

FISHERY RESEARCH



Wild Trout Investigations

Bull Trout Investigations

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Project 3: Wild Trout Investigations

Subproject 1: Whirling Disease—Sentinel Exposure Studies

Subproject 2: Whirling Disease—Fumagillin Studies

Subproject 3: Bull Trout Investigations

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TABLE OF CONTENTS

	<u>Page</u>
SUBPROJECT #1: WHIRLING DISEASE—SENTINEL-EXPOSURE STUDIES.....	1
ABSTRACT	1
INTRODUCTION	2
OBJECTIVES.....	2
METHODS	2
RESULTS	3
DISCUSSION.....	4
RECOMMENDATIONS.....	5
ACKNOWLEDGMENTS.....	6
LITERATURE CITED	7
SUBPROJECT #2: WHIRLING DISEASE—FUMAGILLIN STUDIES.....	8
ABSTRACT	8
INTRODUCTION	9
OBJECTIVES.....	9
METHODS	10
RESULTS	11
DISCUSSION.....	13
RECOMMENDATIONS.....	14
ACKNOWLEDGMENTS.....	15
LITERATURE CITED	16
SUBPROJECT 3: BULL TROUT INVESTIGATIONS	17
ABSTRACT	17
INTRODUCTION	18
METHODS	18

RESULTS 18

TABLE OF CONTENTS (Continued.)

	<u>Page</u>
DISCUSSION.....	19
RECOMMENDATIONS.....	20
ACKNOWLEDGEMENTS	21
LITERATURE CITED.....	22

LIST OF TABLES

- Table 1. Infection rates of *M. cerebralis* for rainbow trout (Rb) and cutthroat trout (Ct) exposed in the Spokane River drainage, Idaho from July 8-17, 1998.4

- Table 2. *Myxobolus cerebralis* spore counts and percent spore deformities in chinook salmon and steelhead trout feed treatment trials using the antibiotic fumagillin. Trials included 10-day exposure to the parasite followed by low (3.75 mg fumagillin/kg body weight/day) and high (7.5 fumagillin/kg body weight/day) feed treatments for 10 consecutive days. Test results at the end of 180 day trial.12

- Table 3. Bull trout data from trapping at Rapid River, Crooked River, East Fork Salmon River and Sawtooth Hatchery, 1973-199819

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Subproject #1: Whirling Disease—Sentinel
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ABSTRACT

Past sampling in Idaho determined the presence of *Myxobolus cerebralis* (MC) in the Coeur d'Alene drainage in north Idaho east of Coeur d'Alene, Idaho. I conducted sentinel fish exposures for hatchery cutthroat trout *Oncorhynchus clarki lewisi* and rainbow trout *O. mykiss* in North Fork Coeur d'Alene and St. Joe rivers to quantify the potential infection of salmonids. Three sentinel exposure sites were selected based on the locations of MC positive samples, the locations of past hatchery releases of potentially positive hatchery rainbow trout, and angler reports of whirling disease symptoms. Results from sentinel tests indicated no infection by the parasite during the period of sentinel exposures conducted July 7-17, 1998. A combination of water temperatures, which exceeded 20°C during sentinel exposures, and site selection limit the conclusions to be drawn from these results.

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INTRODUCTION

Statewide sampling during 1995 indicated *Myxobolus cerebralis* (MC), the causative agent of whirling disease in salmonids, was widespread in Idaho (Elle 1998). Population monitoring in Colorado and Montana indicate this parasite can result in large losses of wild trout, with the greatest losses reported in rainbow trout *Oncorhynchus mykiss* populations (Walker and Nehring 1995; Vincent 1996; Nehring 1998). Studies in Colorado and Montana indicated high levels of infection in age-0 trout exposed during spring or summer with subsequent mortality of these trout during late fall and winter (Nehring and Thompson 1996; Vincent 1996).

Since an initial assessment of parasite distribution was completed in Idaho in 1995 (Elle 1998), Idaho Department of Fish and Game (IDFG) has conducted evaluations to determine potential impact of MC on wild trout populations in Idaho. One phase of these evaluations includes the use of sentinel trout exposures in drainages testing positive for the parasite. Sentinel exposures provide quantification of percent infection and the level of infection to which wild trout are exposed in a given drainage (Elle 1997; Nehring and Thompson 1996). As such, sentinel tests are quite useful in identifying potential problem drainages.

During 1998, sentinel exposures were conducted in the St. Joe and North Fork Coeur d'Alene (NFCDA) rivers. These were initial efforts to quantify infection rates in these drainages at sites where MC was found in samples of westslope cutthroat *O. clarki lewisi* and mountain whitefish *Prosopium williamsoni* during 1995 (Elle 1998).

OBJECTIVES

Research Goal: Evaluate the effects of MC on naturally-producing salmonid populations in Idaho.

1. Determine the incidence and level of infection of sentinel trout within drainages testing positive for the parasite.

METHODS

Sentinel tests are designed as a surrogate measure of parasite infection of wild salmonids. Ten-day exposures have been shown to be sufficient to reflect natural levels of infection in wild trout in infected waters (Vincent 1996). Timing of exposures was selected to coincide with suspected emergence of wild spawned trout. The exposure dates were July 7-17, 1998 based on input from Regional Fish Manager (personal communication, Ned Horner, IDFG). Sentinel cages were located at Pritchard Creek on the NFCDA and at Midget Creek on the St. Joe. These two sites coincided with 1995 MC positive samples of mountain whitefish and westslope cutthroat, respectively. I added a sentinel site on lower Marble Creek to coincide with an angler observation of possible MC infection based on typical whirling disease symptoms. A domesticated strain of kamloops rainbow trout purchased from Trout Lodge Incorporated and west slope cutthroat provided from the IDFG Clark Fork Hatchery were used as sources of fish for sentinel tests. Size of fry at time of exposure was 25 mm to 28 mm for rainbow and 22 mm to 25 mm for cutthroat trout. Trial exposures

consisted of holding fry for 10 days in live cages in the test streams. Vincent (1996) demonstrated that a 10-day exposure reflected the level of infection present in the natural stream environment.

Following the 10-day exposure period, the sentinel fish were transported to offsite rearing at the University of Idaho wet lab. They were reared on parasite-free well water at 13°C for 84 days to achieve an incubation of approximately 1100 temperature units centigrade. At the termination of the rearing period, 20 fish samples were collected for histological examination. As in 1996 and 1997, histological evaluations were completed at the Washington Animal Diagnostic Laboratory in Pullman, Washington using the following rating system:

- Grade 0: No skeletal abnormalities. No infection.
- Grade 1: Discrete, rare (usually single, small islands of spores/trophozoites) with minimal associated inflammation are seen.
- Grade 2: A single, locally extensive focus, or several small foci (usually two) of cartilage necrosis with associated trophozoites or mature spores and mild inflammation are seen.
- Grade 3: Multiple foci or cartilage necrosis (usually three or four) with accompanying moderate inflammation are present. Moderate numbers of trophozoites/spores are within lesions.
- Grade 4: Widespread, extensive cartilaginous necrosis with severe inflammation. Trophozoites and/or spores are within cartilaginous lesions.

RESULTS

No MC infection was detected from any of the test groups exposed during the 1998 sentinel test exposures (Table 1). All histological samples graded out as 0. No clinical signs of whirling disease were observed in any of the test groups before termination of the rearing period. The water temperatures during the exposure periods averaged 17°C (range 13°C to 21°C) in the NFCDA and 16°C (range 12°C to 21°C) in Marble Creek. The thermograph malfunctioned at the St. Joe site, but hand-held temperature readings were similar to Marble Creek during the startup period of exposure.

During the rearing period at the University of Idaho, the cutthroat exposure test group from NFCDA contracted *Ichthyophthirius multifiliis* and was terminated to prevent any further spread. As a result, no histological results were available from these fish. Up to the time of termination, no clinical signs of disease were observed in these fish.

Table 1. Infection rates of *M. cerebralis* for rainbow trout (Rb) and cutthroat trout (Ct) exposed in the Spokane River drainage, Idaho from July 8-17, 1998.

Drainage	Species	Exposure Temp. (°C)		Histological Ranking				
		Mean	Range	0	1	2	3	4
N Fk. Coeur d'Alene ^a	Rb	17	13-21	20	0	0	0	0
	Ct	47	13-21	ND ^c	ND	ND	ND	ND
St. Joe River ^b	Rb	ND ^d	ND	21	0	0	0	0
	Ct	ND	ND	20	0	0	0	0
Marble Creek	Rb	16	12-21	20	0	0	0	0

^a N Fk. Coeur d'Alene River at Pritchard Creek.

^b St. Joe River near Midget Creek.

^c No data. Test group contracted Ichthyophthirius resulting in 100% mortality.

^d No data. Temperature recorder malfunction.

DISCUSSION

I found no evidence of MC infection in sentinel tests in the NFCDA or St. Joe River sites for the period and locations tested during 1998. There are several possible reasons for not detecting infection in our sentinel tests: 1) there was no infection present during the exposure periods tested during 1998; or 2) our sample size was too small to detect the parasite if infection was low. Several factors could have contributed to low infection rates. I selected test sites based on the location of MC positive adult fish samples collected previously. Cutthroat in these drainages typically spawn and rear in headwater tributaries. If MC exposure occurs in these natal areas and not the mainstem sites tested, the sentinel tests would not detect the parasite. Mountain whitefish do spawn in the mainstem areas I tested. However, whitefish emergence occurs in early spring, and the time period I selected for sentinel exposure does not coincide with whitefish time of hatching and early rearing. Infection in other salmonids has been highest in the youngest groups of fish tested (Nehring 1998).

Our sentinel tests coincided with a period of high ambient air temperatures and corresponding high water temperatures. During the sentinel exposures, water temperatures averaged 16°C to 17°C, and daytime highs reached 21°C during the 10-day exposure. It is possible the high water temperatures affected the test results. Vincent (1999) indicates the highest rate of MC infection occurs at water temperatures of 12°C to 13°C. His results show infection in rainbow trout declined at higher and lower temperatures. Waldrop et al. (1999) indicated reduced production of triactinomyxons (Tams), the infective stage of *M. cerebralis*, in the intermediate worm host, *Tubifex tubifex*, at 17°C compared to 13°C. They showed destruction of parasite developmental stages in the gut epithelium of infected *T. tubifex* worms 10 days after transfer of infected worms to 20°C water. El-Matbouli et al. (1998) found that worms infected at 15°C and held until they began releasing Tams stopped Tam production when placed into 20°C water, and subsequently stopped releasing Tams after 15 days. However, sentinel tests conducted in southern Idaho where water temperatures reached 16°C to 18°C did result in infections of rainbow and cutthroat trout (Elle, in press).

An *Ichthyophthirius* infection resulted in the loss of the cutthroat replicate from the NFCDA sentinel station. Past studies have indicated rainbow trout are equally or more susceptible to MC infection compared to cutthroat (Elle 1997; Nehring 1998). Therefore, I believe the rainbow trout sentinel results from NFCDA accurately reflect a level of infection equal to, or greater than, what I would have expected for the cutthroat replicate.

Cutthroat populations in NFCDA and St. Joe rivers have been managed under restricted harvest regulations since the 1970's. Cutthroat harvest regulations are either catch-and-release or allow one fish over 14 inches. Compared to before implementation of restricted cutthroat harvest regulations, cutthroat populations are currently depressed in the NFCDA but, based on long-term snorkel trend counts, have increased and stabilized in the St. Joe (personal communication, Ned Horner, IDFG). Stable populations in the St. Joe River suggest whirling disease is not impacting the cutthroat population at this time. The sentinel results from this study support this conclusion. In NFCDA River, the depressed cutthroat populations are thought to coincide with habitat degradation from the last 30 years of timber management (personal communication, Ned Horner, IDFG). It is possible whirling disease is contributing to the cutthroat decline, but my results would not support this conclusion.

In past studies (Elle 1997; Elle In press; Nehring 1998; Nehring and Thompson 1996), sentinel tests have provided valuable information regarding MC infection rates within positive watersheds. Exposure tests conducted over short time periods (e.g. 10 days) have yielded results similar to trials where exposure to spores lasted 120 days (Vincent 1996). Results from this study did not document MC at the study sites. However, the parasite has been positively identified in the drainage in past studies. Whirling disease is not an obvious factor affecting westslope cutthroat trout and mountain whitefish in our study sites.

RECOMMENDATIONS

1. Future sampling in spawning and rearing areas is recommended if further quantification of parasite distribution and potential impacts on trout populations are desired or large population declines are detected. This sampling should be completed for age-0 and age-1+ salmonids after mid-October with a sample size increase from 20 to 60 fish.

ACKNOWLEDGMENTS

The University of Idaho provided rainbow trout for sentinel trials. Cutthroat were provided by John Thorpe at Sandpoint Hatchery. Liz Mamer completed the sentinel exposures and transported the fish to University of Idaho for rearing. Monica Hiner and Yasu Kiryu reared the test fish at University of Idaho wet lab during spore maturation. Dan Schill provided critical review. Funding for this study was provided by Federal Aid to Fish Restoration.

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ABSTRACT

Prior research indicates the antibiotic Fumagillin DCH may control *Myxobolus cerebralis* (MC) infections in salmonids. A field study was designed to test the efficacy of Fumagillin on control of MC infection in steelhead trout *Oncorhynchus mykiss* and chinook salmon *O. tshawytscha* exposed and reared in a MC positive water source. Following a 14 d exposure to MC, fish were fed a fumagillin treated diet for 10 d at two concentrations: low treatment (3.75 mg fumagillin/kg body weight/d) and high treatment (7.50 mg fumagillin/kg body weight/d). Following rearing to 180 d post exposure, all groups had high spore counts, and no significant difference existed in the number of spores between control versus low or high feed treatment groups for either steelhead or chinook. High numbers of deformed spores were observed in all groups for both species, indicating no effect on spore deformities caused by fumagillin. When considered across all replicates, chinook salmon had significantly fewer spore counts compared to steelhead trout, indicating a possibly higher resistance to infection by the parasite. Additional trials with larger sample sizes and longer fumagillin treatment should be conducted to fully explore the drug potential.

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INTRODUCTION

Myxobolus cerebralis (MC), the sporozoan parasite considered the causative agent of salmonid whirling disease (Markiw and Wolf 1974), was first documented in Idaho during 1987 and has since been found in wild populations across the state (Elle 1998). Declines in wild salmonid populations have been associated with accidental introductions of the parasite into drainages in Colorado, Montana, and Idaho (Walker and Nehring 1995; Nehring 1998; Vincent 1996; Elle 1998), but the presence of the parasite does not always result in population declines (Elle In press).

The parasite is present at several Idaho Department of Fish and Game (IDFG) state fish hatcheries. It has been documented in water sources at one resident trout hatchery (Hayspur) and two anadromous hatcheries (Pahsimeroi and Sawtooth). Release of hatchery fish infected with the parasite appears to have been a factor in the spread of the parasite to wild salmonid populations in previously uninfected Idaho watersheds (Elle 1998).

Currently, management options to reduce infection rates in hatcheries where the parasite is present include conversion of earthen to concrete rearing facilities, to convert from surface to well water source, or to curtail/discontinue rearing of salmonids at the facility. The latter approach has been implemented at the Hayspur Hatchery where resident rainbow trout are no longer reared. Instead, this facility is currently only used for egg collection; this life stage is not susceptible to MC infection. The closure option is not practical for several upriver Salmon River anadromous hatchery stock. Suitable water and alternate brood sources are unavailable. In addition, the monetary costs to convert facilities to concrete or develop new water sources can be extremely high and in some cases is infeasible. Therefore, a need exists for alternative methods to control the proliferation of the parasite at MC positive hatchery facilities.

Preliminary research investigations (El-Matbouli and Hoffman 1991) indicate that the antibiotic fumagillin, a metabolite of the fungus *Aspergillus fumigatus*, may provide a mechanism to reduce the presence and overall infectivity of MC in rainbow trout *Oncorhynchus mykiss*. They reported that feeding fumagillin to trout exposed to MC resulted in both a reduction in the spore numbers and a high incidence of spores with morphological deformities. Hedrick et al. (1988) demonstrated that a treatment with fumagillin could inhibit the myxosporean that causes proliferative kidney disease (PKD) in experimentally infected chinook salmon *O. tshawytscha*.

This study represents one phase of a combined effort to document the efficacy of fumagillin in reducing MC infection rates in salmonids and subsequent outbreaks of whirling disease. I used the drug to determine its affect on steelhead trout and chinook salmon exposed to the parasite at Pahsimeroi Hatchery under normal rearing conditions. Parallel controlled laboratory trials on rainbow trout were undertaken at the U.S. Fish and Wildlife Service Fish Technology Center in Bozeman, Montana.

OBJECTIVES

Research goal: Evaluate the effects of MC on naturally-producing salmonid populations in Idaho.

1. Evaluate the efficacy of the drug fumagillin in reducing or eliminating spore production of the parasite MC in hatchery-reared salmonids.

METHODS

This study was initiated at the IDFG Pahsimeroi Fish Hatchery located on the Pahsimeroi River near Salmon, Idaho. The surface water source is positive for MC and has resulted in past infections of steelhead trout, cutthroat trout *O. clarki*, and chinook salmon exposed during hatchery rearing. Test fish included hatchery steelhead trout (mean size = 44 mm, 1.1 g) provided by Magic Valley Steelhead Hatchery and chinook salmon (mean size = 65 mm, 2.4 g) provided by Rapid River Chinook Hatchery. Both hatcheries are free from MC infection. Fish from both sources were transported to Pahsimeroi Hatchery on May 28, 1998.

Based on their prior experience in fumagillin based research, Monsour El-Matbouli (University of California-Davis and University of Munich) and Ron Hedrick (University of California-Davis) were consulted to determine the experimental design for our trials. They recommended two feed treatment concentrations of 3.75 mg and 7.50 mg fumagillin/kg body weight/day. The design included three replicate groups of 100 fish each for control, low treatment (3.75 mg fumagillin/kg body weight/d), and high treatment (7.50 mg fumagillin/kg body weight/d). Thus when considering both species, 18 test lots were used in the study. Test lots were held in individual 75 liter rearing containers with flow-through surface water from the Pahsimeroi River. Each container had a 12 h belt feeder to provide daily feed rations.

Treatments were randomly assigned to each container. All feed (Bioproducts™) was treated by top dressing with appropriate quantities of fumagillin at the Bozeman Fish Tech Center. Treated feed was refrigerated during feed trials.

Fish were exposed to surface water (mean water temperature = 15°C) for 14 d before any fumagillin feed treatments to initiate MC infection (May 28 to June 10). Such brief time exposures have been shown by Vincent (1996) to result in high infection rates in the presence of the MC infective stage. This was followed by a 10 d fumagillin feed treatment period (June 11-20) with the fish remaining in the same water source. Following the 10 d feed trial, the remaining feed was returned to Bozeman for a follow-up bioassay to insure the trial drug concentrations had been maintained. Following feed trials, the fish were scheduled for rearing in pathogen positive water for 180 days to simulate typical exposure conditions that occur at MC positive hatcheries.

Pahsimeroi Hatchery was chosen for the trial exposures due to past history of high MC infectivity. Due to elevated summer water temperatures in the Pahsimeroi River, tests lots were moved to IDFG Sawtooth Hatchery, located 100 km south of Pahsimeroi, for rearing following the feed treatment trials. Fish were returned to Pahsimeroi for final rearing on November 17, 1998. Rearing was completed in the same tanks used during exposure. Both hatchery staffs monitored each holding tank daily for mortality and clinical signs of whirling disease during the experiment.

Five fish histology samples were collected from all groups at 90 d post exposure (PE) to determine if test lots were infected with MC. Five fish samples were collected at 180 d PE for histology and pepsin-trypsin digest analysis. Linda Staton completed lab analysis at the Fish Tech Center in Bozeman. All lab analysis was completed "blind," without prior knowledge of treatment application. Digest analysis provided results on the number of spores per fish. Histological examination was used to determine the percentage of observed spores that were deformed. Polymerase chain reaction (PCR) was used to genetically confirm the presence or absence of MC DNA in experimental groups.

Digest results provided spore numbers for individual fish in all trial groups. I used a logarithmic transformation (Zar 1984) of the mean spore count data to normalize the data for statistical analysis. I used a two-way ANOVA to test for significant differences ($\alpha = .05$) in spore counts between treatments for steelhead and chinook. Data from replicates by species were pooled when no significant difference was found and data were tested for each species using one-way ANOVA.

RESULTS

Polymerase chain reaction analysis confirmed MC infection in all chinook and steelhead test groups. ANOVA indicates no significant difference exists between control versus treatment groups for both species combined ($P = 0.111$), but did indicate a highly significant difference exists between spore counts between chinook salmon and steelhead trout ($P = 0.001$). Chinook spore counts were lower compared to steelhead regardless of treatment groups. Therefore, we ran ANOVA for each species individually.

All individual steelhead, control and test groups alike, tested positive for MC with spore counts in excess of 27,000 (range 27,000 to 1,804,000) (Table 2). Mean spore counts were 504,000, 775,000, and 232,000 for control, low and high treatment groups, respectively. At the completion of the 180 d trial, there was no significant difference in steelhead spore counts between control versus treatment groups ($P = 0.068$). Although not significant, mean spore counts were approximately double in the control versus the high feed group. However, the low feed trial had the highest mean spore count of any trials. During the course of the study, steelhead trout in all test groups exhibited clinical signs of whirling disease, and a number of fish had shortened opercula and snouts. The percentages of spores that were morphologically deformed were highly variable between trial groups (Table 2). Although the low treatment groups had the highest percentage of deformed spores, no consistent trend toward higher percentage of deformed spores in treated groups was present. Based on the presence of clinically ill fish and spore count data, the drug treatment did not provide measurable benefits for preventing infection in steelhead trout.

All individual chinook also tested positive for MC infection with a minimum detected infection of 5,000 spores (range 5,000 to 1,081,000) (Table 2). No chinook from any group exhibited clinical signs of whirling disease during the rearing period. Mean spore counts for chinook were 47,000, 129,000, and 119,000 for control, low, and high treatment groups, respectively. A significant difference existed between control and treatment groups for chinook ($P = 0.016$). However, both low and high treatment groups had higher spore counts compared to the controls. The percentage of deformed spores was higher in control groups compared to low and high feed treatment groups. These results are opposite what might be expected if the fumagillin treatment had been effective in reducing infection rates.

During the rearing phase at Sawtooth Hatchery, high water temperatures led to an outbreak of *Ichthyophthirius multifiliis* in the steelhead. This resulted in high mortalities. Hatchery personnel treated with a formalin bath that effectively halted the disease. However, all steelhead in one control and two low feed trial groups died from the disease. This reduced the sample replications available for the steelhead trials.

Table 2. *Myxobolus cerebralis* spore counts and percent spore deformities in chinook salmon and steelhead trout feed treatment trials using the antibiotic fumagillin. Trials included 10-day exposure to the parasite followed by low (3.75 mg fumagillin/kg body weight/day) and high (7.5 fumagillin/kg body weight/day) feed treatments for 10 consecutive days. Test results at the end of 180 day trial.

	Steelhead			Summer Chinook		
	Tank #	Number of spores	Ratio % def/tot	Tank #	Number of spores	Ratio % def/tot
Control	SA 2	705,000	6	SC 1	56,333	83
	SA 2	188,333	0	SC 1	6,056	100
	SA 2	250,778	11	SC 1	35,333	0
	SA 2	1,408,333	31	SC 1	72,889	75
	SA 2	178,889	26	SC 1	16,444	0
	SA 5	888,667	10	SC 4	120,833	53
	SA 5	69,444	0	SC 4	11,000	100
	SA 5	181,500	19	SC 4	52,889	13
	SA 5	1,138,722	9	SC 4	11,111	100
	SA 5	27,333	100	SC 4	5,056	100
			SC 8	156,778	15	
			SC 8	105,556	45	
			SC 8	35,000	33	
			SC 8	6,111	0	
			SC 8	121,389	53	
Mean		503,700	21		54,185	51
Low	SA 1	510,000	51	SC 5	116,667	20
	SA 1	1,803,889	34	SC 5	95,000	22
	SA 1	513,889	30	SC 5	1,080,889	15
	SA 1	165,278	35	SC 5	17,778	100
	SA 1	880,000	28	SC 5	56,000	63
	SA 1	880,000	28	SC 5	56,000	63
				SC 6	43,889	20
				SC 6	73,333	40
				SC 6	93,333	50
				SC 6	26,667	100
				SC 6	73,111	36
				SC 7	111,944	46
				SC 7	9,278	0
				SC 7	34,000	50
			SC 7	72,500	22	
			SC 7	35,278	40	
Mean		792,176	34		124,729	43

Table 2. (Continued.)

	Steelhead			Summer Chinook		
	Tank #	Number of spores	Ratio % def/tot	Tank #	Number of spores	Ratio % def/tot
High	SA 3	560333	11	SC 2	29,444	20
	SA 3	156278	17	SC 2	157,500	44
	SA 3	68444	50	SC 2	51,500	44
	SA 3	394667	39	SC 2	186,000	37
	SA 3	63778	57	SC 2	136,889	77
	SA 4	107333	43	SC 3	73,333	55
	SA 4	72722	27	SC 3	355,333	20
	SA 4	105000	36	SC 3	38,889	14
	SA 4	355000	26	SC 3	227,500	54
	SA 4	36333	17	SC 3	44,722	29
	SA 7	135111	47	SC 9	71,111	10
	SA 7	97111	11	SC 9	129,000	44
	SA 7	330000	15	SC 9	82,667	42
	SA 7	593778	9	SC 9	134,056	26
	SA 7	408500	4	SC 9	69,000	33
Mean		232,293	27		119,130	37

DISCUSSION

EI-Matbouli and Hoffman (1991) provided results that suggest fumagillin can effectively reduce the number of MC spores through feed treatment trials. However, they used twice the concentration of fumagillin in their feed treatments compared to this study. They began feeding at 14 d and 30 d post-exposure, but continued treated feed for 130 days to the termination of the tests. They found no efficacy in the 30 d post-exposure treatment, but observed 70% to 100% spore reduction in the 14 d post-exposure treatment. Additionally, they showed a large percentage of deformed spores in feed treatment trials versus controls and speculated these spores might be nonviable. They expressed a concern that such a long period of drug exposure could result in some toxicity to fish as observed in Hedrick et al. (1988). Therefore, EI-Matbouli advised us to experiment with a shorter time duration in our feed trials.

The results of this study do not support the efficacy of fumagillin to prevent or control MC infection in steelhead and chinook salmon. Results of this study showed no significant reduction in the number of spores between control versus low or high feed treatments. Additionally, both control and treatment groups showed similar percentages of spore deformity. Based on the high spore counts and high variability between counts, the sample size of five fish per trial group was likely insufficient to provide adequate power to detect significant differences between drug trials tested. This problem of insufficient sample size was exacerbated by the mortalities due to the *Ichthyophthirius multifiliis* infection in steelhead control and low drug treatment trials.

The Pahsimeroi exposure was part of a larger study to evaluate fumagillin efficacy in treating MC. Lab trials in Bozeman represent the best conditions under a controlled environment and were

expected to be directly comparable to the 1991 studies. Even if the drug worked under lab conditions, as suggested by El-Matbouli and Hoffman, it was desirable to test it under field conditions. Additionally, this field test was designed to use continuous rearing on parasite positive water, as opposed to the limited exposure planned in the Bozeman Lab. Pahsimeroi Hatchery was selected because it represents a field location where high MC infectivity has historically been observed.

As noted, during the course of the Pahsimeroi field trial, a lab study using similar methods was completed at Bozeman Fish Tech Center using hatchery rainbow trout. At Bozeman similar methods were used, with the exception that the exposure to MC only occurred during the 14 days before feed treatment. A second field trial using rainbow trout was completed by IDFG Eagle Fish Health Lab in the South Fork Boise River beginning in August 1998. This trial used a 14 d in-river exposure, followed by feed treatment and rearing on parasite free water at the Eagle Fish Health Center. Preliminary results from both the Bozeman lab trial and the South Fork Boise field trials indicate no benefits from feeding fumagillin treated feed to reduce or prevent MC infections. No significant reduction in spore numbers were observed, and a large number of deformed spores were observed in all trials, indicating fumagillin was not efficacious in limiting MC infections (Dave Erdahl, U. S. Fish and Wildlife Service, Bozeman, Montana, personal communication).

Although studies conducted in 1998 did not prove effective, results by El-Matbouli and Hoffman (1991) and Hedrick et al. (1988) suggest additional testing is warranted. Determination of a drug treatment that limits MC infection in hatchery facilities would greatly reduce the exposure of naturally-produced salmonids in waters receiving fish from hatcheries infected with MC. Reducing infection rates seems especially critical for anadromous fish that migrate hundreds of miles and potentially could carry the parasite into downstream populations.

The Pahsimeroi results did provide data that suggests chinook salmon may be more resistant to infection by MC compared to steelhead trout. These results are consistent with past lab tests on MC adult chinook and steelhead tested for infection at spawning at the Pahsimeroi Hatchery (Keith Johnson, Idaho Department of Fish and Game, personal communication).

RECOMMENDATIONS

1. Small sample size and high variability of spore counts in infected fish limits study conclusions. Sample size should be increased, as determined by power analysis, to improve the ability to detect treatment effects in future studies.
2. Steelhead trout are highly susceptible to MC infection. Therefore, rearing and acclimation of steelhead in Pahsimeroi surface water should be minimized as much as possible. Development of parasite-free well water and switching to concrete rearing facilities would be desirable for the Pahsimeroi station.

ACKNOWLEDGMENTS

Dave Erdahl and Jim Bowker, U.S. Fish and Wildlife Service, Bozeman, Montana assisted in developing the experimental design for this study. All lab studies were completed at the Bozeman Fish Health Center, which helped minimize the potential variation in lab procedures and analysis. I am deeply grateful for all the work of Linda Staton, who completed all lab analysis with assistance of Crystal Hudson and Elizabeth MacConnell, Fish Health Biologists, USFWS, Bozeman. Doug Engmann and Kurt Schilling (IDFG) directed feeding and tank maintenance at Pahsimeroi and Sawtooth fish hatcheries, respectively. They were assisted by permanent and temporary personnel.

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ANNUAL PERFORMANCE REPORT
Subproject #3: Bull Trout Investigations

State of: Idaho

Grant No.: F-73-R-21, Fishery Research

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Title: Wild Trout Investigations

Subproject 3: Bull Trout Investigations

Contract Period: July 1, 1998 to June 30, 1999

ABSTRACT

Monitoring adult bull trout *Salvelinus confluentus* at salmon trapping facilities represents one method to monitor bull trout populations in response to proposed listing under the Endangered Species Act (1992) and implementation of no-harvest regulations (January 1, 1994). Idaho Department of Fish and Game maintains trapping facilities on four rivers where bull trout and chinook salmon *Oncorhynchus tshawytscha* upstream migrations occur. During 1998, 112 bull trout were collected in the Rapid River upstream trap, similar to the trap counts in 1997. Following no-kill regulations bull trap counts at Rapid River increased during 1995 and 1996 before declining during 1997 and 1998. Thirty-five bull trout were trapped at Crooked River (South Fork Clearwater River). The 1998 total was similar for the past two years at Crooked River. During 1998, the trap at East Fork Salmon River was not operated, and high water resulted in incomplete trap counts at Sawtooth Hatchery. Trap data are inconclusive regarding bull trout population response following implementation of no-harvest regulations in Idaho.

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INTRODUCTION

Bull trout *Salvelinus confluentus* were petitioned for listing under the Endangered Species Act (ESA) in 1992. In response to proposed listing, Idaho Department of Fish and Game (IDFG) enacted no-harvest regulations January 1, 1994. Subsequently, bull trout were formally listed as a threatened species June 5, 1998. Monitoring of bull trout populations at several sites has been conducted by IDFG since regulation changes in 1994. Bull trout are collected during operation of IDFG upstream salmon migration weirs at Rapid River (Little Salmon River tributary), East Fork Salmon River, Sawtooth Hatchery (Salmon River headwaters), and Crooked River (South Fork Clearwater River). This report provides an update of bull trout trapping records from these facilities.

METHODS

Upstream trapping facilities are maintained for monitoring and collection of brood stock for chinook salmon *Oncorhynchus tshawytscha* at Crooked River in the Clearwater River Drainage and Rapid River, South Fork Salmon River, East Fork Salmon River and Sawtooth Hatchery in the Salmon River Drainage. Bull trout are collected by project and hatchery personnel at all facilities except South Fork Salmon River. Since the proposed bull trout listing, data on bull trout numbers, size, and migration timing have been collected.

RESULTS

A total of 112 bull trout were trapped at Rapid River during 1998 (Table 3). Average size equaled 445 mm total length with 17% >500mm. The 1998 bull trout escapement was similar to 1997, but the lowest number recorded since the no-harvest regulation was adopted in 1994. Average size was similar to the past four years, but percent of fish >500 mm declined for the first year since the regulation change.

Thirty-five bull trout were trapped at Crooked River. Average size equaled 485 mm total length with 37% >500 mm. Numbers and size of fish was similar to prior years (Table 3).

The trap at East Fork Salmon River was not operated during 1998 due to concerns about potential impacts to chinook salmon, also listed under ESA. High water conditions at Sawtooth Hatchery resulted in incomplete trap records. This was the fourth consecutive year high water precluded accurate bull trout counts at Sawtooth.

Table 3. Bull trout data from trapping at Rapid River, Crooked River, East Fork Salmon River and Sawtooth Hatchery, 1973-1998

Year	Rapid River			Crooked River			EF Salmon River			Sawtooth Hatchery		
	No.	Mean	%>500 mm	No.	Mean	%>500 mm	No.	Mean	%>500 mm	No.	Mean	%>500 mm
1998	112	445	17	35	485	37				4 ^a		
1997	117	454	29	38	473	32	77 ^a	461	38	5 ^a	370	20
1996	221	455	26	36	438	17	175	475	37	4 ^a	492	50
1995	223	454	14	18	468	22	17 ^a	425	12	6 ^a	440	17
1994	146	421	6				61	469	24	38	363	16
1993	149	411	8	2 ^a			27 ^a	486	33	5 ^a		
1992	271	412	12	18	459	17	73	437	16	24	414	20
1991	293	414	12	1 ^a			89	478	44	17	429	12
1990	258			32	477	31	2 ^a			7		
1989	170						37					
1988	136											
1987	128						12 ^a					
1986	151						119	420	9			
1985	149											
1984	347						49	414	11	3		
1983	131											
1982	91											
1981	143											
1980	220											
1979	262											
1978	136											
1977	212											
1976	414											
1975	461											
1974	290											
1973	114											

^a Incomplete trap counts due to high water.

DISCUSSION

Bull trout were closed to harvest by sport fishing beginning in 1994. Bull trout escapement increased during 1995 and 1996 following the closure. In 1998, bull trout numbers at Rapid River were down for the second consecutive year compared to the 1995 and 1996. The 1998 number trapped was the second lowest observed since 1973, but still within the historic escapement range observed at Rapid River. This trend is opposite of other bull trout fisheries where harvest

restrictions were implemented. Bull trout populations increased in Oregon, Montana, and Alberta following harvest restrictions (Ratliff et al. 1994; Fraley and Shepard 1989; Mushens and Post 1998). Increases in bull trout at Rapid River during 1995 and 1996 occurred when no chinook fisheries occurred.

Trap counts of bull trout at Crooked River remained at the upper end of the observed range for the past 10 years. The lack of complete records for East Fork Salmon River and Sawtooth Hatchery preclude any conclusions for those bull trout populations.

RECOMMENDATIONS

1. Continue to monitor Rapid River bull trout escapement to determine if 1997 and 1998 escapement trends represent a threat to stock viability.
2. Operate the East Fork Salmon River trap every three to five years to maintain the bull trout data set. Years with average or below average snow pack represent the best opportunity to obtain trap data over the entire bull trout migration period.

ACKNOWLEDGEMENTS

Personnel from Clearwater, Rapid River, and Sawtooth hatcheries operated trapping facilities on Crooked River, Rapid River, and East Fork Salmon River and Sawtooth weirs, respectively. They added bull trout data collection to their normal chinook collection duties.

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