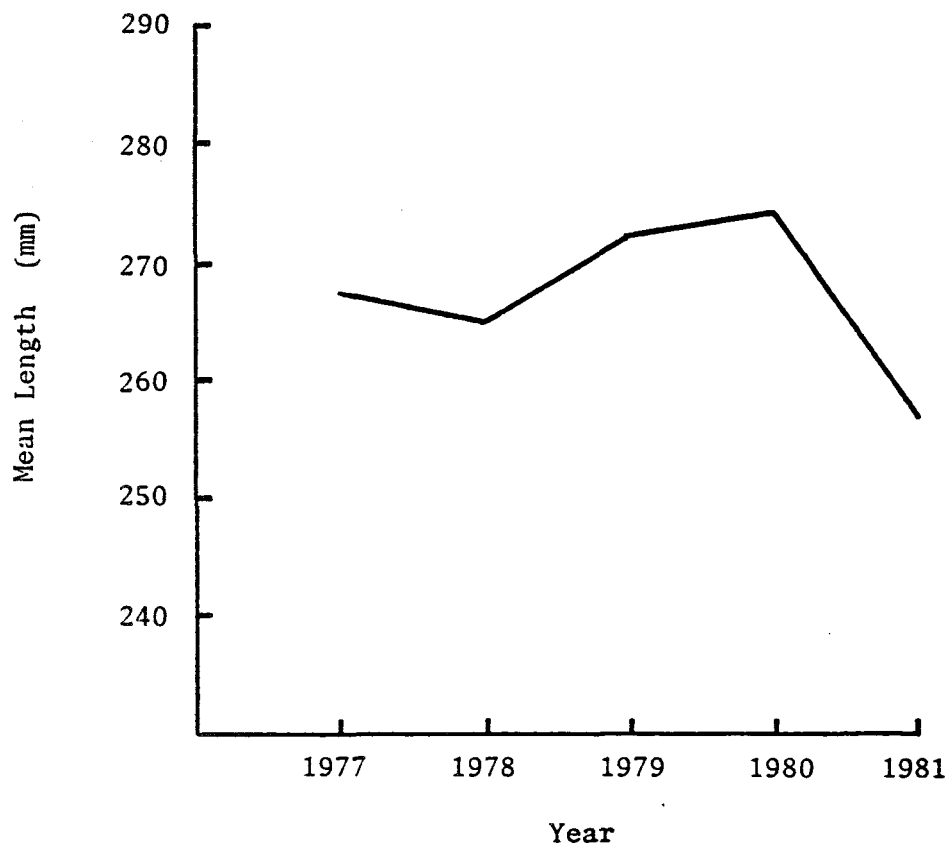


Figure 57. Mean length of trout landed at Soda Butte Creek below Icebox Canyon, 1977-1981.

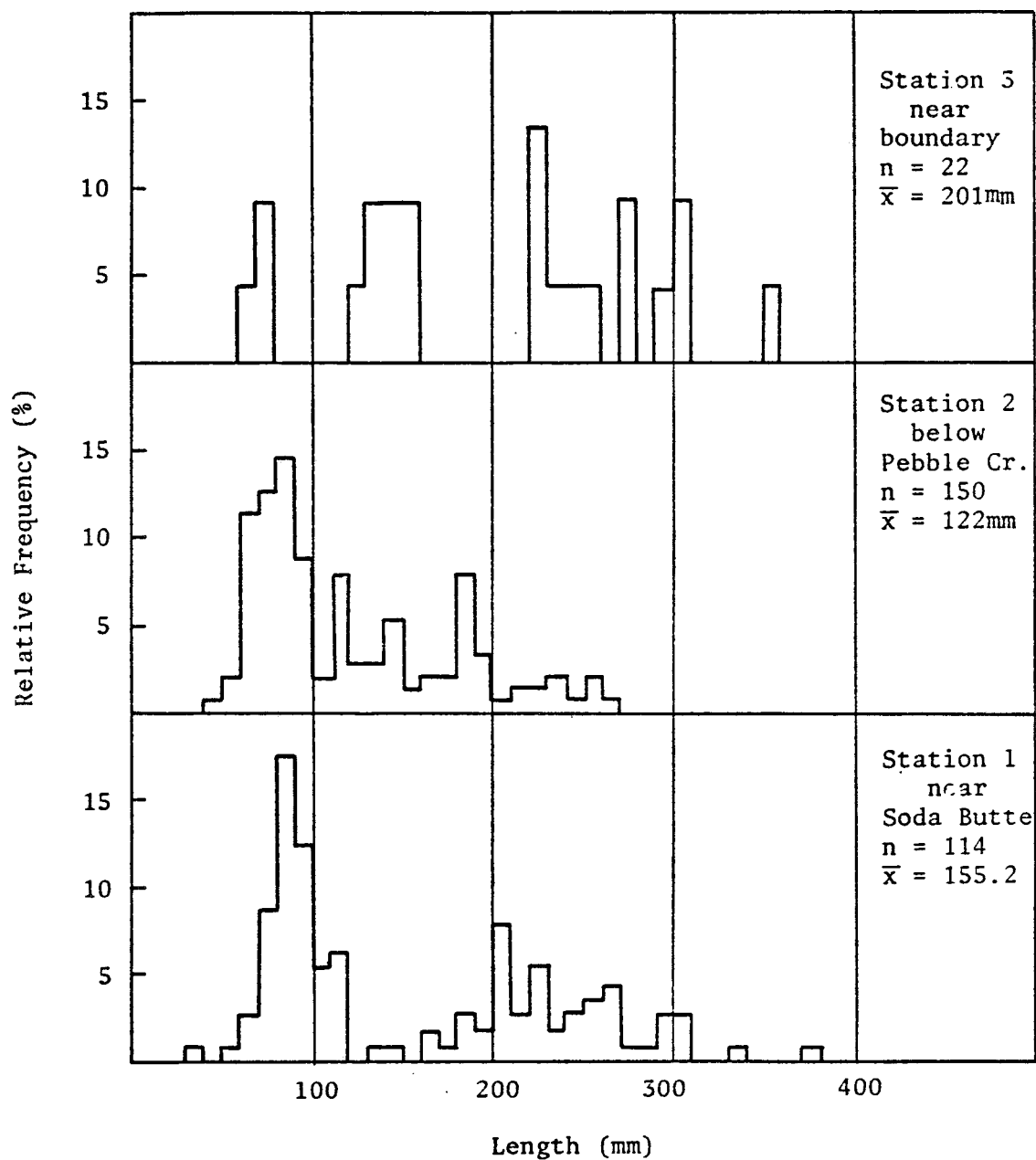


Figure 58. Mean length of cutthroat trout captured by electrofishing, Soda Butte Creek, August 18-20, 1981.

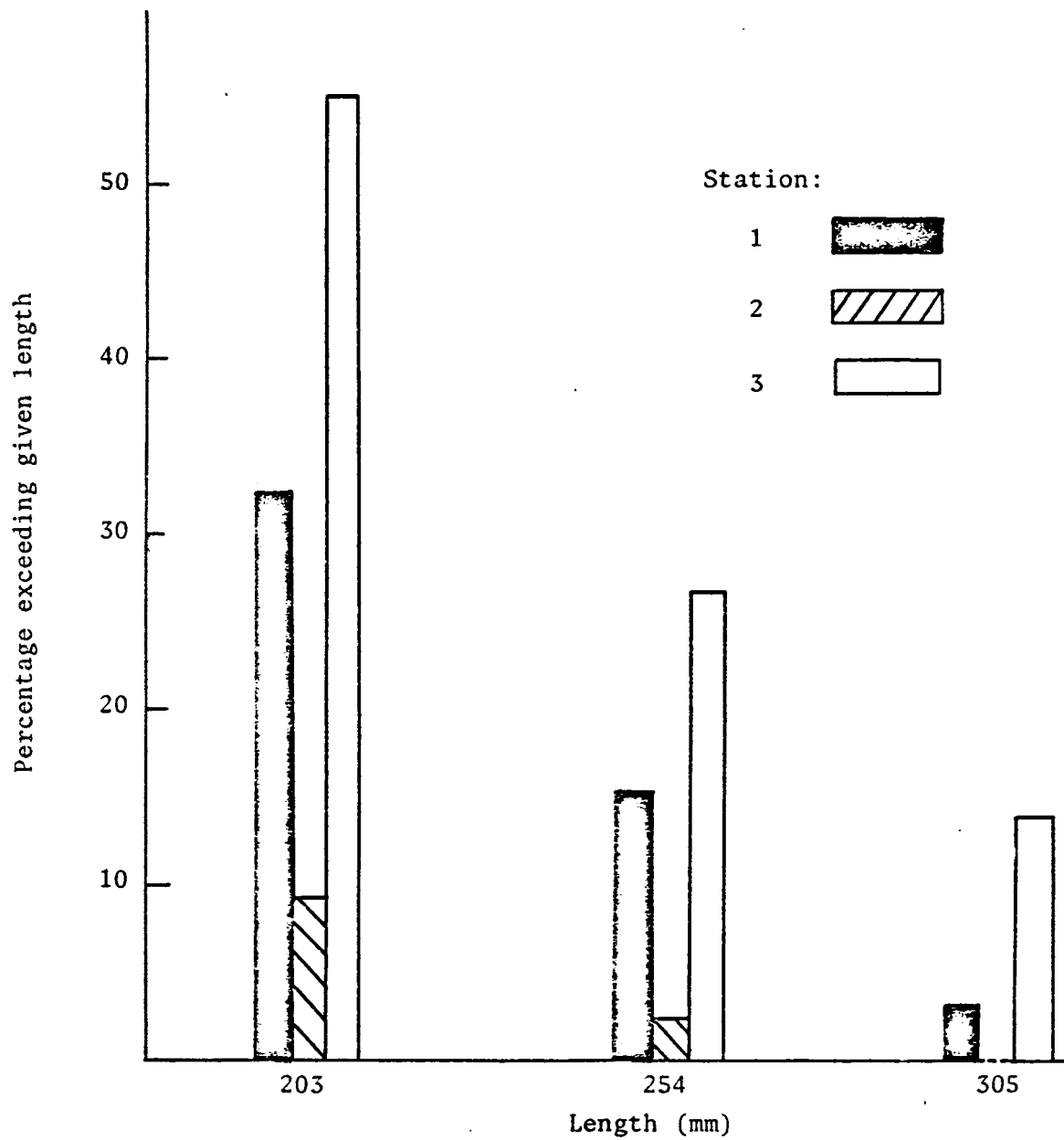


Figure 59. Percentage of cutthroat trout greater than 203, 254 and 305 mm (total length), captured by electrofishing, Soda Butte Creek, August 18-20, 1981.

Mining Company has discontinued present efforts to reclaim these tailings, future removal of this pollution source would allow downstream migration of the exotic brook trout. The admission of this species, which has demonstrated the ability to out-compete the native cutthroat trout in headwater situations, would cause irreparable changes in the entire upper Lamar Drainage. Although we are planning a joint operation with Montana Department of Fish, Wildlife and Parks to remove these exotic trout and replace them with cutthroat, it is imperative that the cutthroat population downstream be maintained in a robust condition.

Current data have reaffirmed the need to implement catch and release regulations on Soda Butte Creek. It has been demonstrated in Yellowstone Park that it provides excellent protection for vulnerable cutthroat trout while providing the highest quality angling (in terms of landing rate and mean size) for the greatest number of sports anglers.

NONCONSUMPTIVE USE OF THE AQUATIC RESOURCE

In Yellowstone Park, there are presently two sections of Yellowstone River closed to angling to provide protection to the spawning trout. These areas have provided an excellent opportunity to study the level of visitation of an area available only to nonconsumptive uses, such as photography or simple observation.

Fishing Bridge, spanning Yellowstone River at the outlet of Yellowstone Lake, has been closed to fishing from the lake to a point 1.6 km downstream since 1973. Although once very popular with anglers, Fishing Bridge has not been considered a high quality fishery in recent times. Average catch per hour for 1963 (Sharpe 1964), was 0.20 varying from a high of 0.48 during the first sample day to a low of 0.00 during the last sample day. In 1966, Arnold (1967) reported the catch per unit effort low compared to other park waters.

In 1972, Dean (1973) conducted a study to determine the number of years of prior fishing experience for park anglers. Of the 346 anglers interviewed at Fishing Bridge, the average amount of prior fishing experience was only 0.27 years, the lowest figure obtained in the park. Only 12% had fished the bridge in previous years. These figures support Dean's (1973) conclusion that few anglers return to the bridge after an initial experience there probably due to the crowding and low success rates.

LeHardy's Rapids, located approximately 5.7 km downstream from the lake on Yellowstone River, has been closed to fishing 100 yards upstream and downstream from the rapids since 1949. During high water (May through July) fish ascending the river in their upstream spawning migration accumulate 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.

The effects of these closures to angling has been monitored at both Fishing Bridge and LeHardy's Rapids. For the fourth consecutive year, estimates of visitor use, including total time spent and number of visitors, have been made at these sites. Mean length of stay was determined in 1978, 1980 and 1981.

Methods

A "time available" method (Matheson 1949, Bulkley 1966, Geiger 1972 and Brown 1978) of data collection was employed; such methods have been used when effort available for counts was limited. Instantaneous counts of visitors were made whenever possible at both Fishing Bridge and LeHardy's Rapids, usually while en route to a work site. The location of project activities,

precluded an equal sampling effort at each site, however, and sample size at LeHardy's Rapids was small.

The critical aspects of this type of estimate are the average time spent per person and the accurate determination of the daily use pattern. Each day was divided into intervals with a length slightly less than the mean length of stay. The daily use curve was determined by averaging all counts for each interval. Total visitor hours for each interval were then calculated using the standard trapezoidal formula:

$$\text{Effort (visitor hours)} = \frac{1}{2}I(t_i + t_{i+1}), \text{ where}$$

I = interval
 t_i = mean number counted at interval i

To obtain 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. The total number of visitors for each day was obtained by dividing visitor hours by the mean length of stay, and season totals were calculated by summing daily totals.

Results

In 1981, mean length of stay at Fishing Bridge for 3,425 people was calculated to be 12.3 minutes per person. This represents an increase of approximately 1.5 minutes over 1978 and 1980. Total number of visitors using Fishing Bridge for viewing in 1981 also increased over 1980 (approximately 19%) to 147,013 visitors. These changes led to a subsequent rise in total visitor hours (approximately 61%) over 1980 to 35,386 hours (Table 39).

In order to evaluate the effect of sample size on these calculations, estimates were also made using only one half of the data points. Results indicated that sample size had minimal effects on the use values.

At LeHardy's Rapids length of stay for 187 people was calculated to be 16.2 minutes. Total number of visitors was estimated at 12,047 people and total time spent at the rapids was 3,260 hours. Both values increased (54% and 134%, respectively) from 1980.

Discussion

Creel census data for the last eight years (1965-1972) of angling on Fishing Bridge yields an average of 33,275 total anglers and 36,714 total angler hours per year (Table 40). While the 1981 figures represent virtually no change in total hour usage of Fishing Bridge, the number of people enjoying this area

Table 39. Nonconsumptive use of the aquatic resource, 1978-1981

	Year	Number Counts	Total Number of Visitors	Mean Minutes per Person	Total Visitor Hours
Fishing Bridge	1978	582	111,167	10.8	19,821
	1979	670	161,108	--	28,726
	1980	551	123,438	10.7	22,009
	1981	1015	147,013	12.3	35,386
LeHardy's Rapids	1978	222	3,044	8.4	543
	1979	206	9,338	--	1,665
	1980	94	7,808	5.3	1,392
	1981	155	12,047	16.2	3,260

Table 40. 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

has increased over 300%. At the same time, Park visitation has only risen approximately 16%.

At LeHardy's Rapids usage shows a great deal of variation over the four year period. Because LeHardy's Rapids has a longer length of stay, is not as visible from the road and is less accessible, (visitors must descend a short but steep bank), use here would be expected to be lower and more variable. While not necessarily a major factor, low sample sizes would tend to accentuate the fluctuations.

Next to Park visitation, weather conditions may be the most influential factor affecting use of these viewing sites. Although there is great variation in the weather, (Tables 41 and 42), and trends do not completely correlate, generally, increased cloudiness and duration of precipitation, (actual amount of precipitation is unimportant here), lead to decreased use, with more people staying longer during good weather.

Comparing nonconsumptive use to Park fisheries, more people made use of Fishing Bridge than any single fishery in the Park other than Yellowstone Lake (Table 5). LeHardy's Rapids ranks only behind Yellowstone Lake, Yellowstone River, Madison River and Firehole River in total number of people using the water. Looking at the total number of man hours spent, Fishing Bridge still ranks fifth and LeHardy's Rapids twenty-third Parkwide in popularity. These figures emphasize the importance of these areas used as viewing sites.

Conclusions

The prohibition of angling from Fishing Bridge has not only provided the much needed protection for spawning trout but also developed an unique viewing platform for the Park visitor. As pressures and demands on our natural surroundings have increased steadily, nonconsumptive use has become a very important utilization of our aquatic resources. The challenge we face today is how to find ways of enjoying our natural aquatic areas without destroying them. Even a very minimal impact made by each individual, when multiplied by the millions of visitors passing through the park in one summer, can severely impact the aquatic system. Although catch and release fishing does not allow the creeling of any fish, hooking mortalities and the mere presence of the anglers do have negative effects. Nonconsumptive use provides each visitor with the opportunity to enjoy and appreciate nature with negligible side effects.

The educational value of nonconsumptive use is also quite important. People who ordinarily might not have any contact with fish or their environment

Table 41 Observed Fire Weather, Mount Sheridan lookout, precipitation records, 1978-1981

Month	Total Duration of Precipitation (hours)				Total Precipitation			
	1978	1979	1980	1981	1978	1979	1980	1981
June ¹⁾	-	-	6	1	-	-	0.21	0.02
July	31	18	33	19	1.12	0.40	1.55	0.75
August	45	71	51	12	2.02	2.57	1.22	0.90
September ²⁾	69	10	31	26	1.84	0.35	1.67	0.94
Total	145	99	121	58	4.98	3.32	4.95	2.61

1) For June, during 1978 no weather observations were taken, in 1979, 6 were taken, in 1980, 7 were taken, and in 1981, 4 were taken.

2) For September, during 1980, there were only 7 observations taken.

Table 42 Observed Fire Weather, Mount Sheridan lookout, State of the Weather¹⁾, 1978-1981

	June				July				August				September				Total			
	1978	1979	1980	1981	1978	1979	1980	1981	1978	1979	1980	1981	1978	1979	1980	1981	1978	1979	1980	1981
Clear	-	1	2	3	4	4	5	7	4	1	5	2	1	4	-	6	9	10	12	18
< 1/10 cloud cover																				
Scattered Clouds	-	2	2	-	6	5	8	10	9	4	7	9	7	9	-	8	22	20	17	27
1/10-5/10 cloud cover																				
Broken Clouds	-	1	2	1	12	16	2	6	9	10	5	6	3	7	3	4	24	34	13	17
6/10-9/10 cloud cover																				
Overcast	-	-	-	-	-	1	6	-	1	2	2	2	2	-	2	4	3	3	10	6
> 9/10 cloud cover																				
Foggy	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1	1	1	1	1	1
Drizzling	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	0	1	0	0
Raining	-	-	1	-	1	-	2	-	1	-	2	-	-	-	1	-	2	0	6	0
Snowing or Sleet	-	-	-	-	-	-	-	-	1	1	1	-	2	1	-	-	3	2	1	0
Showering	-	-	-	-	-	-	1	-	-	5	-	-	-	1	-	1	0	6	1	1
Thunderstorm in Progress	-	2	-	-	2	3	2	4	3	6	3	4	1	-	-	-	6	11	5	8

1) Weather observations were taken between 1200-1300 hours.

are provided an excellent chance to view this animal going through its natural life cycle. Visitors can also learn the importance of fish in the food chain as they observe the abundant piscivorous birds and mammals feeding. Other wildlife are often attracted to these areas as well, including moose, muskrat and beaver.

The number of people actually making use of this area has increased dramatically since its closure to fishing. Observing the interactions of a fish population within its natural habitat, including natural reproduction, feeding and as prey, is truly an educational experience for both the angling and nonangling public.

LeHardy's Rapids provides the public with another unique viewing site. Here, as the native cutthroat trout are passing upstream on their annual spawning migration, visitors are able to observe them in full coloration as they jump the rapids with incredible ability.

Visitor use at both areas is not only enjoyable but also has educational value and should therefore be encouraged to help make the visitor's "Yellowstone experience" complete. These areas provide the National Park Service with an excellent opportunity for educating the public in various aspects of a fish population's cycles in their natural habitat and should be made use of to the fullest degree possible. With continuing high numbers of Park visitors, nonconsumptive use affords an exceptional experience, which can be enjoyed repeatedly by many without depleting the resource.

NATIVE SPECIES RESTORATION PROGRAM

The native fishes of Yellowstone Park consist of eleven species. The Montana grayling, three or more genotypes of cutthroat trout and the mountain whitefish are the best known. In addition, three species of suckers, four species of minnows (Cyprinidae) and the mottled sculpin are also native. The range and densities of several of these fishes have been altered substantially in the past century.

The restoration of native fish species in natural areas of the National Park system is a matter of policy (U.S. Dept. Interior 1975). Yellowstone has a number of species, genotypes or races of sport fish that are threatened with extinction (Varley et al 1976). At present, an active program of restoration is underway in the park that seeks to expand the ranges of these threatened fishes. The management strategies developed to attain restoration objectives consist of the enclave concept and the selective exploitation concept (Varley et al 1976).

In 1981, the native species restoration program consisted of 1. Montana grayling restoration project; and 2. the Sedge Creek cutthroat transplant program.

Montana Grayling Restoration Project

A review of the historical background and rationale of the Montana grayling restoration program and the Canyon Creek project has been presented in previous reports (Varley et al 1976 and Jones et al 1978, 1980). The Canyon Creek restoration project was discontinued in 1981 except for occasional monitoring due to poor survival of past plants and the expanding exotic fish population. The objective of the grayling restoration program, however, continues to be directed toward reestablishing a wild self-reproducing population of a fluvial stock, similar to that which once existed in the drainage.

A new cooperative program with the Montana Department of Fish, Wildlife and Parks was initiated in 1981. An effort will be made to establish a brood stock from a wild fluvial stock from the Big Hole River drainage which will be used to produce grayling for stocking and selected streams in Montana and Yellowstone Park. The search for new streams and egg collections for establishing a brood stock will begin in 1982.

Sedge Creek Cutthroat Transplants

The Yellowstone River originates outside the Park boundaries in the Teton Wilderness area. The branches of the Yellowstone above Woodard Canyon were fishless due to falls preventing upstream fish movement. The Wyoming Game and Fish Department, who have management jurisdiction over fishes in this area, have aspired to establish cutthroat trout in this region for many years. Previous transplants using stocks from Yellowstone Lake have proven fruitless. These fish apparently have strong inherent instincts to drift downstream to the lake. Due to these instincts, a search was made for a suitable and pure Yellowstone cutthroat strain for transplant. Trout from Sedge Creek were ultimately chosen for a variety of reasons. In recent geologic time Sedge Creek was directly connected to Yellowstone Lake but as the depth diminished, upper Sedge Creek was isolated from Yellowstone Lake proper by Turbid Lake, a geothermal body of water. In subsequent years, the population evolved to become a fluvial form adapted to a very harsh, subalpine environment. Some morphological changes in the fish also occurred (Bulkley 1963), but there is no evidence that this population has been altered by fish stocking or fishing pressure; therefore, it is truly a distinctive and pristine strain.

Using this strain for transplant to the upper Yellowstone River area served two purposes: it provided an optimally adapted population of Yellowstone cutthroat for another harsh, subalpine environment, and it provided a second, secure enclave for this unique genotype.

During June, 1977, 457 trout were collected and transplanted by helicopter. The planted trout varied in size from 51 to 221 mm total length. Aging suggested the group included yearlings through five year-olds. Numerous prespawning individuals were present in the group, although it is not known whether they would spawn in their new environment following transplant. On July 7, 1978, 413 trout were transplanted. Of one hundred measured for length, the average length for these cutthroats was 113 mm, ranging from 58-254 mm. On July 24, 1979, electrofishing on Sedge Creek yielded 604 cutthroat trout of which approximately 550 were successfully airlifted to the South Fork.

On July 16, 1980, approximately 350 cutthroat trout were collected from Sedge Creek by electrofishing and airlifted to the South Fork of the Yellowstone River. A wilderness survey crew from the Wyoming Game and Fish Department visited the South Fork of Yellowstone River on July 29, 1981. The introduced fish were distributed throughout Boulder Basin. No young-of-the-year or yearling fish were observed or sampled. What appeared to be redds and a check of gonads of sacrificed specimens indicated that spawning occurred in 1981.

On July 17, 1981, approximately 330 cutthroat trout were collected from Sedge Creek by electrofishing and airlifted to Senecio Creek which is a tributary to Atlantic Creek and the upper Yellowstone River. Senecio Creek was chosen because, like the South Fork, it has a natural fish barrier, was fishless and will provide a third secure enclave for this unique genotype.

OTHER PROJECT ACTIVITIES

Young Adult Conservation Corps

Since the inception of the Y.A.C.C. program in Yellowstone Park, enrollees have provided needed assistance to both our winter and summer operations. Their presence initially allowed a substantial expansion of project capabilities and in the past two years corpsmembers became the backbone of our entire operation. Despite limited experience and/or education, these people provided the dedication and tireless effort required to make this project a success. We are sincerely disappointed that such a worthwhile program had to be terminated, and we extend our deepest gratitude to those who have participated in the fishery management program in Yellowstone Park.

Assistance to Independent Researchers

This project continues to act as administrative liaison and provide logistical support to independent researchers working on aquatic related studies in Yellowstone Park. In 1981, we assisted in hooking mortality research on the catch and release section of Yellowstone River, which is currently being conducted by Dr. Jack Griffith and graduate student Dan Schill from Idaho State University. Nancy Dyse, a graduate student from University of Virginia utilized our Yellowstone Aquatic Library and both current and historical files of water chemical data in conjunction with her study concerning the sensitivity of Park waters to acid precipitation. In addition, numerous requests for data and reprints of papers concerning Park aquatic systems were completed in 1981.

Youth Conservation Corps

The Y.C.C. program has provided annual assistance to our summer operations since 1976. Y.C.C. crews have been especially valuable in labor intensive projects such as the Pelican and Clear Creek fish traps. In conjunction with meeting our job objectives, corpsmembers receive an introduction to the dynamics of aquatic systems. During 1981, they assisted in the operation of the Pelican Creek trap and accomplished major repairs to the by-pass weir.

Yellowstone, Lewis, Shoshone and Heart Lake Limnology

Limnological monitoring of the four large oligotrophic lakes in Yellowstone Park continued in 1981. Thus far data has been collected for six years on Yellowstone Lake, five years on Lewis Lake and three years on Heart and Shoshone Lakes (Tables 43-47). It has been the persistent efforts of Park Rangers stationed at the latter two lakes which has enabled a consistent sampling program on these back-country waters.

The overall objective of this program has been to provide continuous baseline limnological data for these four major lakes. Such data provide information necessary for the evaluation of the effects of the natural fire program in the Park. Analysis of these data has been hampered by funding and manpower restrictions and results are forthcoming.

Yellowstone Aquatic Library

Begun in 1973, the Yellowstone Aquatic Library currently consists of almost 700 titles concerning the aquatic resources in Yellowstone Park. Each paper is cross-referenced by author, species, water and subject. Although most historical works are now included in the library, substantial effort is necessary on an annual basis to insure that recent works are included. This project was initially possible and has been a primary responsibility of Y.A.C.C. personnel.

Medicine Lake Refuge Bathymetries

By request of the Billings Area Office and Medicine Lake National Wildlife Refuge, fish population sampling and lake bathymetries were conducted on three impoundments on Medicine Lake NWR in October of 1981. Gillnet findings and detailed bathymetric maps were completed and relayed to the refuge for their use.

Formal Presentations

During the course of each year, project personnel are frequently called upon to make formal presentations to various groups concerning the fisheries management program in Yellowstone Park. In 1981, papers were presented at the national meeting of the American Fisheries Society, the Snake River Flyfishers, and the Pocatello chapter of the Federation of Flyfishermen. Student-faculty seminars were conducted at Utah State University and Idaho State University.

We also participated in the Yellowstone Park Rangers conference as part of the Resource Management module and contributed to a panel discussion during a Montana Department of Fish, Wildlife and Parks workshop in Bozeman, Montana.

Table 43 Beaver Creek water chemistry, 1979 - 1981

	1979						
	8/9	8/9 1400 hrs.	8/19	8/20	8/27	8/28	8/31
Water temp °C							
Spec. Cond. mhos							
pH							7.2
Secchi (meters)							
Pheno. alk.	0	0	0	0	0	0	0
Total alk.	52	55	27	50	24	34	29
Ca hardness	22	20	33	14	27	16	20
Total hardness	24	23	36	14	34	22	24
Total diss. solids	38	62	53	50	63	75	73
Carbonate alk.	0	0	0	0	0	0	0
Bicarbonate alk.	32	35	27	30	24	34	29
Carbonates	0	0	0	0	0	0	0
Bicarbonates	39	43	53	57	29	42	34
Hydroxides	0	0	0	0	0	0	0
Carbon dioxide	21	29	55	10	24	29	31
Chloride	2.3	1	5	1.4	1	3	2
Sulfate	2	2	2	2	14	4	10
Fluoride	1.5	1.2	1.2	1.24	1.4	1.69	1.49
Phosphate	0.06	0.34	0.66	0.6	0.57	0.62	0.63
Potassium	1.6	1.8	1.5	1.7	1.7	2.5	2.1
Mg hardness	2	3	3	4	7	6	4
Calcium	8.8	6	13	5.6	3.9	6.4	8
Magnesium	0.5	0.7	0.7	1	0.5	1.5	1
Sodium	6	6.9	5.7	4.7	5.7	6.4	5.4
Iron	0.09	0.07	0.09	0.07	0.21	0.12	0.14
Manganese	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Copper	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Silica	41	30	0.65	10	26	59	34
Color (PCU)	0	0	0	0	0	0	0
Turbidity (NTU)	0.66	0.67	0.68	0.72	1	0.75	0.76
TOC	2	2.4	3.2	2.4	3.1	2.6	1.9
Ortho-phosphate	0.06	0.31	0.36	0.39	0.51	0.42	0.43
Kjeldahl N	*0.03	*0.14	*0.14	*0.14	*0.23	*0.31	*0.13
Nitrate N	0.01	0.02	0.01	0.02	0.01	0.04	0.04

*Total Kjeldahl N

1980					1981	
6/12	6/30	7/13	8/1	9/26	4/14	6/18
12.2	12.2	14.4				
55	49	48			77	
7.2	7.2	7.0			7.3	
-	-	-			-	
0	0	0	0	0	0	0
20	19	24	24	34	44	50
17	14	18	16	24	24	21
14	20	35	20	28	52	42
37	41	54	57	61	53	50
0	0	0	0	0	0	0
20	18	24	24	34	44	50
0	0	0	0	0	0	0
24	22	30	29	41	54	37
0	0	0	0	0	0	0
16	4.6	3.2	6.1	27	2.3	4.1
1	2	1	2	1	2	1
3.1	3	8.5	2.9	3	3.1	4
0.52	0.72	0.89	1.1	1.3	1.9	0.73
-	-	0.16	0.09	0.09	0.16	0.19
1.5	1.1	1.5	1.8	1.8	0.3	1
7	6	17	4	4	28	21
4.8	5.6	7.2	6.4	9.6	9.6	8.4
0.5	1.5	4.1	1	1	6.8	5.1
4	4.6	4.5	5	6	8.3	2.7
0.05	0.05	0.07	0.07	0.18	0.22	0.05
0.05	0.05	0.05	0.05	0.05	0.05	0.05
0.1	0.1	0.05	0.1	0.1	0.2	0.3
14	17	24	33	19	22	16
0	0	0	0	0	0	0
1	0.85	0.75	0.80	1	1.6	1.5
3.7	4.9	7.5	7.9	3.7	4	5.2
1.06	0.05	0.12	0.03	0.06	0.12	0.19
*0.06	*0.1	*0.09	0.21	-	*0.15	*0.07
0.01	0.01	0.02	0.01	0.01	0.03	0.02

Table 44 Heart Lake water chemistry, 1978 - 1981

	1978					1979										1980				
	7/13	7/30	8/20	9/7	9/17	6/23	7/7	7/21	8/4	8/13	8/19	8/25	9/7	11/1	6/13	6/25	7/18	7/31	9/26	
Water temp. °C	14.4	16.6	14.4	15.5	12.2	10	12.2	17.7	16.6	16.6	16.6	15.5	11.1		7.7	11.1	15	18.3	10	
Spec. cond. μ mhos	195	-	170	174	160	200	200	210	200	200	205	195	210		200	210	210	195	200	
pH	7.6	7.8	7.8	7.6	7.4	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.4	7.4	7.4	7.4	7.4	7.4	
Secchi (meters)	6.7	8.8+	5.5	8.2	7.3	4.3	6.9	8.4	8.9	8.2	8.4	7.9	7.5		5.2	5.3	7.7	8.2	7.0	
Pheno. alk.	0	0	0	0	0	0	0	0		0	0	0	0	0	0		0		0	
Total alk.	36	20	50	40	48	0	35	48		42	48	48	44	48	46		36		53	
Ca hardness	18	15	35	6	18	17	10	11		13	18	18	14	17	12		16		18	
Total hardness	21	20	40	8	24	23	14	35		17	33	24	20	18	14		20		41	
Total diss solids	122	110	100	150	165	45	145	160		148	132	137	130	151	132		140		150	
Carbonate alk.	0	0	0	0	0	0	0	0		0	0	0	0	0	0		0		0	
Bicarbonate alk.	36	20	50	40	48	0	35	48		42	48	48	44	48	46		36		53	
Carbonates	0	0	0	0	0	0	0	0		0	0	0	0	0	0		0		0	
Bicarbonates	44	24	61	49	59	0	43	59		51	59	59	54	59	56		44		65	
Hydroxides	0	0	0	0	0	0	0	0		0	0	0	0	0	0		0		0	
Carbon dioxide	7.4	2	6.5	2.6	5	<1	36	7.8		34	16	20	11	9.9	15		29		11	
Chloride	32	28	28	30	28	26	25	28		27	24	41	28	24	21		40		26	
Sulfate	14	15	15	14	19	5.5	17	22		14	17	2	12	15	21		17		14	
Fluoride	2.9	2.8	2.8	2.8	2.9	2.7	3.1	2.7		3.0	2.8	2.9	3.0	3.0	2.7		2.7		2.9	
Phosphate	0.09	0.22	<0.06	<0.06	0.19	0.78	0.62	0.62		0.16	0.19	0.25	<0.06	0.19	-		0.06		0.03	
Potassium	2.9	2.8	2.6	0.6	3.7	3.8	3.5	3.6		3.7	3.4	3.6	3.3	3.8	3.3		3.4		3.8	
Mg hardness	3	5	5	2	6	5	4	4		4	15	6	6	1	2		4		23	
Calcium	7.2	6	14	2.4	7.2	7	4.1	4.4		5.3	7.2	7.2	5.6	6.8	4.8		6.4		7.2	
Magnesium	0.7	1.2	1.2	0.5	1.5	1.2	1	5.8		1	3.6	1.5	1.5	0.2	0.5		3.8		5.6	
Sodium	33	31	30	35	38	43	40	41		38	31	38	28	42	38		38		37	
Iron	<0.01	0.03	<0.01	0.02	0.01	0.04	0.03	<0.01		<0.01	<0.01	0.99	0.04	<0.01	0.02		<0.01		0.01	
Manganese	<0.05	<0.05	<0.05	0.02	<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	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1		<0.1	
Silica	3.5	30	39	38	32	35	36	27		29	13	27	24	25	21		15		11	
Color (PCU)	0	0	0	0	0	0	0	0		0	0	0	0	0	0		0		0	
Turbidity (NTU)	0.42	0.40	0.54	0.56	0.52	0.67	0.73	0.25		0.85	0.90	1	0.44	0.33	0.30		0.51		0.31	
TOC	6.1	3	5.2	4.3	1.4	4.2	4.6	3.7		10	12.7	11	12	3.5	4.8		3.4		3.7	
Ortho-phosphate	<0.09	0.11	<0.06	<0.06	0.12	0.16	0.31	0.31		0.12	0.12	0.18	<0.06	0.16	0.09		<0.03		0.03	
Kjeldahl N	0.05	0.04	0.50	0.02	0.14	*0.14	*0.21	*0.14		*0.14	*0.23	*0.33	*0.02	0.22	0.10		0.33		-	
Nitrate N	<0.01	0.02	0.01	<0.01	<0.01	0.32	0.05	0.01		<0.01	<0.01	0.01	<0.01	0.02	0.01		<0.01		0.01	

*Total Kjeldahl N

Continued on next page.

Table 44. Continued

	6/18 ¹⁾	7/4 ¹⁾	7/4 ²⁾	7/16 ¹⁾	7/16 ²⁾
Water temp. °C		15.0	15.0	17.8	17.2
Spec. Cond. μ mhos		190	190	200	190
pH	7.2	7.0	7.6	7.6	7.6
Secchi (meters)		6.2	5.9	8.1	8.7
Pheno. Alk.	0	0		0	
Total Alk.	44	54		44	
Ca Hardness	20	18		16	
Total Hardness	28	24		24	
Total Diss. Solids	140	146		140	
Carbonate Alk.	0	0		0	
Bicarbonate Alk.	44	54		44	
Carbonates	0	0		0	
Bicarbonates	54	66		54	
Hydroxides	0	0		0	
Carbon dioxide	6	22		7.2	
Chloride	18	19		26	
Sulfate	16	21		13	
Fluoride	3.7	3.8		3.8	
Phosphate	0.25	0.28		0.28	
Potassium	3.2	3.3		3.1	
Mg Hardness	8	6		8	
Calcium	8	7.2		6.4	
Magnesium	1.9	1.5		1.5	
Sodium	35	35		36	
Iron	0.08	1.6		0.02	
Manganese	<0.05	<0.05		<0.05	
Copper	<0.2	<0.3		<0.2	
Silica	2.9	13		18	
Color (PCU)	0	0		0	
Turbidity (NTU)	1.7	1.6		0.95	
TOC	13.8	4.7		4.7	
Ortho-phosphate	0.25	0.28		0.28	
Kjeldahl N	*0.24	*0.34		*0.08	
Nitrate N	<0.02	0.03		<0.02	

* Total Kjeldahl N

1) Station A.

2) Station B.

1981							
8/2 ¹⁾	8/2 ²⁾	8/16 ¹⁾	8/16 ²⁾	8/30 ¹⁾	8/30 ²⁾	9/18 ¹⁾	9/18 ²⁾
16.7	16.1	15.6	16.7	17.2	16.7	14.4	15.6
210	200	210	200	210	210	210	200
7.6	7.4	7.6	7.6	7.6	7.6	7.6	7.6
8.1	8.4	7.9	8.1	7.3	7.5	9.1	8.5
0		0		0		0	
40		40		54		42	
24		24		18		18	
40		24		18		18	
142		150		150		151	
0		0		0		0	
40		48		54		42	
0		0		0		0	
49		59		66		51	
0		0		0		0	
4.1		5		1.4		0.7	
33		34		23		29	
18		24		19.4		15	
3.3		3.4		4.26		5	
		0.74		0.28		1.1	
1.6		6.3		0.33		4.4	
16		<1.0		<1.0		0	
9.6		9.6		7.2		7.2	
3.9		<0.2		<0.1		<1.0	
35		39		64		29	
0.02		<0.01		<0.01		<0.01	
<0.05		<0.1		<0.05		<0.05	
<0.2		<0.3		<0.3		<0.03	
15		19.5		2.5		9.5	
0		0		0		0	
0.4		0.4		0.28		0.27	
3.6		21		5.4		3.4	
		0.56		0.28		0.93	
*0.11		*0.42		*0.64		*0.55	
<0.02		<0.02		<0.02		<0.02	

Table 45 Lewis Lake water chemistry, 1977 - 1981

	1977			1978				1979				1980				1981			
	7/18	8/11	10/4	6/29	7/27	8/31	10/4	6/23	7/20	8/28	10/6	6/25	7/30	9/9	9/26	6/26	7/23	8/29	10/2
STA. 2																			
Water temp. °C		16	9.3	14.5	17	14	9.5	10.5	18	15	12	13.5	17	12	10.2	11	16.5	17	
Spec. Cond. umhos		95	88.5	97	91	88	81	84	90	86	85	84	84	80	84	120	98	115	138
pH		7.4	7.2	7.2	7.4	7.4	7.2	7.2	7.4	7.4	7.4	7.2	7.6	7.4	7.2	7.2	7.4	7.4	7.2
Secchi (meters)		13.1	12.2	7.6	10.1	7.6	10.6	9.8	10.7	7.3	9.5	8.5	7.9	8.5	11.0	6.1	10.7	9.7	
Pheno. alk.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total alk.	36	30	33	28	15	18	32	42	0	26	36	30	26	21	32	32	32	28	20
Ca hardness	10	12	21	8	5	6	18	10	10	8	11	8	10	11	16	10	12	12	12
Total hardness	12	15	24	12	10	8	30	17	13	12	17	10	12	12	22	12	16	16	16
Total diss. solids	110	100	85	85	70	70	110	90	95	84	85	70	77	94	74	90	42	65	70
Carbonate alk.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonate alk.	36	30	33	28	15	18	32	42	0	26	36	30	26	21	32	32	32	28	20
Carbonates	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates	44	37	40	34	18	22	39	51	0	32	41	37	32	25	39	39	39	34	24
Hydroxides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Carbon dioxide	7.8	0.8	9.2	1.4	1.0	3.7	21	34	<1	27	19	7.8	8.5	17	16	<1	10.3	1.1	3
Chloride	1	20	6.6	9	9.1	9	6.4	6	3.3	8	5.9	5.1	8.1	10	5.8	6.1	5.2	7.3	7
Sulfate	5	2	3	7	3	2.5	16	5	6.9	7	6.9	1	6.1	<1.0	3.2	2	4	1.9	8
Fluoride	1.5	2.9	2.4	2.5	2.6	2.7	2.77	2.6	2.7	2.7	2.8	2.4	2.6	2.7	2.5	3.4	3.4	3.82	3.45
Phosphate	0.40	0.01	3.41	0.22	0.09	<0.06	0.19	0.43	0.12	<0.06	0.16	-	0.29	0.12	0.09	0.43	<0.03	0.31	0.19
Potassium	3.3	3.10	4	3	2.8	3.8	1.6	3.5	3.1	3.3	3.9	3.2	3.6	0.8	3.5	0.32	3.1	0.32	4
Mg hardness	2	3	3	4	5	2	12	7	3	4	6	2	2	0.2	6	2	1	1	4
Calcium	4	4.8	8.4	3.2	2	2.4	7.2	4.1	4	3.2	4.4	3.2	4	4.4	6.4	4	4.8	4.8	4.8
Magnesium	0.5	0.7	0.7	1	1.2	0.5	2.9	1.7	0.7	1	2.6	1.9	0.5	0.2	1.5	0.5	1	1	1
Sodium	16	19	16	15	15	14	9.6	17	14	17	17	16	16	16	16	15	14.4	16.5	11.6
Iron	0.03	0.03	<0.02	0.04	0.02	<0.01	<0.01	<0.05	0.03	0.01	0.03	0.01	<0.01	0.01	0.02	0.04	<0.01	0.04	<0.01
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	0.27	<0.05	<0.05
Copper	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.2	<0.3	<0.03
Silica	46	33	24	39	16	40	52	43	38	17	30	26	36	77	19	19	8.7	2.8	10
Color (PCU)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Turbidity (NTU)	0.50	0.30	0.27	0.37	0.34	0.30	1.4	0.56	0.43	0.37	0.35	0.30	0.33	0.30	0.40	0.6	0.5	0.37	0.29
TOC	2.45	2.40	3.5	2.8	1.4	1.26	1.7	16	13	5.1	8.5	17	11	9.8	3.9	2.7	3.4	1.8	2.3
Ortho-phosphate	0.40	0.01	3.1	0.06	<0.06	<0.06	0.19	0.25	0.07	<0.06	0.12	0.12	0.28	0.12	0.09	0.37	<0.03	0.16	0.16
Kjeldahl N	0.44	0.07	0.14	0.3	0.26	0.13	0.04	0.08	0.16	0.08	0.25	0.07	0.33	0.03	-	*0.4	*0.11	*0.38	*0.16
Nitrate N	0.03	0.02	0.03	0.08	0.01	<0.01	<0.01	0.02	0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.02	0.04

* Total Kjeldahl N

Table 47 Shoshone Lake water chemistry, 1987 - 1991

	1978					1979					1980						1981					
	7/20	8/3	8/18	9/3	9/17	7/9	7/15	7/28	8/15	9/6	7/10	7/22	7/27	8/6	8/10	8/24	6/24 ¹⁾	7/8 ¹⁾	7/10 ²⁾	8/3 ¹⁾	8/20 ²⁾	8/29 ¹⁾
Water temp. °C	11.7	14.4	11.1	13.3	11.1	13.3	12.2	15.5	15.5	15.5	14.4	15.3	15.5	15.5	15.2	13.3	8.9	13.3	13.3	16.6	16.7	16.7
Spec. Cond. mhos	90	77	28	80	77	80	75	79	70	78	74	73	77	76	73	77	75	-	-	79	68	69
pH	7.3	7.4	7.8	7.4	7.4	6.0	6.0	6.0	7.0	7.0	7.4	7.4	7.4	7.3	7.3	7.3	7.2	7.4	7.4	7.4	7.2	7.2
Secchi (meters)	9.1	9.7	9.7	13.1	12.2	10.0	22.6	12.1	14.0	15.2	10.2	11.8	13.1	12.5	12.1	12.8	9.7	10.7	10.4	11.6	11.0	11.0
Pheno. alk.	0	0	0	0	0			0	6		0				0				0			0
Total alk.	21	15	20	16	30			39	24		37				24				33			32
Ca hardness	12	5	5	6	12			10	21		15				6				11			12
Total hardness	21	10	15	8	18			17	24		18				9				18			20
Total diss. solids	75	65	70	70	85			70	46		60				72				67			83
Carbonate alk.	0	0	0	0	0			0	0		0				0				0			0
Bicarbonate alk.	21	15	20	16	30			30	24		27				24				33			32
Carbonates	0	0	0	0	0			0	0		0				0				0			0
Bicarbonates	26	18	24	20	37			37	24		33				29				40			39
Hydroxides	0	0	0	0	0			0	0		0				0				0			0
Carbon dioxide	22	1.5	63	1.7	7.8			31	10		11				7.7				21			1.6
Chloride	8.2	8.5	7.3	8.5	7.8			9.1	8		12				12				6.1			8
Sulfate	5	2	2	2	4			5			3.1				2.6				1			2.4
Fluoride	2.4	2.4	2.4	2.3	2.3			2.2	2.4		2.2				2.4				2.9			3.1
Phosphate	0.12	0.06	0.37	0.06	0.18			0.29	0.31		0.29				0.09				0.5			0.65
Potassium	1.9	3.3	3.3	3.3	2.8			2.4	2.8		2.4				3.1				2.8			2.8
Mg hardness	11	5	10	2	6			7			5				3				7			2
Calcium	4.8	2	2	2.4	4.8			4	4.4		6				2.4				4.4			4.8
Magnesium	2.7	1.2	2.4	0.5	1.5			1.7			0.7				0.7				1.7			2
Sodium	12	13	11.5	11.8	14			18	10		12				13				13			14
Iron	0.01	0.01	0.01	0.02	0.01			0.01	0.07		0.01				0.01				0.03			0.02
Manganese	0.05	0.05	0.05	0.05	0.05			0.05	0.05		0.05				0.05				0.05			0.05
Copper	0.1	0.1	0.1	0.1	0.1			0.1	0.1		0.1				0.1				0.3			0.2
Silica	32	33	22	40	37			26	41		32				35				19			5.5
Color (P)	0	0	0	0	0			0	0		0				0				0			0
Turbidity (NTU)	0.35	0.2	0.31	0.25	0.35			1	0.4		0.15				0.21				0.28			0.23
DOC	1.6	0.9	1.9	0.9	0.5			1.3	1.2		0.7				5.5				0.8			4.6
Ortho-phosphate	0.09	0.06	0.18	0.06	0.12			0.29	0.41		0.26				0.06				0.4			0.25
Kjeldahl N	0.09	0.11	0.3	0.05	0.09			0.19	0.14		0.21				0.06				0.37			0.22
Nitrate N	0.01	0.01	0.01	0.02	0.01			0.02	0.02		0.1				0.01				0.02			0.02
Arsenic	-	-	-	-	-			-	0.1		-				-				-			-

1) Station B.

2) Station A.

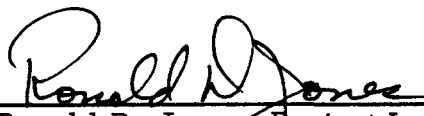
* Total Kjeldahl N.

ACKNOWLEDGEMENTS

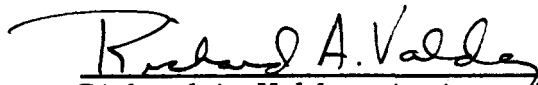
Considering the increasing scope of this project and the current limitations on personnel and budget, we have become increasingly dependent on those who work so hard to make this report possible. For their effort, we thank the following persons: Sandy Rubrecht, a member of the Yellowstone project for over eight years, left to continue her formal education this past fall. Sandy contributed greatly to the smooth operation of this station, and devoted much time, effort and patience to assure the adequate training of summer personnel in every aspect of our field work. She was responsible for the collection of much data reported herein, and has been sorely missed since her departure. Dan Carty worked as a full time VIP from January to September and contributed significantly to both our winter and summer operations. Bill Noble was also a full time VIP from April to September. Without the dependable service of these two individuals our summer operations would have been severely hampered. Bob Wolak, our only seasonal in 1981, deserves recognition for his efforts in the field and his bathymetric map work and graphics. Karrie West again receives our heart-felt thanks for typing this report and its tables, her graphics work, her extensive data punching and for updating our aquatic library. Mary Wunderlich again identified our zooplankton and aquatic invertebrates. Y.A.C.C. enrollees Lori Rice, Linda Lienard, Jeff Rodgers and Dave Streadwick provided us with greatly needed assistance during our summer field season. Frank Losos, along with several other Y.A.C.C. members and volunteers, fought high waters at the traps day and night during early spring floodings; without their help our Pelican Creek operation would not have succeeded. Paul Linnemeyer, who was a VIP part time during the summer and a Y.A.C.C. enrollee throughout the winter, deserves special thanks for his extensive work on the VFR files, numerous hours of scale reading and the superb job of detecting and correcting erroneous tabular data. Don G. Despain again freely gave his time and talents identifying the aquatic plants. Ellen Snoeyenbos did an excellent job processing all our VFR data, typed numerous drafts for this report and also contributed to our summer operation. Marion Jones and Melanie Wilson also did VIP work for us throughout our hectic summer season and deserve special thanks. The Heart and Shoshone Lake rangers, Tim Stone and Don Yestness, collected limnological data from those lakes in a highly competent manner. Fish and Wildlife Service personnel from the Billings Area Office and stations in Bozeman, Ennis and Jackson and David Thurow of Washington made the fall gillnetting a pleasure. Dan Schill, although working full time on his graduate research, contributed time and effort conducting various population estimates.

Our special thanks to all of the above and also to those who contributed, but have been unfortunately forgotten.

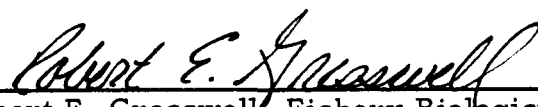
This report was submitted by:



Ronald D. Jones, Project Leader

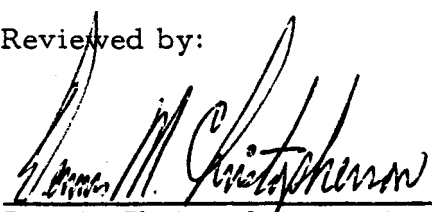


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