BULL TROUT LIFE HISTORY, GENETICS, HABITAT NEEDS, AND LIMITING FACTORS IN CENTRAL AND NORTHEAST OREGON

ANNUAL REPORT

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Abstract

To fulfill one objective of the present study, genetic characteristics of Oregon bull trout will be determined by analysis of mitochondrial and nuclear DNA. During 1995, we collected and sampled a total of 1,217 bull trout from 46 streams in the Columbia River Basin. DNA analysis of those samples will be conducted at University of Montana. We primarily sampled juvenile fish near natal areas to increase the likelihood of identifying discrete populations while minimizing risk of injury to large spawners. Fork lengths of all fish sampled ranged from 2.6 to 60.5 cm with a median of 12 cm. Eighty-four percent of all bull trout sampled were less than 19 cm while two percent were larger than 27 cm.

Bull trout were collected by several methods, mostly by electrofishing. Eighty-six percent of all bull trout sampled were collected by electrofishing with a programmable waveform electrofisher. We observed injuries caused by electrofishing to 8% of that proportion. Based on preliminary analysis, no waveform combination used appeared less injurious than others. Highest voltages appeared less injurious than some that were lower. Frequency of electrofishing injury was significantly correlated to fork length over the range from 4 to 26 cm. There were indications for substantial risk for such injury to bull trout larger than 26 cm.

Other species found in association with bull trout included chinook salmon Oncorhynchus *tshawytscha*, mountain whitefish **Prosopium** *williamsoni*, rainbow trout **Oncorhynchus** *mykiss*, sculpins *Cottus* spp., cutthroat trout **Oncorhynchus** *clarki*, non-native brook trout *Salvelinus fontinalis*, and tailed frogs **Ascaphus** *truei*. Rainbow trout was the species most frequently associated with bull trout. No injury or mortality was observed for any of the associated species captured.

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Introduction

Bull trout *Salvelinus confluentus* is a state and federal "sensitive" species whose Oregon distribution includes portions of the Klamath Basin and several subbasins in the Columbia River Basin (Ratliff and Howell 1992). The U.S. Fish and Wildlife Service has determined that bull trout warrants listing as a federal threatened or endangered species but is precluded by other higher priority species. There is increased concern among state and federal management agencies for conservation of bull trout, which likely will depend on adequate protection and recovery strategies.

Knowledge of the population genetic structure is essential for effective conservation of a species (Allendorf and Leary 1988; Meffe and Vrijenhoek 1988; Quattro and Vrijenhoek 1989). Effective conservation should preserve the genetic integrity of bull trout and the evolutionary processes that affect the species. Consequently, a description of the genetic characteristics of Oregon bull trout is needed. That description would identify populations, estimate the diversity within and among them, and help prioritize their evolutionary significance. Bull trout genetic characteristics will be determined by analysis of DNA rather than isozymes because a high proportion of polymorphisms cannot be detected by protein electrophoresis. That leads to an underestimation of variability between and within populations and to inaccurate estimates of genetic drift *or* gene flow between local populations. These problems can be substantially reduced by DNA analysis since variation can be described at the nucleotide level (Guyomard 1993). But an important feature of mitochondrial DNA is its maternal inheritance. Since the ratio of nuclear to mitochondrial nucleotide diversity depends on population parameters including sex ratio and female population size, nuclear and mitochondrial DNA analysis should be undertaken together (Guyomard 1993).

Population distinctions and estimates of genetic diversity among bull trout have been reported (Leary et al. 1993; Williams et al. 1995), but those studies included only 6 streams from 4 Oregon river basins within the Columbia River drainage. This report summarizes the locations and collection of samples to determine the genetic characteristics of bull trout from additional Oregon river basins within the Columbia Basin through analysis of mitochondrial and nuclear DNA. It also presents an analysis of certain effects of those collection methods.

Project area

We sampled bull trout from 46 streams in 11 river basins (Table 1). Most samples came from streams in Oregon, but we also sampled bull trout from the N.F. Touchet River in Washington. Those should provide a good geographical complement to other samples from Walla Walla and S.F. Wenaha drainages.

Table 1.   Streams within the Columbia Basin in Oregon where bull trout tissue samples for DNA analysis were collected in 1995.

Basin	Subbasin	Stream
Willamette River	McKenzie River	S.F. McKenzie Anderson Creek"
Hood River	Middle Fork Hood River	Clear Branch Creek Compass Creek
Deschutes River	Metolius River	Jack Creek Whitewater River Jefferson Creek
	Shitike Creek	Shitike Creek
	Warm Springs River	Warm Springs River
John Day River	Upper John Day River	Indian Creek Call Creek Reynolds Creek[b] Roberts Creek[b] Deardorf Creek[b] Upper mainstem[b]
	Middle Fork John Day	Granite Boulder Creek Big Creek Clear Creek
	North Fork John Day River	Baldy Creek Clear Creek S.F. Desolation Creek S.F. Trail Creek
Umatilla River	N.F. Umatilla River	N.F. Umatilla River
Walla Walla River	Mill Creek	Upper Mill Creek
	S.F. Walla Walla River	S.F. Walla Walla River
	Touchet River	N.F. Touchet River'

Table 1. Continued.

Basin	Subbasin	Stream
Malheur River	N.F. Malheur River	Swamp Creek
	Middle Fork Malheur River	Meadow Fork of Big Cr.
Powder River	Upper Powder River	Silver Creek
	North Powder River	N.F. Powder River
Pine Creek	North Pine Creek	Elk Creek
	Upper Pine Creek	E.F. Pine Creek
Grande Ronde River	Upper Grande Ronde R.	Clear Creek Limber Jim Creek
	Catherine Creek	N.F. Catherine Creek
	Indian Creek	Indian Creek
	Minam River	Elk Creek Dobbin Creek
	Wallowa River	Upper Lostine River Bear Creek Hurricane Creek
	Wenaha River	S.F. Wenaha River W.F. Butte Creek
Imnaha River	Imnaha River	N.F. Imnaha
	Little Sheep	McCully Creek
	Big Sheep	Lick Creek

[a] Fish were collected in a downstream migrant trap.

[b] Groups were sampled from a diversion trap.

[c] Stream is located in Washington.

Methods and Materials

Bull trout from Anderson Creek were captured by a rotary screw trap (E.G. Solutions) set below a road culvert. Bull trout from Reynolds, Roberts, and Deardorff creeks as well as the upper mainstem John Day River (Table 1) were captured in irrigation diversion traps that were sampled daily from late spring through October. On Shitike Creek, Warm Springs River, and Whitewater River a standard bandwidth pulsed direct current electrofisher (Dirigo, Inc) was used. We collected most other bull trout with a single battery powered backpack electrofisher that produced pulsed direct current in variable band widths and frequencies (Smith Root, Inc; Model 12-A). Usually, one collector operated the electrofisher while moving upstream and another captured stunned fish with a dipnet. In some instances, another pair of collectors used a second electrofisher and similarly sampled another stream reach to reduce collection time. On Clear Branch, Compass, Shitike, Limber Jim and Clear (Grande Ronde Basin) creeks and Warm Springs River, a blocking net was stretched across the stream channel and one or two collectors electrofished downstream driving bull trout into the net. All electrofishing collections were from single-pass sampling. A few bull trout from S.F. Desolation Creek were captured by angling.

Target optimal and minimal sample sizes were 30 and 20 bull trout per stream, respectively. Samples from each stream were intended to include at least two age classes, judged from existing length at age data. We began sampling 19 April on Anderson Creek (Willamette Basin) where protocols (Appendix A) were tested. Snowmelt delayed sampling in most other streams until late May in the Metolius subbasin streams and later in other locations.

We recorded shocker voltages and waveform modes used as well as stream conductivity measured with a pocket-sized electronic meter. Sampling locations were logged into a global position recorder (Garmin model 45) and transferred to topographic maps later. Photographs of stream habitats and sampling methods were logged with date and time with a small 35-mm camera (Olympus Infinity Mini DLX).

All sampling equipment other than the electrofisher and dipnets were contained in a day pack carried by one collector. This allowed sampling in remote areas by two individuals. Often, approach hikes greater than 2 km from trai-lheads were necessary. We used felt-soled wading boots worn over light-weight, durable chest waders (Travelwaders, OS Systems) which could be easily carried or worn to sampling sites. Access and sampling at certain locations in the Minam and Imnaha subbasins required multi-day trips using backpacks or horses for support.

Results and Discussion

We collected and sampled 1,217 bull trout from the 46 streams in the Columbia River Basin shown in Table 1. We intend to identify and characterize bull trout populations and targeted sampling on juvenile fish near natal areas for two reasons. First,'such sampling should have minimized the occurrence of migrant fish from two or more populations being included in any given set of samples. We recognize that some fluvial adults may have been included in some sample sets, and that some juveniles sampled may have been progeny of such fluvial adults. However, we currently assume that sampling in the proximity of natal areas provides the greatest likelihood of identification of discrete populations. Second, we wanted to lower the risk of injury to spawners. We assumed that such fish, particularly large spawners, would not likely be near natal areas during summer and terminated sampling early in September.

Relationships between length, age, and maturation schedules are not well defined for most Oregon bull trout. In Metolius River tributaries, bull trout age 3t or less ranged from 2 to 18 cm between late April and early October (Ratliff 1992). In the Flathead River Basin, juvenile adfluvial bull trout were about 5-7 cm at age 1, 10-12 cm at age 2, and 15-17 cm at age 3. Eighty-four percent of all bull trout we sampled were less than 19 cm fork length (Figure 1). Adfluvial spawners in watersheds of the Intermountain West ranged from 30 to 90 cm (Pratt 1992; Kitano et al. 1994). Only two percent of all bull trout sampled were larger than 27 cm (Figure 1). Included in the total sampled but not plotted is one bull trout 60.5 cm from Whitewater River. Scales were collected from 1,180 fish sampled for age analysis later. Length data for bull trout from specific streams are shown in Table 2.
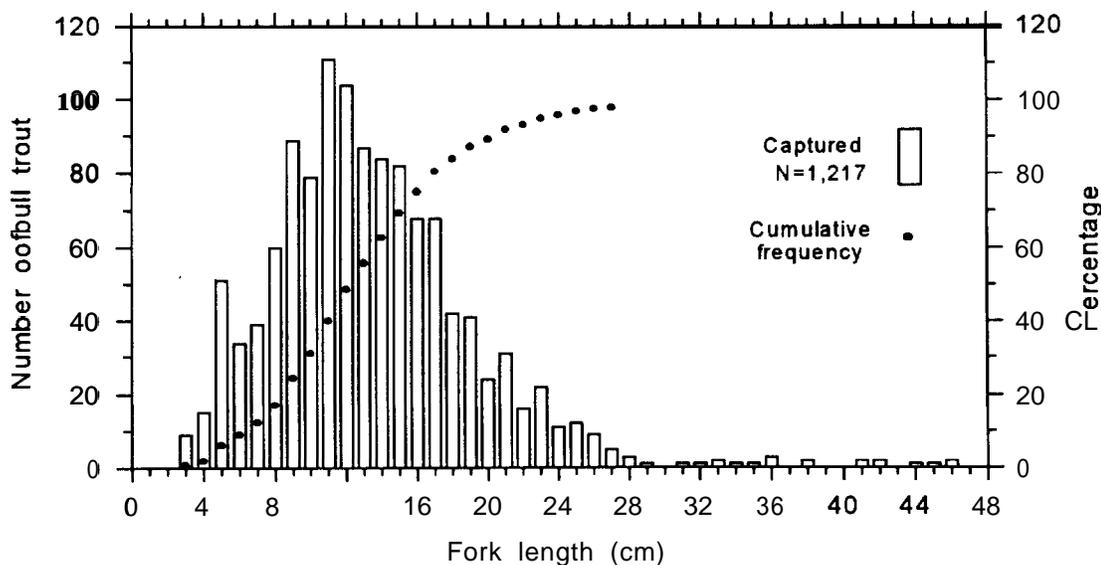

Figure 1. Bull trout captured and sampled for DNA analysis.

Table 2. Length statistics of bull trout sampled for DNA analysis in 1995. Unless noted, all fish were captured by electrofishing.

Basin: Population	N	Min	Max	Mean	SD	Median
				Length (mm)		
Willamette River:						
S.F. McKenzie R	21	49	411	95	86	60
Anderson Cr"	30	26	120	71	31	85
Hood River:						
Clear Branch Cr	33	73	170	102	25	94
Compass Cr	19	203	264	239	20	240
Deschutes River:						
Jack Creek	31	33	161	80	34	85
Whitewater R	30	41	605	127	94	109
Jefferson Cr	30	31	155	73	35	73
Shitike Cr	29	68	118	81	10	80
Warm Springs R	27	43	97	51	10	50
John Day River:						
Indian Cr	16	89	215	161	48	183
Call Cr	32	72	377	145	54	130
Reynolds Cr[b]	12	133	180	158	15	160
Roberts Cr[b]	7	102	330	164	77	147
Deardorf Cr[b]	2	185	246	216	43	216
Upper mainstem[b]	16	130	443	220	86	193
Granite Boulder Cr	25	80	205	116	34	108
Big Cr	30	56	167	120	31	126
Clear Cr	25	46	177	123	36	133
Baldy Cr	30	63	420	155	61	155
Clear Cr	30	86	190	126	22	125
S.F. Desolation Cr	17	90	222	156	31	158
S.F. Trail Cr	26	80	453	170	113	115
Umatilla River:						
N.F. Umatilla R	33	41	153	88	28	96

Table 2.   Continued.

| Basin: | | Length (mm) | | | | |
Population	N	Min	Max	Mean	SD	Median
Walla Walla River:						
Mill Cr	30	46	255	**93**	45	100
S.F. Walla Walla R	32	41	360	119	67	100
N.F. Touchet R	32	61	214	141	35	142
Malheur River:						
Swamp Cr	31	87	228	151	31	159
Meadow Fork Big Cr	30	87	330	195	53	210
Powder River:						
Silver Cr	30	81	171	133	22	137
N.F. Powder R	30	75	198	136	38	140
Pine Creek:						
Elk Cr	30	87	224	137	31	138
E.F. Pine Cr	30	78	257	176	45	183
Grande Ronde River:						
Clear Cr	31	60	180	122	29	119
Limber Jim Cr	22	56	229	119	59	103
N.F. Catherine Cr	26	78	355	155	61	146
Indian Cr	29	64	174	113	33	118
Elk Cr	36	71	254	153	50	151
Dobbin Cr	31	62	223	126	31	125
Lostine R	25	69	186	114	26	114
Bear Cr	30	98	454	154	84	112
Hurricane Cr	30	87	283	154	60	140
S.F. Wenaha R	30	41	188	104	37	109
W.F. Butte Cr	26	63	342	119	58	127
Imnaha River:						
N.F. Imnaha R	31	60	275	180	55	198
McCully Cr	14	83	230	149	49	157
Lick Cr	30	92	410	168	60	155

[a] Downstream migrants captured in a rotary screw trap.

[b] Downstream migrants captured in diversion traps.

By targeting juvenile bull trout, we may have reduced the estimated population genetic variance by reducing the number of age-classes sampled. We attempted to compensate by sampling within a range of lengths that may have included subadult fish as well as juveniles. We attempted to minimize the occurrence of siblings by extending the length of stream reach where sampling occurred. The optimal sample size (30) was met or slightly exceeded in 27 of 46 cases (Table 2). We were unable to obtain the desired minimum sample size (20) in eight cases, four of which were diversion trap samples.

Ninety-three percent of all bull trout sampled were collected by electrofishing (Table 3). Diversion traps captured downstream migrants from four streams associated with the upper mainstem John Day River as mentioned before. A rotary screw trap captured all bull trout sampled from Anderson Creek and one from S.F. McKenzie. Another S.F. McKenzie bull trout was captured by a trap net set in Cougar Reservoir by management biologists. We angled for 10 bull trout from upper S.F. Desolation Creek where the stream meanders through meadows. Biologists from the Confederated Tribes of the Warm Springs used a non-programmable waveform electrofisher that produced a standard bandwidth of pulsed direct current (DC) to capture 86 bull trout from Shitike Creek, Warm Springs River, and Whitewater River. All other bull trout (86 % of total), were captured with a programmable waveform electrofisher. With bull trout captured by that electrofisher, we evaluated injuries associated with collection.

Table 3. Methods used to capture bull trout sampled.

	Bull trout captured	
Method	N	% of total
Programmable waveform electrofisher (Smith-Root model 12-A)	1,052	86.4
Non-programmable waveform electrofisher (800 V Dirigo)	86	7.1
Diversion trap	37	3.0
Rotary screw trap	31	2.5
Angling	10	0.8
Trap net	1	0.1
Total	1,217	

Electrofishing injuries were defined as quickly developing, externally visible dark bands usually posterior to the dorsal fin related to sub-dermal hemorrhage. We did not use X-ray analysis or monitor delayed mortality. Eight percent of the bull trout captured with the programmable waveform electrofisher had visible injury (Figure 2). Such electrofishing caused known mortality to only one 16-cm bull trout from Meadow Fork of Big Creek in the Malheur Basin.
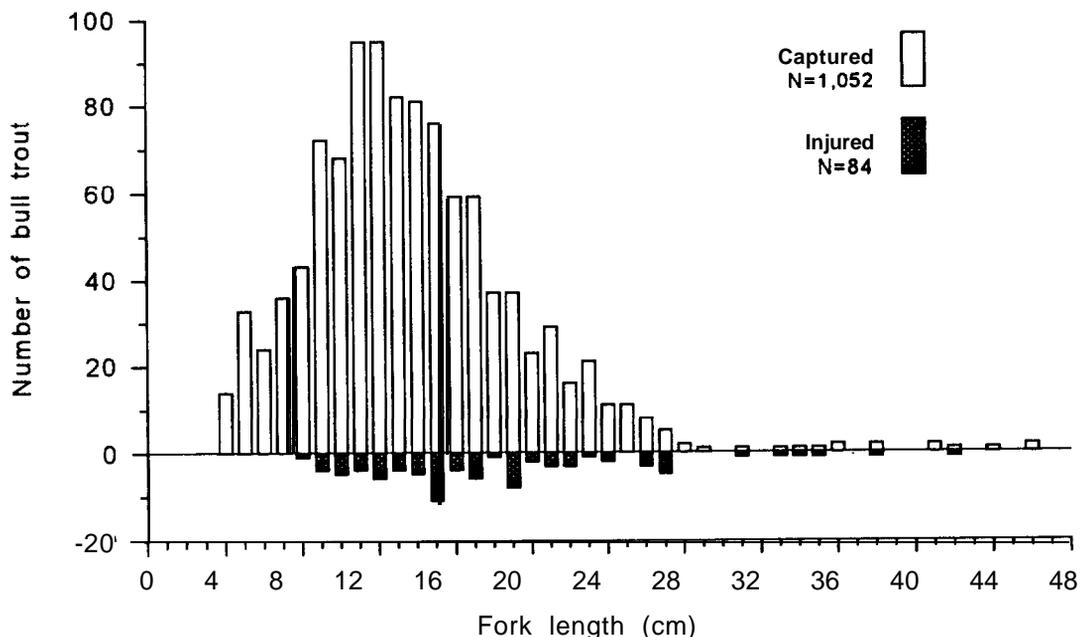

Figure 2. Bull trout collected with a variable waveform electrofisher.

The programmable waveform electrofisher can produce pulsed DC waves of standard, variable frequency, or variable pulse-width forms as well as gated bursts and continuous (non-pulsed) DC current. A standard pulsed waveform applies constant frequency and pulse width'while switched on. A variable frequency waveform decreases over the frequency range chosen within a chosen period (sweep) of time; pulse width remains constant. The cycle repeats each time the switch is released. A variable pulse width is similar except that pulse width narrows over the range chosen within the sweep time; frequency remains constant. The Smith-Root model 12A allows 256 possibilities within the five waveform types, any of which can be operated at a variety of voltages. In theory, variable waveform types would minimize injury since either frequency or pulse width are diminished as a fish is pulled from the periphery of the electrical field towards the anode. Preferred settings were within those waveform types, although we also used settings within the standard pulsed waveform Initially, we attempted to minimize frequency and voltage. Both were increased as necessary to effectively capture bull trout

depending on field conditions. Throughout sampling, we used only 21
combinations of settings within three possible waveforms (Table 4). Our
primary objective was to collect necessary samples, not thoroughly evaluate
waveform possibilities.   But we were able to query the data to examine the
relative injury rate associated with certain waveforms and voltages.

Table 4.   Pulsed direct current waveform combinations used to capture bull
trout.   Those used were various combinations of frequency, bandwidth, or sweep
time values shown within each form   Asterisks denote most frequently used
combinations within each waveform

| Waveform | Number | | Frequency (Hz) | Width (ms) | Sweep (sec) |
	possible	used			
Standard:	**90**	6	20	4	
			30*	6*	
			40	8	
			60		
Variable frequency:	75	5	40-4	4	6*
			60-6*	6*	8
Variable width:	75	10	30*	4-0.2	2
			45	6-0.3*	4
					6
					8*

   First, we determined the proportions of bull trout both captured and
injured with each waveform type. If a particular waveform was less injurious
than others, the proportion that it injured should be less than the proportion
that it captured.   Only variable frequency waveforms produced that tendency
(Figure 3).   However, an underlying assumption is that injury is independent
of fish size.   This will be addressed later, but it should be noted that
variable frequencies were used in situations where average fish length was
relatively low.   Furthermore, although those waveforms accounted for only 4%
of the injuries, they may have been less preferred by collectors since they
accounted for only 9% of bull trout captured.   Variable bandwidth waveforms
accounted for 57% of fish injured but were used to capture 54% of all bull
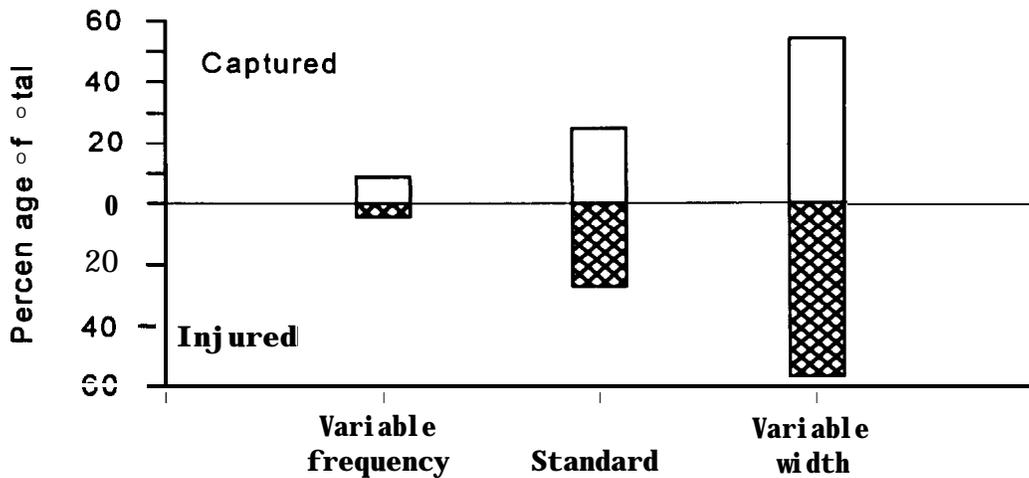trout sampled.

Figure 3. Proportion of bull trout collected at various waveforms.

Next, we determined the proportions of bull trout both captured and injured with each voltage regardless of waveform type. Like before, if a particular voltage was less injurious than others, the proportion that it injured should be less than the proportion that it captured. In addition, we expected to see increased proportions injured as voltage increased. Results were not as expected (Figure 4). In four of six cases, proportions injured were similar to proportions captured, and the second lowest voltage (600) produced the second highest injury percentage (24). Although we preferred low voltages, high streamflow and low conductivity sometimes required otherwise. Conductivities of 30 uS/cm or less were frequent; only Hurricane Creek and North Fork Imnaha River had conductivity greater than 100 uS/cm (Table 5).
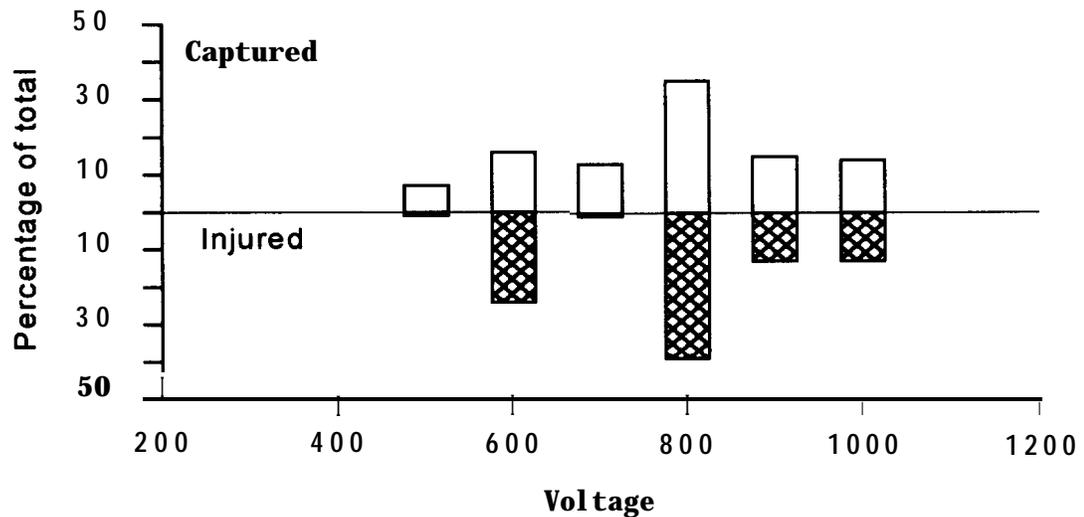
Figure 4. Proportion of bull trout collected at various voltages.

Finally, we tested the hypothesis that electrofishing injury would occur more frequently among larger than smaller bull trout. We determined the proportion of fish in each size class (1-cm increments) that were injured regardless of voltage or waveform setting. We considered only cases where the number of captured fish in each class was 8 or greater. There was a rather weak (r^2 = 0.39) but significant (P = 0.0014) linear relationship over lengths from 4 to 26 cm (Figure 5). Only five bull trout in the 27-cm class were captured, and beyond that length there were only 1 or 2 in each class which contained fish. Because of those low numbers, we were unable to quantify the relationship for bull trout larger than 26 cm. However, 11 of 22 bull trout from 27 to 46 cm were injured, suggesting a substantial risk for injury by electrofishing to older bull trout. The low r^2 indicates other factors also influenced the occurrence of injury. Two such factors probably include time spent by the fish in the electrical field and proximity to the anode when the current was first applied.

Table 5. Sampling dates, conductivities, and sympatric species associated with bull trout collected in 1995.

Basin: Population	Date sampled	Conductivity (uS/cm)	Sympatric species[a]						
			Bt	Co	Ch	Ct	Rb	Wh	Tf
Willamette River:									
S.F. McKenzie R	30 Aug	40			X	X			
Anderson Cr	19 Apr-25 May					X			
Hood River:									
Clear Branch Cr	05-08 Jun	30					x	x	X
Compass Cr	06 Jun, 06 Jul	30					x	x	
Deschutes River:									
Jack Creek	19-30 May	50							
Whitewater R	21 Aug	–							
Jefferson Cr	21 May-01 Jun	20							
Shitike Cr	26 Jun	20		X			X		
Warm Springs R	18 Jul	–							
John Day River:									
Indian Cr	19 Jul	60					x	x	
Call Cr	20 Jul	30					x	x	
Reynolds Cr[b]	31 May-10 Jul	–							
Roberts Cr[b]	14 Jun-16 Aug	–							
Deardorf Cr[b]	19 Jun, 18 Jul	–							
Upper mainstem[b]	15 Jun-07 Aug	–							
Granite Boulder Cr	18 Jul	40			X		X		
Big Cr	17 Jul	30					X		
Clear Cr	18 Jul	50			X		X		
Baldy Cr	03 Aug	–		X			X		
Clear Cr	17 Aug	–					x	x	
S.F. Desolation Cr	27 Jul	–				X			
S.F. Trail Cr	04 Aug	–					X		
Umatilla River:									
N.F. Umatilla R	28-29 Jun	20			X		X		

Table 5.   Continued.

Basin: Population	Date sampled	Conductivity (uS/cm)	Sympatric species[a]						
			Bt	Co	Ch	Ct	Rb	Wh	Tf
Walla Walla River:									
Mill Cr	10,13 Jul	50		X			x	x	
S.F. Walla Walla R	11-12 Jul	30		X			X		
N.F. Touchet R	05 Sep	30					X		X
Malheur River:									
Swamp Cr	25 Jul	20		X			X		
Meadow Fk of Big Cr	24,26 Jul	30	X	X			X		
Powder River:									
Silver Cr	16 Aug	50					X		
N.F. Powder R	15 Aug	20	X						
Pine Creek:									
Elk Cr (N. Pine)	17 Aug	60					X		
E.F. Pine Cr	18 Aug	70							X
Grande Ronde River:									
Clear Cr	22 Jun	20					X		
Limber Jim Cr	20-21 Jun	40							
N.F. Catherine Cr	28 Jul	30					X		X
Indian Cr	26-27 Jun	10					X		X
Elk Cr	01 Aug	10	X				X		
Dobbin Cr	03 Jul	10					X[c]		
Lostine R	22 Aug	10	X	x	x		X		
Bear Cr	02-03 Aug		X	X			X		
Hurricane Cr	23-24 Aug	160	X				X		
S.F. Wenaha R	04 Aug	30		X			X		X
W.F. Butte Cr	07 Sep	70							
Imnaha River:									
N.F. Imnaha R	26 Jul	190							
McCully Cr	26 Jul, 03 Aug	20							
Lick Cr	25 Jul	20		X			X		

[a] Bt = brook trout; Co = Cottus spp.; Ch = chinook salmon; Ct = cutthroat trout; Rb = rainbow trout; Wh = mountain whitefish; Tf = tailed frog.

[b] Traps were operated and sampled into October.

[c] Rainbow trout were found in the Little Minam River from the confluence of Dobbin Creek upstream, not in Dobbin Creek itself.
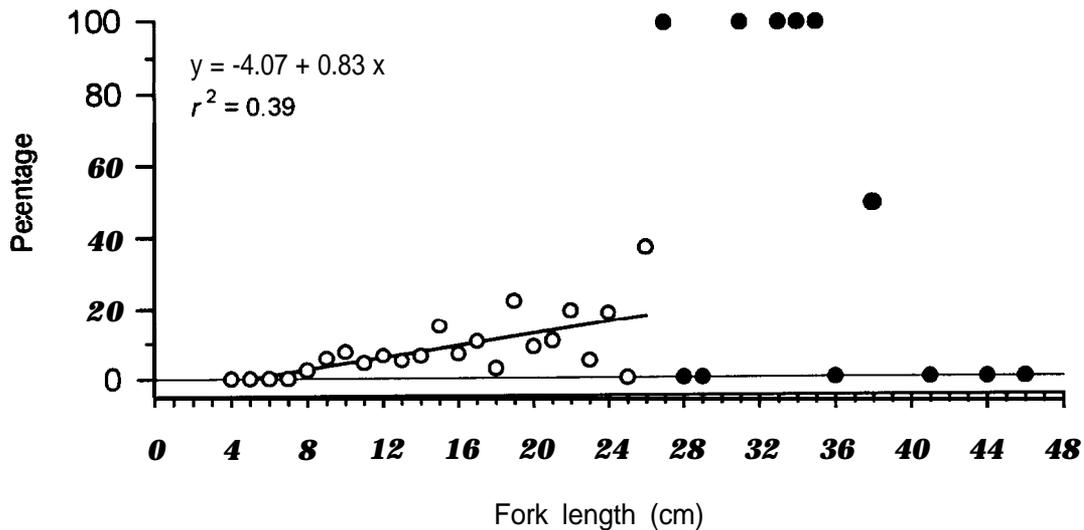
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Figure 5. Proportions of bull trout by size class with electrofishing injury. Classes where the number captured (*N*) was at least 8 have open circles. For *N* < 8, circles are closed.

We did not observe injuries to bull trout smaller than 8 cm. Their size coupled with frequent dark coloration may have obscured visual detection of injuries in some cases, thereby making some percentage of injury a possibility. Although we think the observed lack of injuries to fish smaller than 8 cm is related to size, we presently cannot rule out the possibility that it was also related to variable frequency waveforms (Figure 3).

In reaches sampled by methods other than diversion traps, bull trout were found alone in eight streams (19%); four of those were in the Deschutes Basin. Others included the North Fork Innaha River and Limber Jim, West Fork Butte, and McCully creeks (Table 5). A few juvenile chinook salmon Oncorhynchus tshawytscha were captured with bull trout in the upper Lostine River while some mountain whitefish *Prosopium williamsoni* were observed in Mill Creek. Rainbow trout Oncorhynchus mykiss were most frequently associated with bull trout (69% of streams), followed by sculpins Cottus spp. (31%), cutthroat trout Oncorhynchus *clarki* (19%) and non-native brook trout *Salvelinus fontinalis* (19%). The frequencies of association of those species with bull trout are very similar to those reported by Danbacher and Jones (In Press). We also encountered tailed frogs *Ascaphus truei* in six (14%) of those 42 streams. No injury or mortality was observed for any of the associated species captured.

Summary and Conclusions

We collected and sampled a total of 1,217 bull trout from 46 streams in the Columbia River Basin during 1995. For streams where samples were collected by methods other than diversion traps (42 cases), we successfully collected the necessary sample size (20-30 fish) in 38 cases. In the remaining four cases we sampled at least 14 bull trout in each. Diversion trap sample sizes (4 cases) ranged from two to 16. Mitochondrial and nuclear DNA analysis of samples to determine population distinctions will be conducted at University of Montana through 1996 and reported later. Sampling began 19 April on Anderson Creek in the Willamette Basin; it concluded 07 September on West Fork Butte Creek in the Grande Ronde Basin. The remoteness and complexity of habitats sampled for that collection required that sampling gear and collection procedures be lightweight, durable, easily transportable, and efficient. We believe that sampling protocols developed and refined during this study met those requirements and may be applied to similar sampling elsewhere.

Fork lengths of all fish sampled ranged from 2.6 to 60.5 cm with a median of 12 cm Eighty-four percent of all bull trout sampled were less than 19 cm while two percent were larger than 27 cm Scales were collected for 1,180 bull trout 5 cm or larger for age analysis.

Eighty-six percent (1,052) of all bull trout sampled were collected by electrofishing with a programmable waveform electrofisher. We observed injuries caused by electrofishing to 8% (84) of that number. No injuries associated with capture were seen on any other bull trout. Based on preliminary analysis, no waveform combination used appeared less injurious than others. Highest voltages appeared less injurious than some that were lower. Frequency of electrofishing injury was significantly correlated to fork length over the range from 4 to 26 cm There were indications for substantial risk for such injury to bull trout larger than 26 cm Given the complexity and remoteness of habitats, sampling and monitoring of bull trout populations by electrofishing likely will continue. We urge caution with such efforts, and suggest that sampling designs be well founded and schedules be timed to minimize encounters with larger, older individuals.

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Appendix A

Procedures for collection of tissue samples for DNA analysis.

Captured bull trout were carried in plastic buckets until they were sampled. A 9-l collapsible plastic bucket proved most useful, particularly in remote locations. Bull trout were anesthetized with a stock solution (10 g/l) of tricaine methansulfonate (MS-222), measured to fork length, then placed on a 25 x 15 x 1 cm piece of white plastic. From the caudal fin of bull trout 60 mm or larger, we cut two pieces of tissue each about the size of the cross-sectional area of a number 2 pencil. That size was necessary to insure a dried weight of at least 5 mg after storage in ethanol. Each piece of fin was then placed in a 2-ml cryopreservation vial filled with 95% ethanol and capped with a screw-on lid and O-ring seal. We numbered and labeled vials before going to the field to expedite sampling. All vials were kept in a storage rack fitted in a 25 x 14 x 5 cm plastic container covered with a snap-on lid secured with rubber bands. By taking two samples per fish, we produced duplicate sample sets from each stream. One set was shipped (United Parcel Service) to the University of Montana for mitochondrial and nuclear DNA analysis. The other was stored and archived at the ODFW lab in Corvallis. Fin samples from bull trout less than 60 mm were combined into a single vial with no duplication.

Scale samples were taken from all fish 50 mm or larger. Previous investigations of Oregon bull trout indicated generally that scales from fish smaller than 50 mm lacked circuli (L. Borgerson, ODFW, personal communication). Visible sub-dermal hemorrhages associated with electrofishing were noted. Finally, we placed sampled bull trout in a plastic tub with fresh water for recovery from anesthesia, then returned them near sites of capture.