



Effects of whirling disease on recruitment of brown trout in the Ruby River and Poindexter Slough,  
Montana  
by Scott Travis Opitz

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

Brown trout numbers began to decline in the mid 1990s in the Ruby River and Poindexter Slough. Possible causes for the decline were investigated and no likely cause was found. Infection by *Myxobolus cerebralis* was diagnosed in brown trout from both waters in 1995 and was considered the possible cause of the declines. To determine if this was the cause of the declines, abundances of age-0 brown trout were monitored with the use of electrofishing to see if any sudden drastic declines occurred during this susceptible life stage. Exposure experiments were also conducted in both waters with age-0 brown and rainbow trout to determine experimentally if whirling disease was present in these systems. Fish were collected during electrofishing and from the exposure experiments for histological confirmation of whirling disease. Age-0 abundances declined gradually as would normally be expected. Brown trout in the exposure experiments were minimally infected, if at all, and the rainbow trout were moderately to severely infected as confirmed by histology. Histology also confirmed the presence of whirling disease in some of the fish collected during electrofishing. Data collected by Montana Department of Fish, Wildlife & Parks suggest that the populations are increasing. Whirling disease did not affect the recruitment of brown trout in both waters during the time the study was conducted.

**EFFECTS OF WHIRLING DISEASE ON RECRUITMENT OF BROWN TROUT  
IN THE RUBY RIVER AND POINDEXTER SLOUGH, MONTANA**

by

**Scott Travis Opitz**

**A thesis submitted in partial fulfillment  
of the requirements for the degree**

of

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in

**Fish and Wildlife Management**

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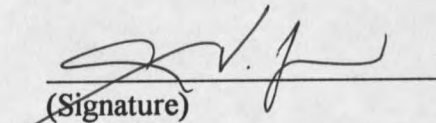
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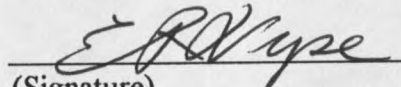
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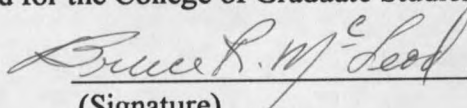
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## ABSTRACT

Brown trout numbers began to decline in the mid 1990s in the Ruby River and Poindexter Slough. Possible causes for the decline were investigated and no likely cause was found. Infection by *Myxobolus cerebralis* was diagnosed in brown trout from both waters in 1995 and was considered the possible cause of the declines. To determine if this was the cause of the declines, abundances of age-0 brown trout were monitored with the use of electrofishing to see if any sudden drastic declines occurred during this susceptible life stage. Exposure experiments were also conducted in both waters with age-0 brown and rainbow trout to determine experimentally if whirling disease was present in these systems. Fish were collected during electrofishing and from the exposure experiments for histological confirmation of whirling disease. Age-0 abundances declined gradually as would normally be expected. Brown trout in the exposure experiments were minimally infected, if at all, and the rainbow trout were moderately to severely infected as confirmed by histology. Histology also confirmed the presence of whirling disease in some of the fish collected during electrofishing. Data collected by Montana Department of Fish, Wildlife & Parks suggest that the populations are increasing. Whirling disease did not affect the recruitment of brown trout in both waters during the time the study was conducted.

## INTRODUCTION

Whirling disease is a parasitic infection of trout and salmon caused by the myxosporean *Myxobolus cerebralis* (Markiw 1992a). *M. cerebralis* developed as a nonpathogenic parasite in brown trout *Salmo trutta* in northern Asia and central Europe (Hoffman et al. 1962; Hoffman 1970, in Halliday 1976; Hoffman 1990). It was discovered in rainbow trout *Oncorhynchus mykiss* in Germany in 1893 (Hofer 1893, in Hoffman 1990). It is believed to have reached the United States in frozen trout from Europe and was diagnosed in 1958 in Pennsylvania (Hoffman 1990). The disease was first diagnosed in the western United States in hatcheries in Nevada and California in 1966 (Yasutake and Wolf 1970). Whirling disease was diagnosed in rainbow trout in the Madison River, Montana, in December 1994 (M. Lere, Montana Department of Fish, Wildlife & Parks (FWP), Bozeman, Montana, personal communication).

### Hosts

*M. cerebralis* has a two-host life cycle. The hosts are salmonids and the aquatic oligochaete *Tubifex tubifex* (Markiw and Wolf 1983; Wolf and Markiw 1984; Wolf et al. 1986). Not all salmonids are equally susceptible to the disease. Susceptibility varies among species and strains and may also vary among individual fish (Markiw 1992b). The species in the following list are ranked according to susceptibility from greatest to least: rainbow trout, sockeye salmon *O. nerka*, golden trout *O. aguabonita*, cutthroat trout *O. clarki*, brook trout *Salvelinus fontinalis*, steelhead *O. mykiss*, chinook salmon *O.*



*tshawytscha*, Atlantic salmon *Salmo salar*, brown trout, coho salmon *O. kisutch*, lake trout *Salvelinus namaycush*, and splake (hybrid between brook and lake trout) (O'Grodnick 1979; Hoffman 1990; Markiw 1992a). Eurasian grayling *Thymallus thymallus* are reported to be infected by *M. cerebralis* (Volf 1957, in Halliday 1976; Havelka and Volf 1970; Bagdanova 1971, in Halliday 1976), but Arctic grayling *T. arcticus* are resistant to infection (Matthew Clow, Montana State University, Bozeman, Montana, personal communication).

Hoffman et al. (1962) stated that brown trout become infected but not diseased. In contrast, Havelka and Volf (1970) reported 80-90% mortality of brown trout infected with whirling disease. The differences in the results from these two studies may have been caused by the age and size of fish exposed, the number of triactinomyxons they were exposed to, the length of the exposures, and environmental conditions associated with the exposure of the fish. Brown trout, which are native to Europe, were introduced to Montana in 1889 by the Bureau of Fisheries (Brown 1971; Luton 1985). Brown trout tend to be found in valley portions of large rivers, but also do well in reservoirs. They must use streams to spawn successfully. Most brown trout become sexually mature by age 3, but may be mature as early as age 2 or as late as age 4 or 5. They spawn from October to December and may move long distances upstream to do so. Females dig the redd and both males and females guard it. The eggs hatch the following February to April. Hatching usually takes 50 days at 10 °C. Brown trout feed on aquatic insects and adults may prey on sculpins, suckers, and trout fingerlings (Brown 1971).

Brown trout exhibiting clinical signs of whirling disease were collected in 1994 in the Colorado River, Colorado (Walker and Nehring 1995). Blacktail was found on 21 of 256 wild brown trout held in sentinel cages on July 14, 1994. On August 4, 1994, 17 of 234 brown trout had blacktail and two had cranial deformities such as protruding eyes, shortened sloping snouts, or both. In wild, free-ranging brown trout, blacktail was easily observed from the banks in mid-July 1994 (Walker and Nehring 1995). The appearance of it at this time is in concordance with evidence showing that blacktail develops 35-45 days after exposure to the parasite (Markiw 1992a; Walker and Nehring 1995). Blacktail was highest in these populations from July to September and in upstream reaches. Sixty percent of the brown trout in the upper reaches had blacktail and some had lordosis or scoliosis.

Nonsalmonids have been reported to be infected by *M. cerebralis* as well. These fish are tench *Tinca tinca*, gudgeon *Gobio gobio*, pike *Esox lucius*, European perch *Perca fluviatilis* (Ramirez-Medina 1962, in Halliday 1976), and young Atlantic herring *Clupea harengus* raised in aquaria (Dannevig and Hansen 1952, in Halliday 1976). However, these reports may be misidentification of other myxosporeans as *M. cerebralis* (Halliday 1976; Markiw 1992a).

#### Life Cycle

*M. cerebralis* myxosporean spores are released from infected fish by death and decay. The spores are biconvex or lenticular with a width of 8 to 10  $\mu\text{m}$  at their widest point. Coiled filaments are contained in two ovate capsules at the anterior or polar end of

the spore (Wolf and Markiw 1985; Markiw 1992a). Spores ingested by *Tubifex* worms transform to actinosporean triactinomyxons (the stage that infects fish) in 3.5 months at 12.5 °C (Markiw 1992a). This transformation takes place in the gut epithelium of the *Tubifex* worm (El-Matbouli and Hoffmann 1989).

Triactinomyxons are anchor shaped and topped with three polar capsules. The anterior end or episore is 36  $\mu\text{m}$  long and the style extends 90  $\mu\text{m}$  below this. The arms taper and extend 170  $\mu\text{m}$  (Wolf and Markiw 1984). After release from the worm host, triactinomyxons enter susceptible fish through the skin, buccal cavity, upper esophagus, fins, or the lining of the digestive tract. The triactinomyxons transform back to *M. cerebralis* spores in the cartilage of the fish (El-Matbouli and Hoffmann 1989). This process takes about 2.6 months at 12.5 °C (Markiw 1992a).

Clinical signs may appear in fish from 35-80 days after infection. Head and axial skeleton deformations, cranial depressions, and shortening of the snout can last throughout the life of the fish (Markiw 1992a). Cranial deformities are caused by interference with osteogenesis (Hoffman et al. 1962; Christensen 1966, in Halliday 1976; Hoffman 1970, in Halliday 1976). Blacktail is caused when the spinal column is infected posterior to the 26th vertebra and pressure is exerted on caudal nerves that control pigment cells (Phlen 1904, in Halliday 1976; Schaperclaus 1954, in Halliday 1976; Hoffman et al. 1962; Hoffman 1966; Hoffman 1970, in Halliday 1976). This pressure can also cause spinal deformities (Hoffman 1966; Havelka et al. 1971, in Halliday 1976; Hoffmann 1970; Hoffman 1970, in Halliday 1976). Blacktail appears 35-45 days after infection at 12.5 °C. Whirling behavior appears around the same time or later (Markiw

1992a). Whirling may be caused by neural damage from lesions and disintegration of cartilaginous tissue around the equilibrium organs and can cause exhaustion, malnutrition, and death (Halliday 1976; Hoffman 1970, in Halliday 1976).

Research conducted in Willow Creek, the Madison River, the Missouri River, and Little Prickly Pear Creek, Montana, in 1997 showed that severe infections in rainbow trout occurred in a temperature range from 9 °C to 17 °C. A peak of infection occurred around 14 °C. This data suggests that there are certain times when young fish are more likely to become severely infected based on water temperatures (E. R. Vincent, FWP, Bozeman, Montana, personal communication). *Triactinomyxon* release from infected *T. tubifex* peaks at 13 °C to 14°C (Thomas Waldrop, National Fish Health Research Laboratory, Kearneysville, West Virginia, personal communication).

#### Whirling Disease in Montana

Concurrent with the discovery of whirling disease in the Madison River, Montana, the rainbow trout population there declined in abundance. In the upper river, a 90% decline in abundance of yearling rainbow trout was observed (Vincent 1996). All possible causes for the decline were investigated, but age-0 monitoring of rainbow trout and histological examination of fish confirmed that whirling disease was responsible for the decline. Whirling disease had no apparent effect on brown trout in this river (Vincent 1996).

Abundances of brown trout in the Ruby River and Poindexter Slough in southwestern Montana declined in the mid-1990s, causing concern among anglers and

managers about the future of these valuable fisheries (R. A. Oswald, FWP, Dillon, Montana, personal communication). Estimated abundances of brown trout >15.2 cm (total length) in the Silver Spring section of the Ruby River exceeded 1,200 fish per 1.6 km in 1989-1992, but were less than 700 fish per 1.6 km in 1993-1995 (Figure 1). Abundance estimates of brown trout in Poindexter Slough did not decline as sharply, but were generally lower in 1993-1995 than in 1989-1992 (Figure 1). Brown trout from both rivers tested positive for whirling disease in 1995. Six of the 11 fish collected in Poindexter Slough and 5 of the 15 fish collected in the Ruby River were positive for the disease (E. MacConnell, Bozeman Fish Technology Center, Bozeman, Montana, personal communication). Although brown trout are considered resistant to whirling disease, no other factors were identified that could have caused the observed declines in abundances (R. A. Oswald, personal communication).

The objective of this study was to determine if whirling disease was responsible for the declines in abundances in brown trout observed in the Ruby River and Poindexter Slough. Abundances of age-0 brown trout were periodically monitored in both systems to assess survival rates, and individuals were examined for clinical signs of whirling disease and disease severity. Sentinel-fish exposures were conducted to determine experimentally if whirling disease was present in these systems.

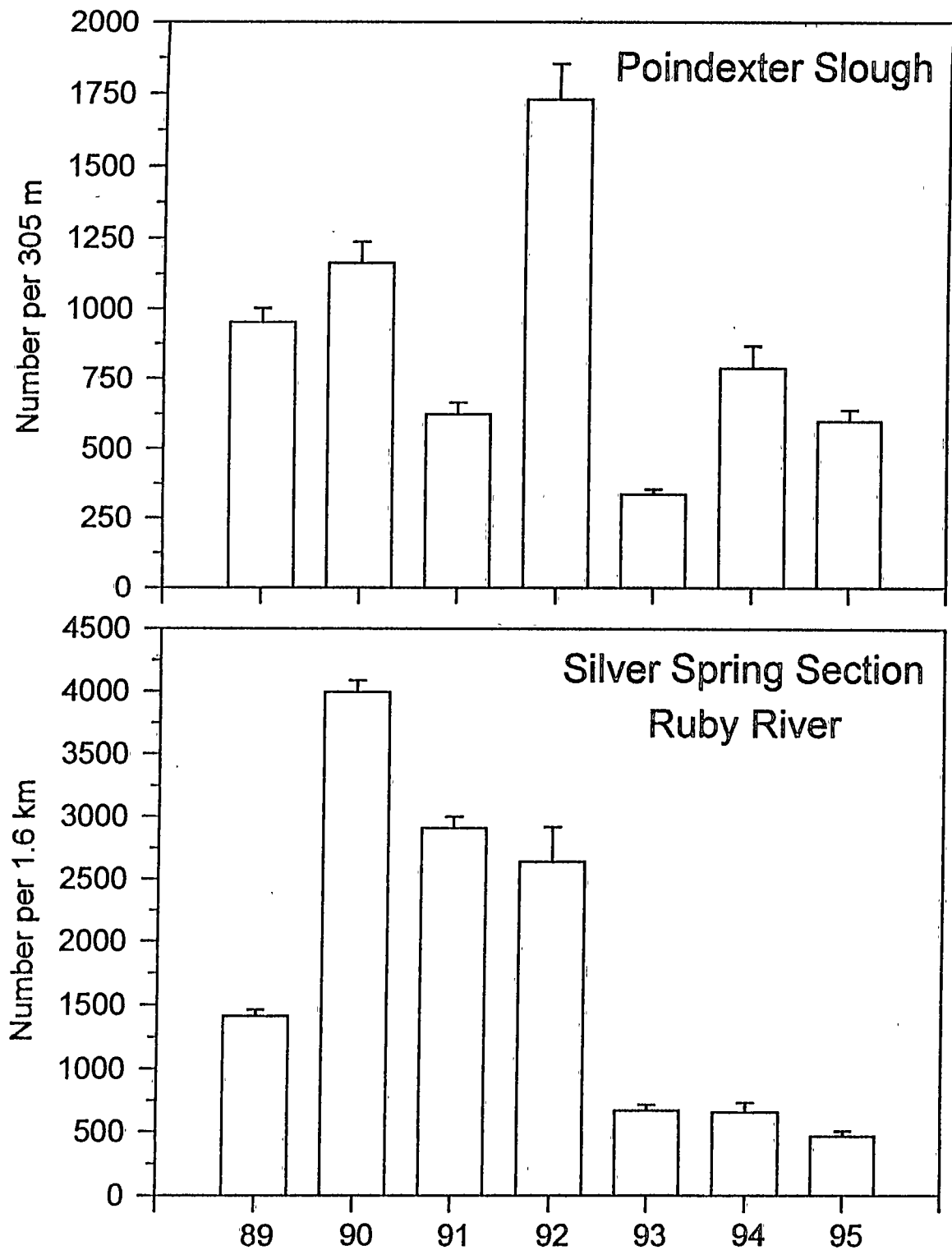


Figure 1: Brown trout population abundance estimates (+1 SD) at Poindexter Slough and the Silver Spring section of the Ruby River made by FWP from 1989-1995.

## STUDY AREAS

The Ruby River and Poindexter Slough are both located in the Jefferson River drainage in southwestern Montana. The Ruby River sites are in Madison County and Poindexter Slough is in Beaverhead County. The Ruby River was originally called Passamari, which means "pleasant valley," by the Shoshone Indians. It was later named Philanthropy in August 1805 by Meriwether Lewis during the Lewis and Clark Expedition. Later, it was named Stinking Water and in 1877 the legislature changed the name to the Ruby because of the large number of red garnets found in the river by miners. The Ruby River has a drainage area of 1,801 square km. It is fed by tributaries draining the Greenhorn, Snowcrest, Gravelly, Tobacco Root, and Ruby Mountains. It flows north for 105 km through Ruby Reservoir to its confluence with the Beaverhead River.

Work was conducted at three sites on the Ruby River, designated the Woodson site, the Barnosky site, and the Snowcrest site. The Woodson site was on the Woodson Ranch, northwest of Laurin, Montana. This site was located in Sections 30, 31, and 32 of Township 5 S, Range 4 W. The study section was 3,000 m long and began 1,000 m downstream from the confluence with Alder Gulch Creek. The section ended at the bridge on the ranch road 1,300 m downstream from the confluence of California Creek. It began at an elevation of 1,540 m and ended at 1,525 m. The gradient for the study section was 5.0 m/km. The section of the river used in the study was sinuous. A section of the river that had recently undergone rehabilitation work was omitted from the study site. The sentinel-fish exposure cages were located about 400 m downstream from the end of

the section used for abundance monitoring (Figure 2). The site for the cages was chosen because it was an area that was not likely to be disturbed by people or animals. It was also shallow enough that water fluctuations would not submerge the cages. Mean daily water temperatures at the Woodson site from June 1996 through March 1998 ranged from 16.8 °C to -1.2 °C (Figure 3). The primary types of vegetation that were found at the site were willow, cottonwood, and various grasses and forbs. Cattle and hay production took place on the ranch. The cattle were excluded from the riparian area by electric fencing.

The Barnosky site was located southwest of Sheridan, Montana, on the Silver Springs Ranch. The section of river used was located in Sections 10, 14, and 15 of Township 5 S, Range 5 W. The study section was 3,900 m long and began about 1,150 m upstream from the ranch-road bridge that crosses the river and ended where the Silver Spring Road crosses the Ruby River. The reach was sinuous. The section began at an elevation of 1,504 m and ended at 1,491 m. The gradient of the study section was 3.3 m/km. Exposure cages were placed about 125 m downstream from the bridge on the ranch road. This was an area that was shallow and unlikely to be disturbed by people or animals (Figure 4). Mean daily water temperatures ranged from 17.0°C to -4.1 °C (Figure 5) from June 1996 to March 1998. The primary vegetation in the area was willow, and various grasses and forbs. The ranch maintained a cattle operation and hay production.

The Snowcrest site, on the Ruby River, was on the Snowcrest Ranch, south of and upstream of Ruby Reservoir. The study section was in Sections 33 and 34 of Township 8 S, Range 4 W. The section was 4,800 m long and began 550 m downstream of the



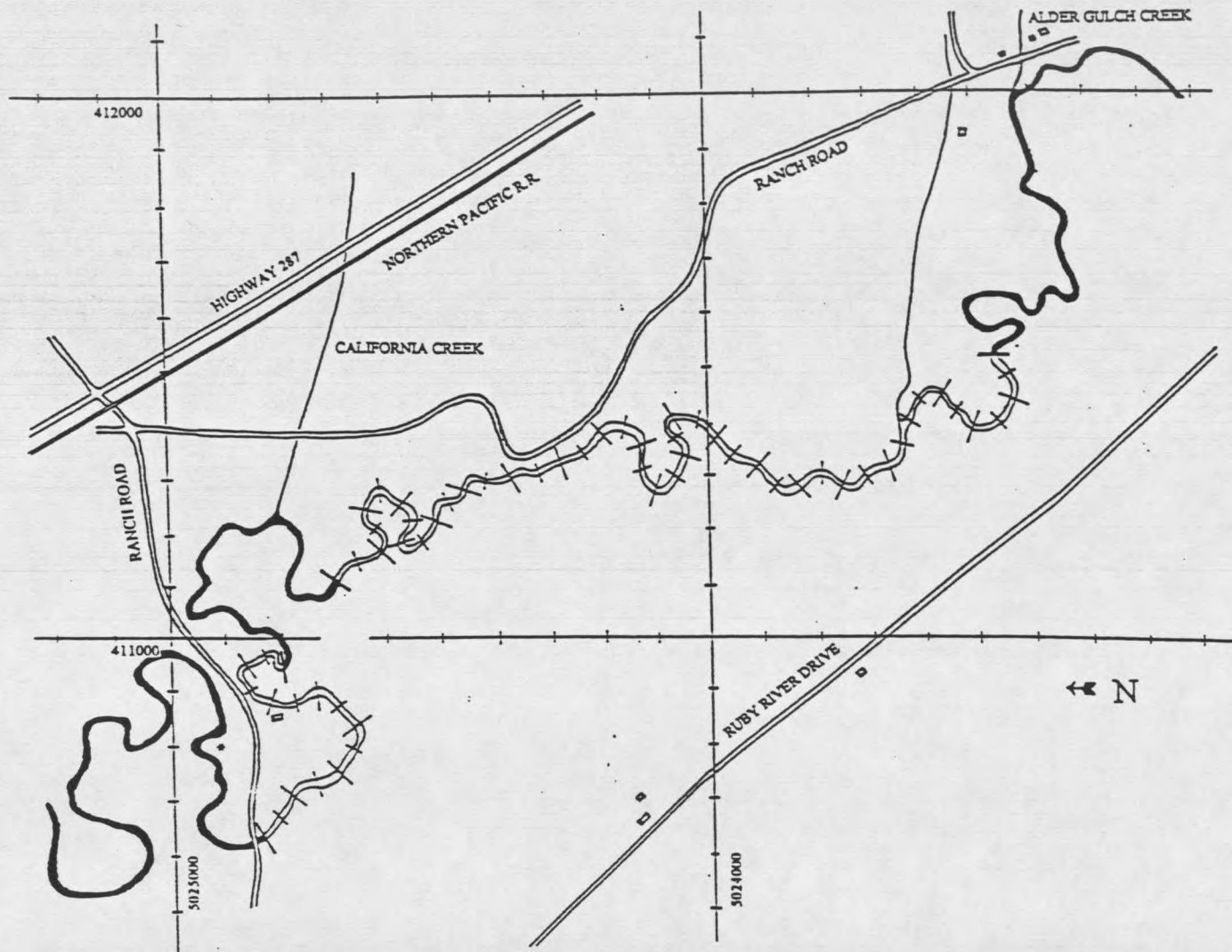


Figure 2. Map of the Woodson site. The vertical and horizontal grid lines represent the UTM coordinates. The tick marks on the river represent the 50 m transects. The exposure experiment cage location is represented by \*.

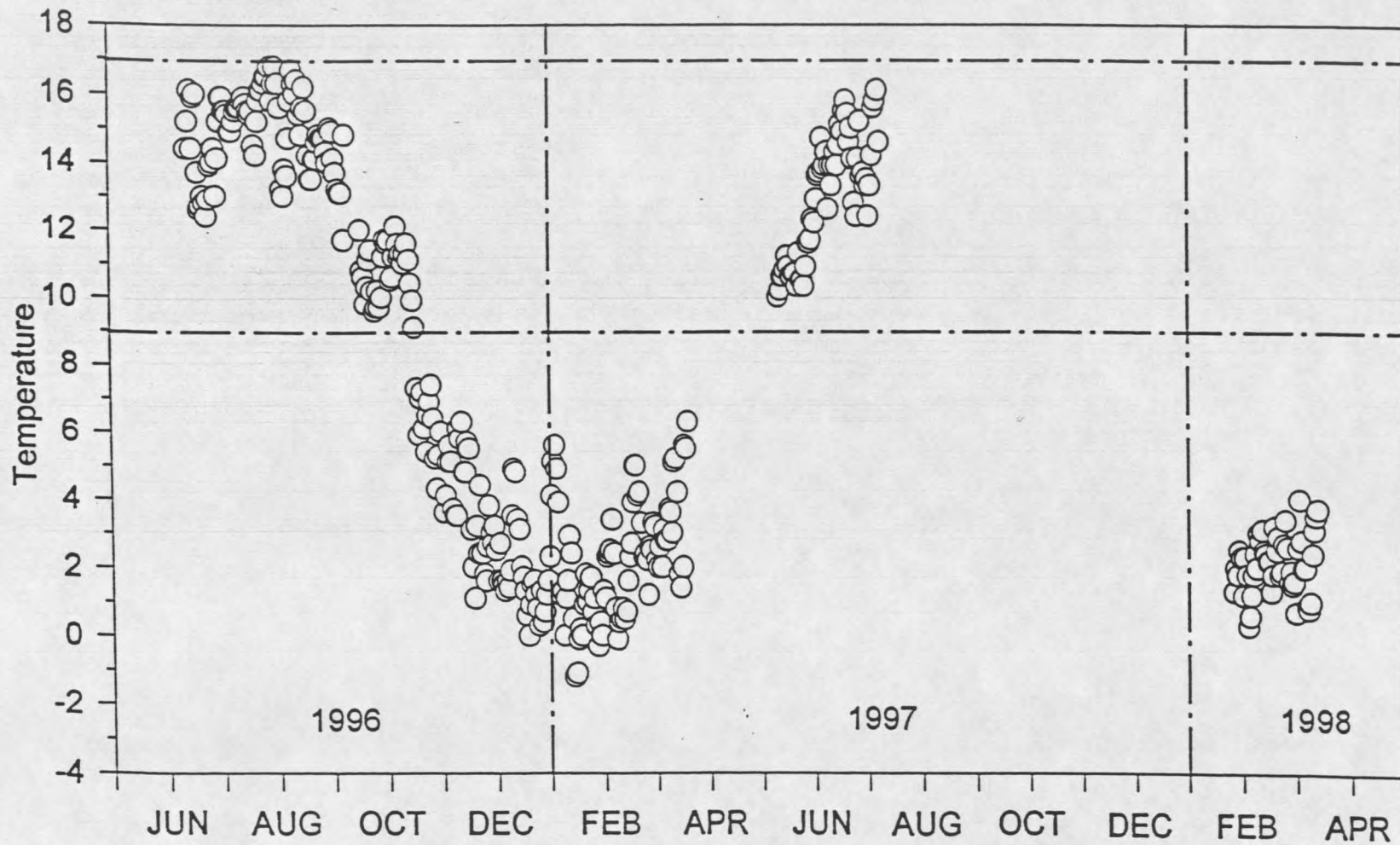


Figure 3. Mean, daily water temperature ( $^{\circ}\text{C}$ ) at the Woodson site from June 1996 to March 1998. The vertical, dashed lines denote years and the horizontal, dashed lines show the 9 to 17  $^{\circ}\text{C}$  range.





































































































































































































