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Technical Report for Upper Snake River Biological Opinion # 1009.2700

Distribution, Abundance, and Influence of Habitat Conditions for Bull Trout (*Salvelinus confluentus*) in the North Fork Boise River Basin, Idaho

U.S. Department of the Interior
Bureau of Reclamation

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DISTRIBUTION, ABUNDANCE, AND INFLUENCE OF HABITAT CONDITIONS FOR BULL TROUT (*Salvelinus confluentus)* IN THE NORTH FORK BOISE RIVER BASIN, IDAHO

Abstract

Forty-two 100-m stream reaches were surveyed annually during the months of July and August, 1999-2002 in the North Fork Boise River watershed to collect data on fish community composition and abundances and related habitat conditions. Emphasis was placed on environmental conditions that affect distribution and abundance of federally listed bull trout (*Salvelinus confluentus*). A total of 2,618 fish were sampled representing six species using two-pass electrofishing surveys. Electrofishing catch per unit effort was negatively correlated to seasonal stream flow and accumulated precipitation. A total of 469 bull trout were sampled for a four-year average two-pass depletion population estimate of 759 combined for all sites sampled. Two-pass depletion estimates ranged from 0 to 121 bull trout per reach, with 34 sites containing bull trout in at least one of the four years of sampling. Bull trout abundance was positively correlated to elevation, and negatively correlated to rainbow and brook trout abundances. Bull trout captured were aged from 0+ to 3+ with most sites containing 3 age classes, 0+ to 2+.

Introduction

With growing concerns surrounding fisheries in the Northwest, the status of many native salmonid fishes such as bull trout *Salvelinus confluentus* have become a focus of interest. The status of Pacific Northwest bull trout populations have been under Federal agency review for over fifteen years. The Columbia and the Klamath River Basin populations of bull trout were listed as threatened under the Endangered Species Act in June 1998 and the final rule was published in the Federal Register (USFWS 1998). Reasons for declining bull trout populations included habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, poor past management practices, and the introduction of non-native competitors such as brook trout *Salvelinus fontinalis*.

In response to the federal listing, the U.S. Forest Service and the U.S. Bureau of Reclamation initiated a four-year cooperative study to investigate the factors affecting the distribution of bull trout in the North Fork Boise River basin. The study began in July 1999 and continued through August 2002. The purpose of the work was to assess habitat, water temperature, and flow conditions as they relate to bull trout presence or absence, abundance, movement, and age-class distribution on a large-watershed scale. The study was designed to meet the following objectives:

1. To determine the distribution of bull trout and the environmental factors that affect their distribution within the North Fork Boise River Basin;
2. To quantify sizes related to age classes and growth rates of bull trout within tributary streams;
3. To assess the efficiency of electrofishing methods related to environmental conditions and a sampling method for monitoring protocol;
4. To determine the effects of forest management practices on bull trout habitat and populations;
5. To develop potential conservation measures that would be most beneficial to migratory bull trout;

Study Area

The Boise River basin is located in southwestern Idaho and is a major tributary to the Snake River. The Boise River basin covers 5,700 km^2 of the granitic rock-dominated landscape with elevations ranging from 931 m to 3,231 m elevation. The upper Boise River includes three sub-basins: the North, Middle, and South Forks of the Boise River. The majority of the study work occurred in the North Fork Boise River that joins the Middle Fork Boise River 30 km upstream from the South Fork/ Middle Fork Boise River confluence (Figure 1). The North Fork Boise River encompasses approximately 1,250 km^2 of the Boise River watershed area and extends to 3,231 m elevation. The Boise River system is fed primarily by snowmelt run-off with highest flows occurring in May and lowest in September-October. Flows range from 5.06 m^3/s to over 198.28 m^3/s in the mainstem Boise River below the confluence of the North and Middle Fork Boise Rivers. The North Fork Boise River flows range from 4.25 m^3/s to 113.28 m^3/s. Land uses in the North Fork watershed include grazing, mining, recreation, and both commercial and individual timber harvest. The majority of the Boise River basin lies within Forest Service or Wilderness area boundaries.

Seven of the eight major tributary watersheds (distinguished at the sixth hydrologic unit code level) were sampled in the North Fork Boise River from 1999-2002. The watersheds sampled were Crooked River, Bear River, Johnson Creek, Lodgepole Creek, Big Silver Creek, Ballentyne Creek, and the Upper North Fork headwaters (a group of small streams: McLeod Creek, McPhearson Creek, upper North Fork Boise River, and West Fork Creek). The stream sites ranged from 2.18 m to 8.81 m in average wetted width and from 1,524 m to 2,127 m in elevation. Stream conductivities ranged from 48 µS to 84 µS with water temperatures ranging from -4ºC to 27 ºC.

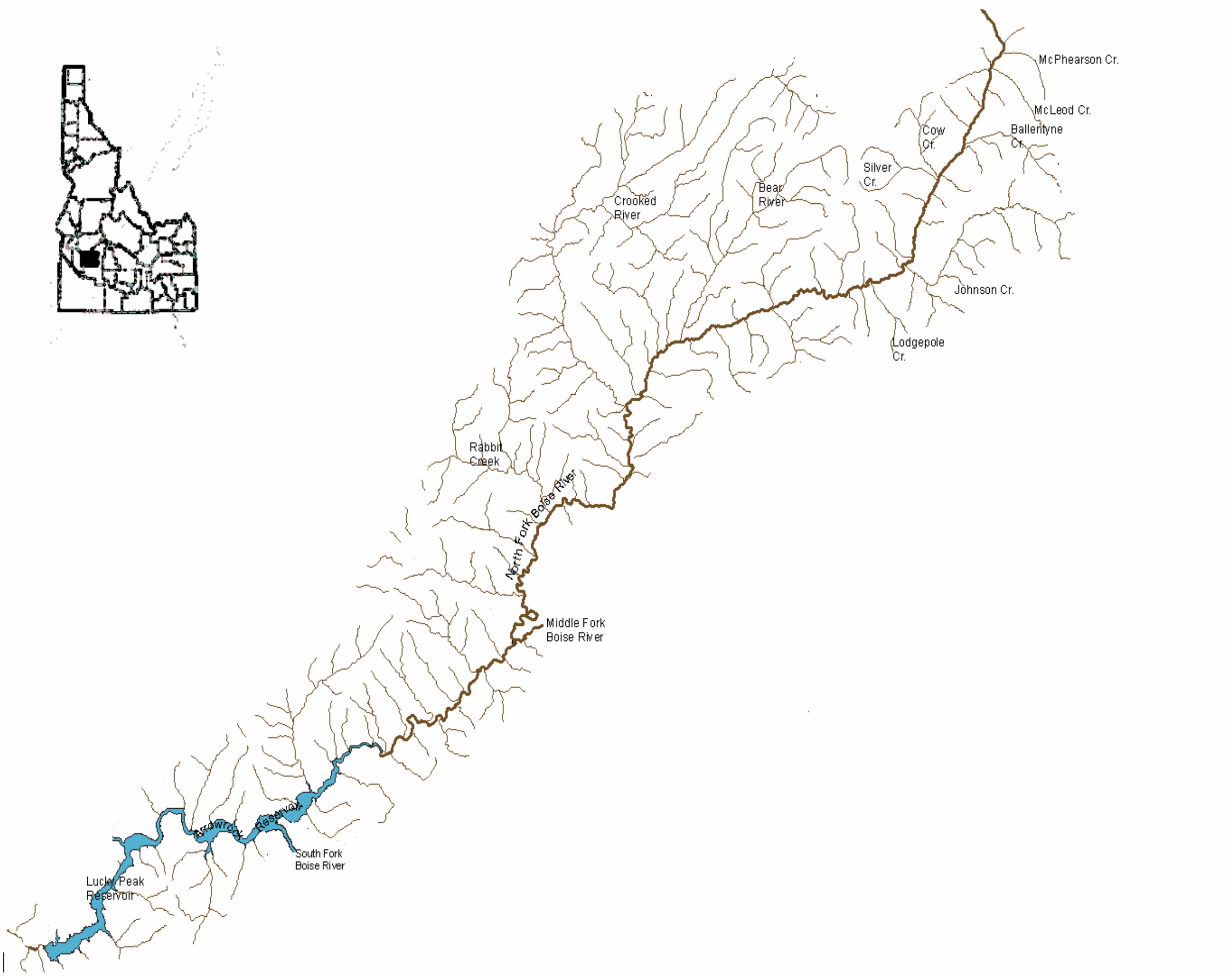

Figure 1. North Fork Boise River watershed showing Arrowrock and Lucky Peak Reservoirs.

Methods

Fish Data Collection

Stream reaches were sampled by electrofishing. Two-pass backpack electrofishing was performed at 42, 100-m reaches across the North Fork Boise River watershed annually. It was not feasible to use blocknets because of limited accessibility of remote sites and inadequate field staff to carry gear. Smith-Root™ battery-operated electrofishers were used; batteries were changed every 3,500 to 4,000 operating seconds. Electrofishers were set between 500 and 900 volts and 30 to 40 Hz, depending on stream size and conductivity. The North Fork and its tributaries have low conductivity, which averaged 53 µS (range: 48 µS - 84 µS). Gasoline-powered generator electrofishing units were not used during any part of the sampling due to designated Wilderness Area restrictions on motors in the higher elevation sites.

All captured fish were identified to species and enumerated. Total length (TL) was recorded for all species. All amphibians were counted and released, though stage of development was not noted. Bull trout were anesthetized using diluted tricaine methanesulfonate (MS-222) (approximately 100 mg/L). When a fish was considered anesthetized (could not right itself), its total length and weight were measured and recorded. Scale samples and fin clips were taken, and the fish was scanned for Passive Integrated Transponder (PIT) tags (AVID Computer Corporation, Norco, CA 1999). All bull trout > 100 mm TL that did not carry tags were tagged with 2.5 mm x 14 mm, 125 kHz PIT tags in accordance with instruction from Idaho Department of Fish and Game personnel (Russ Kiefer, IDFG, pers. comm.). Bull trout were held and monitored in live wells until full recovery (minimum 15 minutes), and then returned to the stream in the vicinity of capture. All recaptured bull trout were measured and weighed so that data for growth over the time period for mark and recapture could be recorded.

Habitat Data Collection

Habitat condition was measured following modified R1/R4 methods of the USFS as described in Burton (1999).

Each stream site was located with a Garmin™ GPS 76, and UTM coordinates were recorded. Habitat was measured using the following methodology: waters were first categorized by the observer as slow or fast based on USFS training (Burton 1999). Different measurements are taken for either slow or fast water. A two-meter stadia rod marked in tenth meter units was used to measure all habitat variables. Field staff was trained each year for habitat measurement under guidance of the USFS.

Parameters collected for slow water habitats were: thalweg lengths, maximum depth, mean depth, crest depth, averaged wetted width, available cover area, and percent fines. Parameters collected for fast water habitats were: thalweg length, mean depth and wetted width.

Definition of Habitat Parameters Collected

Thalweg Length: thalweg length was the measured distance in the path of a stream that followed the deepest part of the channel from the crest of the slow water unit to the formative feature of the habitat unit (Armantrout 1998).

Crest depth: crest depth is the downstream point of transition of slow water habitat types. It is the shallow downstream end of the depression in scour pools and the point of greatest flow over a dam.

Maximum Depth: maximum depth was the greatest depth measured in the slow water type.

Mean Depth: mean depth was taken at the area where average width was measured.

*Depths were measured at approximately ¼, ½, and ¾ of the channel width and the average was calculated by dividing the sum by four (to account for zero depth at the banks).

Average Width: average width was the wetted width measured at location of the pool that was the the mean depth calculated from the depth at the crest and maximum depth of the pool.

Available Cover Area: cover was categorized as large wood debris, overhanging vegetation, or undercut banks. All cover types had to be at least 0.30 m in width to be measured and capable of providing refuge to fish. All aggregates of wood were measured for combined total area (each piece was added to calculate a combined total). Each habitat feature was measured by length and width and area was calculated. The area of cover is reported in square meters (m^2).

Grid Fines: percent fines were estimated at each slow water pool tail. Fines were measured using a 100-intersection grid. Field staff measured the percent of the wetted substrate area of pool tail that is made up of fine particles, defined as sand/silt less that 6 mm, by randomly tossing the grid. The cross section of the pool tail was subdivided into 3 segments: right, middle, and left. The grid intersections were counted only where substrate was smaller than 6 mm.

Elevation: site locations were mapped using UTM coordinates collected with a Garmin GPS 76 unit at each site. Waypoint locations were mapped and elevation (m) was taken from coordinates.

Water Temperature, Precipitation, and Stream Flow Measurements

The relationships between water temperature, precipitation, flow, and total number of fish captured were evaluated on an annual basis for all four years of the study. Three methods were used to collect and calibrate water temperature readings. Water temperature and conductivity readings were taken at each electrofishing site at the time the sites were sampled to appropriately set electrofisher voltage and pulse widths. Water temperature was also recorded every 1-2 hours at 12 locations in North Fork tributary streams across a range of elevations and stream sizes by Tidbit™ (Onset Computer Corporation, Pocasset, MA 1999) water temperature dataloggers (sites shown in the Appendix: Figure 1). Finally, data were also collected at two USBR Hydromet stations (U.S. Bureau of Reclamation 2002). Hydromet stations provide data for daily-accumulated precipitation, mean daily flow, and mean daily temperature. The two Hydromet stations were located near Twin Springs (BTSI) and Atlanta (ATLA) Idaho. To calculate total precipitation, daily accumulations were summed for November 1st to March 31st each year from the Hydromet data collected at ATLA. Dates for total precipitation were chosen to match the time period that overwintering eggs and alevins may be exposed to freezing and flood conditions during incubation and emergence. Maximum discharge was the highest mean daily flow that occurred each year as recorded at BTSI. Maximum water temperatures from the temperature dataloggers were used for analyses and were calculated as the average maximum temperature for the four years of data collection. Maximum water temperatures were used because they would be more accurate than an average for representation of temperatures to which fish were actually exposed (J. Dunham RMRS, personal communication). Maximum temperature, maximum discharge, and seasonal accumulated precipitation are highly correlated variables. Analysis was conducted by year, with four years of data available. Pearson correlation coefficients were used to show potential relationships between total fish captured and these variables.

Aging of Bull Trout

Scales were collected from bull trout and processed following methods described in Flatter (2000). Bull trout scale samples were collected from the section of the fish's body posterior to the dorsal fin and dorsal of the lateral line. All scales collected were mounted on clear 2.54 cm x 10.16 cm x 0.05 cm acetate slides and pressed with a Carver heat press at 10,000 PSI, 110 °C, for 35 seconds. Impressions were then projected using a microfiche reader. Annuli were counted by three individual readers. Each reader aged the samples twice to calculate average percent error for the individual reader and to calculate error between the readers (Chang 1982). Bull trout were assigned to age classes using the mean length at age and proportion of overlap of fish between age classes from the actual length at age data. This method is more accurate for smaller fish with clear distinctions in age class, but as fish were aged to older classes (5+ or older), overlap between each age class and corresponding lengths complicated differentiation of age groups. Scale aging work was validated by comparing age estimates of otoliths to those of scales from capture mortalities. The time of sampling may cause a discrepancy in the length-frequency data as maximum growth for bull trout is presumed to occur over the summer in warm temperatures. Sites at higher elevations were sampled at later dates and had colder water temperatures and a shorter overall season for growth. To account for the affect of date and growth within age classes in the length-frequency data, data from the the 6th field Hydrologic Unit Code (HUC). The length-frequencies were then graphed by 6th field HUC and year.

Data Analyses

All statistical analyses were conducted with SAS Version 8 statistical software (SAS 1999). Abundances of fish were estimated for each stream reach using Seber and LeCren (1967) two-pass depletion population estimation equations (Everhart and Youngs 1981).

The Seber-LeCren equation used for the two-pass estimate was:

$$N = \frac{Ç^2}{Ç - Ċ}$$

Where: Ç = Catch of fish in first pass

Ċ = Catch of fish in second pass

N = the estimate of fish in the stream reach

variance were estimated by:

$$V(N) = \frac{Ç^2\,Ċ^2\,(Ç + Ċ)}{(Ç - Ċ)^4}$$

General relationships between fish and their environment were described using Pearson correlation coefficients using the four-year average abundance estimates for each species and the four-year average estimates of the habitat variables for each site. Statistical modeling to predict bull trout abundances using habitat data was conducted using multiple regression. Fourteen distinct measurements made for each site. Many of these variables were highly correlated as they were used to calculate area, reach size or were essentially measurements of similar parameters. Therefore the correlation coefficients for these variables were reviewed and highly correlated variables or variables that were calculated from measurements were removed from the data set to validate the assumptions of any of the regression modeling. The four-year mean Seber and Le Cren (1967) two-pass abundance estimates of bull trout captured at each site were used as the dependent variables. Independent variables used to predict bull trout abundances were the four year average estimates of the following variables:

- pool (slow water) maximum and average depth

- Run (fast water) length, width
- maximum pool (slow water) depth to pool width ratio
- grid fines
- area cover: large wood debris, undercut banks, and overhanging vegetation
- elevation
- maximum annual water temperature

Results

Fish Data Collection

Over 2,600 fish were captured, representing six species throughout the 42 sites sampled each year (Table 1). Sculpin comprised the majority of fish captured (47.9%), followed by rainbow trout (30.0%). Very few brook trout, cutthroat trout, and whitefish were captured. A total of 469 bull trout (17.9 %) were sampled over the four years of the study.

Table 1. Number of fish captured, two-pass estimate, and number of sites where each species were present each year.

	1999			2000			2001			2002			Total 4-years	
Species	Number Captured	2-pass estimate	Number of sites where present	Number Captured	2-pass estimate	Number of sites where present	Number Captured	2-pass estimate	Number of sites where present	Number Captured	2-pass estimate	Number of sites where present	Number Captured	2-pass estimate
Bull trout *(Salvelinus confluentus)*	143	205.25	24	192	372.05	23	354	549.92	29	134	182.08	21	469	759.38
Rainbow trout (*Oncorhynchus mykiss*)	140	225.57	28	363	535.84	32	481	601.14	36	282	428.8	34	785	1190.2
Mountain whitefish (*Prosopium williamsoni*)	3	3	2	2	2	1	4	4	4	4	5	2	9	10
Westslope cutthroat (*Oncorhynchus clarki lewisi)*	2	2	1	15	15	4	5	5	2	1	1	1	18	18
Brook trout (*Salvelinus fontinalis*)	31	47.83	9	42	47.37	10	57	64.86	12	30	37.33	12	103	132.53
Sculpin (*Cottus sp.)*	113	267.58	18	576	1303.6	19	532	1091.9	25	545	1354.9	26	1234	2926.1
Total	**432**	**751.23**	**40**	**1190**	**2276**	**36**	**1433**	**2317**	**41**	**996**	**2009**	**40**	**2618**	**5036**

Bull trout were distributed in a four-year average 24 of the 42 sites sampled each year. Two-pass abundance estimates ranging from 0 to 121 bull trout per survey site. Bull trout catch ranged of 0 to 29 bull trout actually captured at each site. Figure 2 shows the distribution of bull trout using the four-year average 2-pass abundance estimates at each stream reach sampled. Four-year average 2-pass estimates ranged from 0 to 42.06 bull trout per stream reach, with 34 of 42 stream reaches containing bull trout in at least one of the four years sampled. Fish abundances could be shown to be interspecies related. Brook trout and rainbow trout abundances were positively correlated to each other ($r = 0.63$, $p < 0.0001$), sculpin abundance was positively correlated with rainbow trout ($r = 0.48$, $p < 0.0014$). Bull trout abundance was negatively correlated with both rainbow trout ($r = 0.63$, $p < 0.0001$) and slightly with brook trout ($r = 0.31$, $p < 0.05$).

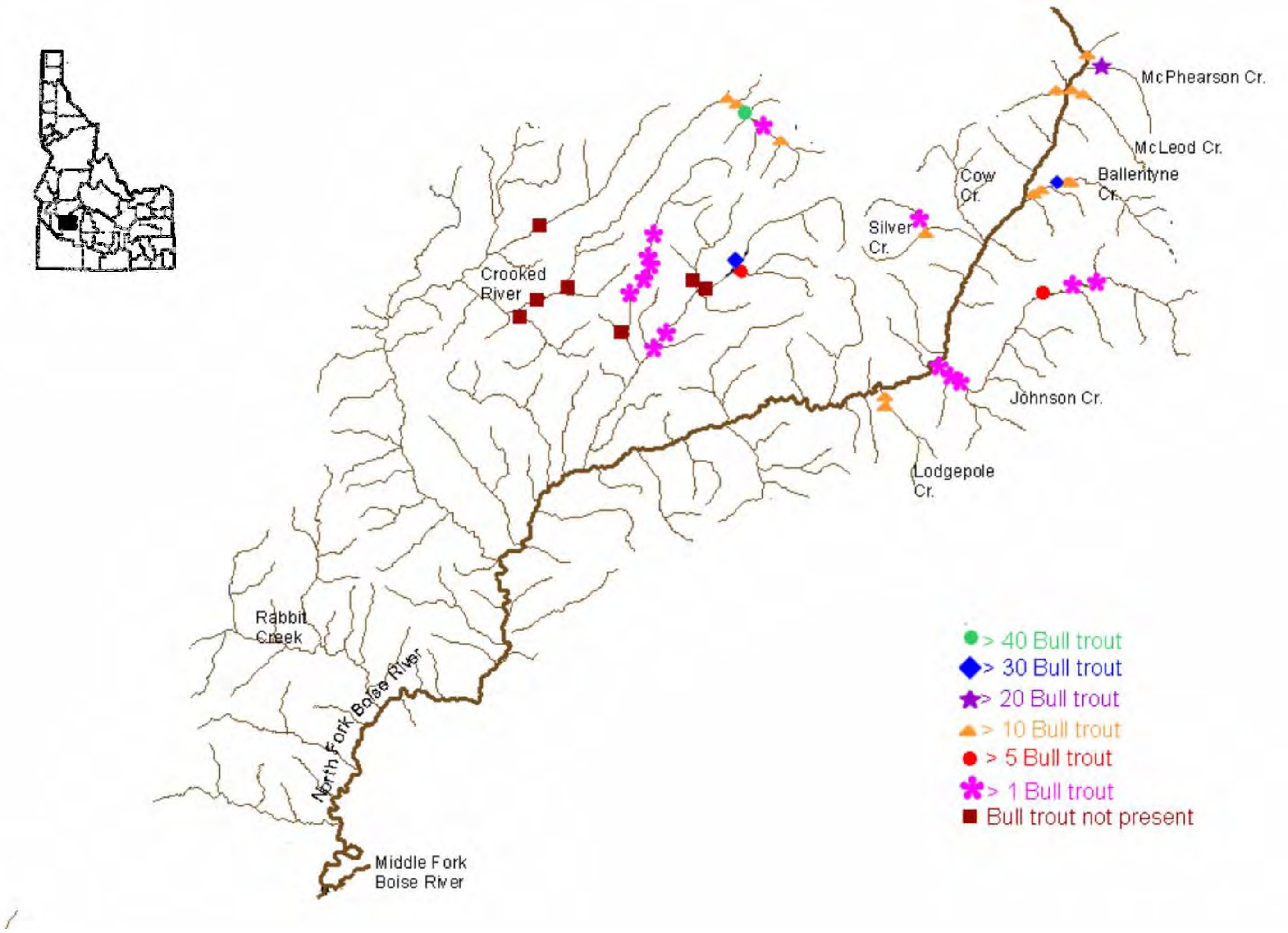

Figure 2. Distribution of bull trout using the four-year average two-pass abundance estimates.

Relationships to Habitat Variables

Environmental relationships to fish distribution and density were determined for both the individual stream reach scale and for the North Fork Boise River Basin scale. Data were averaged over the four years of the study for stream reach scale analysis.

Environmental conditions affecting Fish Capture at the Basin-wide Scale

On a basin-wide scale, numerous factors that affect fish capture and distribution tat the study sites over the four years of the project. The four years of surveys covered a wide range of annual accumulated precipitation which resulted in changes in fish capture efficiency and distribution. Maximum water temperature and maximum discharge were negatively correlated ($r = -0.90$, $p = 0.09$). Water temperature and total fish capture were positively correlated ($r = 0.99$, $p = 0.0019$). Stream flow at the time of survey affected electrofishing efficiency and capture rates for all fish species. Additionally, extremely dry years such as 2000 and 2001 had increased stream temperatures and reduced wetted channels that could have significantly impacted fish survival, leading to fewer fish captured, though stream flow was reduced in 2002 (see Discussion). Figure 3 illustrates the relationship between peak discharge (m^3/s maximum recorded at Hydromet gauge at Twin Springs), accumulated precipitation (total cm recorded at Atlanta Hydromet gauge from November 1 to March 31 each year), 4-year average maximum water temperature from all sites, and total fish captured each year.

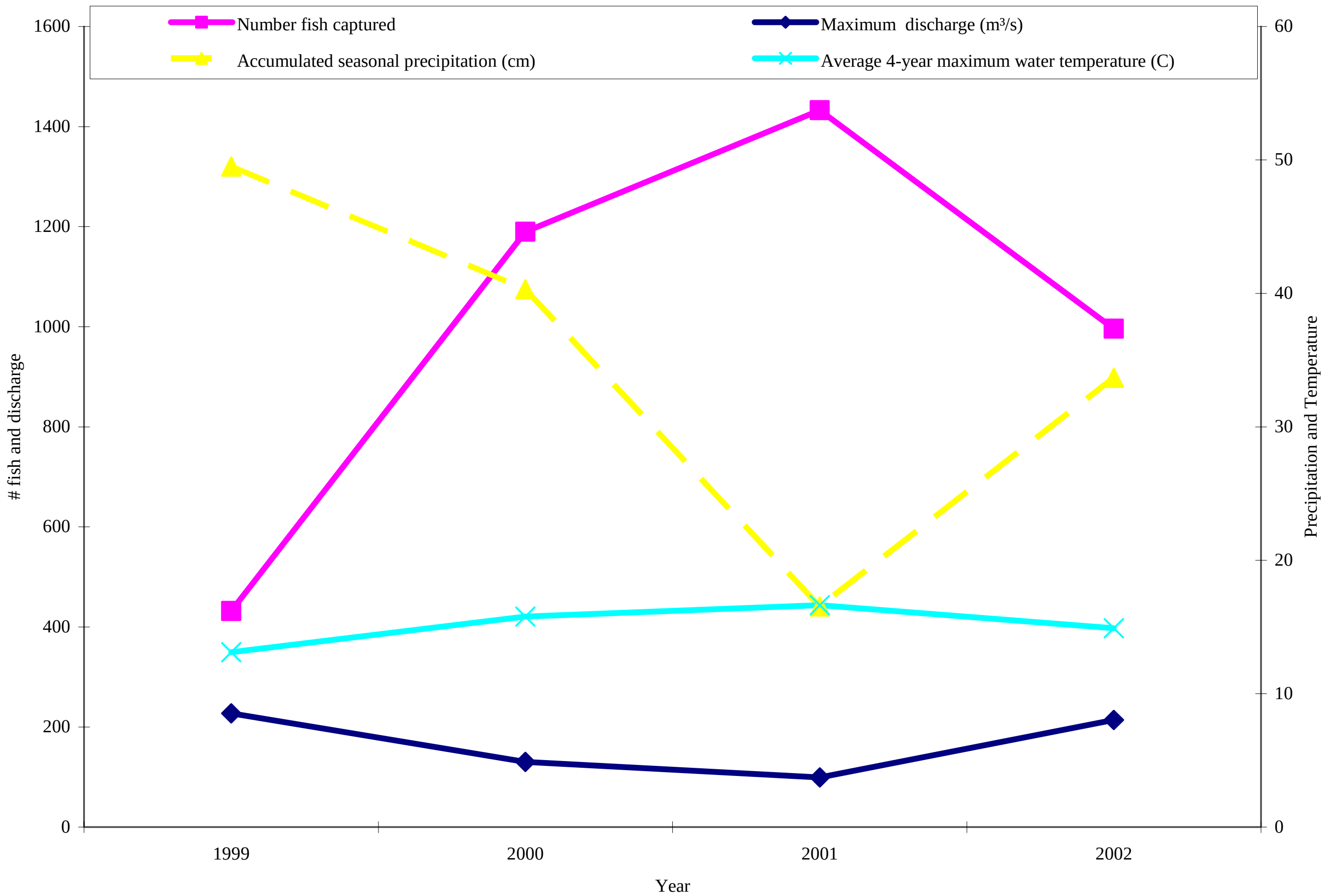

Figure 3. Relationship between total fish captured, maximum discharge, maximum Water temperature and seasonal accumulated precipitation.

Environmental conditions affecting Distribution of Fish at a Stream Reach Scale

At the stream reach level, numerous relationships exist between fish abundance and the habitat variables that were collected. Relationships are reported for significance values of $p < 0.01$, correlation coefficients > 0.40. Elevation of the site played an important role in the distribution of fishes. Rainbow trout 4-year average abundances were negatively correlated with elevation ($r = -0.55$) and positively correlated with fines ($r = 0.65$) and overhanging vegetation ($r = 0.48$). Sculpin abundances were negatively correlated with elevation ($r = -0.40$) and positively correlated with overhanging vegetation ($r = 0.68$) and fines ($r = 0.39$). Whitefish abundances were positively correlated with pool maximum depth-to-width ratios ($r = 0.46$). Brook trout abundances were negatively correlated with elevation ($r = -0.49$) and positively correlated with fines ($r = 0.59$) and undercut banks ($r = 0.49$). Bull trout abundances were positively correlated with elevation ($r = 0.45$) with only weak relationships inferred by other habitat variables. The lowest elevation stream site in which a bull trout was captured at was elevation 1524 m , although this was only one fish in four years and it was relatively large (170 mm). Bull trout were found in greatest abundances in stream sites that were above 1700 m in elevation (Figure 2).

Aging of Bull Trout

Bull trout captured in tributary streams comprised 4 age classes (0+-3+) as illustrated by length-frequency data (Figure 4). Scale age data reflected 3 age classes, though this was due to the inability to collect scales from fry < 85 mm in total length. Therefore, age class 0+ estimates were made with length-frequency data from electrofishing captures (Table 2).

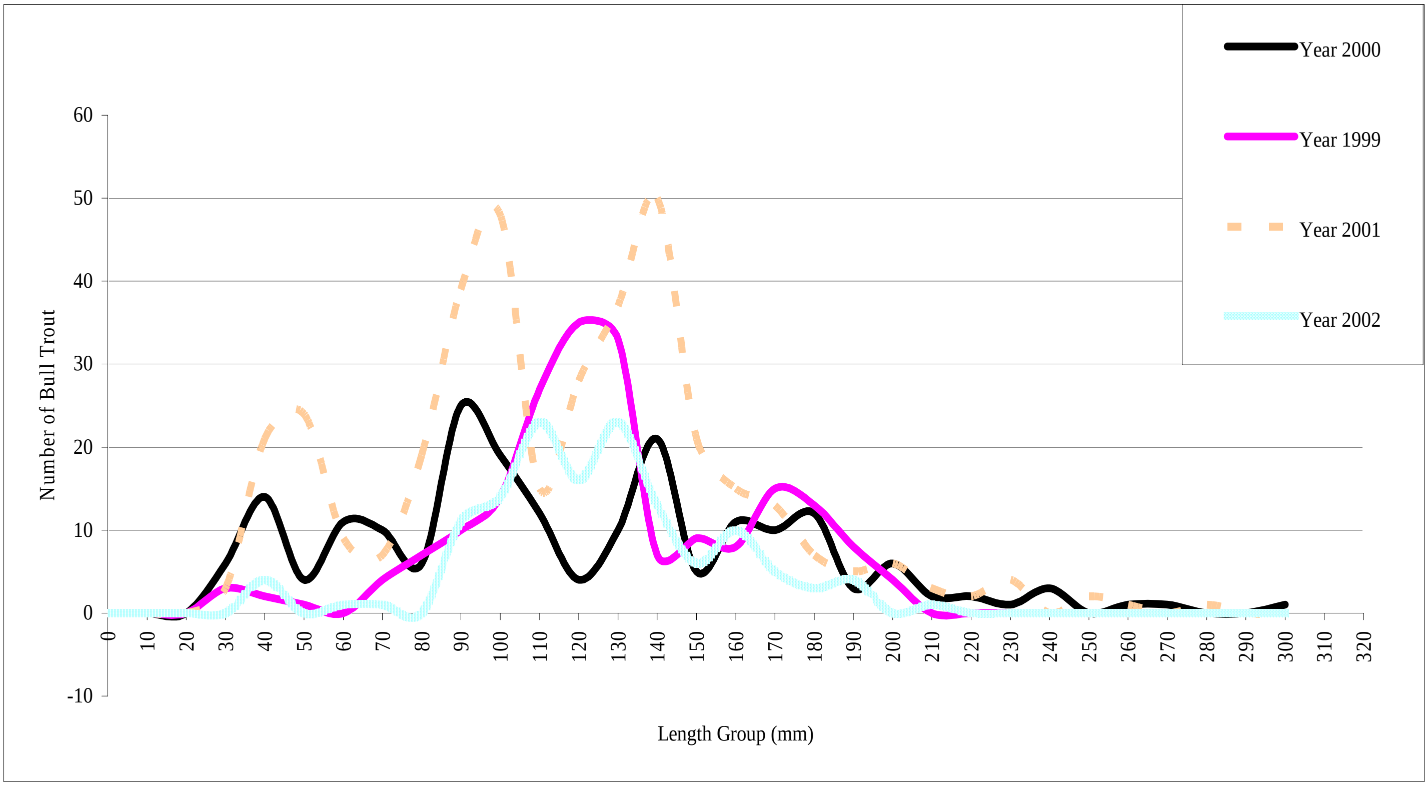

Figure 4. Length-frequency histogram of bull trout captured in tributary surveys.

Table 2. Length at age and confidence intervals from scale aging data. Age class 0 data are estimated from length-frequency data.

Age and Length Classes					*Composition of Bull Trout Captured**			
Age class	*Mean length (mm)*	*Std. Dev.*	*Lower Bound, 95% CI*	*Upper Bound 95%CI*	*% of bull trout 1999*	*% of bull trout 2000*	*% of bull trout 2001*	*% of bull trout 2002*
**0+	47.35	4.78	37.99	56.72	1.5%	10.6%	10.3%	3.0%
1+	95.48	9.01	77.81	113.15	27.7%	30.2%	31.1%	26.5%
2+	144.20	9.06	126.44	161.96	27.2%	19.6%	32.2%	40.2%
3+	201.19	18.40	165.12	237.26	20.4%	18.6%	10.3%	6.8%
4+	264.51	23.01	219.41	309.61	0.5%	0.0%	1.3%	0.0%
5+	321.56	17.92	286.43	356.68	0.5%	0.0%	0.5%	0.0%
*Composition is the number of bull trout captured that had lengths within the one standard deviation of the mean length-at-age group								

Water temperature may play a role in growth of bull trout that reside in spawning and rearing habitat. Since water temperature is can be predicted by elevation ($r^2 = 0.53$, $p < 0.01$), the length-frequency data were split into 6th field HUCs to examine the effect of elevation and watershed size (Appendix, Figure 2). Mean fish length differed at the 6th HUC scale ($F = 13.56$, $p < 0.01$). When fish were grouped by 6th field HUC, age-by-length groups were more easily separated for smaller tributary streams (Appendix B, Figures 1-7). However; HUCs such as Johnson Creek and Bear River, with a single large tributary, had larger sized fish and more variable size distributions with difficult to separate age-by-length groups.

Growth patterns were difficult to derive from recaptured bull trout due to low sample size (10 fish). However, fish that moved into the larger river and reservoir systems generally had higher growth rates (as indicated by fish recaptured at the weir located in the mainstem Boise River, Table 3) than fish that remained within the tributary system. Mean growth for fish moving into the larger river system was 0.20 mm/day (SE = 0.08) and mean growth for fish that remained in the tributaries was 0.08 mm/day (SE = 0.05). Growth information for recaptured fish is listed in Table 3.

Table 3. Growth for total length of marked and recaptured bull trout from tributary streams.

Recapture Length (mm)	*Recapture Weight (g)*	*Recapture Site*	*Recapture Date*	*Initial Tag site*	*Length (mm)*	*Weight (g)*	*Date*	*Growth (mm)*	*M- R time (days)*	*Growth/ day (mm)*
173	40	BC 4.0	7/17/01	BC 4.1	120	15	8/23/99	53	694	0.076
214	60	BC 5.4	7/17/01	BC 4.8	188	68	7/18/00	26	364	0.071
140	26	BC 4.1	7/19/00	BC 4.1	115	10	8/23/99	25	331	0.076
153	36	BR 9.8	7/17/01	BR 9.8	104	16	7/25/00	49	357	0.137
156	45	BR 9.8	7/17/01	BR 9.8	147	34	7/25/00	9	357	0.025
171	50	CU 0.0	7/16/02	CU 0.0	118	18	7/17/01	53	364	0.146
253	168	weir	9/4/00	MCP 0.0	165	NW	8/3/99	88	398	0.221
222	96	weir	9/11/00	NFB 40.5	185	60	8/18/99	37	390	0.095
253	146	weir	9/28/00	J 1.0	240	136	8/17/00	13	42	0.310
343	302	weir	10/17/02	NFB 41.5	140	30	8/18/99	203	1156	0.176

Discussion

Fish Data Collection

Several possible explanations exist for the relationships shown between the fish abundances as related to other fish species. Brook trout and rainbow trout were often found together in low elevation, meandering streams such as Banner Creek, Pikes Fork Creek, Willow Creek, and Bear Creek. All of these creeks had similar habitat features that appear to sustain strong sympatric populations of brook and rainbow trout. These creeks are low elevation, warmer, lower gradient, stable streams with c-type channels which appear to be beneficial to brook and rainbow trout. Rainbow trout were also found with sculpin, but this relationship was not true for brook trout. Since brook trout tend to be more piscivorous than rainbow trout, populations of sculpin may be limited by brook trout presence. Bull trout densities were strongly negatively correlated with rainbow trout and a slightly negatively correlated to brook trout and sculpin. Brook trout are known to be competitors for spawning habitat and prey with bull trout, so a negative abundance relationship might be expected. Rainbow trout eggs, alevins and sculpin may serve as prey for piscivorous bull trout. Therefore, rainbow trout and sculpin may have limited distribution within strong bull trout populations. Relationships for whitefish and cutthroat trout were weak most likely due to poor sample size for both species. Westslope cutthroat trout have historically been stocked in high elevation lakes and have distributed themselves into lake-fed streams such as Bear Creek and Lodgepole Creek. Whitefish are traditionally known as larger river or pelagic lake species and only a few parr were captured in Johnson Creek during the stream survey work.

Habitat Data Collection

There are many reasons for the variation in habitat data collected between sites. High variation was noted between observers measuring each parameter because there were different observers collecting data at each site and individual variation in interpretation of measurements. Additionally, hydrograph data demonstrated natural variation in stream conditions over each year (Figure 3). Data that demonstrates a clearer trend across multiple years for habitat data related to bull trout abundances and distributions will require a longer time frame and a more comprehensive study effort. Recommendations for improved data quality include a focus on removing unnecessary observer error. Intensive temperature and flow data could be mechanically collected as opposed to occasional manual sampling. Additionally, habitat parameters with high observer variation such as pool size, run size and percent fines could be replaced by collecting stream gradient data at each site.

Environmental conditions affecting Fish Capture at the Basin-wide Scale

Basin wide relationships are inferred from a low sample size (four years). Relationships inferred from such a small sample may be weak or a product of other or confounded influences. Drought years (such as what occurred in 2001) may result in higher mortality rates of fish species rearing in headwater streams due to increased summer temperatures and reduced cover in more shallow and narrow stream channels. Overwintering eggs and alevins of bull trout may also experience increased mortality in drought years due to increased anchor ice accumulation corresponding to the lack of the insulation resulting from reduced snow pack. The affect of the drought in 2001 may have led to largely reduced capture of fish in 2002, even though that year was a slightly higher precipitation year.

Though electrofishing has been shown to be one of the more effective methods for estimating abundances of bull trout (Thurow and Schill 1996), efficiency is reduced in water years with greater precipitation and higher run-off due to decreased visibility, increased stream size, reduced mean temperatures, and higher velocity. These factors combined complicate the ability to both shock and net fish. The first year of work (1999) was a normal to higher water year for the basin, with peak run-off occurring for all years near May 25. The second and third year of work began a drought year series, with minimum flows dropping to 5.06 m^3/s at Twin Springs in October during 2001. Removing the effect of total precipitation on electrofishing efficiency to assess survival from year to year is difficult with limited years of data for tributary streams. Survival may be more effectively shown through the distribution of age classes in post-spawning fish or through a longer period of monitoring of reference stream sites.

Environmental conditions affecting Distribution of Fish at a Stream Reach Scale

The role of temperature in the distribution of bull trout has been discussed at length (Dunham et al. 2003, Dunham and Rieman 1999). I did not use temperature as a habitat variable in the stream site models for several reasons. Annual maximum temperatures were determined to be the strongest predictive variable (Dunham et al. 2003), and this data was only available from the twelve temperature loggers in the North Fork for all four years. Additionally, logger temperature data was highly variable depending on where the logger was located and how strongly the location was affected by spring run-off each year. Although the one-time temperature readings were taken at each site prior to sampling, these could not represent the magnitude of variation at each creek and most likely did not encompass the maximum temperature as sites were sampled at differing times throughout the day. Since temperature was predictable by elevation, stream width, and fines, stream site elevation was used instead of temperature at the reach level for analysis.

Aging of Bull Trout

We found that the accuracy of prediction for age-at-length data using length frequency distribution can be improved by separating the fish into 6th HUC levels. The length frequency histogram for all bull trout captured basin wide shows two age classes though they are not distinctly separate for fish 80-150 mm total length (age classes 1+ and 2+). Fish could more easily be separated into length frequency age classes when separated into 6th HUC geographic areas. There are several possible explanations for the large overlap in these length groups. First, sampling occurred over an eight week period each year, which also coincides with the maximum growth period for bull trout. Length frequency groups created for basin wide sampling therefore may be confounded by growth during the sampling season. Additionally, sampling times were focused on accessibility, starting at low elevation sites and moving to higher elevation sites as the season progressed. Cooler temperatures at higher elevation sites may limit growth of fish, possibly confounding age at length data.

Clear growth patterns were difficult to discern from marked and recaptured bull trout. The general increase in daily growth rates for fish moving into the large river system may be indicative of maturity and a prey shift to becoming primarily piscivorous that would be expected from increasing growth and gape size. However, we did not conduct stomach content analysis to investigate this hypothesis. Increases in size were also clear on scales when aging. Scales from older fish had a wider annulus appearing on most scales near the 3+ annulus. We would like to investigate this pattern further with scales from older fish and by fitting a general growth curve model. The sample of fish for this study comprised predominantly juvenile-sized bull trout. Only a few large adult size bull trout were captured in tributary streams prior to spawning, and these were released immediately to avoid adding stress to the animal. Therefore, the sample lacks the large, older, adfluvial adult sized fish necessary to fit most growth curve data.

Implications and Recommendations for Management

Drought years in river systems that are fed primarily by precipitation may affect spawning and rearing salmonids by reducing stream size and therefore suitable rearing habitat, dewatering redds, and increasing anchor ice in redds over the winter season. Much of the habitat currently occupied by bull trout within the North Fork Boise River is located in designated Wilderness Areas or is difficult to access for human activities. Data from this study therefore reflects primarily natural environmental variation with the highest potential for human influence primarily on migratory adult fish. Currently the U.S. Fish and Wildlife Service is developing plans for recovery and critical habitat designation for bull trout throughout the listed range (USFWS 2000). Recommendations for recovery include monitoring programs for bull trout that focus on a sample of reference sites within each 6th field HUC that represents the range of distribution based on the information on distribution and natural variation expressed in this four year study. In addition to spawning and rearing site monitoring, we strongly recommend monitoring and enforcing fishing regulations for the migratory component of the populations as this group of fish becomes critical in re-establishing populations that have been extirpated by drought.

One of the objectives of this study was to identify conservation measures that may improve conditions for the fishery. Several areas of habitat within the watershed are in decline due to human disturbances, creating high sediment levels and warm temperatures. Recommendations include implementing measures to reduce side-cast sedimentation of streams during road building and maintenance in Pikes Fork Creek, Bear Creek, and lower Crooked River from Edna Creek to Crooked River rkm 26. Additional activities which may also impact stream temperatures and sedimentation include timber harvest and unregulated camping within the riparian areas similar to what has been observed on lower Crooked River and Pikes Fork Creek. We observed only one potential migratory barrier in the North Fork Boise River study site during the four years of work. This culvert, located on lower Big Silver Creek, became degraded during the spring of 2001, when Little Silver Creek washed out. Finally, motorized vehicle use also contributes to degradation of riparian area habitat in some areas of the Boise National Forest such as Black Warrior Creek and Grouse Creek on the Middle Fork of the Boise River. There was little off road use observed in the North Fork Boise River study area due to Wilderness area restrictions or accessibility with the current road system.

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APPENDIX A: Location of Temperature Loggers and Environmental Data Collection Sites

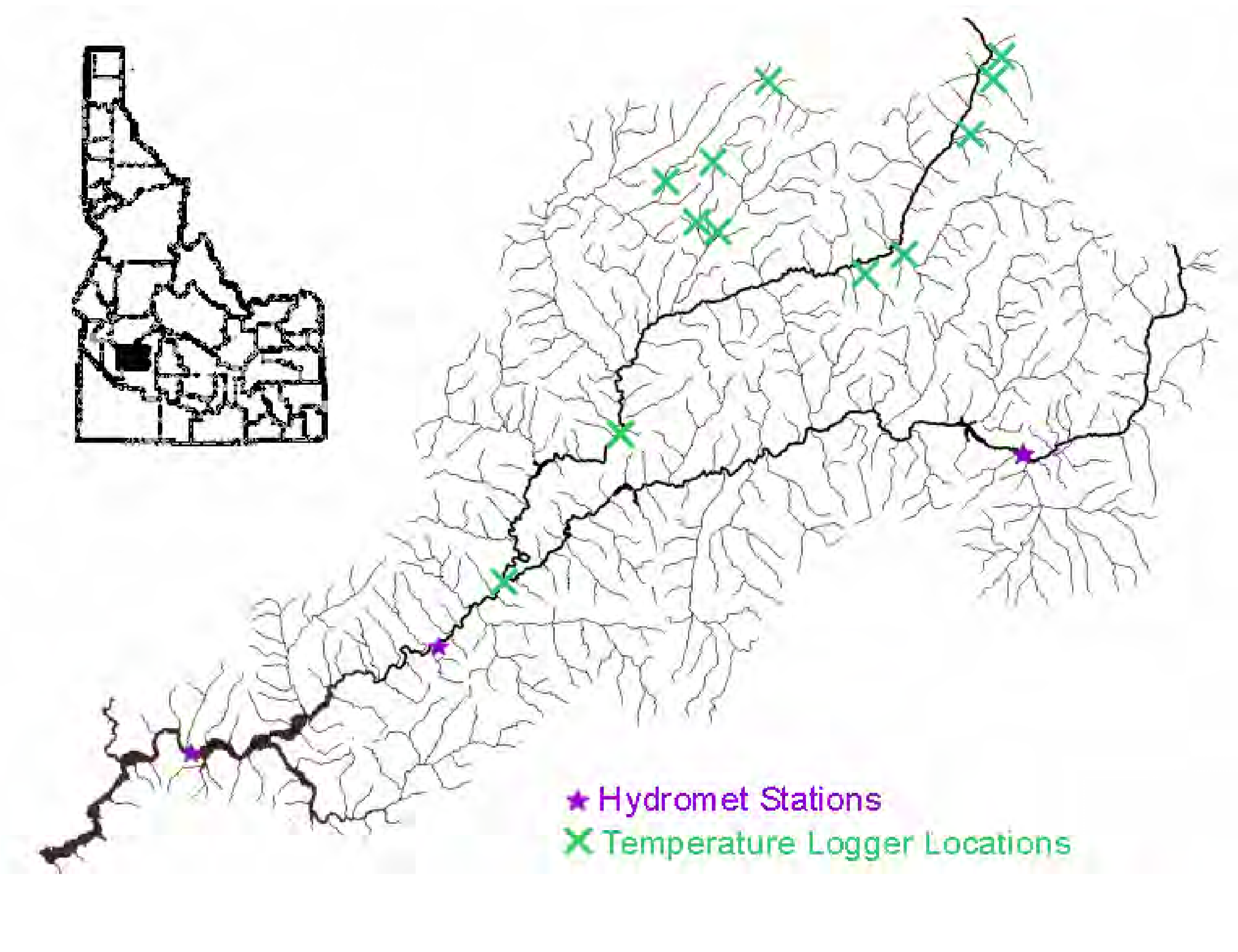

Figure 1. Locations of Tidbit™ Temperature Loggers and U.S. Bureau of Reclamation Hydromet stations

APPENDIX B: Length Frequency Histograms for Bull Trout Collected by 6th HUC Watersheds

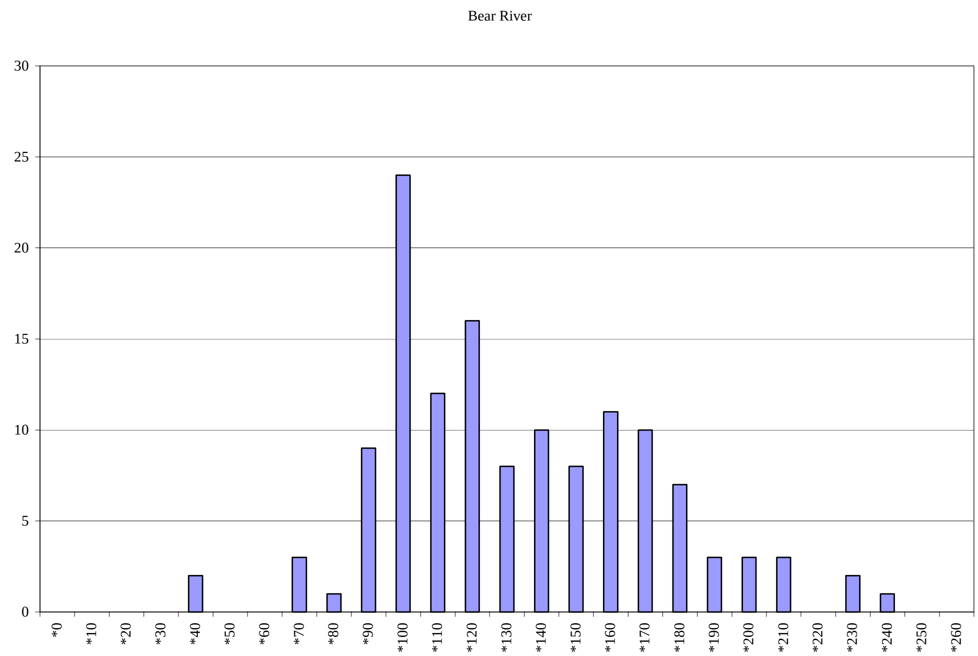

Figure 1. Bear River and Bear Creek Watershed Bull Trout Length Frequency Histogram

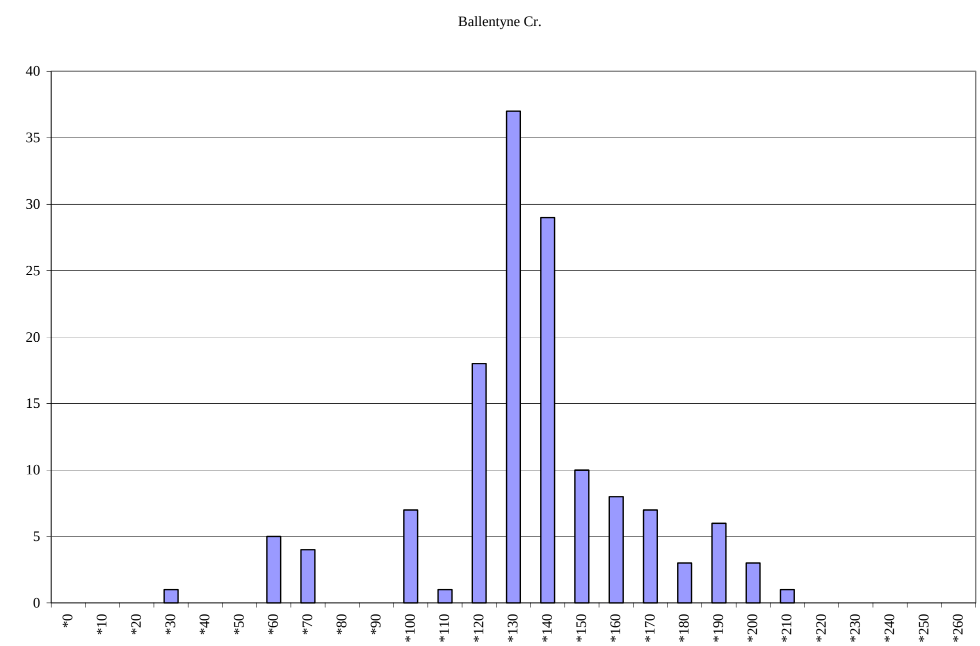

Figure 2. Ballentyne Creek Watershed Bull Trout Length Frequency Histogram

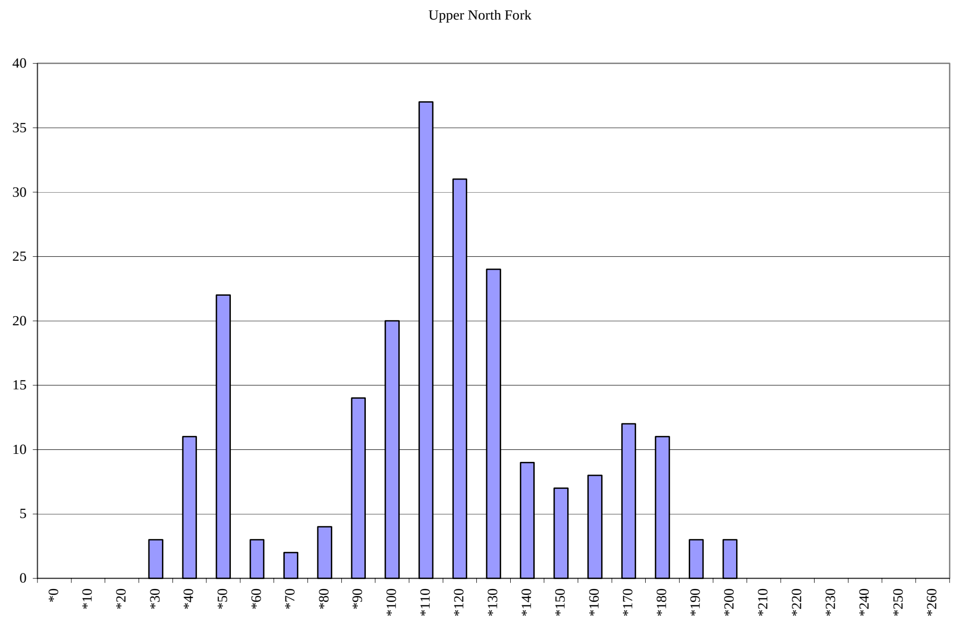

Figure 3. Upper North Fork Boise River Watershed Bull Trout Length Frequency Histogram

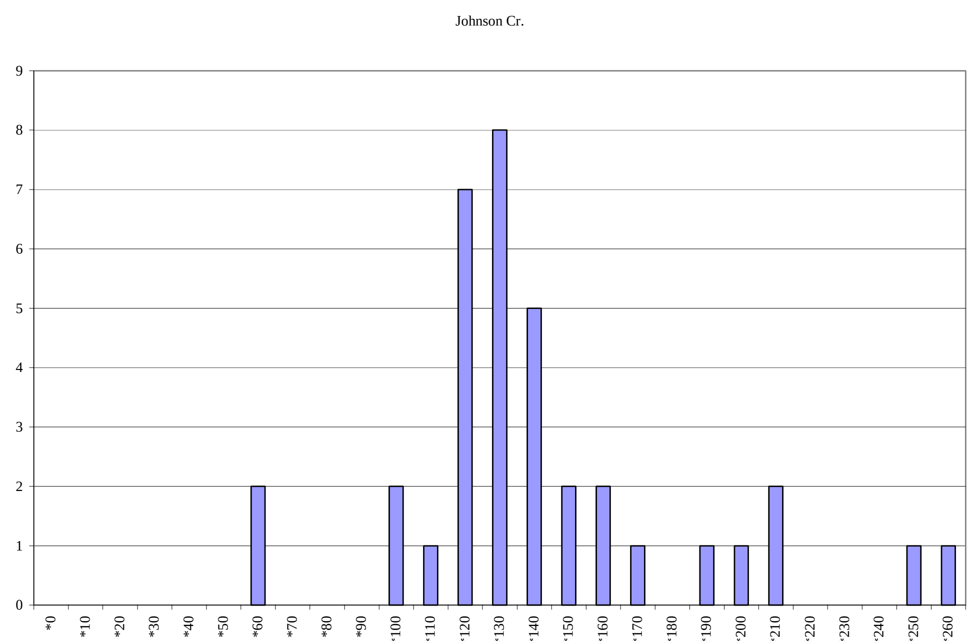

Figure 4. Johnson Creek Watershed Bull Trout Length Frequency Histogram

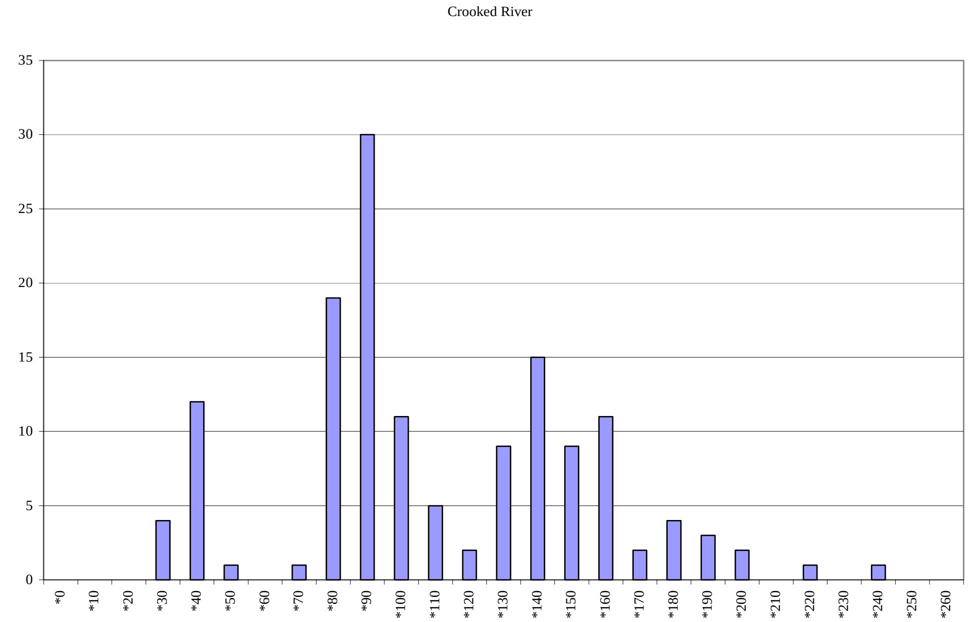

Figure 5. Crooked River Watershed Bull Trout Length Frequency Histogram

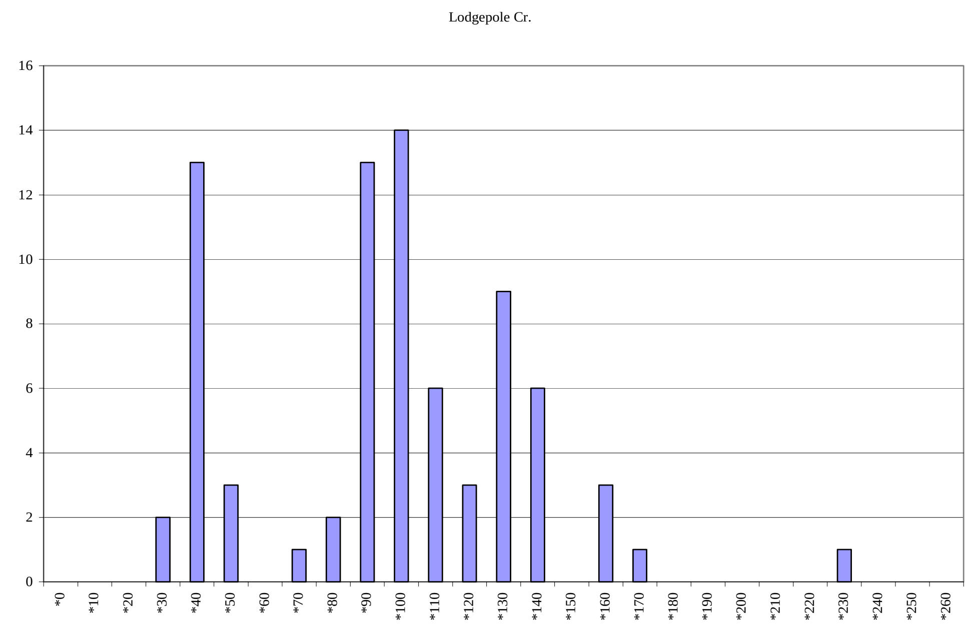

Figure 6. Lodgepole Creek Watershed Bull Trout Length Frequency Histogram

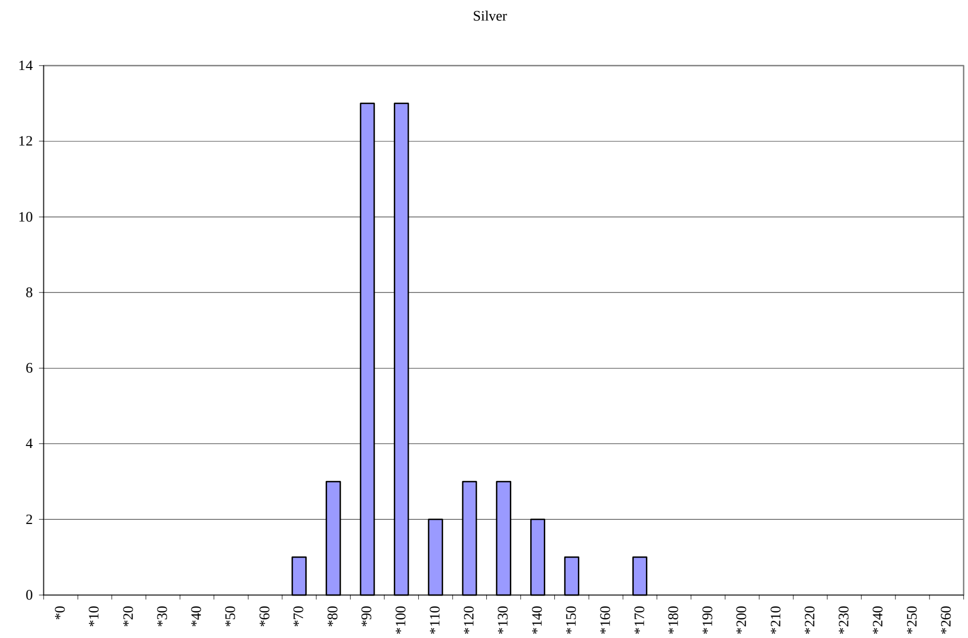

Figure 7. Silver Creek Watershed Bull Trout Length Frequency Histogram