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MADISON RIVER THERMAL PROBLEM

INTRODUCTION

The effect of water temperature on aquatic organisms, especially fish, has been the subject of extensive biological investigation. The major investigative thrust has been to identify those temperatures that are lethal to individual species at some stage of their life cycle. Considerably less attention has been focused on the effects of altered temperature regimes, specifically thermal additions to running waters, on fish production.

In most situations, thermal additions to running waters, be they natural or a result of man's activities, undoubtedly have a greater influence on fish production than survival. This has implications for the fishery manager for, as Doudoroff (1968) pointed out, we must be concerned with the production of valuable fish species and not merely their continued survival.

As a result of being cold blooded, fish are markedly affected by changes in water temperature. As water temperature rises, so does a fish's metabolic rate. This increase in metabolic rate requires an increase in food intake just to maintain body weight with no growth. Recent studies by Brett *et al* (1969) showed young sockeye salmon to grow best in aquaria at temperatures near 15°C when fed to satiety. Their growth rates decreased markedly above and below these temperatures. However, when fed a restricted ration, they grew best at temperatures near 5°C and not at all at 15°C.

Thus, there appears to be a definite relationship between water temperature and the amount of food necessary for growth. In a natural stream where food is not unlimited and energy must be expended in its procurement, we might expect elevated water temperatures to play an even

more important role in the growth of fish.

A BRIEF HISTORY OF THE MADISON RIVER

The Madison River arises in Yellowstone National Park at the confluence of the Gibbon and Firehole River. It flows one hundred and forty miles, first westerly and then north, uniting with the Gallatin and Jefferson Rivers to form the Missouri River near Three Forks, Montana.

The settlement of the Madison River Valley by white men began in earnest the latter half of the nineteenth century. The discovery of gold in the Virginia City area in 1863 hastened this process. The Madison River and its tributaries furnished water for irrigation for the stock raising and farming enterprises that developed.

However, it is in the area of power development that the Madison River has been most affected by man and his activities. Madison Dam near Ennis, Montana was constructed in 1900 to provide electrical power for use in southwest Montana and Hebgen Dam was constructed in 1915. Today, these two dams are operated by the Montana Power Company primarily to regulate the flow of the Missouri River power generating system downstream.

The use of the Madison River for recreation began early on and has become a major economic industry in the Madison Valley. Biologically, the river is very productive and is internationally famous for its abundance of trout. The Montana Fish and Game Department, in 1959, classified the river a "blue ribbon" trout stream, based on its national as well as statewide importance as a trout fishery.

THE PROBLEM

Hebgen Reservoir is a relatively deep reservoir whose main body stratifies thermally (Martin, 1967). The withdrawal system is a bottom type which results in a summer cooled but winter warmed outflow into the downstream channel.

Ennis Reservoir, located 58 miles downstream from Hebgen Dam lies in a shallow basin. The reservoir has become shallower over the last 75 years due to sedimentation from upstream sources and does not stratify thermally (E.R. Vincent, personal communication). At maximum storage capacity, the reservoir inundates over 4,000 acres, furnishing a large surface area for absorption of solar energy. The consequent warming of the shallow reservoir waters has resulted in elevated summer water temperatures in the Madison River below Ennis Dam. This elevation in water temperature during the summer months poses a threat to the "blue ribbon" trout fishery in the lower 35 miles of the Madison River. There have been periodic fish kills over the last 25 years which may have been aggravated by the elevated water temperatures. In 1961, a Montana Fish and Game Department study showed summer water temperatures below Ennis Dam to be elevated 10-15^{o} from those of water entering the reservoir.

An ongoing study was initiated in March, 1976 by the Montana Fish and Game Department to obtain monthly trout growth rates for the May to September period above (Varney) and below (Norris) Ennis Reservoir. Water temperature is also being monitored above and below the reservoir in an attempt to correlate water temperature with trout growth. As part of the "208" effort, the 1976 portion of the Madison River Thermal Study by the Montana Fish and Game Department is attached. The principal

investigator of this study is E. R. Vincent.

DISCUSSION

The results of Vincent's (1977) study indicate that Ennis Reservoir has a pronounced effect on the summer water temperatures of the Madison River downstream. It further suggests that these elevated water temperatures while apparently not lethal to trout, affected their growth rates during the period of study. When compared to Varney, it appears that the elevated summer water temperatures at Norris resulted in increased growth rates for brown and rainbow trout during their first two summers of growth (ages 0 and I) but decreased growth rates beginning in their third summer of growth (age II and older). Length-weight relationships showed a similar trend with June, 1976 condition factors of Varney trout being greater than those in the Norris section for all ages except yearling* (age I).

Thus, it appears that the elevated water temperatures downstream from Ennis Reservoir are adversely affecting the growth and well being of trout age II and older.

Growth in fish depends on the amount of energy available in relationship to body weight. Thus, a large fish tends to grow with less efficiency than a small fish due to difficulty of obtaining as much food as smaller fish in relation to body weight (Parker and Larkin, 1959).

The increase in summer water temperatures downstream from Ennis Reservoir causes an increase in the metabolic rate of fish which results in an increase in the amount of food a fish must take in to maintain its body weight and grow. Since a large fish grows with less efficiency

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* Age 0 fish not included.

than a small fish, it would be reasonable to expect larger fish to be more affected by elevated water temperatures than small ones in an environment where food was equally available.

The effect of these elevated water temperatures on aquatic invertebrates (the primary food source of trout) in the Norris section is unknown but Vincent's study indicates that not only is there sufficient food available for young trout (age 0 and I) to grow but that they grow faster and are in better condition than young (age 0 and I) trout in the Varney section. However, the situation is reversed for trout age II and older. It appears that older trout in the Norris section find it increasingly difficult to obtain enough food to surpass their maintenance requirements and grow.

It is the older and larger trout that are prized by fishermen and responsible for the "blue ribbon" status of the Madison River. Vincent's study suggests that Ennis Reservoir is adversely affecting the growth rates and condition of trout age II and older and hence endangering the "blue ribbon" status of the lower 35 miles of the Madison River.

LITERATURE CITED

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