Habitat use by adult brown trout and rainbow trout in response to gas supersaturation downstream of the Yellowtail Afterbay Dam, Bighorn River, Montana
by Thomas Herbert Williams, III

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:
High levels of gas supersaturation did not have a detectable influence on the distribution of brown trout Salmo tiytta and rainbow trout Oncorhynchus mykiss in the Bighorn River downstream of Yellowtail Afterbay Dam. Snorkel surveys indicated that trout were concentrated along river banks during winter and spring and used bank and midchannel areas during summer and fall. Although gas levels remained high, the percentage of trout exhibiting external symptoms of gas bubble trauma decreased during periods of midchannel use. Seasonal trout movement appeared to be related to changes in availability of energetically suitable habitat created by aquatic vegetation. I hypothesize that vegetation in midchannel areas created usable habitat with adequate depth to provide hydrostatic compensation, reducing the incidence of gas bubble trauma. Radio telemetry data collected during gas supersaturation manipulation tests (delta P values 63 mmHg to 123 mmHg) indicated that adult brown trout and rainbow trout did not actively avoid high dissolved gas levels. Trout movements were restricted to localized areas and sounding by trout as an avoidance behavior was not detected by pressure sensitive radio transmitters.

# HABITAT USE BY ADULT BROWN TROUT AND RAINBOW TROUT IN RESPONSE TO GAS SUPERSATURATION DOWNSTREAM OF THE YELLOWTAIL AFTERBAY DAM, BIGHORN RIVER, MONTANA

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APPROVAL

of a thesis submitted by

Thomas Herbert Williams III

This thesis has been read by each member of the thesis 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.

19 June 1990
Date

Robert G. White
Chairperson, Graduate Committee

Approved for the Major Department

19 June 1990
Date

Robert S Moore
Head, Major Department

Approved for the College of Graduate Studies

July 2, 1990
Date

Henry L Parsons
Graduate Dean

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# ABSTRACT

High levels of gas supersaturation did not have a detectable influence on the distribution of brown trout *Salmo trutta* and rainbow trout *Oncorhynchus mykiss* in the Bighorn River downstream of Yellowtail Afterbay Dam. Snorkel surveys indicated that trout were concentrated along river banks during winter and spring and used bank and midchannel areas during summer and fall. Although gas levels remained high, the percentage of trout exhibiting external symptoms of gas bubble trauma decreased during periods of midchannel use. Seasonal trout movement appeared to be related to changes in availability of energetically suitable habitat created by aquatic vegetation. I hypothesize that vegetation in midchannel areas created usable habitat with adequate depth to provide hydrostatic compensation, reducing the incidence of gas bubble trauma. Radio telemetry data collected during gas supersaturation manipulation tests (delta P values 63 mmHg to 123 mmHg) indicated that adult brown trout and rainbow trout did not actively avoid high dissolved gas levels. Trout movements were restricted to localized areas and sounding by trout as an avoidance behavior was not detected by pressure sensitive radio transmitters.

# INTRODUCTION

Gas bubble trauma (GBT) is a physically induced condition caused by supersaturation of dissolved gases that often occurs in fish living below dams. Plunging water entrains atmospheric gases and forces them to a depth where water becomes supersaturated (Bouck 1980). Bouck (1980) describes GBT as "a noninfectious process caused by uncompensated, hyperbaric total dissolved gas pressure, that produces primary lesions in blood (emboli) and in tissues (emphysema) and subsequent physiological dysfunctions." Much of the information available on dissolved gas supersaturation and GBT is related to problems associated with Columbia River hydroelectric dams (Weitkamp and Katz 1980). In most cases, existing spillways and stilling basins have been modified to reduce supersaturation (Crunkilton et al. 1980). Recent literature reviews by Weitkamp and Katz (1980) and Colt et al. (1986) describe the history and sources of GBT in fishes.

Detection and avoidance of supersaturated water by fish may influence their survival in waters that contain high levels of dissolved gases (Jenson et al. 1986). Avoidance can occur by fish sounding or moving away from supersaturated water (Stevens et al. 1980). Change in hydrostatic pressure associated with an increase in water depth of 1 m reduces gas saturation by approximately 10% (Gray and Haynes 1977). Most studies of detection, avoidance, and tolerance of supersaturated waters by salmonids have been conducted with juvenile fish.

Weitkamp and Katz (1980) state that it is generally accepted that fish are not able to detect supersaturated water and therefore do not avoid it, although there appear to be exceptions. Lund and Heggberget (1985) found that 2-year-old rainbow trout

(*Oncorhynchus mykiss*) did not avoid 115 to 125% supersaturated water in tank experiments. An apparent avoidance of high dissolved gas levels by squawfish (*Ptychocheilus oregonenis*) below Little Goose Dam on the Snake River was described by Bentley et al. (1976). They collected fewer squawfish during periods of high supersaturation than during periods of lower supersaturation. Stickney (1968) found that Atlantic herring (*Clupea harengus harengus*) avoided gas supersaturated water when dissolved gas levels were high enough to produce GBT (122% TGP). Dawley et al. (1976) reported that juvenile chinook salmon ( *Oncorhynchus tschawytscha*) and steelhead trout (*Oncorhynchus mykiss*) apparently avoided high dissolved gas levels by using deeper water that provided hydrostatic compensation. Both species were found at deeper average depths as gas concentrations increased in deep (2.4 m) tank experiments. Stevens et al. (1980) found that rainbow trout (30 to 45 g) moved laterally to avoid supersaturated water in tank experiments. Heggberget (1984) found that brown trout (*Salmo trutta*) were less tolerant to supersaturated water than were perch (*Perca fluviatilis*) and eel (*Anguilla anguilla*) in river cage studies.

Because of its relatively small size compared to other western hydroelectric projects where gas supersaturation problems exist (e.g., the Columbia River), the Bighorn River downstream of Yellowtail Afterbay Dam, Montana, provided a unique opportunity to examine the relationships between gas supersaturation and fish behavior. Gas bubble trauma was first documented in the Bighorn River downstream of Yellowtail Afterbay Dam in 1973 (Swedberg 1973). Deflector plates where installed in 1982 to reduce supersaturation, but were removed in 1983 due to turbulence that threatened to erode the base of the dam.

The Bighorn River supports a major trout sport fishery. Angler use days were estimated to be 17,737 in 1987 and 15,548 in 1988 on the upper 19.3 km of river (J.

Darling, personal communication). Trout population estimates for 1987 in the upper 6.1 km of river were over 6000 trout/km (April and September estimates), with brown trout outnumbering rainbow trout approximately 10 to 1 (White et al. 1988). Incidence of GBT in the Bighorn River appears to be higher in brown trout than in rainbow trout, and highest in brown trout longer than 356 mm (White et al. 1988). Reasons for these differences in incidence of GBT are not known, but could be related to differences in habitat selection between brown trout and rainbow trout and among different size or age classes. Differences in habitat selection that expose a particular species or age class to high gas supersaturation may also influence relative abundance of these species by causing a differential mortality. The objectives of this study were to conduct *in situ* observations of trout behavioral distribution in the Bighorn River to determine: 1) whether differences in incidence of GBT between brown trout and rainbow trout can be explained by habitat use, 2) whether habitat used by different length groups of trout results in differences in exposure to GBT between length groups, and 3) whether brown trout and rainbow trout avoid high dissolved gas levels. Field observations were conducted between June 1986 and December 1988.

# DESCRIPTION OF STUDY AREA

Yellowtail and Afterbay Dams are located in south-central Montana on the Bighorn River approximately 69 km southeast of Billings, Montana (Figure 1). The Yellowtail/Afterbay facility was constructed from 1963-1966 (WPRS 1980). The principal uses of the Yellowtail facility include irrigation, power generation, flood control, and fish and wildlife enhancement. Yellowtail Dam is a thin-arch concrete structure with a height of 160 m and a crest length of 442 m. A 250 MW peaking plant is located at its base. Afterbay Dam is a reregulating facility located 3.5 km downstream of Yellowtail Dam. The height of Afterbay Dam is 22 m, crest length is 414.5 m, and crest elevation is 956 m. The spillway has a discharge capacity of 566.4 $m^3/s$, and is 49.4 m wide; flows are controlled by five 9.1 m x 4.1 m radial gates and by a 10.4 m wide sluiceway. The sluiceway discharge is adjusted by three 3 m x 2.4 m vertical slide gates. The height from the streambed to the maximum controlled water surface is 16.1 m; the sluiceway gates can release water 6.9 m lower than the radial gates. Flow is continually adjusted, usually by the automated sluiceway slide gates, to maintain a relatively uniform flow to the river. Mean daily discharge from Afterbay Dam was 73.97 $m^3/s$ (range: 49.56 $m^3/s$ - 113.28 $m^3/s$) in 1987 and 58.37 $m^3/s$ (40.44 $m^3/s$ - 84.79 $m^3/s$) in 1988. High dissolved gas levels result from gas entrainment when water passes through gates in the Afterbay Dam, particularly the sluiceway gates.

The study area extended approximately 4.8 km downstream of Afterbay Dam (Figure 1). River gradient is approximately 1.9 m per river kilometer (Stevenson 1975) and the channel has a relatively uniform rectangular shape, with several islands. River