Ecology of Yellowstone cutthroat trout and an evaluation of potential effects of angler wading in the Yellowstone River
by Barbara Marie Kelly

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
There has been concern that heavy angling pressure in the Yellowstone River between Yellowstone Lake and the Upper Falls may result in high wading-caused mortality of Yellowstone cutthroat trout embryo and pre-emergent fry. Effects of angler wading were evaluated for 1991. Factors considered included: number and distribution of redds; timing of spawning, embryonic development, and emergence; and amount and distribution of angler wading. In 1991, mortality from angler was estimated at 9.3% of the eggs laid. Estimated mortality was low because of the closure of 12 of 26 km of the river, which protected 60% of the redds, and the July 15 opening date which protected eggs for part of their development. Annual differences in the timing of embryonic development and emergence will change the amount of potential wading caused mortality. Cutthroat trout fry emergence was about 2 weeks earlier in 1990 than in 1991. Population level effects of reduced survival to emergence were evaluated by considering population limitations and regulations at several life stages. Based on visual estimation of surface substrate composition and amount of spawning in the river, spawning did not appear to be limiting. Recruitment of cutthroat trout from tributaries was insignificant. Trout fry were generally abundant along shorelines during peak emergence, but numbers declined by over 90% within 25 d in counting transects in 1990 and 1991, due to mortality and emigration. The adult cutthroat trout population appeared to be large. Population regulation probably occurs at stages other than the incubation period in the Yellowstone cutthroat trout population of the study area.

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Barbara Marie Kelly

This thesis has been read by each member of the graduate committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

23 April 1993
Date

Robert G. White
Chairperson, Graduate Committee

Approved for the Major Department

22 April 1993
Date

Robert S. Moore
Head, Major Department

Approved for the College of Graduate Studies

5/3/93
Date

R L Brown
Graduate Dean

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Signature Barbara M. Kelly

Date April 22, 1993

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ABSTRACT

There has been concern that heavy angling pressure in the Yellowstone River between Yellowstone Lake and the Upper Falls may result in high wading-caused mortality of Yellowstone cutthroat trout embryo and pre-emergent fry. Effects of angler wading were evaluated for 1991. Factors considered included: number and distribution of redds; timing of spawning, embryonic development, and emergence; and amount and distribution of angler wading. In 1991, mortality from angler was estimated at 9.3% of the eggs laid. Estimated mortality was low because of the closure of 12 of 26 km of the river, which protected 60% of the redds, and the July 15 opening date which protected eggs for part of their development. Annual differences in the timing of embryonic development and emergence will change the amount of potential wading caused mortality. Cutthroat trout fry emergence was about 2 weeks earlier in 1990 than in 1991. Population level effects of reduced survival to emergence were evaluated by considering population limitations and regulations at several life stages. Based on visual estimation of surface substrate composition and amount of spawning in the river, spawning did not appear to be limiting. Recruitment of cutthroat trout from tributaries was insignificant. Trout fry were generally abundant along shorelines during peak emergence, but numbers declined by over 90% within 25 d in counting transects in 1990 and 1991, due to mortality and emigration. The adult cutthroat trout population appeared to be large. Population regulation probably occurs at stages other than the incubation period in the Yellowstone cutthroat trout population of the study area.

INTRODUCTION

Yellowstone cutthroat trout Oncorhynchus clarki bouvieri entered Yellowstone Lake and the Yellowstone River after the last ice age, 8,000 years ago, and now this population is the largest concentration of native interior cutthroat trout (Behnke 1992). The Upper Falls and Lower Falls of the Yellowstone River, downstream from Yellowstone Lake, have prevented upstream movement of non-native fishes into the system, and Federal legislation and National Park Service policies have also protected this population. The current goal of the Yellowstone National Park aquatic management program is to "... allow ecological processes to function as if uninfluenced by modern man, while providing for visitor use and education" (Jones et al. 1992)

The Yellowstone cutthroat trout population in the Yellowstone River between Yellowstone Lake and the Upper Falls may be the most intensively fished native trout stock in North America (Jones et al. 1990). Annual angler effort in the 14 km of stream open to angling has averaged 127,000 h/yr for the past 5 years, which is equivalent to 1,257 angler hours per hectare (Jones et al. 1992). Yellowstone cutthroat trout are vulnerable to angling, but hooking

mortality in the Yellowstone River is low (Schill et al. 1986).

Cutthroat trout from both the river and the lake spawn in the Yellowstone River; allacustrine spawners comprise a discrete stock within the lake (Bowler 1975; Liebelt 1968; Raleigh and Chapman 1971; Varley and Gresswell 1988). The importance of the Yellowstone River tributaries for cutthroat trout reproduction and recruitment into the river is unknown.

Because of the heavy angling pressure within spawning areas, there has been concern that anglers wading on cutthroat trout redds in the Yellowstone River may reduce survival. Roberts (1988) and Roberts and White (1992) evaluated wading-caused mortality of embryo and pre-emergent trout fry in the laboratory. Embryo mortality rates varied with stage of development at the time of wading and with the frequency of wading. Eggs were most sensitive just prior to hatching, when a single wading event killed up to 46% of the embryos. Maximum mortality of up to 96% resulted from twice-daily wading throughout development.

The different mortality rates due to angler wading relate to trout embryonic development. When an egg enters the hypotonic medium, fluids fill the perivitelline space, hardening the chorion (Knight 1963; Blaxter 1969). Lipid droplets buoy the embryo in a dorsal position within the

chorion (Knight 1963). During this pre-eyed period the egg is very resistant to crushing (Hayes 1949), and wading mortality is low (Roberts 1988; Roberts and White 1992). The embryo is sensitive to physical disturbance during blastopore closure, which occurs about mid-way between fertilization and eye-up (Johnson et al. 1983; Dwyer et al. in press). Wading-caused mortality of pre-eyed eggs during blastopore closure ranged from 4-10%, compared to 76-94% mortality from handling, perhaps due to relatively little physical disturbance within the substrate (Roberts 1988; Roberts and White 1992). Half-way between eye-up and hatch, enzymes are excreted into the perivitelline space to soften the chorion for hatching (Blaxter 1969; Knight 1963). Wading mortality is highest between the start of chorion softening and hatch (Roberts 1988; Roberts and White 1992); less than 1 kg pressure is required to burst eggs at this stage (Hayes 1949). After hatch, the pre-emergent fry's fragile body parts are vulnerable to crushing and wading mortality is high, although less than during the period of chorion softening (Roberts 1988; Roberts and White 1992). Indirect mortality from wading can result from the spread of Saprolegnia spp. from dead eggs (Smith et al. 1985).

The goal of this study was to evaluate the potential effects of angler wading on the Yellowstone cutthroat trout population between Yellowstone Lake and Upper Falls and to

gather information about this Yellowstone cutthroat trout population and its habitat.

Specific objectives of the study were to:

1. Describe the physical and chemical characteristics of the Yellowstone River and tributaries.

2. Evaluate the distribution and availability of spawning habitat in the Yellowstone River and tributaries, and to evaluate the potential for recruitment of cutthroat trout from the tributaries to the Yellowstone River.

3. Quantify the number and distribution of redds.

4. Document the timing of cutthroat trout spawning, embryonic developmental stages, hatching, and emergence, and to relate this to the timing of wading.

5. Monitor the abundance, growth, and distribution of cutthroat trout fry.

6. Characterize the adult cutthroat trout population and examine their movements.

7. Document the amount and distribution of wading by anglers.

8. Estimate wading-caused mortality of trout eggs and pre-emergent fry.

STUDY AREA

The study area is in the central part of Yellowstone National Park, located in northwest Wyoming. The study was conducted on the Yellowstone River between Yellowstone Lake and the Upper Falls, 26 km downstream, and on the tributaries to the river within this reach: Thistle, Elk Antler, Trout, Cottongrass, Sour, Alum, and Otter creeks (Figure 1).

The Yellowstone River drains Yellowstone Lake at its northern end. Several characteristics of the river are influenced by the lake. Yellowstone Lake is a large, oligotrophic lake with a watershed of 261,590 ha, a surface area of 354 km^2 and a mean depth of 42 m (Benson 1961). Ice covers the lake from mid-December through May or June and the lake temperatures rarely exceed 18°C (Jones et al. 1992), and water temperatures in the river are moderated by those in the lake. Inflow to the river is relatively constant, and mean annual flow, measured 0.6 km downstream of the lake outlet, during the period of record, 1927-1991, was 37.64 m^3/s (U.S. Geological Survey 1991).

From Yellowstone Lake to Upper Falls the Yellowstone River drops from an elevation of 2357 m to 2326 m, an average gradient of 1.2 m/km. The river pattern is