GAS BUBBLE TRAUMA MONITORING IN THE CLEARWATER RIVER DRAINAGE, IDAHO 1998

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REPORT TO NATIONAL MARINE FISHERIES SERVICE AND PACIFIC STATES MARINE FISHERIES COMMISSION, PORTLAND, OR

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

ABSTRACT

Select portions of the Clearwater and North Fork of the Clearwater rivers were electroshocked to estimate the incidence of gas bubble trauma (GBT) occurring in resident fish populations for the spring and summer months of 1998. The study area was divided into four sections and sampled weekly during periods of spill and non-spill from Dworshak Dam. Five thousand five hundred and forty one fish, representing 22 different species, were captured and examined for GBT. Two fish were detected with signs of GBT; exhibiting the lowest incidence of GBT in the last four years (0.04%). Reduced discharge and lower levels of total dissolved gases may have resulted in lower incidence of GBT in the 1998 monitoring period.

INTRODUCTION

Dissolved gas levels in the Clearwater River were expected to exceed standards of the Idaho Division of Environmental Quality (110% saturation) when discharges from Dworshak Dam exceeded 15,000 cfs during periods of flow augmentation for listed Snake River chinook salmon during 1998. The National Marine Fisheries Service (NMFS) requested a variance from these standards to allow a spill program that could result in total dissolved gas levels up to 120% saturation.

The Idaho Department of Fish and Game (IDFG) was contracted by NMFS to monitor the effects of flow augmentation on resident fish populations. Gas bubble trauma (GBT) is a condition found in fish as a result of elevated levels of total dissolved gases. Therefore, a GBT monitoring project was initiated by IDFG before, after and during flow augmentation.

STUDY AREA

The area monitored included approximately 1.5 miles of the North Fork Clearwater River from Dworshak Dam downstream to its confluence with the Clearwater River (Figure 1) and 39 miles of the Clearwater River downstream of the North Fork Clearwater River to Memorial Bridge in Lewiston. The study area was then divided into four sections:

(Section 1)--the 1.5 miles of North Fork Clearwater River between Dworshak Dam and the Clearwater River.
(Section 2)--the 12 miles of Clearwater River from the North Fork Clearwater River (RM 41) downstream to the town of Lenore (RM 29).
(Section 3)--the 14 miles of Clearwater River from the town of Lenore downstream to the Potlatch River (RM 15).
(Section 4)--the 13 miles of Clearwater River from the Potlatch River downstream to Memorial Bridge in Lewiston (RM 2).

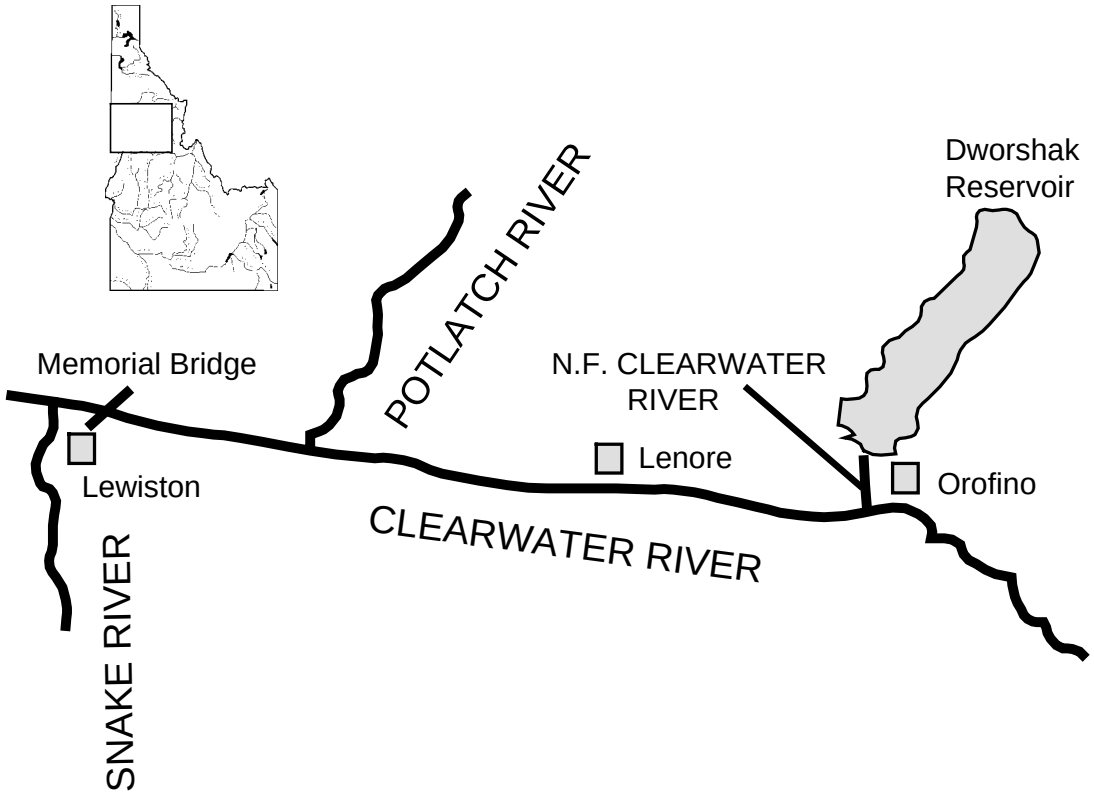

Figure 1. Location of gas bubble trauma sampling on the Clearwater River and the North Fork Clearwater River, 1998.

METHODS

Each section was sampled weekly from April 26 through August 22. As a general rule, one hundred fish were captured and examined from each section each week. An attempt was made to capture a representative sample of each fish species. Thus, when possible, no species was to comprise more than 30% of any given sample. Because of the concern regarding electroshocking trauma to the smaller chinook salmon juveniles, capture of these fish was avoided when possible. Individual fish were captured using standardized electroshocking techniques. A six meter aluminum boat, constructed for sampling large rivers, was equipped with a generator-powered pulsator providing controlled electrical power to two electrodes supported by arm booms at the bow of the boat. As fish were drawn to either electrode, they were netted and placed in a fresh flow live box until adequate numbers were obtained for sorting and examination.

Fish were anesthetized using tricanemethonate (MS-222). Once anesthetized, we identified fish to species, measured the fork length (mm), and examined each fish for external signs of GBT (exophthalmia and macroscopic bubbles in fins and on body surfaces). The eyes, lateral lines, and all unpaired fins were examined using 2x-6x magnifying lenses or a 40x microscope. Locations and extent of bubbles were noted for each fish. The fish were recovered in fresh water and then released within the sections from which they were collected.

A rank was assigned to each body part examined (fin, eye, and lateral line) based on percent area covered with gas bubbles. A single rank was assigned for both eyes. Therefore, the highest rank of either eye was recorded. If the area covered by bubbles was estimated to be near the boundary between ranks, then the higher rank was reported. A summary of ranks used in recording GBT data is listed below.

Rank	Percent area affected
0	0
1	1 to 5%
2	6 to 25%
3	26 to 50%
4	greater than 50%

RESULTS

The rate of discharge from Dworshak Dam averaged 9.31 kcfs during the monitoring period. Discharge reached a maximum level of 19.9 kcfs on July 21 and remained above 19.0 kcfs for the next ten days (Table 1). The discharge, by way of spill, averaged 2.19 kcfs and peaked at 10.2 kcfs, concurrently with the maximum level of discharge. Total dissolved gas (TDG) levels were equal to or in excess of 110% saturation in 13 of the 17 sample periods. Levels equal to or exceeding 115% saturation occurred in 2 of the sample periods. TDG levels did not reach 120% saturation during the monitoring period.

Five thousand five hundred and forty one individual fish comprising 22 different species were captured during the monitoring period (Table 2). The most common species captured was largescale sucker *Catostomus macrocheilus* (N=1,310) followed by hatchery steehead trout *Oncorhynchus mykiss* (N=918) and mountain whitefish *Prosopium williamsoni* (N=894). The most common species observed in each section were; hatchery steelhead trout (section 1), largescale sucker (sections 2 and 4), and mountain whitefish (section 3) (Appendix).

Two of the 5,514 fish captured exhibited signs of GBT: one hatchery steelhead trout captured May 7 in section 3 and one hatchery rainbow trout captured August 1 in section 1. Both cases of GBT resulted in an incidence of less than 0.03% of the fish captured during the sampling period (Table 3). The steelhead trout exhibited signs of GBT in only the left eye, which consisted of a single bubble covering approximately 25% of the eye. The hatchery rainbow trout, captured later in the monitoring project, exhibited signs of GBT in all unpaired fins and both eyes.

Table 1. Percent saturation of total dissolved gases (TDG) and average daily discharge (kcfs). The data was collected immediately below Dworshak Dam, Clearwater County, Idaho, 1998. (Information provided by the U.S. Geological Survey).

	April		May		June		July		August	
Date	TDG	KCFS	TDG	KCFS	TDG	KCFS	TDG	KCFS	TDG	KCFS
1			102	4.4	104	10.2	103	4	116	15.6
2			112	1.3	109	11.2	104	4	114	1.1
3			111	1.3	110	13	104	4.3	112	6.5
4			111	1.3	104	10.6	103	6.7	111	14.1
5			113	1.3	103	9.1	103	4.2	112	14.1
6			113	1.3	103	8.4	109	3.2	111	14.1
7			113	1.3	104	8.5	110	2.9	112	14.2
8			113	1.3	104	8.5	111	2.9	112	14.2
9			112	1.3	104	6.6	109	2.9	112	14.2
10			109	1.3	104	6.4	104	7	112	14.1
11			118	1.3	103	7.5	nd	9.1	111	14.3
12			111	1.3	104	8	100	9.4	111	14.3
13			110	1.3	105	8	110	12.9	111	14.3
14			108	1.3	104	7.6	110	13	112	14.4
15			107	1.3	104	6.1	110	13	111	14.4
16			109	1.3	104	7.4	113	14	111	14.4
17			107	1.3	102	7.7	112	14	111	14.3
18			108	1.3	103	5.2	112	14	111	13.8
19			111	6.1	102	5.2	117	15.5	109	14.1
20			nd	8	102	7.1	116	17.1	110	14.1
21			103	8.5	102	6.3	118	19.9	109	13.0
22			104	10	103	5.2	118	19.8	103	10.6
23			109	12.2	107	5.6	119	19.8		
24			109	13.4	107	6.1	117	19.8		
25			109	12.6	107	6.1	117	19.8		
26	98	9.9	106	11.9	102	6.1	118	19.8		
27	98	9.9	111	14.1	102	6.3	118	19.8		
28	99	9.9	109	11	105	6.3	118	19.8		
29	100	9.9	108	9.7	105	5.5	118	19.8		
30	100	9.9	109	12.4	106	4.6	118	19.7		
31			109	11.9			117	19.7		

Table 2. Number of fish captured in the Clearwater River, 1998. Numbers in parentheses indicate individual fish exhibiting signs of gas bubble trauma.

WEEK	BBH	BLS	BUL	CAR	CMC	COHO	CUT	HRBT	HSC	HST	KAM	KOK	LND	LSS	MWF	PKS	PMC	RSS	SCU	SMB	SPD	SQW	WST	Σ
1	---	1	1	---	3	2	---	---	---	118	---	---	---	69	7	---	---	3	6	---	---	1	7	218
2	---	38	---	---	3	---	---	2	---	202(1)	---	---	2	94	31	---	3	3	5	3	---	14	5	405(1)
3	---	13	1	---	4	---	---	1	1	179	---	---	1	85	46	---	1	5	34	8	---	12	6	397
4	---	29	---	---	11	---	---	1	---	141	---	---	1	109	33	---	1	8	38	6	1	11	5	395
5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
6	---	33	---	---	16	---	---	1	1	23	---	---	---	122	43	---	1	7	25	5	---	14	5	296
7	---	11	---	---	29	3	---	---	2	33	---	---	---	80	44	1	---	9	57	19	---	5	7	300
8	---	14	---	---	74	13	---	---	1	21	---	---	---	53	26	1	---	18	36	16	---	21	4	298
9	---	14	---	1	11	8	---	---	1	18	1	---	---	113	43	---	1	16	37	45	---	16	3	328
10	1	26	---	---	9	7	---	---	---	45	---	---	1	99	45	---	1	5	72	34	---	14	8	367
11	1	30	---	6	23	1	---	1	2	24	---	---	2	77	64	3	3	39	60	14	---	20	9	379
12	1	11	---	---	4	2	---	---	---	31	1	---	2	80	99	2	---	4	35	26	---	17	35	350
13	---	6	1	5	29	---	---	2	---	9	---	---	1	70	97	1	---	44	43	12	---	13	5	338
14	---	7	---	---	26	10	---	1	---	18	4	---	---	78	78	---	---	43	31	15	---	22	7	340
15	---	17	1	---	37	---	---	4	---	21	3	12	---	61	70	2	---	21	59	14	1	26	15	364
16	---	14	---	---	19	---	---	5(1)	---	9	2	1	---	70	87	2	---	21	36	14	---	40	19	339(1)
17	---	47	---	---	54	2	1	5	---	26	3	4	1	50	81	---	---	31	46	8	---	37	4	400
Σ	3	311	4	12	352	48	1	23(1)	8	918(1)	14	17	11	1310	894	12	11	277	620	239	2	283	144	5514(2)

BBH = brown bullhead (*Ameiurus nebulosus*)
BLS = bridgelip sucker (*Catostomus columbianus*)
BUL = bull trout (*Salvelinus confluentus*)
CAR = carp (*Cyprinus carpio*)
CMC = chiselmouth (*Acrocheilus alutaceus*)
COHO = coho salmon (*Oncorhynchus kisutchi*)
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LSS = largescale sucker (*Catostomus macrocheilus*)
MWF = mountain whitefish (*Prosopium williamsoni*)
PKS = pumpkinseed (*Lepomis gibbosus*)
PMC = peamouth (*Mylocheilus caurinus*)
RSS = redside shiner (*Richardsonius balteatus*)
SCU = sculpin spp. (*Cottus spp.*)
SMB = smallmouth bass (*Micropterus dolomieu*)
SPD = speckled dace (*Rhinichthys osculus*)
SQW = northern pikeminnow (*Ptychocheilus oregonensis*)
WST = wild steelhead (*Oncorhynchus mykiss*)

Table 3. Maximum total dissolved gases (TDG) per sampling period and percent occurrence of gas bubble trauma (GBT).

Date	Maximum TDG	Section 1 % GBT	Section 2 % GBT	Section 3 % GBT	Section 4 % GBT	Section 5 % GBT	All Sections % GBT
Apr 26-May 2	112	0.00	0.00	0.00	0.00	0.00	0.00
May 3-9	113	0.00	0.00	0.00	**1.02**	0.00	**0.25**
May 10-16	118	0.00	0.00	0.00	0.00	0.00	0.00
May 17-23	111	0.00	0.00	0.00	0.00	0.00	0.00
May 24-30	111	0.00	0.00	0.00	0.00	0.00	0.00
May 31-Jun 6	110	0.00	0.00	0.00	0.00	0.00	0.00
Jun 7-13	105	0.00	0.00	0.00	0.00	0.00	0.00
Jun 14-20	111	0.00	0.00	0.00	0.00	0.00	0.00
Jun 21- 27	107	0.00	0.00	0.00	0.00	0.00	0.00
Jun 28-Jul 4	106	0.00	0.00	0.00	0.00	0.00	0.00
Jul 5-11	111	0.00	0.00	0.00	0.00	0.00	0.00
Jul 12-18	113	0.00	0.00	0.00	0.00	0.00	0.00
Jul 19-25	119	0.00	0.00	0.00	0.00	0.00	0.00
Jul 26-Aug 1	118	0.00	0.00	0.00	0.00	0.00	0.00
Aug 2-8	114	0.00	0.00	0.00	0.00	0.00	0.00
Aug 9-15	112	**2.56**	0.00	0.00	0.00	0.00	**0.29**
Aug 16-22	111	0.00	0.00	0.00	0.00	0.00	0.00

DISCUSSION

Maximum discharge (kcfs), average total dissolved gases (TDG averaged throughout the monitoring period), and maximum total dissolved gases for 1998 were all lower than data from the previous three years (Cochnauer 1995, Cochnauer 1996, Cochnauer and Putnam 1997) (Table 4).

As a result of lower flows and lower TDG saturation only 2 of 5,541 total fish (0.04%) and 1 of 5,460 resident fish (0.02%) exhibited signs of GBT in the 1998 monitoring period. This is notably lower than data from previous years

The circumstances surrounding the two cases of GBT detected appear atypical and deserving of attention. The first case, a 225mm hatchery steelhead trout captured on May 7 in section 3, was found prior to flow augmentation (1.3 kcfs). Acquiring GBT via elevated TDG levels as a result of discharge from Dworshak Dam seems unlikely. However, in 1995, three individual fish (2 mountain whitefish, 1 chiselmouth chub) also exhibited signs of GBT during minimum flow period (≈ 1kcfs). This may suggest short periods of elevated TDG levels during dam operation at extremely low discharge. The second case was a 390mm hatchery rainbow trout captured August 1. Hatchery rainbow trout are designated as such, if they have no fin clips, are over 250mm, and show signs of abnormal dorsal fin growth, resulting from hatchery habitation. These fish are assumed to have been entrained through Dworshak Dam. In conclusion, the 1998 flow augmentation program appeared to have no detrimental population effects to resident fish.

Table 4. Discharge (kcfs), duration of elevated discharge (≥ 20 kcfs), percent saturation of total dissolved gases (TDG), and occurrence of gas bubble trauma (GBT) in resident fish species.

Year	**Discharge** (kcfs) Average	Maximum	# of days over 20 kcfs	**Total Dissoved Gases (%)** Average	Maximum	**GBT** (%)
1995	8.68	22.9	12	109.15	121.00	0.20
1996	9.01	22.6	24	109.01	122.95	0.20
1997	14.10	25.1	51	110.63	122.96	1.02
1998	9.24	19.9	0	106.97	119.00	0.02

LITERATURE CITED

Cochnauer, T. 1995. Gas bubble trauma monitoring in the Clearwater River drainage, Idaho 1995. Idaho Department of Fish and Game, Report to Pacific States Marine Fisheries Commission and National Marine Fisheries Service, Portland, OR. Lewiston, ID. 14pp.

Cochnauer, T. 1996. Gas bubble trauma monitoring in the Clearwater River drainage, Idaho 1996. Idaho Department of Fish and Game, Report to Bonneville Power Administration and National Marine Fisheries Service, Portland, OR. Lewiston, ID. 17pp.

Cochnauer, T. and S. Putnam. 1997. Gas bubble trauma monitoring in the Clearwater River drainage, Idaho 1997. Idaho Department of Fish and Game, Report to National Marine Fisheries Service and Pacific States Marine Fisheries Commission, Portland, OR. Lewiston, ID. 17pp.

Appendix A1. Number of fish captured in the Clearwater River (section 1), 1998. Numbers in parentheses indicate individual fish exhibiting signs of gas bubble trauma.

WEEK	BBH	BLS	BUL	CAR	CMC	COHO	CUT	HRBT	HSC	HST	KAM	KOK	LND	LSS	MWF	PKS	PMC	RSS	SCU	SMB	SPD	SQW	WST	Σ
1	---	---	1	---	1	2	---	---	---	18	---	---	---	15	2	---	---	---	2	---	---	---	5	46
2	---	2	---	---	2	---	---	---	---	83	---	---	2	8	---	---	---	2	5	---	---	---	2	106
3	---		---	---	2	---	---	---	1	67	---	---	---	10	---	---	---	1	12	1	---	---	3	97
4	---	3	---	---	---	---	---	---	---	61	---	---	---	17	4	---	---	---	13	---	---	---	2	100
5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
6	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
9	---	2	---	---	---	1	---	---	---	13	---	---	---	6	---	---	---	---	4	---	---	---	2	28
10	---	11	---	---	2	1	---	---	---	36	---	---	---	19	1	---	---	3	26	---	---	1	---	100
11	1	11	---	---	1	1	---	---	1	24	---	---	---	13	6	1	---	1	30	3	---	1	6	100
12	---	---	---	---	---	---	---	---	---	22	---	---	---	2	19	---	---	---	4	---	---	2	7	56
13	---	---	1	---	1	---	---	2	---	6	---	---	---	4	17	---	---	---	5	3	---	---	2	41
14	---	---	---	---	---	10	---	---	---	9	---	---	---	11	3	---	---	---	4	---	---	1	2	40
15	---	1	1	---	1	---	---	1	---	17	---	9	---	5	10	---	---	1	8	1	---	---	9	64
16	---	2	---	---	---	---	---	3(1)	---	7	---	---	---	11	11	---	---	---	2	---	---	1	2	39 (1)
17	---	7	---	---	1	2	1	4	---	24	---	3	---	6	28	---	---	2	17	---	---	2	3	100
Σ	1	39	3	0	11	17	1	10(1)	2	387	0	12	2	127	101	1	0	10	132	8	0	8	45	917 (1)

BBH = brown bullhead (*Ameiurus nebulosus*)
BLS = bridgelip sucker (*Catostomus columbianus*)
BUL = bull trout (*Salvelinus confluentus*)
CAR = carp (*Cyprinus carpio*)
CMC = chiselmouth (*Acrocheilus alutaceus*)
COHO = coho salmon (*Oncorhynchus kisutchi*)
CUT = cutthroat trout (*Oncorhynchus clarki*)
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SMB = smallmouth bass (*Micropterus dolomieu*)
SPD = speckled dace (*Rhinichthys osculus*)
SQW = northern pikeminnow (*Ptychocheilus oregonensis*)
WST = wild steelhead (*Oncorhynchus mykiss*)

Appendix A2. Number of fish captured in the Clearwater River (section 2), 1998. Numbers in parentheses indicate individual fish exhibiting signs of gas bubble trauma.

WEEK	BBH	BLS	BUL	CAR	CMC	COHO	CUT	HRBT	HSC	HST	KAM	KOK	LND	LSS	MWF	PKS	PMC	RSS	SCU	SMB	SPD	SQW	WST	Σ
1	---	---	---	---	---	---	---	---	---	59	---	---	---	11	---	---	---	---	3	---	---	---	---	73
2	---	2	---	---	---	---	---	1	---	50	---	---	---	25	7	---	---	---	---	3	---	11	1	100
3	---	4	---	---	1	---	---	---	---	47	---	---	---	20	10	---	---	3	7	---	---	6	2	100
4	---	4	---	---	8	---	---	---	---	27	---	---	---	23	10	---	1	7	8	2	1	4	---	95
5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
6	---	7	---	---	6	---	---	---	1	20	---	---	---	26	14	---	---	---	13	---	---	7	3	97
7	---	1	---	---	18	---	---	---	---	22	---	---	---	27	8	1	---	1	19	---	---	1	2	100
8	---	6	---	---	19	6	---	---	---	13	---	---	---	19	8	---	---	7	14	---	---	5	1	98
9	---	6	---	---	6	4	---	---	1	5	---	---	---	49	4	---	---	16	5	1	---	3	---	100
10	---	7	---	---	4	1	---	---	---	8	---	---	---	30	15	---	---	1	23	---	---	9	2	100
11	---	5	---	---	7	---	---	1	---	---	---	---	1	21	23	---	1	---	13	---	---	7	---	79
12	---	5	---	---	1	---	---	---	---	6	---	---	---	19	40	1	---	4	10	1	---	11	2	100
13	---	---	---	4	14	---	---	---	---	---	---	---	1	22	19	1	---	27	3	2	---	7	---	100
14	---	5	---	---	6	---	---	---	---	6	1	---	---	16	40	---	---	---	14	2	---	10	---	100
15	---	6	---	---	15	---	---	---	---	3	---	---	---	17	8	1	---	16	18	3	---	10	3	100
16	---	6	---	---	---	---	---	---	---	2	2	---	---	25	37	2	---	12	6	1	---	6	1	100
17	---	9	---	---	15	---	---	---	---	---	---	---	---	18	22	---	---	14	5	3	---	14	---	100
Σ	0	73	0	4	120	11	0	2	2	268	3	0	2	368	265	6	2	108	161	18	1	111	17	1542

BBH = brown bullhead (*Ameiurus nebulosus*)
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HRBT = hatchery rainbow trout (*Oncorhynchus mykiss*)
HSC = hatchery spring chinook salmon (*Oncorhynchus tshawytscha*)
HST = hatchery steelhead (*Oncorhynchus mykiss*)
KOK = kokanee salmon (*Oncorhynchus nerka*)
KAM = kamloop trout (*Oncorhynchus mykiss*)
LND = longnose dace (*Rhinichthys cataractae*)
LSS = largescale sucker (*Catostomus macrocheilus*)
MWF = mountain whitefish (*Prosopium williamsoni*)
PKS = pumpkinseed (*Lepomis gibbosus*)
PMC = peamouth (*Mylocheilus caurinus*)
RSS = redside shiner (*Richardsonius balteatus*)
SCU = sculpin spp. (*Cottus spp.*)
SMB = smallmouth bass (*Micropterus dollmieu*)
SPD = speckled dace (*Rhinichthys osculus*)
SQW = northern pikeminnow (*Ptychocheilus oregonensis*)
WST = wild steelhead (*Oncorhynchus mykiss*)

Appendix A3. Number of fish captured in the Clearwater River (section 3), 1998. Numbers in parentheses indicate individual fish exhibiting signs of gas bubble trauma.

WEEK	BBH	BLS	BUL	CAR	CMC	COHO	CUT	HRBT	HSC	HST	KAM	KOK	LND	LSS	MWF	PKS	PMC	RSS	SCU	SMB	SPD	SQW	WST	Σ
1	---	---	---	---	---	---	---	---	---	28	---	---	---	10	4	---	---	3	---	---	---	1	1	47
2	---	7	---	---	---	---	---	---	---	55	---	---	---	22	12	---	2	---	---	---	---	1	2	101
3	---	4	1	---	---	---	---	1	---	31	---	---	1	26	22	---	1	1	9	---	---	3		100
4	---	7	---	---	---	---	---	---	---	23	---	---	1	39	11	---	---	---	15	---	---	1	3	100
5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
6	---	16	---	---	8	---	---	---	---	2	---	---	---	34	16	---	---	5	9	2	---	5	2	99
7	---	9	---	---	1	---	---	---	2	6	---	---	---	23	28	---	---	1	23	1	---	2	4	100
8	---	5	---	---	22	5	---	---	1	5	---	---	---	28	5	1	---	1	14	4	---	6	3	100
9	---	6	---	---	5	---	---	---	---	---	1	---	---	25	30	---	---	---	22	6	---	4	1	100
10	---	2	---	---	1	2	---	---	---	---	---	---	1	27	14	---	---	---	17	---	---	3	---	67
11	---	8	---	2	4	---	---	---	1	---	---	---	1	29	30	---	2	2	10	1	---	7	3	100
12	---	3	---	---	2	---	---	---	---	2	1	---	2	43	21	---	---	---	17	1	---	4	4	100
13	---	3	---	---	4	---	---	---	---	1	---	---	---	28	36	---	---	11	10	1	---	3	3	100
14	---	1	---	---	6	---	---	---	---	2	3	---	---	30	27	---	---	11	9	4	---	3	4	100
15	---	5	---	---	6	---	---	1	---	---	2	1	---	21	33	1	---	1	17	5	---	6	1	100
16	---	4	---	---	19	---	---	---	---	---	---	---	---	15	10	---	---	9	10	2	---	30	1	100
17	---	12	---	---	8	---	---	1	---	2	3	1	1	19	23	---	---	7	18	1	---	3	1	100
Σ	0	92	1	2	86	7	0	3	4	157	10	2	7	419	322	2	5	52	200	28	0	82	33	1514

BBH = brown bullhead (*Ameiurus nebulosus*)
BLS = bridgelip sucker (*Catostomus columbianus*)
BUL = bull trout (*Salvelinus confluentus*)
CAR = carp (*Cyprinus carpio*)
CMC = chiselmouth (*Acrocheilus alutaceus*)
COHO = coho salmon (*Oncorhynchus kisutchi*)
CUT = cutthroat trout (*Oncorhynchus clarki*)
HRBT = hatchery rainbow trout (*Oncorhynchus mykiss*)
HSC = hatchery spring chinook salmon (*Oncorhynchus tshawytscha*)
HST = hatchery steelhead (*Oncorhynchus mykiss*)
KOK = kokanee salmon (*Oncorhynchus nerka*)
KAM = kamloop trout (*Oncorhynchus mykiss*)
LND = longnose dace (*Rhinichthys cataractae*)
LSS = largescale sucker (*Catostomus macrocheilus*)
MWF = mountain whitefish (*Prosopium williamsoni*)
PKS = pumpkinseed (*Lepomis gibbosus*)
PMC = peamouth (*Mylocheilus caurinus*)
RSS = redside shiner (*Richardsonius balteatus*)
SCU = sculpin spp. (*Cottus spp.*)
SMB = smallmouth bass (*Micropterus dolomieu*)
SPD = speckled dace (*Rhinichthys osculus*)
SQW = northern pikeminnow (*Ptychocheilus oregonensis*)
WST = wild steelhead (*Oncorhynchus mykiss*)

Appendix A4. Number of fish captured in the Clearwater River (section 4), 1998. Numbers in parentheses indicate individual fish exhibiting signs of Gas Bubble Trauma.

WEEK	BBH	BLS	BUL	CAR	CMC	COHO	CUT	HRBT	HSC	HST	KAM	KOK	LND	LSS	MWF	PKS	PMC	RSS	SCU	SMB	SPD	SQW	WST	Σ
1	---	1	---	---	2	---	---	---	---	13	---	---	---	33	1	---	---	---	1	---	---	---	1	52
2	---	27	---	---	1	---	---	1	---	14(1)	---	---	---	39	12	---	1	1	---	---	---	2	---	98(1)
3	---	5	---	---	1	---	---	---	---	34	---	---	---	29	14	---	---	---	6	7	---	3	1	100
4	---	15	---	---	3	---	---	1	---	30	---	---	---	30	8	---	---	1	2	4	---	6	---	100
5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0
6	---	10	---	---	2	---	---	1	---	1	---	---	---	62	13	---	1	2	3	3	---	2	---	100
7	---	1	---	---	10	3	---	---	---	5	---	---	---	30	8	---	---	7	15	18	---	2	1	100
8	---	3	---	---	33	2	---	---	---	3	---	---	---	6	13	---	---	10	8	12	---	10	---	100
9	---	---	---	1	---	3	---	---	---	---	---	---	---	33	9	---	1	---	6	38	---	9	---	100
10	1	6	---	---	2	3	---	---	---	1	---	---	---	23	15	---	1	1	6	34	---	1	6	100
11	---	6	---	4	11	---	---	---	---	---	---	---	---	14	5	2	---	36	7	10	---	5	---	100
12	1	3	---	---	1	2	---	---	---	1	---	---	---	16	19	1	---	---	4	24	---	---	22	94
13	---	3	---	1	10	---	---	---	---	2	---	---	---	16	25	---	---	6	25	6	---	3	---	97
14	---	1	---	---	14	---	---	1	---	1	---	---	---	21	8	---	---	32	4	9	---	8	1	100
15	---	5	---	---	15	---	---	2	---	1	1	2	---	18	19	---	---	3	16	5	1	10	2	100
16	---	2	---	---	---	---	---	2	---	---	---	1	---	19	29	---	---	---	18	11	---	3	15	100
17	---	19	---	---	30	---	---	---	---	---	---	---	---	7	8	---	---	8	6	4	---	18	---	100
Σ	2	107	0	6	135	13	0	8	0	106(1)	1	3	0	396	206	3	4	107	127	185	1	82	49	1443

BBH = brown bullhead (*Ameiurus nebulosus*)
BLS = bridgelip sucker (*Catostomus columbianus*)
BUL = bull trout (*Salvelinus confluentus*)
CAR = carp (*Cyprinus carpio*)
CMC = chiselmouth (*Acrocheilus alutaceus*)
COHO = coho salmon (*Oncorhynchus kisutchi*)
CUT = cutthroat trout (*Oncorhynchus clarki*)
HRBT = hatchery rainbow trout (*Oncorhynchus mykiss*)
HSC = hatchery spring chinook salmon (*Oncorhynchus tshawytscha*)
HST = hatchery steelhead (*Oncorhynchus mykiss*)
KOK = kokanee salmon (*Oncorhynchus nerka*)
KAM = kamloop trout (*Oncorhynchus mykiss*)
LND = longnose dace (*Rhinichthys cataractae*)
LSS = largescale sucker (*Catostomus macrocheilus*)
MWF = mountain whitefish (*Prosopium williamsoni*)
PKS = pumpkinseed (*Lepomis gibbosus*)
PMC = peamouth (*Mylocheilus caurinus*)
RSS = redside shiner (*Richardsonius balteatus*)
SCU = sculpin spp. (*Cottus spp.*)
SMB = smallmouth bass (*Micropterus dolomieu*)
SPD = speckled dace (*Rhinichthys osculus*)
SQW = northern pikeminnow (*Ptychocheilus oregonensis*)
WST = wild steelhead (*Oncorhynchus mykiss*)