MONTANA FISH AND GAME REPORT

In Cooperation with U.S. Forest Service

FISHERIES DIVISION

JOB PROGRESS REPORT

ANNUAL PROGRESS REPORT

ELK LAKE - NARROWS CREEK STUDY,

May 14, 1973 - October 6, 1973

by

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April 20, 1974

BACKGROUND

Elk Lake is located in the Centennial Valley of southwestern Montana at an elevation of 6,675 feet. The lake has an area of 283 acres and a maximum depth of 70 feet. Elk Lake provides sport fishing for Arctic grayling (*Thymallus arcticus*), cutthroat trout (*Salmo clarki*), lake trout (*Salvelinus namaycush*), rainbow trout (*Salmo gairdneri*), and rainbow-cutthroat trout hybrids.

Narrows Creek is the main tributary to Elk Lake and its principle spawning stream. It has in the past provided most of the natural recruitment of Arctic grayling and cutthroat trout to the lake. A small number of rainbow trout and rainbow-cutthroat trout hybrids also use the stream and produce significant numbers of fry.

Limestone Creek, another small tributary, is used for spawning by Arctic grayling. Horse Creek, a third inlet, was diverted from the lake in 1972 because of loss of flow during periods when fry would migrate. It now enters Elk Creek just below the outlet of Elk Lake.

Further information and background material are presented in Peterson (1972) and Lund (1973).

OBJECTIVES

The objective of this study was to collect data for the evaluation of present management practices and to help in the formation of future management plans for Elk Lake. Information on spawning activity, fry recruitment from the two inlets, species composition in Elk Lake, fishing intensity, and total game fish yield were obtained for this purpose. It is hoped that by understanding the exact requirements for spawning success the natural recruitment of the two native species, cutthroat trout and Arctic grayling, can be increased.

PROCEDURES

Adult spawners were captured in Narrows and Limestone Creeks using two-way weirs, in 1973. These adult traps were designed and placed to catch fish entering and leaving the streams. Narrows Creek and Limestone Creek traps were in operation from May 16-July 5, 1973 and from May 23-June 25, 1973, respectively.

All adults going upstream were counted, measured for total length, sexed, and checked to determine species. The adults returning to the lake were weighed, measured for total length, sexed, checked for hatchery marks, checked to determine species, and tagged with numbered "T" tags. Females were also checked to determine whether or not they had spawned. Adult traps were checked three times a day, at 8:30 a.m. and 1:00 and 6:30 p.m.

The fry trap assembly used in 1973 was the same one described by Peterson (1972) and used in 1971 and 1972. It was placed 15 feet downstream from the adult trap in Narrows Creek on June 23, 1973 and was in operation until September 13, 1973. The fry trap was checked three times a day at 8:30 a.m. and 12:30 and 8:00 p.m. Migrating fry and fingerling were counted and placed downstream. Fry were classified as trout or grayling. Fingerling were identified, if possible, to species. Approximately 10 percent of the fry and all of the fingerling were measured for total length. Another fry trap was operated in Limestone Creek from June 26 to July 23, 1973. A one-way trap designed to capture advanced fry and fingerling was placed just below the pond on Narrows Creek. It was operated from May 16 to September 13, 1973.

A creel census was also conducted on a daily basis from May 15 to September 12, 1973. As many fishermen as practicable were interviewed. Data collected included length of time fished, total number in the fishing party, methods of fishing, and the species, number, weight and total length of the fish caught. All fish were also checked for the presence or absence of tags. Cutthroat trout were also checked for fin clips identifying them as hatchery products and the year they were planted.

Fishermen were counted daily at 10:00 a.m. and 1:00, 4:00, and 8:00 p.m. in order to determine the daily distribution of fishing itensity and obtain an estimate of fishermen-hours. Only those actually fishing were counted.

The maximum and minimum daily temperatures of Narrows and Limestone Creeks were recorded from May 18 to September 11, 1973. Stream flows, using the "float method" (Welch, 1948), were measured twice weekly on both streams. All flows and temperatures were measured near the mouths of the two streams. Temperature and oxygen profiles of Elk Lake were taken on a biweekly schedule.

Other data included the success of cutthroat and grayling redds as related to depth of gravel available at spawning sites.

FINDINGS

Narrows Creek

Arctic grayling, cutthroat trout, rainbow trout, and rainbow-cutthroat trout hybrids passed through the adult trap on spawning runs in 1973. The upstream spawning migration started on May 17, one week later than in 1972; however, it again coincided with increased flow in the creek due to runoff and disappearance of ice from the lake. Cutthroat, rainbow and hybrid trout began upstream migration on May 17. Grayling began on May 27. Peak upstream movement for cutthroat occurred on May 27 and for grayling on June 5. Total numbers, lengths and weights of spawners during upstream migration are shown in Table 1. Weights of spawners were recorded during downstream migrations and were less than pre-spawning weights.

A summary of marked hatchery cutthroat entering Narrows Creek during upstream spawning migrations is shown in Table 2. The 1969 plant of subcatchables again dominated the run as it did in 1972; however, their numbers decreased from 69 to 27 fish. All cutthroat declined from a total of 167 migrating in 1972 to 92 in 1973.

The decline of the 1969 plant, the lack of a four-year-old age class and the small number of age 3 spawners (Table 2) seem to account for the lower migration. Grayling and hybrids in the run increased by 5 and 13 percent, respectively, in 1973 while rainbow decreased by 25 percent.

Tag returns from the 1972 spawning run show that 183 (64 percent) of the grayling, 50 (31 percent) cutthroat, 9 (26 percent) hybrids, and 6 (30 percent) rainbow made spawning runs again in 1973. Grayling which failed to return in 1973 may have been lost due to natural causes since only about 5 percent of the marked fish were taken by fishermen in 1972. It is estimated that about 46 percent of the tagged cutthroat were caught by fishermen during the summer of 1972, with an additional 11 percent caught during May of 1973.

A total of 12 grayling, 10 cutthroat, 2 hybrids and one rainbow were collected for egg counts in 1972 and 1973. Grayling averaged 14.7 inches in total

length and had an average of 8,170 eggs per female, while cutthroat averaged 17.3 inches and had 1,954 eggs per female. The two hybrids averaged 21.0 inches and averaged 2,712 eggs per female, while the rainbow was 18.2 inches long and had 2,414 eggs.

TABLE 1. Species, numbers, lengths and weights of spawners which entered Narrows Creek in 1973.

Species	Total Counted	% of Total	Total Measured	Size Range Total Ins. (Ave.)	Total Weighed	Wt. Range in Lbs. (Ave.)
Grayling	312	68.0	312	11.7-18.0 (15.0)	217	0.50-1.59 (1.06)
Rainbow	15	3.3	15	13.4-20.6 (17.4)	13	1.05-2.60 (1.63)
Rainbow-cutthroat hybrids	40	8.7	39	9.7-21.6 (17.9)	39	0.57-3.18 (1.92)
Cutthroat--unmarked 1/	41	8.9	41	15.0-22.5 (17.9)	34	1.38-2.95 (1.89)
Cutthroat--marked, hatchery	51	11.1	51	14.2-19.8 (17.4)	48	1.28-2.52 (1.74)
Grand Total	459	100.0	458		351	

1/ Includes wild and unmarked hatchery trout.

TABLE 2. Number, length and age of marked hatchery cutthroat trout which spawned in Narrows Creek, 1973.

Mark (fin clip)	Year Planted	Age at Planting	Age This Year	Total Counted	% of Total	Size Range Total Ins. (ave.)
Left pectoral	1968	0+	5	6	11.8	17.0-19.8 (18.8)
Adipose,right pelvic 1/	1969	1+	5	27	52.9	14.2-19.2 (17.3)
Adipose	1970	0+	3	3	5.9	15.5-18.2 (17.1)
Right pelvic	1970	0+	3	9	17.6	16.1-18.4 (17.5)
Left pelvic	1971	0+	2	6	11.8	15.5-17.8 (16.3)
Grand Total				51	100.0	

1/ Combination of both marks.

Fry and fingerling were trapped near the mouth of Narrows Creek from June 24 to September 12, 1973. The first grayling fry were caught on June 25 and the first cutthroat fry on July 7 (Table 3). Distribution of fry during the migration period is shown in Table 4. The grayling fry migrated downstream first and peaked on June 28, while the cutthroat peaked on July 18. A second peak of cutthroat fry occurred on August 8 when a beaver dammed up the pond and caused very low overnight stream flows. This sudden loss of water apparently caused a large number of fry to leave the stream. A total of 2,082 grayling fry and 2,484 cutthroat fry migrated during the trapping period in 1973. The three years when fry were trapped in Narrows Creek are compared in Table 5.

Fry and fingerling were also captured leaving the pond on Narrows Creek. The

first trout fingerling was caught on May 17, and the first fry was caught on July 25 (Table 3). It is now known that many, if not all, of the trout fingerling which inhabit the spawning section below the pond are fish that leave the pond during spring runoff. On May 6, the spawning section was checked and no fish were found. On May 14, after a freshet, fingerling were found in the spawning section. Some of the fingerling may have migrated from the lake; however, the lake was mostly ice covered during this period. After the pond trap was installed on May 16, a total of 63 trout fingerling were caught moving downstream (Table 3).

TABLE 3. The numbers and species composition of fingerling and fry caught during downstream migrations in Narrows Creek, 1973.

Species	Fry Trap	Dates of Capture	Pond Trap	Dates of Capture
Fingerling				
Rainbow	34	6-28 to 8-8	36	5-17 to 7-17
Cutthroat	24	6-24 to 8-8	2	5-17 to 8-7
Rainbow-cutthroat hybrids	81	6-24 to 8-27	25	5-19 to 6-30
Subtotals	139		63	
Fry				
Cutthroat[1/]	2484	7-7 to 9-12[2/]	57	7-25 to 8-31
Grayling	2082	6-25 to 7-28	--	--
Grand Total	4705		120	

1/ Includes all cutthroat, rainbow and hybrid fry.
2/ Some fry migrating after this date.

Limestone Creek

A total of 196 grayling and one cutthroat trout were caught during spawning runs in Limestone Creek. The first grayling migrated upstream on June 2. The peak upstream migration occurred on June 4. The cutthroat trout entered the stream on June 4. The numbers, lengths and weights by sex are shown in Table 6.

When the grayling were placed in the stream above the trap, they were observed to act very nervous and most spent less than a day in the creek before returning to the trap. Of 100 grayling female checked during downstream migrations, only 6 of them had spawned. Low stream flows in 1973 may have caused the fish to leave prematurely. Although flows were not measured on this stream in 1972, they were visibly higher than those in 1973. Only 10 grayling (5 males and 5 females) entered Limestone Creek a second time after failing to complete spawning on their initial visit. Nine grayling which entered Limestone Creek initially moved to Narrows Creek to spawn. No grayling moved from Narrows to Limestone Creek to spawn in 1973.

No fry were captured in the fry trap which was operated in Limestone Creek from June 26 - July 23, 1973. In 1972, the estimated fry production here was 158.

TABLE 4. Numbers of fry and fingerling counted during four-day periods from the fry trap assembly in Narrows Creek, 1973.

Date	Number Fry	Number Fingerling[1/]	Totals
June 24-27	419	7	426
June 28-July 1	1519	22	1541
July 2-5	110	25	135
6-9	26	8	34
10-13	242	13	255
14-17	318	7	325
18-21	416	--	416
22-25	286	--	286
26-29	95	7	102
July 30-Aug. 2	44	2	46
Aug. 3-6	63	8	71
7-10	963	38	1001
11-14	22	--	22
15-18	10	--	10
19-22	13	--	13
23-26	6	1	7
27-30	3	1	4
Aug. 31-Sept.3	2	--	2
Sept.4-7	6	--	6
8-11	2	--	2
12-13	1	--	1
Grand Totals	4566	139	4705

1/ All fingerling were at least a year old when trapped.

TABLE 5. Number and species of fry migrating in each of the three study years.

Species	1971	1972	1973
Grayling	14,980	618	2,082
Cutthroat[1/]	7,394	7,502	2,484
Totals	23,374	8,120	4,566

1/ Includes all cutthroat, rainbow and hybrid fry.

TABLE 6. Numbers, sizes and weights of spawners which entered Limestone Creek in 1973.

Species	Total Counted	% of Total	Total Measured	Size Range Total Ins.(Ave.)	Total Weighed	Wt. Range In Lbs.(Ave.)
Grayling females	102	52.0	102	11.7-17.1 (14.2)	100	0.54-1.83 (1.08)
Grayling males	94	48.0	94	11.9-17.7 (14.2)	93	0.53-1.53 (0.94)
Totals	196	100.0	196	(14.2)	193	(1.01)
Cutthroat male	1	100.0	1	19.0 --	1	2.58 --

Elk Lake--Creel Census

The results of the creel census are shown in Table 7. Hatchery marked cutthroat again dominated the creel as they did in 1972; however, unmarked cutthroat decreased 18 percent from the 1972 level. This may reflect the higher percentage of hatchery fish that were marked before planting in the last two years of the study. The percentage of all cutthroat in the creel decreased 4 percent between 1972 and 1973. Lake trout, grayling, and hybrids all gained 1-2 percentage points, while rainbow decreased 0.4 percent.

Marked hatchery cutthroat in the creel were divided into their respective years of planting in Table 8. The 1971 plant again dominated the catch in 1973 as it did in 1972. A total of 220 cutthroat trout of the 1971 plant of some 20,000 fish were found in the 1973 creels. It can be seen by comparing the number marked and the number caught from each year class that plants made in June and July survived to the creel in greater numbers than those planted in September and October. Only five marked cutthroat trout of the approximately 4,100 marked in the 1970 plant were found in creels checked in 1973.

The total fishermen-hours during the period of the creel census (May 15-September 12, 1973) was estimated by constructing monthly "fishing intensity curves" (Figure I) as described in Peterson (1970). The total yield of game fish for each month was estimated as the product of the total fishermen-hours and the catch rate per hour for that period (Table 9). It is estimated that 53 percent of all the fish caught during the period were checked in the creel census. The catch rate increased from 0.30 to 0.38 fish per hour between 1972 and 1973. Estimated game fish yield increased from 1,274 to 1,405; however, the total fishing effort decreased from 3,929 to 3,729 hours in 1973. Fishing pressure was higher in May, June and August, but lower in July. The decrease in July fishing pressure was due to a decrease in out-of-state fishermen.

TABLE 7. Species, numbers and size of measurable game fish which were observed in fishermen's creels at Elk Lake, 1973.

Species	Total Counted	Percent of Catch	Total Measured	Size Range in Total Ins. (Ave.)
Arctic grayling	37	5.0	29	9.0-18.5 (14.6)
Cutthroat-unmarked 1/	61	8.2	55	12.0-20.8 (16.7)
Cutthroat-marked hatchery	365	49.2	337	7.8-20.5 (14.3)
Rainbow-cutthroat hybrid	93	12.5	76	11.1-21.3 (15.8)
Rainbow	19	2.6	17	12.0-19.8 (15.7)
Cutthroat 2/	78	10.5	--	-- --
Lake trout	89	12.0	77	11.4-18.7 (14.9)
Grand Total	742	100.0	591	

1/ Unmarked cutthroat trout would include wild and unmarked hatchery trout.
2/ Cutthroat which were not measured or checked for marks.

The number of boat fishermen again outnumbered shore fishermen by a large margin except in May when 51.2 percent of all fishermen fished from shore (Table 10). A total of 83.3 percent of the fishermen used boats in 1972 as compared to 78.5 percent in 1973. It was calculated that each boat contained 2.1 fishermen. Boat and shore fishermen combined fished an average of 3.7 hours per visit.

TABLE 8. Number and size of marked hatchery cutthroat trout which were observed in fishermen's creels at Elk Lake, 1973.

Mark (Fin Clip)	Date Planted	Age at Planting	Total Counted	Total Measured	Size Range In Total Ins. (Ave.)
Left pectoral	9-12-68	0+	2	2	18.2-20.0 (19.1)
Adipose & right pelvic[1/]	6-23-69	1+	9	9	16.8-20.5 (17.9)
Adipose	10-5-70	0+	1	1	17.3 --
Right pelvic	10-5-70	0+	4	4	16.8-17.8 (17.4)
Left pelvic	7-27-71	0+	220	198	14.0-18.9 (16.0)
Right pectoral	9-6-72	0+	4	4	10.2-14.0 (12.3)
Adipose	6-13-73	1+	42	40	8.1-12.7 (10.7)
Adipose & right pectoral[1/]	6-13-73	1+	83	79	7.8-14.3 (11.5)
		Totals	365	337	

1/ Combination of both marks.

TABLE 9. Estimated game fish yield and catch rate for Elk Lake, May 15-September 12, 1973

Date	Fishermen Contacted	Fish Obs. In Creel	Catch Per Hour	Total Fishermen-Hrs.[1/]	Est. Game Fish Yield
May (15-31)	107	202	0.60	526	316
June	132	248	0.47	1,055	497
July	148	154	0.29	1,250	360
Aug.-Sept. 12	137	138	0.26	898	232
Totals	524	742	Ave. 0.38	3,729	1,405

1/ Total fishermen-hours obtained from fishing intensity curves, Figure I.

TABLE 10. Number of shore and boat fishermen observed at Elk Lake during the summer of 1973 (percents in parentheses).

	May (15-31)	June	July	August	Sept.(1-12)	Summer Totals
Boat	82 (48.8)	243 (74.8)	348 (91.1)	199 (85.0)	47 (75.8)	919 (78.5)
Shore	86 (51.2)	82 (25.2)	34 (8.9)	35 (15.0)	15 (24.2)	252 (21.5)

Physical, Chemical and Biological Data on Narrows and Limestone Creeks

Weekly stream flows were measured in Narrows and Limestone Creeks from May 17-September 10 and from May 21-September 10, 1973, respectively. The 1972 Narrows Creek flow measurements were added to Figure II for comparison. Maximum flows from Limestone Creek occurred before the ice had left Elk Lake in 1973. The average weekly flow had dropped to 0.6 c.f.s. by the time the first measurements were made.

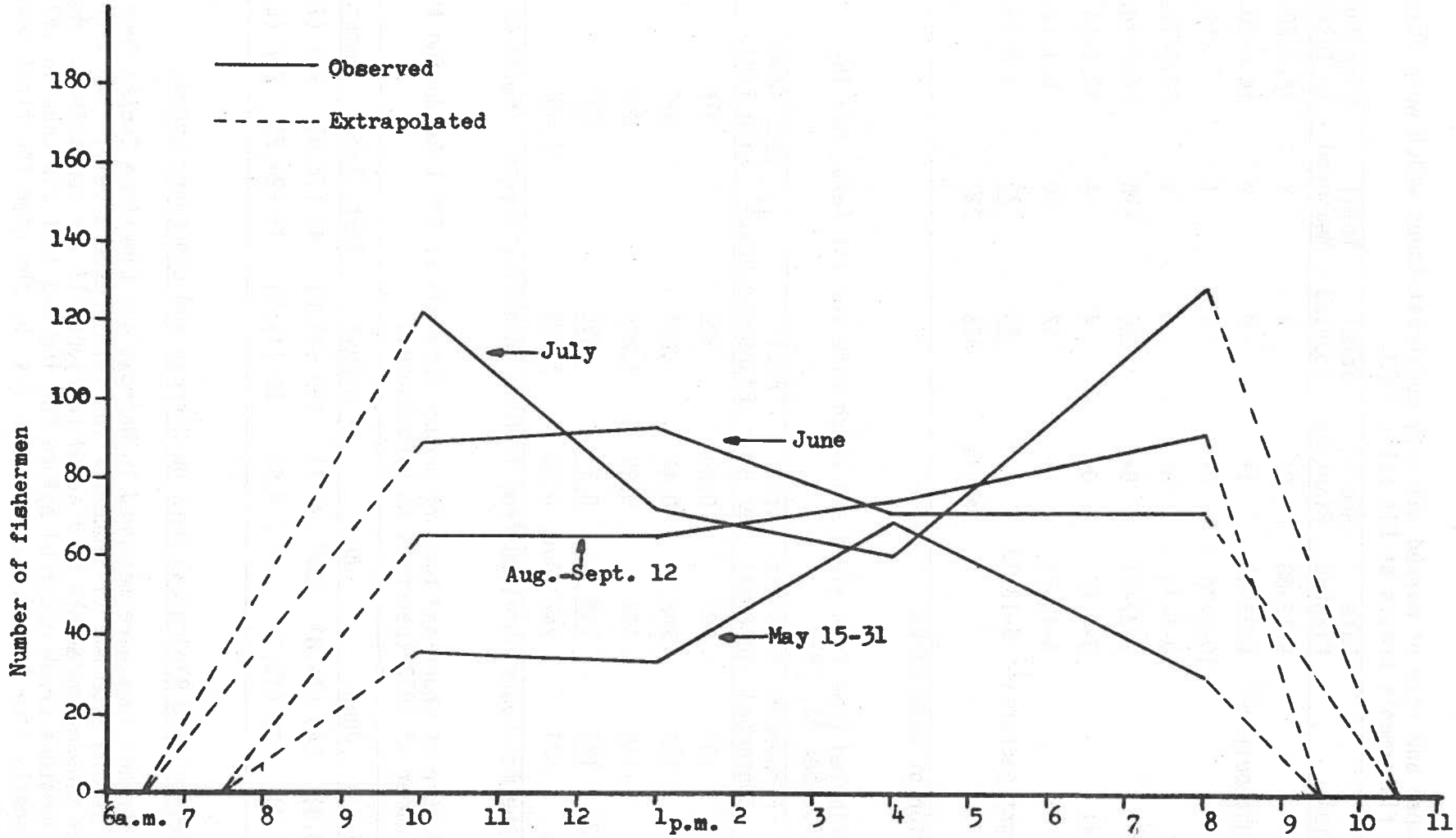

Figure I. Fishing intensity curves for May 15-31, June, July, and August to September 12, 1973, for Elk Lake.

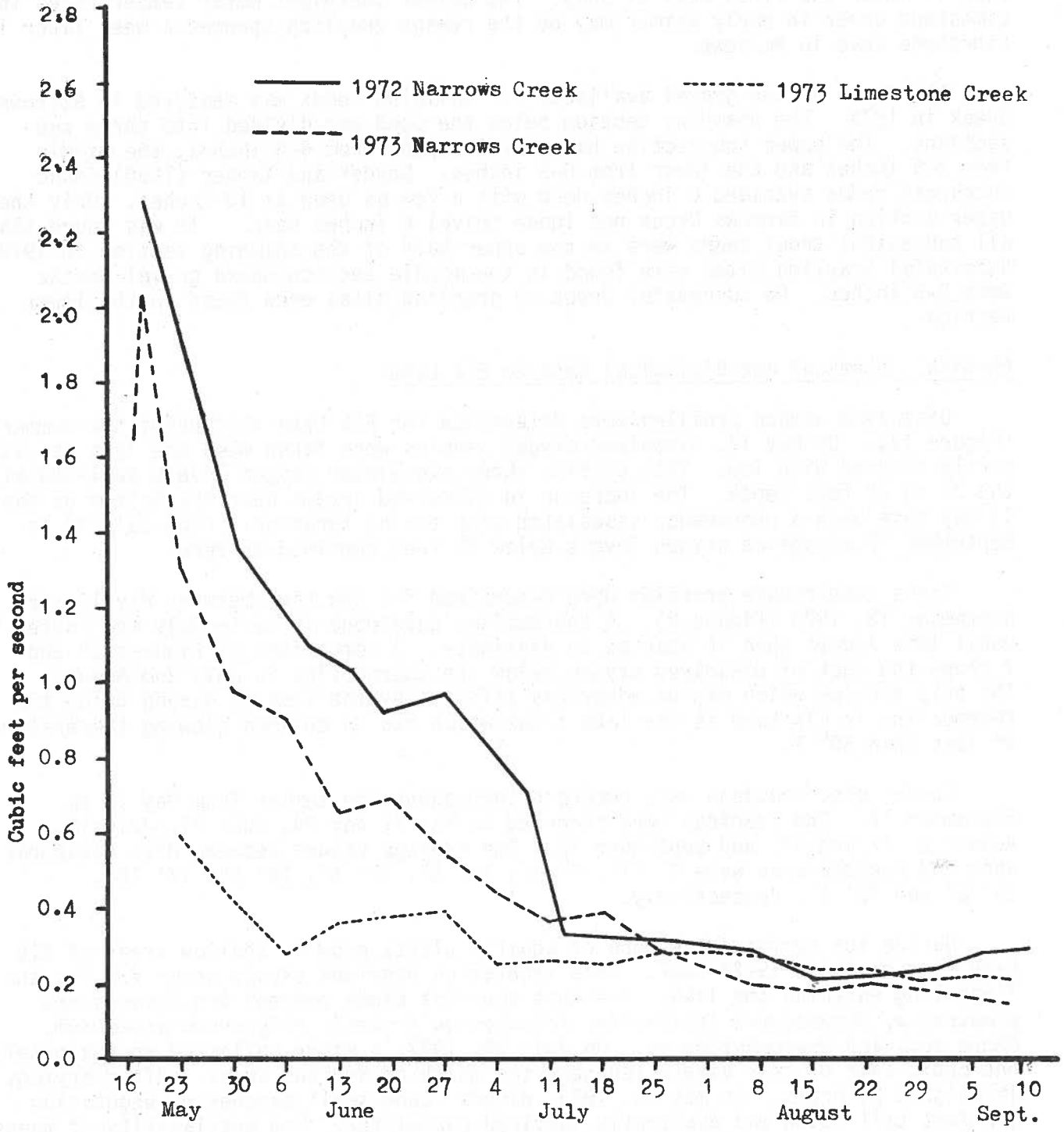

Figure II. Flow levels taken in Narrows Creek 1972 and 1973 and in Limestone Creek 1973.

Stream temperatures were measured in Narrows and Limestone Creeks during the summer with Taylor maximum-minimum thermometers (Figure III). Overnight temperatures were always lower on Limestone Creek. The daytime temperatures from Limestone Creek were again greater than Narrows Creek during early summer but were less than it after the first week of July. The colder overnight water temperatures in Limestone Creek in early summer may be the reason grayling spawned a week later in Limestone than in Narrows.

The depth of the gravel available for building redds was measured in Narrows Creek in 1973. The spawning section below the pond was divided into three sub-sections. The upper sub-section had gravel depths from 4-8 inches, the middle from 3-5 inches and the lower from 0-3 inches. Snyder and Tanner (1960) found cutthroat redds averaged 6 inches deep with a few as deep as 10 inches. Only the upper section in Narrows Creek has loose gravel 6 inches deep. It was found that all successful trout redds were in the upper half of the spawning section in 1973. Successful grayling sites were found in the middle section where gravel depths were 3-5 inches. No successful trout or grayling sites were found in the lower section.

Physical, Chemical and Biological Data on Elk Lake

Dissolved oxygen profiles were determined for Elk Lake throughout the summer (Figure IV). On May 17, dissolved oxygen samples were taken when the lake was still partly covered with ice. This profile shows overwinter oxygen levels depleted at the 35 to 40 foot depth. The increase in dissolved oxygen near the bottom on May 17 may have been a phenomenon associated with spring turnover. From July 19 to September 12 dissolved oxygen levels below 35 feet remained at zero.

Eight temperature profiles were determined for Elk Lake between May 17 and September 12, 1973 (Figure V). A thermocline developed in early July and lasted until late August when it started to dissipate. A comparison of Figures IV and V shows the lack of dissolved oxygen below the thermocline in July and August. The only species which may be adversely affected by the lack of oxygen below the thermocline in Elk Lake is the lake trout which has an optimum growing temperature of less than 50^{0} F.

Secchi disc readings were recorded throughout the summer from May 17 to September 12. The readings were recorded on May 17 and 24, June 21, July 19, August 2, 17 and 31, and September 12. The average values between disc disappearance and reappearance were 9' 11", 7' 5", 14' 6", 17' 5", 14' 9", 17' 10", 14' 8" and 13' 1", respectively.

During the summer, dense beds of aquatic plants grow in shallow areas of Elk Lake to a depth of 15-20 feet. This vegetation provides escape cover for fry and fingerling entering the lake. The most abundant kinds present are *Potamogeton praelongus, Potamogeton filiformis, Potamogeton friesii, Polygonium amphibium, Chara* sp., and *Myriophyllum* sp. On July 20, 1972, a diver collected approximately one cubic foot of this vegetation near the mouth of Narrows Creek. After drying, it weighed 21 grams. On May 26, 1973, divers found small patches of vegetation 1-2 feet tall which had apparently survived overwinter. The availability of these plants as escape cover overwinter may be very important to small fish.

DISCUSSION

The low production of fry encounted during 1972 and 1973 was believed to have been the result of a high loss of embryos during incubation. Observations along

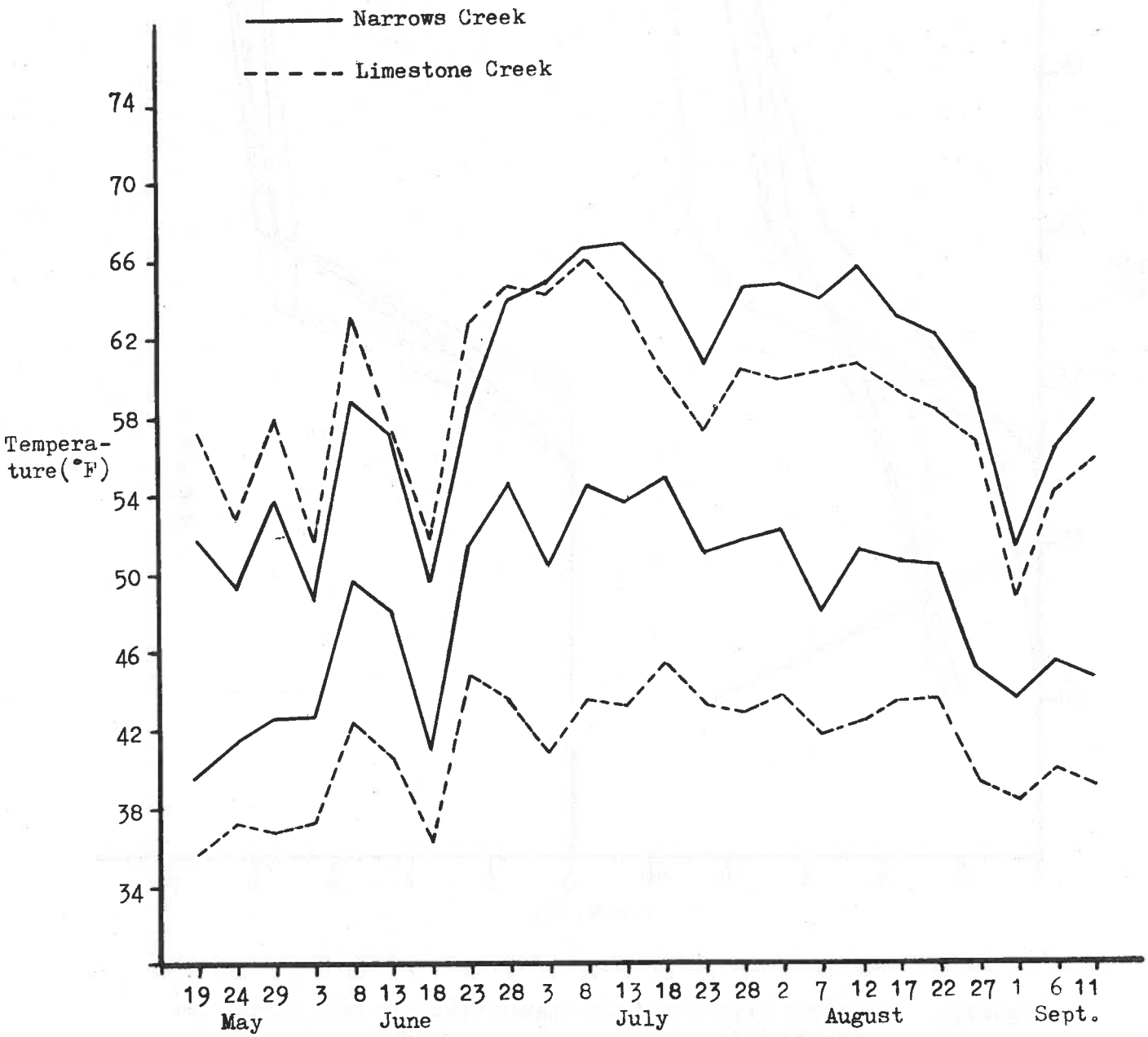

Figure III. Average five-day maximum and minimum temperatures for stations near the mouths of Narrows and Limestone Creeks, 1973.

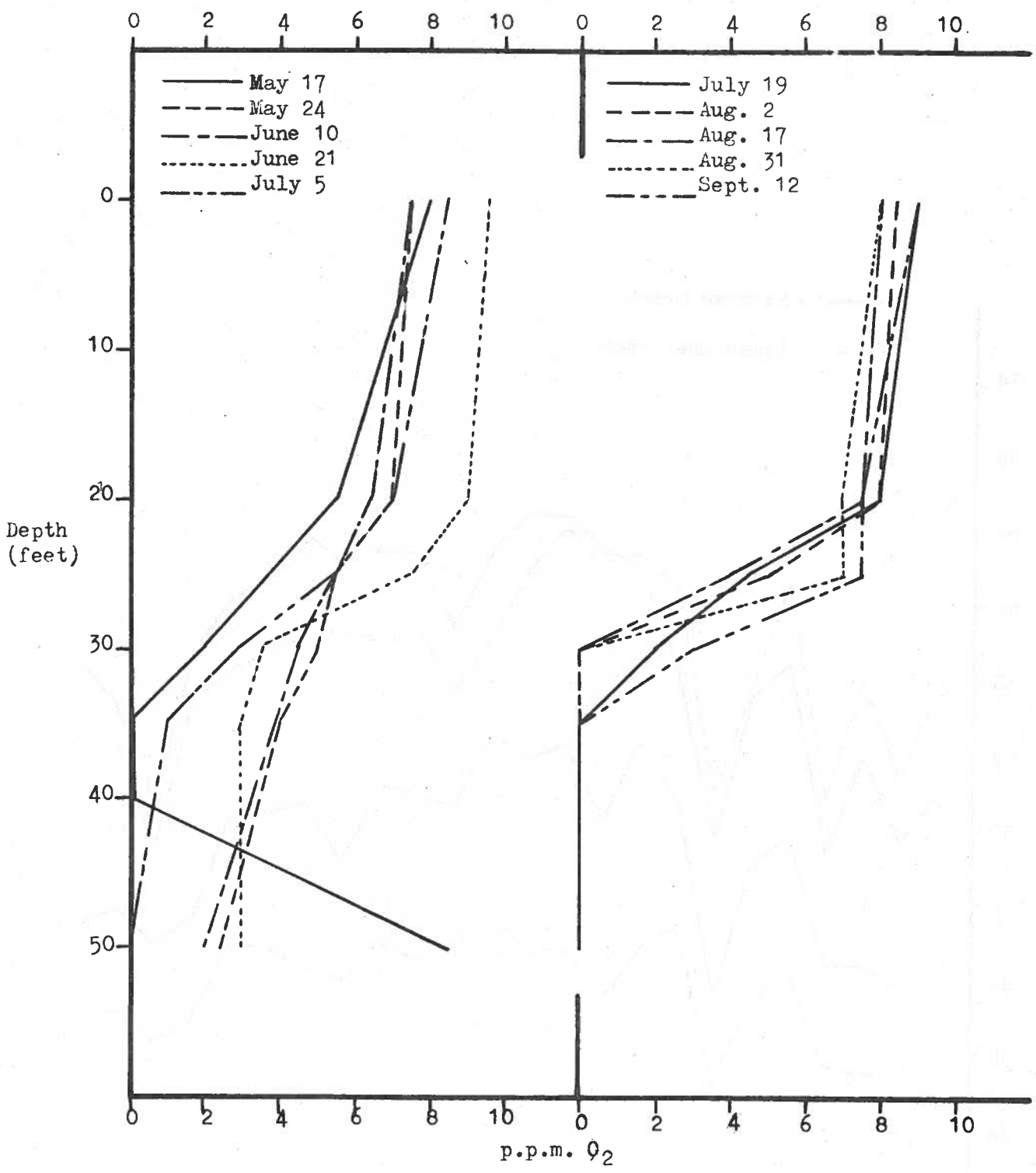

Figure IV. Dissolved oxygen profiles taken from Elk Lake during the summer of 1973.

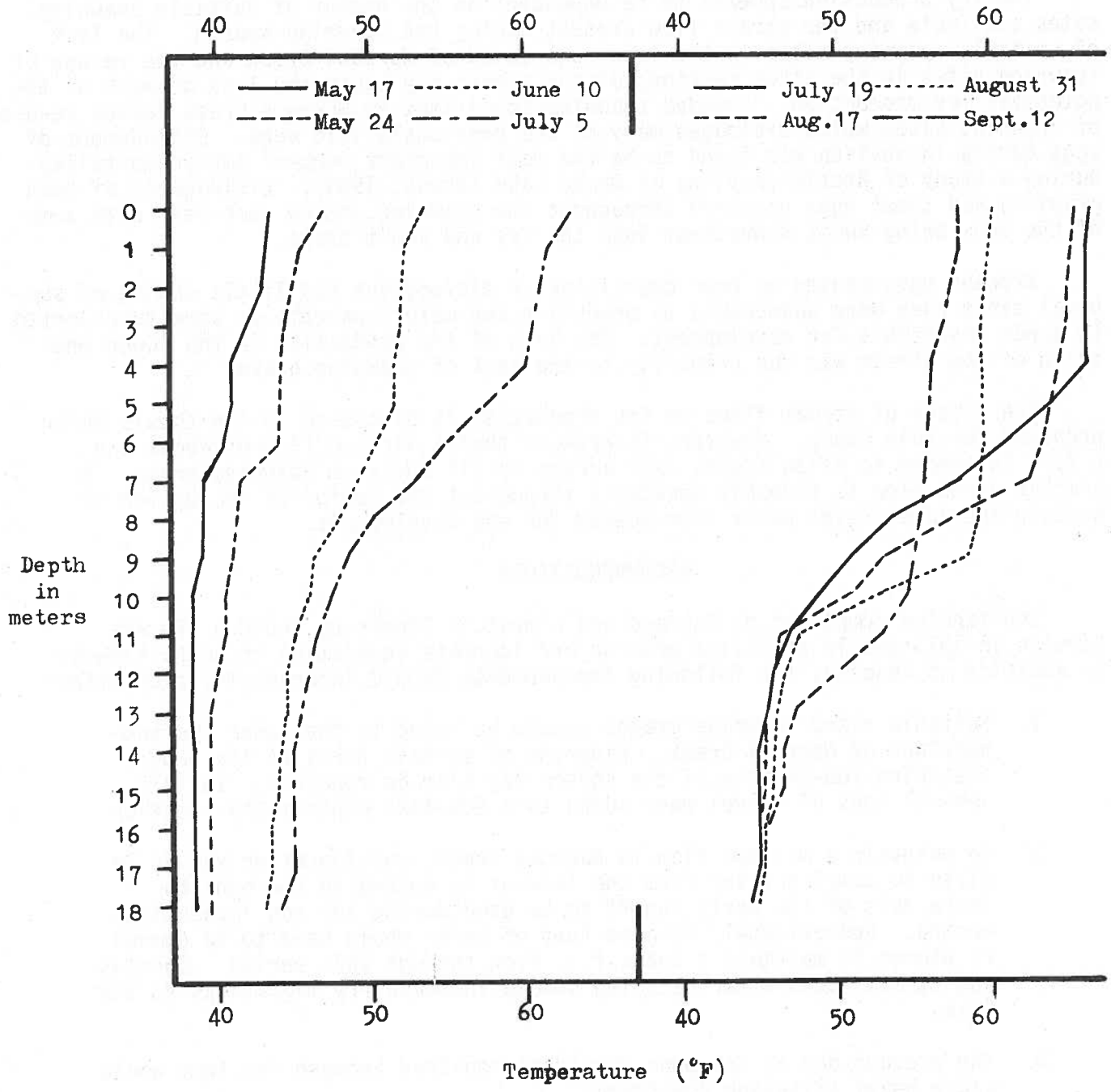

Figure V. Temperature profiles for Elk Lake, summer 1973.

Narrows Creek during emergence and emigration of fry supports this belief since the small numbers of fry observed in the stream agreed with the number being trapped leaving the stream.

The fry production appears to be dependent on the number of suitable spawning sites available and the stream flow present during the spawning season. The lack of suitable spawning sites in the lower one-third of Narrows Creek and the re-use of spawning sites in the other sections of the stream may cause the loss of much of the potential fry production. Crowded spawning conditions in Narrows Creek causes re-use of spawning sites which dislodges many of the previously laid eggs. Dislodgment of eggs during incubation was found to be the most important cause of embryo mortality during a study of Arctic grayling at Grebe Lake (Kruse, 1959). Dislodgment of both grayling and trout eggs occurred throughout the spawning season each year with some of the eggs being swept downstream into the fry and adult traps.

Exposed eggs caused by poor deposition or dislodgment had little chance of survival since they were vulnerable to predation and water currents or were transported to areas unsuitable for development. The lack of fry production in the lower one-third of the stream was due primarily to the lack of spawning gravel.

The effect of stream flows on fry production is discussed in the thesis being prepared for this study. However, it appears that a minimum flow of about one c.f.s. is needed to allow adults full access to all upstream spawning areas. A similar sized flow is probably necessary throughout the period of incubation to sustain the intergravel water flow needed for egg development.

RECOMMENDATIONS

The fencing completed on Narrows and Limestone Creeks by the U.S. Forest Service in 1973 should stabilize erosion and increase vegetation on both streams. In addition to fencing, the following improvements should increase fry production:

1. Suitable sized spawning gravel should be added to the lower two sub-sections of Narrows Creek. Widening of certain parts of the lower one-third sub-section of the stream may also be required. In 1973, several tons of gravel were added to a 500-foot experimental section.

2. To maintain a minimum flow in Narrows Creek, consideration should be given to pumping water from the lake or to enlarging the pond to store part of the early runoff to be used during the egg incubation period. Approximately 50 acre-feet of water would have to be pumped or stored to maintain a one c.f.s. flow through this period. Decreasing stream flows after hatching should increase fry migrations to the lake.

3. The present dam at the pond should be repaired because its loss would cause heavy siltation downstream.

4. The effects of these stream improvements could then be checked by trapping the peaks of emigration of grayling and trout fry.

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Waters Referred To:

Elk Lake	01-8780
Narrows Creek	01-5210
Limestone Creek	01-4340