



Some effects of DDT on cold water fish and fish-food organisms  
by Norman Dean Schoenthal

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of  
DOCTOR OF PHILOSOPHY in Fish and Wildlife Management  
Montana State University  
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**Abstract:**

Bio-assays were conducted on six species of cold-water fish to determine mortality rates under different concentrations of DDT and varying physical, chemical and biological conditions. A total of 6000 fish was tested. The mortality rate of rainbow trout varied little at DDT concentrations between 0.5 and 10 ppm. Mortality rates increased as the size of the fish decreased. Hatchery rainbow trout had a higher mortality rate than wild rainbow trout. Mortality rates increased as the temperature increased but decreased when turbidity and alkalinity increased. Mortality rates were increased by feeding trout aquatic insects treated with DDT. A comparison of six species of fish tested in 1 ppm DDT showed the longnose sucker had a mortality rate of 94 percent while the salmonids had less than 10 percent. Delayed mortality occurred in all species of fish treated in DDT throughout a six month observation period.

Observations were made on fish and fish-food organisms in a test stream eight months before, during and 19 months after treatment with DDT which was applied at one point in the stream at 0.4 ppm. Immature aquatic insect populations were reduced 99 percent following application and required 18 months to regain pre-treatment numbers. Immature aquatic insect populations below 0.75 mile downstream from the point of application regained 15 percent of the pre-treatment numbers 11 months after application. The diet of trout in this downstream area changed from immature aquatic insects to adult insects and aquatic vegetation. Trout populations in the first mile of treated water showed no significant change one year following treatment but below this point showed a 73 percent reduction.

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Approved:

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Head, Major Department

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Bozeman, Montana

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ABSTRACT

Bio-assays were conducted on six species of cold-water fish to determine mortality rates under different concentrations of DDT and varying physical, chemical and biological conditions. A total of 6000 fish was tested. The mortality rate of rainbow trout varied little at DDT concentrations between 0.5 and 10 ppm. Mortality rates increased as the size of the fish decreased. Hatchery rainbow trout had a higher mortality rate than wild rainbow trout. Mortality rates increased as the temperature increased but decreased when turbidity and alkalinity increased. Mortality rates were increased by feeding trout aquatic insects treated with DDT. A comparison of six species of fish tested in 1 ppm DDT showed the longnose sucker had a mortality rate of 94 percent while the salmonids had less than 10 percent. Delayed mortality occurred in all species of fish treated in DDT throughout a six month observation period.

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## INTRODUCTION

DDT is a widely used insecticide for the control of forest insects. Aerial application of this insecticide over millions of acres of forest lands has caused mortalities in aquatic organisms in the waters of these areas. Qualitative studies on the effects of DDT on aquatic organisms have been conducted by Adams et al. (1949), Hoffman and Surber (1949), Cope and Park (1957), and Warner and Fenderson (1962). Long range studies on the effects of DDT were reported in Canada by Ide (1957), Alderdice and Worthington (1959), Crouter and Vernon (1959), and Keenleyside (1959).

Aerial forest spraying at the rate of one pound of DDT per acre to control the spruce budworm in Montana started in 1952. In 1955, large areas of Yellowstone Park and the Gallatin National Forest were sprayed. During early winter of 1956, a heavy fish die-off was reported along the upper Yellowstone River. This stimulated the initiation of a cooperative study by the U. S. Fish and Wildlife Service, the U. S. Forest Service, the Montana Fish and Game Department and the Montana Agriculture Experiment Station to determine the effects of large-scale forest spraying on aquatic organisms (Graham and Scott, 1958). Another investigation was sponsored by the Montana Fish and Game Department. This had a twofold purpose: (1) to determine the effects of various concentrations of DDT under different physical and chemical conditions on the mortality of cold water fishes; (2) to determine the effects of a known concentration of DDT on fish and fish-food organisms in a test stream.



## BIO-ASSAYS

The facilities of the State Fish Hatchery at Ovando, Montana were used for bio-assays which were conducted during the summers of 1957, 1958 and 1959.

### Materials and Equipment

Bio-assays were conducted in modified hatchery troughs. Eight head troughs were used in holding the pre- and post-test fish. The rate of water flow to each of these troughs was regulated by individual faucets. Seven other troughs were used to conduct the experiments. In the early tests it was found that redwood troughs were unsatisfactory for DDT bio-assays. Analyses conducted by the Chemistry Department at Montana State College showed that redwood absorbed DDT from experiments using high concentrations and allowed it to leach out during low concentrations. Late in the experiments of the first year the troughs were painted with a chemical resistant paint. This reduced the leaching effect but was not entirely satisfactory due to chipping. During the last two seasons fiberglass troughs (210 liter capacity) were used. These were inserted into the redwood troughs with clearance at the head, sides and bottom. Overflow water from the head trough served as a water bath to reduce temperature fluctuation in the fiberglass troughs (Figure 1). Hardware cloth was used to cover the troughs and prevent fish from jumping out.

Centrifugal pumps rated at 17 gallons per minute were used to recirculate water in the fiberglass troughs. Plastic pipe was employed for recirculating water. The intake pipe was screened to prevent weakened

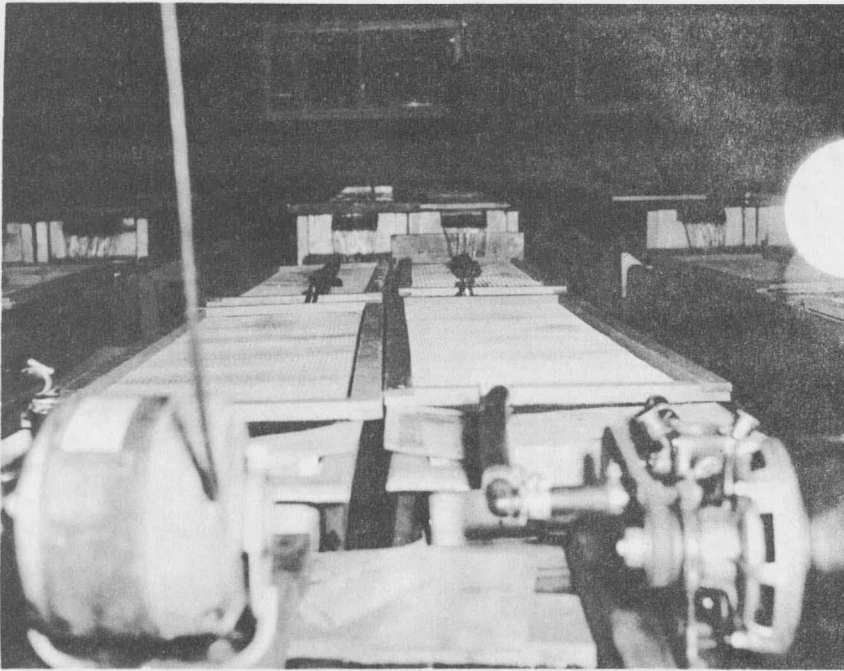


Figure 1. Unit experiment troughs and head troughs.

fish from being sucked into the pump. Test water was aerated by being forced under pressure through small holes in the end section of the ex-current pipe (Figure 2).

Two earthen ponds were used during the experiments. The larger had a surface area of about 2000 square feet with an average depth of 2.5 feet and was divided into six sections (Figure 3). The smaller had a surface area of approximately 250 square feet and was divided into three sections. Frames covered with plastic screen were used as dividers.

The water supply for the troughs and holding ponds was obtained from a spring. Physical and chemical water analyses showed the following ranges: temperature, 40 - 53 F.; turbidity, 0 - 35 ppm; pH, 7.6 - 8.2; methyl orange alkalinity, 180 - 280 ppm; total dissolved solids, 275 -



































































































