FISHERY RESEARCH

LEMHI RIVER AND TRIBUTARIES
INVESTIGATIONS INTO THE DISTRIBUTION OF *MYXOBOLUS CEREBRALIS*

June – October 2003

By:

Keith A. Johnson
Fish Pathology Supervisor

Douglas R. Burton
Fish Pathologist

Carla I. Hogge
Fish Health Technologist

IDFG Report Number 08-124
October 2008

Table of Contents

List of Tables

List of Figures

ABSTRACT

Language of the National Oceanic and Atmospheric Administration (NOAA) Fisheries Biological Opinion on habitat stresses reestablishing connection of tributaries. Both the federal and State of Idaho bull trout recovery plans have similar reconnection provisions. Within the Lemhi River drainage there are several tributaries that are currently either seasonally or permanently disconnected from the main stem. Efforts to evaluate the feasibility of tributary reconnections have been ongoing leading to a prioritization of tributaries within this effort. In this decision process one aspect that has not been addressed is the potential to expand the geographic range of *Myxobolus cerebralis*, the cause of salmonid whirling disease, as a result of reconnection. Therefore, the goal of our study was to evaluate the presence/absence of the parasite within streams being considered for reconnection using exposures of sentinel trout.

The first series of sentinel exposures was made in June, 2003 and utilized four sites in the main Lemhi River: at the L6 irrigation diversion, mid-Lemhi (1.5 km downstream of the confluence of Hayden Creek), upper Lemhi, and Big Springs Creek (2 km downstream of Leadore, ID). Live-boxes were similarly placed in Bohannon Creek, Wimpey Creek, Kenney Creek, Hayden Creek (near former hatchery ponds), Canyon Creek, Big Eightmile Creek, Big Timber Creek, Canyon Creek, and Hawley Creek. The second exposure series (October, 2003) concentrated on the Hayden Creek drainage, repeated the main stem Lemhi River sites of the first exposure series, and added a group of sentinels in Agency Creek.

Generally, sentinel rainbow trout exposed in all main stem and tributaries of the Lemhi River drainage became infected with *M. cerebralis.* The only exceptions were the groups exposed in Bohannon Creek and those exposed in tributaries of Hayden Creek. Disease signs appeared about midway in the 100-day post-exposure holding period at the wet laboratory of the Eagle Fish Health Laboratory, indicating an intense challenge of the parasite had occurred. A strong correlation between spore count and histopathological grade was obtained throughout this study.

The implication of these trials is the demonstration that *M. cerebralis* was uniformly distributed within both the main stem and the tributaries of the Lemhi River basin. Therefore, establishing reconnection of tributaries to the main stem Lemhi River would not further expand the known distribution of this parasite. The spore counts and histopathological grade metrics obtained in these trials were some of the highest we have demonstrated in sentinel trials ever in Idaho. Despite this fact, Chinook salmon population assessments of productivity (smolts produced per spawning female adult) in the Lemhi River are among the highest of Idaho rivers. This may be due to the reduced susceptibility of salmon to whirling disease compared to rainbow trout.

Authors:

Keith A. Johnson
Fishery Pathologist Supervisor

Douglas R. Burton
Fish Pathologist

Carla I. Hogge
Fish Health Technologist

INTRODUCTION

The Lemhi River in Idaho has been the subject of intensive fisheries and riparian habitat restoration efforts through a collaboration of private, state, and federal landowners. The drainage supports naturally reproducing populations of ESA-listed Chinook salmon *Oncorhynchus tshawytscha*, anadromous steelhead trout *O. mykiss*, and bull trout *Salvelinus confluentus*. Other salmonids include native cutthroat trout *O. clarki,* rainbow trout *O. mykiss,* and mountain whitefish *Prosopium williamsoni*, and non-native brook trout *S. fontinalis.* Constraints to natural production of salmonids have been identified to include irrigation withdrawal, degradation of the riparian habitat, and siltation resulting from past and current land uses.

The history of *Myxobolus cerebralis* (MC) detections in naturally-produced salmonids from the Lemhi River drainage begins in 1995 when the parasite was found in mountain whitefish and juvenile rainbow/steelhead trout. Early investigations by Idaho Department of Fish and Game (IDFG) demonstrated that MC was present in springs of Hayden Creek, an important Lemhi River tributary for anadromous fish production and the site of a former fish hatchery that was operated until the mid-80s. Chinook salmon parr from brood years 1994 to 1998 (collected from the main stem Lemhi River for a captive rearing experiment) had an overall MC prevalence of 28%. Chinook salmon smolts examined following a mortality event during main stem trapping in 2002 had a prevalence of 87%. This evidence of widespread distribution of the parasite within the Lemhi suggests that it may have been introduced and well established for some time prior to the first detections.

More than a century of agriculture in the Lemhi Valley has created an extensive system of irrigation diversions that act as fish migration barriers in many tributaries. Federal land managers, private landowners, and IDFG are considering the reconnection of several such tributaries to the main river to allow volitional movement of ESA-listed bull trout (Tom Curet, IDFG Salmon Region Fishery Manager, personal communication). No information on presence or absence of MC in many of these tributaries is available. Establishing reconnection could potentially result in introduction of the parasite into upstream portions of tributaries that also support populations of susceptible salmonids like cutthroat trout. In order to evaluate this risk of expanding the distribution of MC, it was necessary to examine the current distribution of the parasite within several portions of the Lemhi River drainage. Sentinel exposures of rainbow trout were selected as the method to provide this information and evaluations were initiated in 2003. These exposures were made in the same manner as several other trials in Idaho (Burton and Johnson 2003; Munson and Johnson 2003; Cavender et al. 2003) to provide information on prevalence and intensity of MC infectivity at the exposure sites.

STUDY SITE

The Lemhi River drains 326,860 hectares of East-central Idaho near the Montana border. Sentinel site locations were chosen to assess the presence of the parasite at locations where there was a potential for tributary reconnection, and where migration has never been restricted in order to compare the level of infectivity with those disconnected sites.

Twelve sites were chosen for the first trial (Exposure I; June 16-26, 2003). Three sites in the main stem Lemhi River included the L6 irrigation diversion (7.8 km upstream of the town of

Salmon), a mid-river location at the L39 diversion (1.4 km downstream of the confluence with Hayden Creek), and an upper river location (3.5 km NW of the town of Leadore). Tributary sites included Bohannon Creek, Wimpey Creek, Kenny Creek, Hayden Creek, Big Eightmile Creek, Big Springs Creek, Big Timber Creek, Canyon Creek, and Hawley Creek (Figure 1). The actual locations were selected based on the anticipated reliability of continued flow for the ten day exposure period. Coordinates for all sites were recorded using a Magellan 300 GPS device. Exposure I coordinates are presented in Table 1.

Eleven sites were chosen for the second trial (Exposure II; Sept. 29-Oct 9, 2003). These included four sites in the main stem Lemhi River, six sites in Hayden Creek and its tributaries (Basin Creek, Bear Valley Creek, West Fork, and East Fork), and Agency Creek (Figure 2). Map coordinates for Exposure II are recorded in Table 2.

OBJECTIVE

The purpose of these trials was to determine the extent to which MC has become established in the Lemhi River Basin by measuring the prevalence and intensity of parasite infection among sentinel fish exposed at selected sites in the main Lemhi River and key tributaries.

METHODS

Exposure I

Hayspur strain triploid rainbow trout were obtained as eyed-eggs and reared at the Eagle Fish Health Laboratory (EFHL) wet lab to a mean size of 0.42 g. Sentinel groups of fifty fish each were randomly selected from the main population and transported to and from the exposure site in plastic bags with water and oxygen. One group was kept at EFHL as a negative control for the sentinel groups. At the exposure site, each group of fish was placed in a cylindrical aluminum live-box 47.0 cm in length x 30.0 cm in diameter. Two replicate live-boxes were put out at the Lemhi River L6-Diversion site. Fish were exposed at each sentinel location for a ten-day period from June 16 through June 26, 2003.

Water chemistry and physical parameters were taken at each site when the fish were deployed and again when they were retrieved (Table 3). Water velocity (m/sec) was measured next to each the live-box using a FLO-MATE Model 2000 portable flow meter. Turbidity (FTU) was tested using a HANNA Instruments HI93703 turbidity meter. An YSI-556 MPS unit was used to measure pH and conductivity (mS/cm). Water temperatures were recorded at 30-minute intervals by STOWAWAY XTI temperature loggers placed in each live-box (Table 4).

Following the ten-day exposure, groups were returned to the wet laboratory at EFHL and held in separate 37-liter tanks supplied with 13°C flowing well water previously determined to be parasite free. Groups were fed three times weekly and checked daily for mortalities. The first sampling was performed September 3, 2003 at 910 Celsius temperature units post transfer (CTU). Ten sentinels from each exposure site were randomly selected, lethally anesthetized

with MS-222, measured (fork length in mm), weighed (g), and decapitated. Heads were split along the mid-sagittal line and half heads were treated separately. One half was fixed in 10% neutral buffered formalin (NBF) for conventional histological examination and scoring of the intensity of infection according to the MacConnell-Baldwin Scale (Andree et al. 2002), while the other half was frozen for possible future analysis by quantitative polymerase chain reaction testing (QPCR).

The final sampling was performed on October 1, 2003 at 1,300 CTU post transfer. All of the remaining fish were treated as above except one half head from each was frozen for quantitative spore counts using a hemocytometer following pepsin-trypsin digest (QPTD) methodology of Markiw and Wolf (1974), and the other half head frozen for future analysis by QPCR.

Exposure II

Troutlodge strain triploid rainbow trout were obtained as eyed-eggs and reared at the EFHL wet lab to a mean size 0.34 g. Exposure and sampling methods were identical to Exposure I with the following exceptions: Two replicate live-boxes with sentinel trout were placed at six separate exposure sites in the Hayden Creek drainage. The exposure began September 29, 2003 and the fish were returned to the EFHL wet lab on October 9, 2003. Fish were sampled for histology on December 11, 2003 at 936 CTU and on January 12, 2004 at 1300 CTU for QPTD.

RESULTS

Exposure I

The results of Exposure I demonstrated that those sentinel rainbow trout exposed in the main stem Lemhi River sites, including Big Springs Creek, became uniformly infected with MC at 100% prevalence and very high intensity of infection as measured by both spore counts (mean of 274,000) and histology scores (mean of 3.7) on the MacConnell-Baldwin scale (Table 5). These are some of the highest indicators of infection we have demonstrated in Idaho waters using similar methods (EFHL unpublished data). Regression analysis was used to compare QPTD and the MacConnell-Baldwin Scale (MBS) as methods of determining severity of individual infections. A significant positive relationship (P=0.0017) was found for the regression equation $y = 0.0077(x) + 1.7156$, when y = MBS mean score and x = mean QPTD spore count (x1000) with an R^2 of 0.4779. This indicates that either methodology can be used to measure individual severity of infection with similar test results.

Tributary exposures also showed high prevalence (85 – 100%) but lower intensity of infection in sentinel trout exposed at seven of eight sites. Bohannon Creek was the exception with one infected trout detected (4.8% prevalence). Hayden Creek was the only tributary in this series that is constantly connected with the main stem Lemhi River while all the other creeks in this series are either seasonally or permanently disconnected through irrigation diversion. The Hayden Creek exposure was done immediately upstream of the intake structure of a de-

commissioned hatchery site and resulted in 100% prevalence but relatively low intensity of infection. Since the objective of this work was to investigate whether tributary connection has a role in the distribution of the whirling disease parasite, an additional exposure series was needed to provide more information from Hayden Creek.

Exposure II

The four sentinel groups exposed in the main Lemhi River (Table 6) had high prevalence but much lower intensity of infection in the second exposure compared to the first. The trend of highest *M. cerebralis* infectivity in late spring has also been demonstrated in other sentinel studies in Idaho waters (Burton & Johnson; 2003; Munson & Johnson 2003). Sentinels placed in Agency Creek became infected in a manner similar to the tributary groups of the first series. Regression analysis of QPTD mean spore counts to MBS mean scores showed a significant positive relationship (P=0.000003) for the regression equation $y = 0.0307(x) + 0.3927$ (y = MBS mean score and x = mean QPTD spore count x1000) with an R^2 of 0.7774.

The sentinels exposed in the Hayden Creek locations included three sites: Hayden Creek at the former hatchery intake, lower Hayden Creek diversion (LHC 01), and Basin Creek, (two replicate sentinel groups at each site). The agreement of the infection results was very good for both prevalence and intensity measures at these sites. Those groups exposed in Basin Creek, a lower tributary to Hayden Creek, had 100% prevalence and 100,000 spores per head in the sentinels which were the highest of any other groups in this series. Whereas typically during high spring run off there is a water connection of Basin Creek with Hayden Creek, during this exposure series no water connection was observed. Finally, fish exposed in the three upper tributaries of Hayden Creek (Bear Valley Creek, East Fork Hayden Creek, and West Fork Hayden Creek), were all free of detectable infections. This information suggests that there were two origins of MC infection in lower Hayden Creek, while the parasite has not become established in the upper reaches.

DISCUSSION

Myxobolus cerebralis infections of wild salmonids collected from the Lemhi River have been known since 1995. This study is the first to make a systematic survey of the distribution of this parasite within the river basin. This study establishes the baseline data to examine whether establishing migration connection might influence this distribution into the future. A 2006 sentinel study on the Big Lost River was funded by Trout Unlimited (Szymalo 2007) to answer whether the distribution of MC in the Big Lost River has changed in the decade since the work of Elle (1997). The conclusions of the second study were that the distribution of MC remained the same during the intervening decade while the intensity of infection decreased. The current work reported here would allow a similar examination of the time course of MC presence in the Lemhi River as affected by establishing connectivity within various sections of the drainage.

Intuitively, because MC is already widely distributed within all sites examined in this study, establishing tributary reconnections to permit natural migration into these tributaries would not expand the distribution of the parasite within the basin. It is important to note that Hayden Creek has always been connected for migration of anadromous and resident salmonids

and yet the three main tributaries of Bear Valley Creek, East Fork Hayden Creek and West Fork Hayden Creek were not infectious for the parasite.

In spite of this evidence of MC presence in the drainage, redd counts of resident rainbow trout done by IDFG Salmon Region personnel on Big Springs Creek from 1994 to the present demonstrate a stable or increasing population trend (Tom Curet IDFG, personal communication). Within the angling public, this creek has the reputation for having the best fishing for trout in the basin. The Lemhi River has been the site of intensive supplementation research on Chinook salmon and steelhead for many decades. The estimations of smolt productivity per adult female of both species are among the highest for anadromous waters of Idaho. If MC were limiting productivity it should be apparent, especially with steelhead due to their greater susceptibility; this does not seem to be occurring.

ACKNOWLEDGEMENTS

We want to gratefully acknowledge the support provided for this project by the Fish Health Technologists of the Eagle Fish Health Laboratory: Sharon Landin and Roberta Scott. They were successful in generating the spore enumeration data for this test consistently between each of them and providing those data in a timely manner. They also should be commended for implementing the highly technical QPCR protocol. We would also like to thank Mike Colvin who assisted in some of the field work in this study, graciously read our histological slides providing MacConnell-Baldwin pathology scores, and for performing the regression analyses. Angie Klinginsmith provided laboratory assistance and Aaron Golart, along with IDFG Eagle Hatchery technicians, provided animal care. The assistance of Greg Lowell, IDFG Salmon Region was especially appreciated and he provided extensive local knowledge which proved invaluable in conducting the field portion of the test. The efforts of Lani Clifford in formatting the manuscript are greatly appreciated.

REFERENCES

Andree, K.B., R.P. Hedrick, and E. MacConnell, 2002. A review of the approaches to detect *Myxobolus cerebralis,* the cause of salmonid whirling disease. American Fisheries Society Symposium 29:197-211.

Burton, D.R. and K.A. Johnson, 2003. Seasonal infectivity of *Myxobolus cerebralis* to rainbow trout *Oncorhynchus mykiss* exposed at monthly intervals in the South Fork Boise River. Idaho Department of Fish and Game, Fishery Research Report 03-39, Boise, Idaho.

Cavender, W.P., K.A. Johnson, and K.D. Cain. 2003. Distribution of *Myxobolus cerebralis* within a free-flowing river system during the migration period for juvenile anadromous salmonids in Idaho. Journal of Aquatic Animal Health 15(2) 158-166.

Eagle Fish Health Laboratory Database, unpublished. Idaho Department of Fish and Game, 1800 Trout Rd., Eagle, Idaho 83616.

Elle, Steven, 1997. Project 3. Wild Trout Investigations. Idaho Department of Fish and Game, Annual Performance Report 97-38, Boise, Idaho.

Markiw, M. E. and K. Wolf. 1974. *Myxozoma cerebralis*: isolation and concentration from fish skeletal elements – sequential enzymatic digestions and purification by differential centrifugation. Journal of the Fisheries Board of Canada 31:15-20.

Munson, A.D. and K.A. Johnson, 2003. Monthly variation in prevalence and intensity of *Myxobolus cerebralis* in sentinel rainbow trout exposed to river water supplies of Sawtooth and Pahsimeroi Hatcheries. Idaho Department of Fish and Game, Fisheries Research Report 03-51, Boise, Idaho.

Szumylo, D. M. 2007. Investigating Whirling Disease in the Upper Big Lost River Basin of Mackay, Idaho. M.S. Thesis, Duke University, Durham, North Carolina.

Table 1. Map coordinates and stream width of sentinel Exposure I sites in the Lemhi River drainage during June 2003 (mapping datum NAD27).

Site	UTM Coordinates Zone	mE	mN	Stream Width (m)
Lemhi River @ L6 Diversion (Lower reach)	12T	280242	5000829	20
Lemhi River @ L39 Diversion (Middle reach)	12T	292394	4973062	35
Lemhi River Upper reach (I)	12T	310848	4952652	13
Big Springs (I)	12T	310717	4952441	5.8
Bohannon Creek	12T	286672	5002088	2.5
Wimpy Creek	12T	286047	4997174	8
Kenney Creek	12T	290822	4989085	6
Hayden Creek Hatchery	12T	289487	4968187	11
Big Eightmile Creek	12T	303409	4951653	4.4
Big Timber Creek	12T	311580	4947826	3.5
Canyon Creek	12T	319027	4952931	2.6
Hawley Creek	12T	324521	4947198	3.1

Table 2. Map coordinates and stream width of sentinel Exposure II sites in the Lemhi River drainage during Sept.-Oct. 2003 (mapping datum NAD27).

Site	UTM Coordinates			Stream Width (m)
	Zone	mE	mN	
Lemhi River @ L6 Diversion (Lower reach)	12T	280242	5000829	18
Lemhi River @ L39 Diversion (Middle reach)	12T	292394	4973062	21
Lemhi River Upper reach (II)	12T	307431	4955483	9.3
Big Springs (II)	12T	307368	4955335	6.3
Agency Creek	12T	297463	4980282	2.4
Hayden LHC-01	12T	292431	4971386	8
Hayden Creek Hatchery	12T	289487	4968187	5.5
Basin Creek	12T	284121	4968181	1.1
Bear Valley Creek	12T	285544	4960928	5.8
West Fork Hayden Creek @ Boulder Flat	12T	285314	4959543	5.8
East Fork Hayden Creek	12T	285538	4959511	1.5

Table 3. Water chemistry and physical parameters of sentinel exposure sites in the Lemhi River drainage during 2003.

Site	Date	Water Velocity (m/sec)	pH	Turbidity (FTU)	Conductivity (mS/cm)
Lemhi River-L6 Diversion (Lower reach)	June16	0.65	7.6	5.2	0.350
	June 26	0.36	8.4	5.0	0.412
	Sept 29	0.02	8.5	1.06	0.537
	Oct 9	0.02	8.1	6.74	0.549
Lemhi River-L39 Diversion (Middle reach)	June16	0.34	7.5	3.7	0.239
	June 26	0.70	7.8	3.4	0.367
	Sept 29	0.34	8.0	3.33	0.508
	Oct 9	0.40	7.9	8.68	0.528
Lemhi River Upper reach (I)	June16	0.20	8.3	13.2	0.422
	June 26	0.70	8.2	1.7	0.420
Lemhi River Upper reach (II)	Sept 29	0.14	8.2	*	0.408
	Oct 9	0.24	8.5	6.53	0.414
Big Springs (I)	June16	0.38	8.0	2.2	0.302
	June 26	0.80	8.1	5.7	0.309
Big Springs (II)	Sept 29	0.35	8.1	*	0.338
	Oct 9	0.35	8.1	9.75	0.339
Bohannon Creek	June16	0.65	7.9	4.91	0.067
	June 26	0.28	7.5	4.24	0.088
Wimpy Creek	June16	0.05	7.7	15.04	0.102
	June 26	0.80	7.7	9.12	0.160
Kenney Creek	June16	0.49	7.1	4.16	0.082
	June 26	0.80	7.3	3.17	0.121
Hayden Creek Hatchery	June16	0.25	7.0	9.8	0.056
	June 26	0.15	7.8	1.5	0.089
	Sept 29	0.02	8.1	1.34	0.336
	Oct 9	0.02	8.2	10.36	0.188
Big Eightmile Creek	June16	0.65	7.7	2.61	0.053
	June 26	0.66	7.8	0.26	0.068
Big Timber Creek	June16	0.03	7.4	3.66	0.066
	June 26	0.54	7.9	*	0.081
Canyon Creek	June16	0.07	8.2	37.37	0.304
	June 26	1.37	8.2	6.38	0.313
Hawley Creek	June16	0.01	8.2	1.95	0.329
	June 26	0.66	8.4	3.61	0.334

Table 3. Water chemistry and physical parameters of sentinel exposure sites in the Lemhi River drainage during 2003 (continued).

Site	Date	Water Velocity (m/sec)	pH	Turbidity (FTU)	Conductivity (mS/cm)
Agency Creek	Sept 29	0.05	7.2	3.01	0.158
	Oct 9	0.06	7.7	4.87	0.157
Hayden LCH-01	Sept 29	0.05	8.6	2.65	0.403
	Oct 9	0.08	8.2	5.99	0.420
Basin Creek	Sept 29	0.07	7.8	12.09	0.601
	Oct 9	0.18	8.0	10.36	0.647
Bear Valley Creek	Sept 29	0.12	6.4	0.40	0.700
	Oct 9	0.14	7.9	4.47	0.720
West Fork Hayden Creek @ Boulder Flat	Sept 29	0.05	8.6	2.65	0.403
	Oct 9	0.08	8.2	5.99	0.420
East Fork Hayden Creek	Sept 29	0.33	7.0	*	0.099
	Oct 9	0.36	7.5	5.85	0.103

*Not recorded or equipment malfunctioned.

Table 4. Water temperatures in the Lemhi River and tributaries, during two 10-day sentinel trials completed in June (Exposure Trial I) and September/October (Exposure Trial II), 2003. Data were recorded using STOWAWAY XTI temperature loggers placed inside live-boxes with the sentinel fish. Temperature was recorded at 30 minute intervals for the duration of each trial.

EXPOSURE SITE	EXPOSURE TRIAL	MEAN TEMP (C)	STD. DEV.	MINIMUM (C)	MAXIMUM (C)
Lemhi River @ L6	I	13.55	2.495	8.6	19.8
Lemhi River @ L6	II	12.64	1.781	9.0	15.9
Lemhi River @ L39	I	11.25	20.96	6.2	17.4
Lemhi River @ L39	II	10.78	1.939	7.0	14.4
Lemhi River Upper	I	No data			
Lemhi River Upper	II	10.28	20.13	6.2	14.0
Big Springs	I	8.88	2.385	5.3	15.2
Big Springs	II	10.54	3.026	5.3	16.5
Bohannan Creek	I	9.42	1.987	5.3	14.4
Wimpy Creek	I	9.43	2.034	5.3	14.4
Kenney Creek	I	10.67	3.470	4.1	20.3
Big Eightmile Creek	I	8.16	2.316	4.1	13.3
Big Timber Creek	I	9.88	3.373	4.1	17.1
Canyon Creek	I	10.00	3.107	4.5	17.8

Table 4. Continued

EXPOSURE SITE	EXPOSURE TRIAL	MEAN TEMP (C)	STD. DEV.	MINIMUM (C)	MAXIMUM (C)
Agency Creek	II	No data			
Hayden Creek (LHC-01)	II	10.91	1.935	7.4	14.4
Hayden Creek @ Hatchery	I	7.97	1.970	4.5	15.6
Hayden Creek @ Hatchery	II	11.71	1.241	9.4	14.1
Hayden Creek @ Hatchery	II	11.71	1.241	9.4	14.1
West Fork Hayden Creek @ Boulder Flat	II	6.9	1228	4.2	9.9
East Fork Hayden Creek	II	6.59	0.881	4.6	8.4
Basin Creek	II	9.38	2.528	4.9	14.4
Bear Valley Creek	II	7.13	1.228	4.5	9.2

Table 5. Summary statistics for comparison of histology and quantitative pepsin/trypsin digest (QPTD) results for sentinel fish from the Lemhi River Exposure I (June 16 to 26, 2003).

	QPTD			HISTOLOGY		
GROUP	N	PREVALANCE (%)	MEAN SPORES (x1000)	N	PREVALANCE (%)	MEAN SCORE
Control	20	0	0.0	10	0	0.0
Lemhi R. @ L6 r=1	18	100	289	10	100	3.1
Lemhi R. @ L6 r=2	18	100	207	10	100	3.5
Lemhi R. @ L39 (mid)	17	100	248	10	100	3.9
Lemhi R. Upper (I)	28	100	270.5	10	100	4.2
Big Springs Creek (I)	31	100	356.3	10	100	3.7
Bohannon Creek	21	4.8	1.3	10	10	0.1
Wimpey Creek	27	85.2	51.8	10	90	3.1
Kenney Creek	29	100	85.8	10	100	2.8
Hayden Cr. Hatchery	20	100	21.9	10	100	2.6
Big Eight-mile Creek	34	100	142.9	10	100	2.3
Big Timber Creek	39	97.4	80.6	10	100	3.2
Canyon Creek	33	100	96.2	10	100	3.5
Hawley Creek	32	100	186.5	10	100	3.8

Table 6. Summary statistics for comparison of histology and quantitative pepsin/trypsin digest (QPTD) results for sentinel fish from the Lemhi River Exposure II (Sept. 29 to Oct. 9, 2003).

		QPTD			HISTOLOGY		
GROUP		N	PREVALANCE (%)	MEAN SPORES (x1000)	N	PREVALANCE (%)	MEAN SCORE
Control		42	0	0.0	10	0	0
Lemhi R. @ L6		21	100	22.7	10	80	1.8
Lemhi R.@ L39		14	100	129.0	5	100	3.2
Lemhi R. Upper (II)		18	100	62.7	10	100	3.6
Big Springs Cr. (II)		22	100	74.4	10	100	3.6
Agency Creek		14	100	101.7	5	100	2.4
Hayden Cr. @ LHC-01	Rep1	26	100	39.8	5	80	2.6
	Rep2	24	100	41.2	5	60	1.4
Hayden Cr. @ Hatchery	Rep1	33	15.2	0.6	5	20	0.2
	Rep2	31	19.4	2.7	5	40	0.6
Basin Creek	Rep1	20	100	74.7	5	100	4.0
	Rep2	20	100	124.8	5	100	4.0
Bear Valley Creek	Rep1	11	0	0	5	0	0
	Rep2	19	0	0	5	0	0
West Fork Hayden Cr. @ Boulder	Rep1	31	0	0	5	0	0
	Rep2	30	0	0	5	0	0
East Fork Hayden Cr.	Rep1	7	0	0	0		
	Rep2	15	0	0	5	0	0

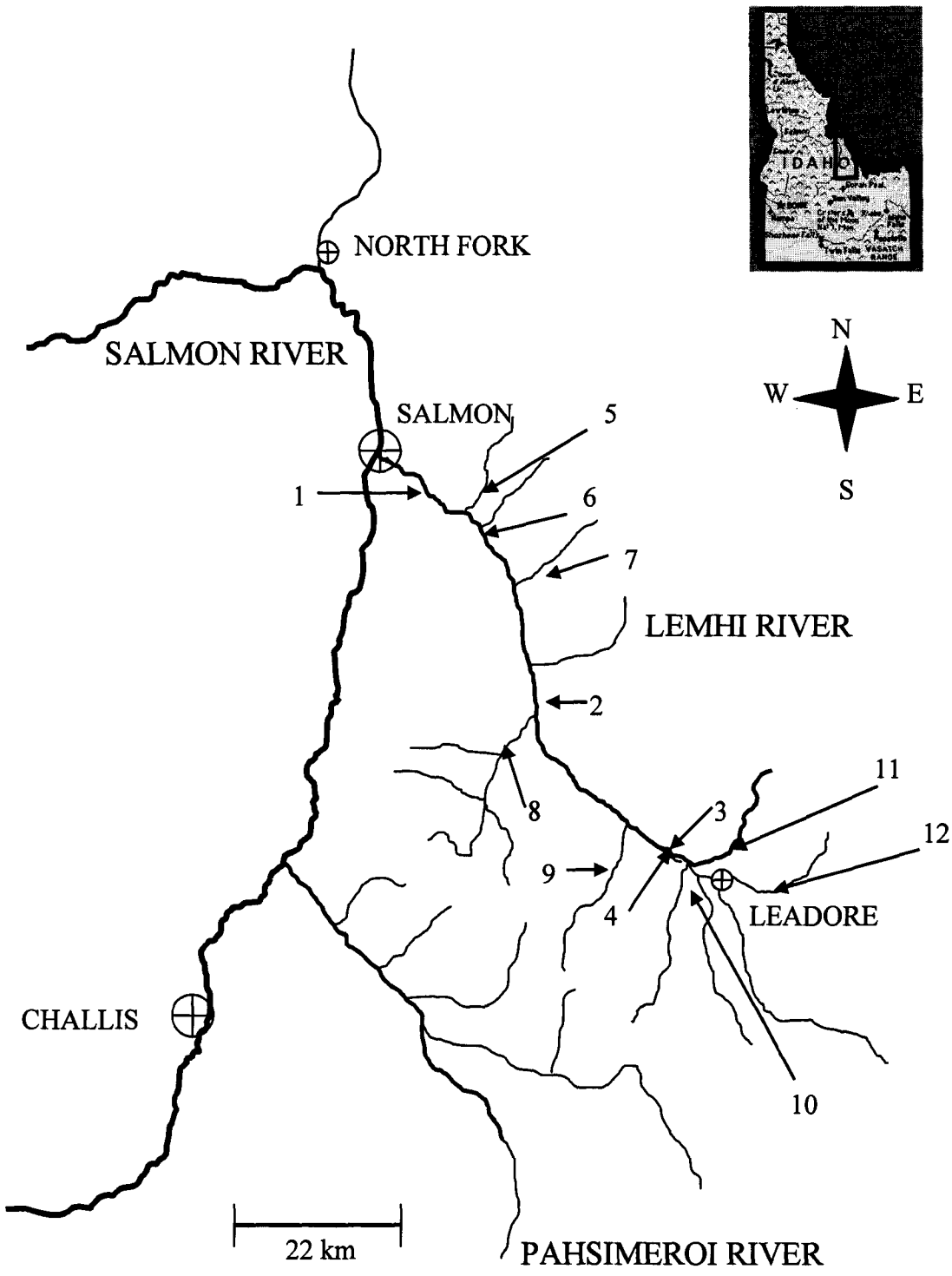

Figure 1. Schematic drawing of the Salmon and Lemhi Rivers showing the sentinel Exposure I sites: 1-Lemhi River @ L6; 2-Lemhi River @ L39; 3-Lemhi River Upper; 4-Big Springs; 5-Bohannon Creek; 6-Wimpy Creek; 7-Kenney Creek; 8-Hayden Creek Hatchery; 9-Big Eightmile Creek; 10-Big Timber Creek; ll-Canyon Creek; 12-Hawley Creek.

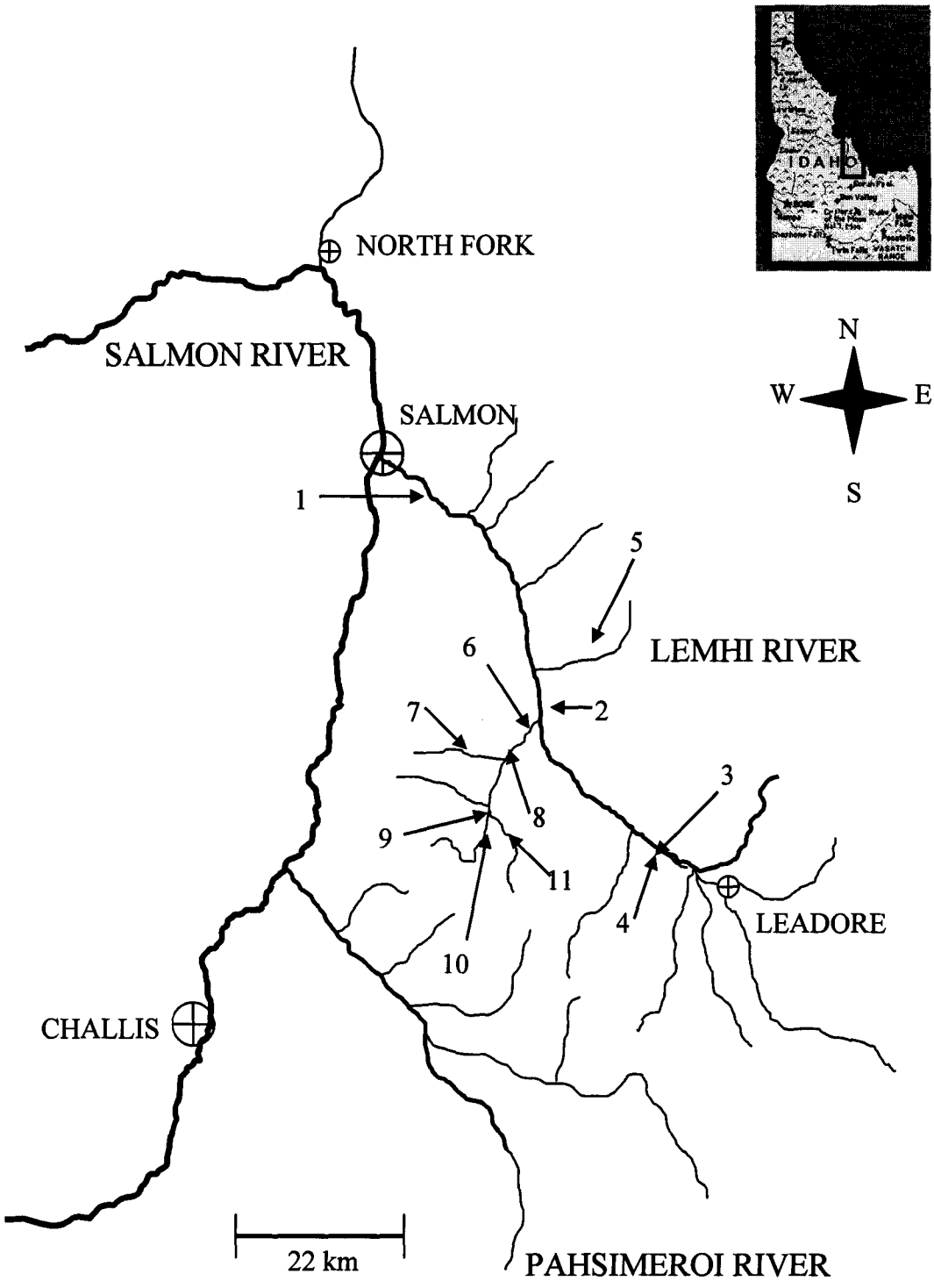

Figure 2. Schematic drawing of the Salmon and Lemhi Rivers showing the sentinel Exposure II sites: 1-Lemhi River @ L6; 2-Lemhi River @ L39; 3-Lemhi River Upper; 4-Big Springs; 5-Agency Creek; 6-Hayden Creek (LHC-1); 7-Basin Creek; 8-Hayden Creek Hatchery; 9-Bear Valley Creek; 10-Hayden Creek Boulder Flat; 11-East Fork Hayden Creek.

Prepared by:

Keith A. Johnson
Fishery Pathologist Supervisor

Douglas R. Burton
Fish Pathologist

Carla I. Hogge
Fish Health Technologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Edward B. Schriever, Chief
Bureau of Fisheries

Paul Kline, Assistant Chief of Fisheries