MONTANA DEPARTMENT OF FISH, WILDLIFE & PARKS

FISHERIES DIVISION

JOB PROGRESS REPORT

State: Montana Title: Southwestern Montana Fisheries

Project No.: F-9-R-28 Investigation

Job No.: II-b Title: Madison River Temperature Study

Period Covered: April 1, 1979 through March 31, 1980

ABSTRACT

Three thermographs were placed in the Madison River above and below Ennis Reservoir to study the effects on the wild trout population by the warming of the lower Madison River water by Ennis Reservoir. Wild trout population estimates show the total biomass of wild trout below Ennis Reservoir (Norris section) to be 73% greater than above Ennis Reservoir (Varney section). Growth of wild trout three-years-old & older is faster above the reservoir than below Ennis Reservoir which is probably due to the high summer water temperatures. In comparing the amount of time the water was in the prime growth temperature range (45-65°F), the Varney section had 48% more hours from June through September than did the Norris section. The summer growth rate of three-year-old & older brown and rainbow trout was significantly slower in 1979 than 1978. This corresponds to a 33% drop in the prime growth temperature span below Ennis Reservoir and a 7% drop above.

BACKGROUND

In 1900, Madison Dam at Ennis was constructed to provide electrical power for southwestern Montana. Ennis Reservoir is located in a shallow basin, which over the last 75 years has slowly become more shallow due to sedimentation from upstream sources. This shallowing of Ennis Reservoir has led to a warming of the Madison River below the dam which endangers the "blue ribbon" trout fisheries in the last 35 miles of the river. There has been periodic fish kills in this area in the last 25 years which may have been caused by the warmer water. In 1961, a Montana Department of Fish and Game study showed that Ennis Reservoir warmed the Madison River 10-15°F from what it was above the reservoir (Heaton, 1962).

OBJECTIVES AND DEGREE OF ATTAINMENT

1. To determine if higher water temperatures below Ennis Reservoir are having detrimental effects on wild trout populations through changes in age structure, size composition, species composition and growth rates. Data included in this report.

2. To obtain wild trout population estimates to include age structure, size composition, species composition and condition factors. Data included in this report.

3. To gather water temperature data above and below Ennis Reservoir from April through September. Data included in this report.

4. To determine if a correlation exists between water temperatures and growth rates from the April through September period. Data included in this report.

PROCEDURES

Electrofishing gear was used to sample fish populations in two sections of the Madison River (Norris and Varney). Electrofishing was carried out while floating through the section in a fiberglass boat. Population estimates were made by using the Peterson-type mark-and-recapture method. Two or more "marking" and/or recapture trips were necessary where sample sizes were small and/or efficiencies were low. Usually, a 10-15 day period was allowed between marking and recapture trips. Scales were taken to determine age and growth rates. Actual mathematical computations were made by a computer programmed to use methods described by Vincent (1971a and 1974).

Three thermographs are set up on the Madison River as follows: (1) Varney Bridge-at U.S.G.S. gaging station near Varney Bridge; (2) below Ennis Reservoir in U.S.G.S. gaging station and operated by U.S.G.S.; and (3) at Norris Bridge (Figure 1). All thermographs recorded water temperatures from March 1, 1979 through October 31, 1979.

FINDINGS

The Madison River is formed by the Gibbon and Firehole Rivers in Yellowstone National Park and flows in a northerly direction to join the Jefferson and Gallatin Rivers forming the Missouri River at Three Forks. Two major reservoirs were built on the Madison River: (1) Hebgen which is located about 1.5 miles west of Yellowstone National Park and (2) Ennis which is located seven miles north of the Town of Ennis.

Wild trout population estimates were made during the spring (April) and (September) for the Varney section and during the spring for the Norris section (Table 1). The total biomass (pounds) of two-year-old & older brown and rainbow trout was 73% higher in the Norris section than in the Varney section on a per mile basis, which means the overall productivity is higher in the lower Norris section. This increase in overall productivity in the lower Madison River is also shown in a higher invertebrate population, as Fraley (1978) found invertebrate numbers to be two or three times greater in the lower river versus the Madison above Ennis Reservoir. Much of this increased trout productivity is concentrated in smaller and/or younger trout, as only 21% of the wild trout population in the Norris section exceeds 12 inches versus 47% in the Varney section.

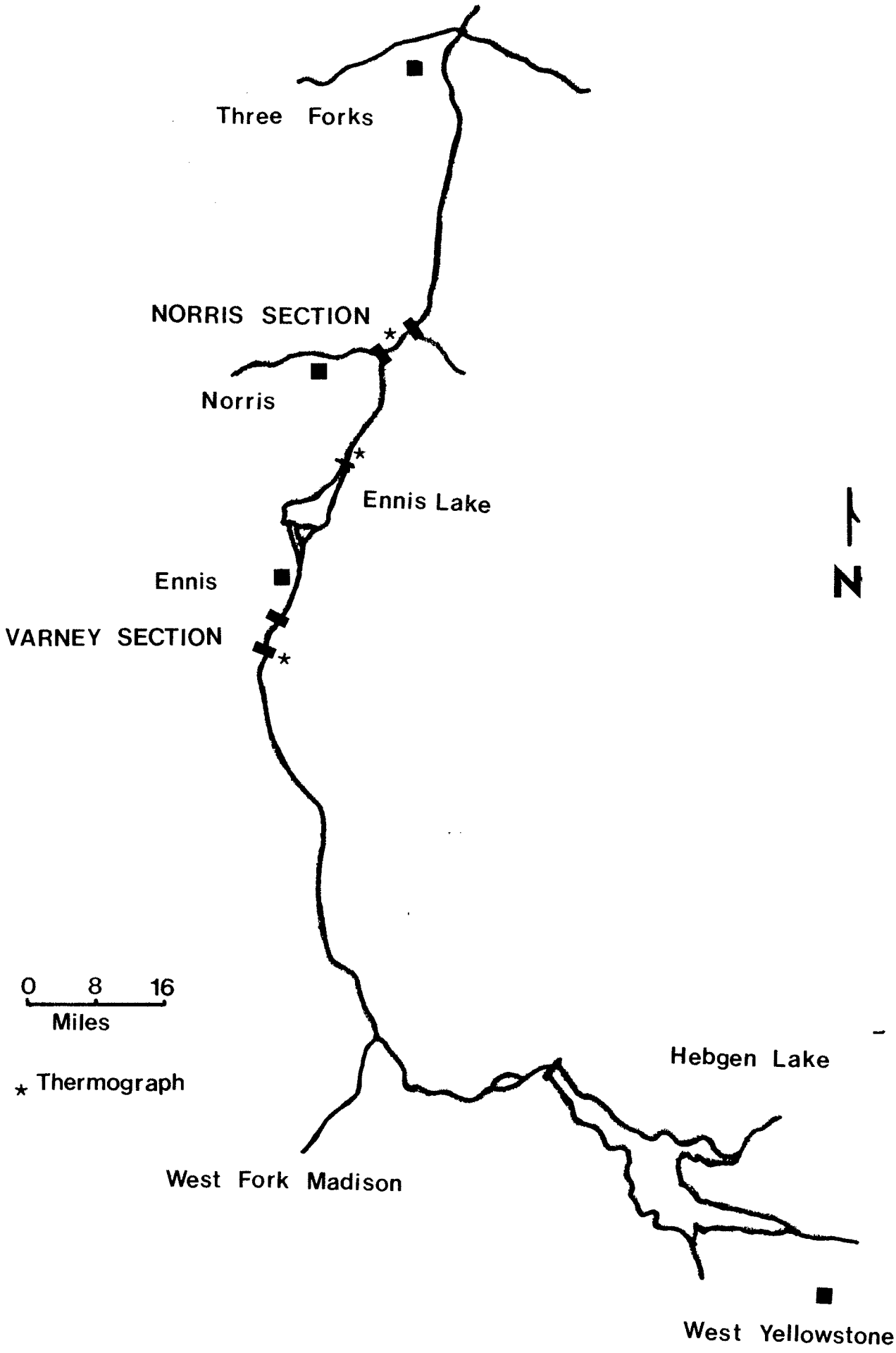

FIGURE 1. Map of the Madison River showing study sections and thermograph stations.

In comparing the 1979 summer growth rates (May through mid-September) between the upper and lower study sections for each age group sampled, the wild trout grew faster in the upper Varney section. This only exception was with the younger brown and rainbow trout. Yearling brown and rainbow trout were 24% and 21% larger, respectively, during the fall 1979 sampling period in the Norris section versus the Varney section. Also, two-year-old brown trout grew 30% faster in the Norris section during the summer of 1979. The greatest summer growth differential was for five-year-old brown trout and three-year-old rainbow trout which grew 500% and 175% faster, respectively, in the Varney section.

This slower growth rate for larger trout below Ennis Reservoir could be due to either the higher water temperatures in the Norris section during the prime growth period from June through September or to changes in the food chain due to higher summer water temperatures or both (Table 3). Fraley (1978) found that the elevated summer water temperatures below Ennis Reservoir increased the abundance of smaller insects, while decreasing the abundance of large forms such as Plecoptera. Brett, et al. (1967), found young sockeye salmon grew best at 59°F, with growth slowing at higher water temperatures even if food supply was abundant. Other research work also found that the optimum water temperature for trout growth is about 57-59°F. The average June-September temperature in the Varney section was 58.5°F versus 65.9°F in the Norris section. Brett (1956) also found that sockeye salmon kept at temperatures below 45°F showed poorer growth. For purposes of comparison, temperatures between 45-65°F were chosen as the optimum growth range for wild brown and rainbow trout. Using the months of June through September as the primary growth period, the Varney section had 48% more hours with the 45-65°F temperature range than the Norris section (Table 4). Also, the water temperature was above 70°F 25% of the time during the June-September period in the Norris section versus 1% in the Varney section.

There was a significant decline in the growth rates of both brown and rainbow trout in both sections of the Madison River during the summer of 1979 versus a comparable period in 1978, with the exception of two-year-old brown trout (Table 5). The growth rate change was the greatest in the Norris section where due to warmer air temperatures during the summer of 1979, the amount of time the water was within the prime growth temperatures of 45-65°F decreased 33% from 1974 hours in 1978 to 1316 in 1979. Being above Ennis Reservoir, the warmer air temperatures had less influence, only decreasing the amount of time between 45-65°F about 7% from the summer of 1978. This decrease in prime growth temperatures probably accounted for the decrease in growth rates of larger trout. Possible explanations for the better success of smaller trout (11.9 inches & smaller) in the warmer Norris section is: (1) a better body surface area-total body weight relationship for smaller trout which makes higher temperatures more tolerable and (2) an excellent food supply because of the predominance of small invertebrates.

The wild rainbow trout populations in the Varney section have shown a very high summer mortality rate in both 1978 and 1979. Two-year-old & older rainbow trout had a 68% mortality during the summer of 1978 and 63% in 1979 versus two-year-old & older brown trout which had a 32% summer loss in 1978 and a 26% loss in 1979. These high summer losses are probably due to over exploitation by anglers similar to that found on the upper Madison as shown by Vincent (1976 & 1977).

Table 1. Comparison of wild trout populations above (Varney) and below (Norris) Ennis Reservoir on the Madison River for 1979. Confidence intervals at the 80% level are shown in parentheses.

Age Groups	Sections: Norris (4 miles) Brown Trout	Norris (4 miles) Rainbow Trout	Varney (5 miles) Brown Trout	Varney (5 miles) Rainbow Trout
		April, 1979		
II	5701	9538	2130	1959
III	2378	3070	2956	1745
IV	857	1399	1512	652
V & Older	596	202	473	228
Total Number	9532	14209	7071	4584
	(±2034)	(±2550)	(±1135)	(±1042)
Total Wt. (lbs.)	5318	5254	5194	2443
	(±1261)	(±1075)	(±734)	(±589)
		Sept., 1979		
I	1/	1/	4084	1210
II	"	"	1524	636
III	"	"	2420	636
IV	"	"	1068	237
V & Older	"	"	262	105
Total Number	"	"	9358	2824
			(±1025)	(±574)
Total Wt. (lbs.)	"	"	6718	1493
			(±1034)	(±309)

1/ No September population estimates made in Norris.

Table 2. Comparison of growth rates (average length in inches) between the Varney and Norris study sections on the Madison River. Average lengths calculated for age groups for both spring (April) and fall (September) for 1978 and 1979.

Age Group (section)		Spring April, 1979	Fall Sept., 1979	Av. Summer Growth (inches) 1979
			Brown Trout	
II	Norris	9.3	11.9	2.6
	Varney	9.3	11.3	2.0
III	Norris	12.6	13.7	1.1
	Varney	12.2	14.4	2.2
IV	Norris	14.3	15.5	1.2
	Varney	14.8	16.2	1.4
V	Norris	16.9	17.1	0.2
	Varney	17.0	18.2	1.2
			Rainbow Trout	
II	Norris	9.0	10.5	1.5
	Varney	8.4	10.7	2.3
III	Norris	11.5	11.9	0.4
	Varney	12.0	13.1	1.1

Table 3. Comparison of average monthly water temperatures for the March 1, 1979 through October 31, 1979 period at the Varney, Ennis Dam and Norris thermograph stations (degrees in farenheit).

Month	Varney	Ennis Dam[1/]	Norris
March	35.8	36.0	36.8
April	41.0	41.0	42.3
May	47.8	53.4	53.9
June	54.6	61.1	61.5
July	62.2	[2/]	69.0
August	60.7	67.4	69.2
Sept.	56.6	[2/]	63.7
Oct.	48.4	49.8	52.2
Average	50.9	[2/]	56.1

[1/] Data supplied by U.S.G.S. from March 1, 1979 through Oct. 31, 1979.
[2/] No data due to U.S.G.S. equipment failure.

Table 4. Comparison of total hours by month between 45-65°F and over 70°F for the Varney and Norris sections of the Madison River for the March 1, 1979 through October 31, 1979 period.

	Hours between 45-65°F		Hours over 70°F	
Month	Varney	Norris	Varney	Norris
March	0	0	0	0
April	130	162	0	0
May	524	682	0	0
June	664	536	0	56
July	534	186	30	318
August	634	136	4	304
Sept.	710	458	0	46
Oct.	550	692	0	0
Total	3746	2852	34	734
Total June-Sept.	2542	1316	34	734

Table 5. Comparison of rainbow and brown trout growth rates between summer 1978 and 1979.

Age Groups & Section		Average Summer Growth (inches) 1978[1/]	1979	Percent Increase or Decrease in Growth Rate from 1978
			Brown Trout	
II	Norris	1.4	2.6	+86%
	Varney	2.3	2.0	-13%
III-V	Norris	1.8	0.8	-56%
	Varney	2.2	1.6	-27%
			Rainbow Trout	
II	Norris	1.2	1.5	-25%
	Varney	2.3	2.3	0%
III	Norris	0.4	0.4	0%
	Varney	1.4	1.1	-21%

[1/] Vincent, 1979.

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Waters Referred to: Madison River 13-3400-01
Ennis Reservoir 13-7560-05

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