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MONTANA DEPARTMENT OF FISH, WILDLIFE & PARKS
FISHERIES DIVISION
JOB PROGRESS REPORT

STATE: Montana TITLE: Southwestern Montana Fisheries

PROJECT NO.: F-9-R-27 Investigation

JOB NO.: IIa TITLE: Madison River Temperature Study

PERIOD COVERED: March 16, 1978 through March 15, 1979

ABSTRACT

Three thermographs were placed in the Madison River above and below Ennis Reservoir to study the effects of the warming of the lower Madison River water by Ennis Reservoir on the wild trout populations. Wild trout population estimates show the total biomass of wild trout below Ennis Reservoir (Norris section) to be 81% greater than above Ennis Reservoir (Varney section). But growth rates on wild trout two-years-old & older were equal or better in the section above Ennis Reservoir, as three-year-old rainbow trout grew 71.4% faster in the summer of 1978 (May-August) in the section above the reservoir. In comparing the amount of time the water was in the prime growth temperature range (45-65°F), the section above the reservoir (Varney) had 36.2% more hours from June through August and 8.8% more hours from May through August. About 13.4% of the June through August period water temperatures were above 70°F in the Norris section with no measureable amounts recorded above Ennis Reservoir (Varney).

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 obtain fish population data on two sections of the Madison River (Varney and Norris). Data included in this report.

2. To obtain growth rates on rainbow and brown trout for the April through September period from a section above (Varney) and below (Norris) Ennis Reservoir. Data included in this report.

3. To obtain water temperature data above and below Ennis Reservoir in an attempt to correlate water temperature with salmonid growth. 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 computor 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, 1977 through October 31, 1978.

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 are built on the Madison River: (1) Hebgen which is located about 1.5 miles north of Yellowstone National Park and (2) Ennis which is located about 7 miles north of the town of Ennis.

Wild trout population estimates were made during the spring (April) and fall (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 81% higher in the Norris section than in the Varney section. This probably indicates a basic total productivity difference between the two sections. Fraley (1978) found the number and total weight of the invertebrate population in the lower river (Norris) to average two to three times greater than the Madison River above Ennis Reservoir. In comparing the 1978 summer growth rates (May through August) between the two study sections for age groups two-year-old & older, the Varney section had equal or better growth rates (Table 2). The greatest growth differential occurred in two-and three-year-old trout, as two-year-old rainbow trout grew 47.8% faster in Varney than in the Norris section, while three-year-old rainbow grew 71.4% faster. Only smaller younger trout grew faster in the Norris section as by the spring of 1978 two-year old brown trout were 8.5% larger than spring two-year-old browns in the Varney section and two-year-old rainbow trout were 2.2% larger in Norris.

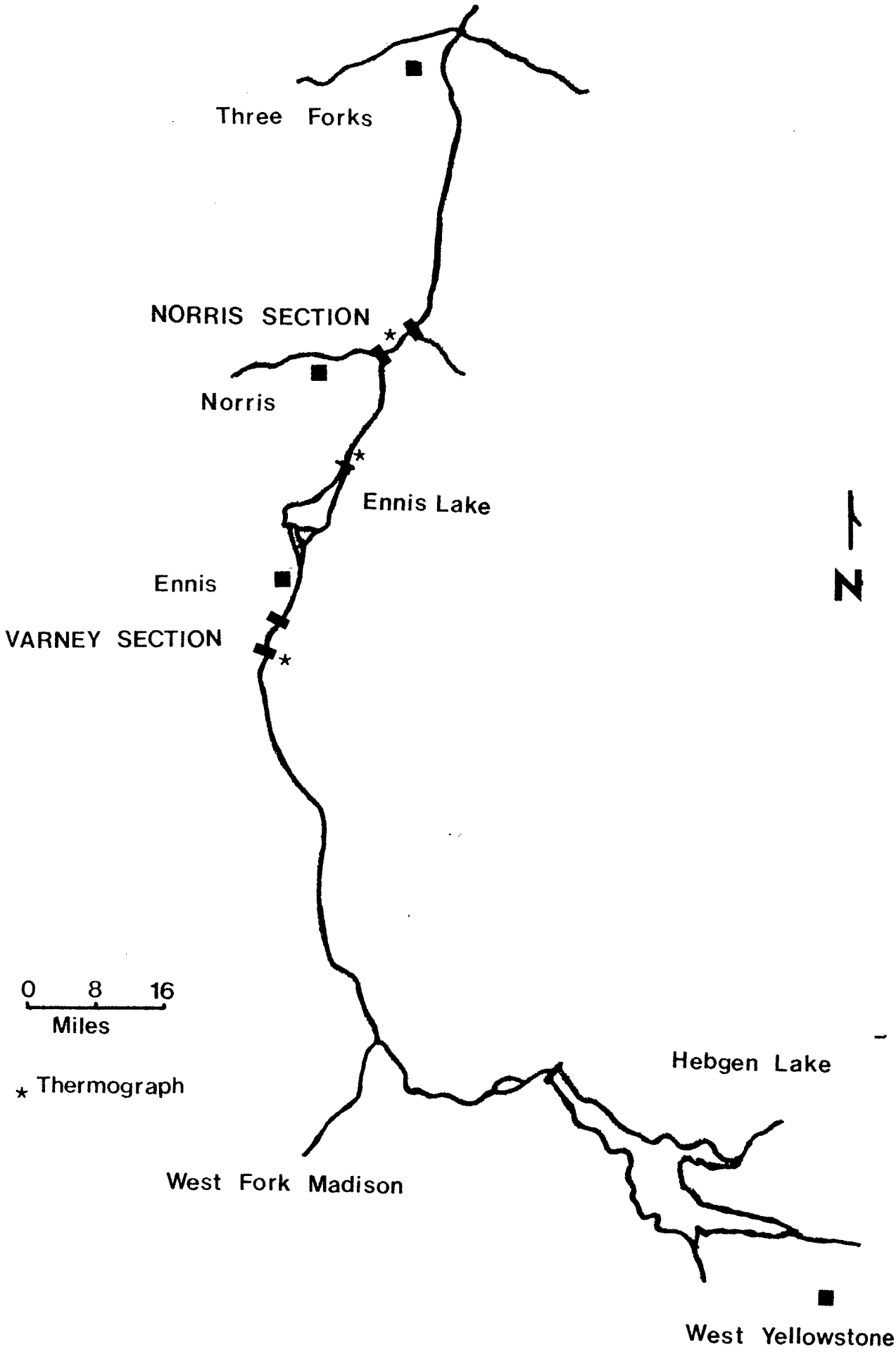

FIGURE 1. Map of the Madison River showing study sections and thermograph stations.

This slower growth rate of larger trout below Ennis Reservoir could be due to either the higher water temperatures in the prime growth period from June through August or to changes in the food chain due to higher 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. Fraley also found the largest stonefly Pternonorcys californica was 13% smaller by weight in the Norris section than above Ennis Reservoir.

Other research work has found that the optimum water temperature for trout growth is about 57-59°F. 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. Brett (1956) also found that sockeye salmon kept at temperatures below 45°F showed poorer growth. For purposes of comparison of favorable growth periods in the Madison River above and below Ennis Reservoir, temperatures between 45 and 65°F was chosen as the optimum growth range for wild brown and rainbow trout. Using the primary growth period as June through August, the Varney section had 36.2% more hours within this 45-65°F temperature range than did the river at the Norris section (Table 4). Using the primary growth period as May through August, there were 8.8% more nours with the 45-65°F temperature range. Also, water temperatures above 70°F in the Norris section accounted for 13.4% of the hours between June and August 31, 1978, while there were no measureable amount of hours above 70°F in the Varney section.

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Waters Referred to: Madison River - 13-3440-01

Ennis Reservoir - 13-7560-05

TABLE 1. Comparison of wild trout populations above (Varney) and below (Norris) Ennis Reservoir on the Madison River for 1978. 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, 1978		
II	4917	8236	3794	6532
III	979	1495	2383	753
IV & Older	2070	972	846	626
Total Number	7966	10,703	7023	7911
	(±1077)	(±1465)	(±1314)	(±2305)
Total Wt. (lbs)	5597	4865	4098	3112
	(±788)	(±805)	(±612)	(±769)
		SEPT., 1978		
I	1/	1/	3597	6023
II	"	"	2584	2891
III	"	"	1615	505
IV & Older	"	"	555	196
Total Number	"	"	8351	9615
			(±1157)	(±2152)
Total Wt. (lbs)	"	"	5380	3319
			(±701)	(±688)

1/ No September population estimates made in Norris section.

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) periods.

Age Group	(section)	Spring April, 1978	Fall Sept., 1978	Summer Growth (inches)	Percent growth differential between Norris and Varney
			Brown Trout		
II	Norris	10.2	11.6	1.4	
	Varney	9.1	11.4	2.3	+39.1
III	Norris	12.5	14.4	1.9	
	Varney	12.3	14.6	2.3	+17.4
IV	Norris	14.0	15.7	1.7	
	Varney	15.3	17.2	1.9	+10.5
V	Norris	15.8	17.5	1.7	
	Varney	17.2	19.2	2.0	+15.0
			Rainbow Trout		
II	Norris	9.4	10.6	1.2	
	Varney	8.9	11.2	2.3	+47.8
III	Norris	12.1	12.5	0.4	
	Varney	11.9	13.3	1.4	+71.4
IV	Norris	13.6	14.9	1.3	
	Varney	14.6	15.9	1.3	0

TABLE 3. Comparison of average monthly water temperatures for the March 1, 1978 through October 31, 1978 period at the Varney, Ennis Dam and Norris thermograph stations.

Month	Varney	Ennis Dam[1/]	Norris
March	39.6	38.7	38.8
April	42.1	46.8	47.5
May	44.8	52.8	51.9
June	57.2	60.1	60.7
July	58.9	65.7	66.8
Aug.	58.8	63.9	64.0
Sept.	54.5	55.7	59.6
Oct.	48.5	48.3	46.6

1/ Data supplied by U.S.G.S. from July 1, 1978 through Oct. 31, 1978.

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, 1978 through October 31, 1978 period.

Month	Hrs. between 45-65°F		Hrs. over 70°F	
	Varney	Norris	Varney	Norris
March	0	2	0	0
April	44	366	0	0
May	166	712	0	0
June	720	602	0	18
July	660	268	0	166
Aug.	670	438	0	110
Sept.	672	666	0	4
Oct.	606	312	0	0
TOTAL	3538	3366	0	298