OPEN FILE REPORT
MONTANA FISH, WILDLIFE & PARKS

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Biological Impacts Associated With Riverine Flow Fluctuation

This file report summarizes the results of our Instream Flow Incremental Methodology (IFIM) research in the Kootenai and Flathead River systems and the biological reservoir modeling of Hungry Horse and Libby Dam operations. We have also drawn from site-specific examinations of the macrozoobenthos community in the two Montana watersheds (see Dr. Rick Hauer's reports and Dr Jack Stanford et al.). IFIM model calibration of the Kootenai River is nearly complete and simulations are ongoing. The Libby IFIM report will be published this year. Research on the Flathead system has been completed for the first year of physical and biological sampling. Completion of the model will quantify the biotic and abiotic effects of flow fluctuations on target native species caused by the operation of the hydropower system.

Flow fluctuation results in the desiccation of the varial zone and associated aquatic plants and zoobenthos. Radio telemetry and visual observation have demonstrated that adult and juvenile trout frequently occupy the shallow, lateral margins of the river, and are displaced as discharges increase or decrease. The spreadsheet below indicates loss of area per 1,000 cfs (=1 kcfs) drop in flow (Table 1). The availability and location of preferred cover at each river stage can be overlaid on river stage and channel morphometry. This can be directly related to fish locations and the resources that those fish use. As flows decline, fish must move to more suitable locations. Preliminary evidence indicates that displaced fish are more vulnerable to predation enroute, and movement to undesirable locations in the river subtracts from the individual's energy budget.

Kootenai River below Libby Dam

Ramping below 9 kcfs is not biologically justifiable due to a number of factors. A flow reduction from 9 kcfs to the minimum flow of 4 kcfs results in a loss of 37.4% of the total available depth, and a loss of 46.4% of the channel width. Flow fluctuations at higher discharges also influence fish habitat use. On average, a 6Kcfs ramp between 12Kcfs and 24Kcfs (normal range of ramping) effects 1.32 ft of depth, 24.86 ft of width, and 131,261 ft^2 of varial zone. Changes in velocity also have adverse effects on juvenile trout. Specifically, if juvenile trout are displaced, they are forced to seek velocity breaks, thus increasing their vulnerability to predation. Eighty-two percent of juvenile rainbow trout observed during snorkeling were in 2.5 – 5.5 ft. of water. Ramping from 12kcfs to 26kcfs would effect every trout within this depth range. Based on our best available data on juvenile bull trout locations, this evidence can be extrapolated to juvenile bull trout as well.

From Hauer, flow manipulation has deleterious effects on all macrozoobenthos. For example, greater than 558 *Baetis tricaudatus* per ft^2 (2,946,240 per mile), and greater than 37 *Hydropsychids* per ft^2 (195,360 per mile) are influenced in some manner by water levels. Baetis are multivoltine, and need suitable habitat year around. Many of the dominant *Plecopterans*, including *Pteronacys*, are semi-voltine, and require quality conditions to complete their life cycles.

Another issue is flow variability as it relates to redd-building of fluvial rainbows during April and May. There appears to be a pretty close correlation between numbers of redds and flow variability in the years that redds counts were conducted.

The Hauer graphs that are attached, as well as Hauers data, are good indicators of the change that has occurred since Libby was built as it relates to daily flow fluctuations and their effect on productivity. The obvious effects of water manipulation on the creatures that depend on that productivity clearly demonstrate that flow ramping rates should be established.

Methods – Habitat Suitability Indexes

Depth was measured to the nearest 0.1 ft, and was grouped in 0.5 ft increments for data analysis. Velocity (nose, and 0.2 and 0.8 x depth) was measured to the nearest 0.001 ft/sec, and was grouped into 0.5 ft/sec increments for data analysis.

Data sets collected for Instream Flow Incremental Methodology (IFIM) were compiled and combined into one set for the two habitat sections of the Kootenai River from Libby Dam to the Idaho border. Observation data were stratified by juvenile or adult life stage based on estimated fish length. Within each life stage, data were pooled from all streamflow, habitat cluster, and habitat type strata into frequency distributions of depth, mean column velocity, and substrate and cover variables. Suitability functions were developed for depth and velocity by fitting polynomial regression models to the raw frequency distributions (Figures 1,2 and 3). Sequential orders of polynomials were added to the regression function in a stepwise manner; when a new order failed to significantly reduce the remaining unexplained variance (the significance was measured with a t-test), the stepwise procedure was terminated and all lower order models were examined for aptness of fit by visual correlation with data, by t-statistics, and with correlation tests. The simplest model fulfilling these criteria was selected to describe habitat suitability. Minor hand-drawn adjustments to the deep (for depth) or fast (for velocity) tail of the regression curves were typically necessary to maintain a realistic fit.

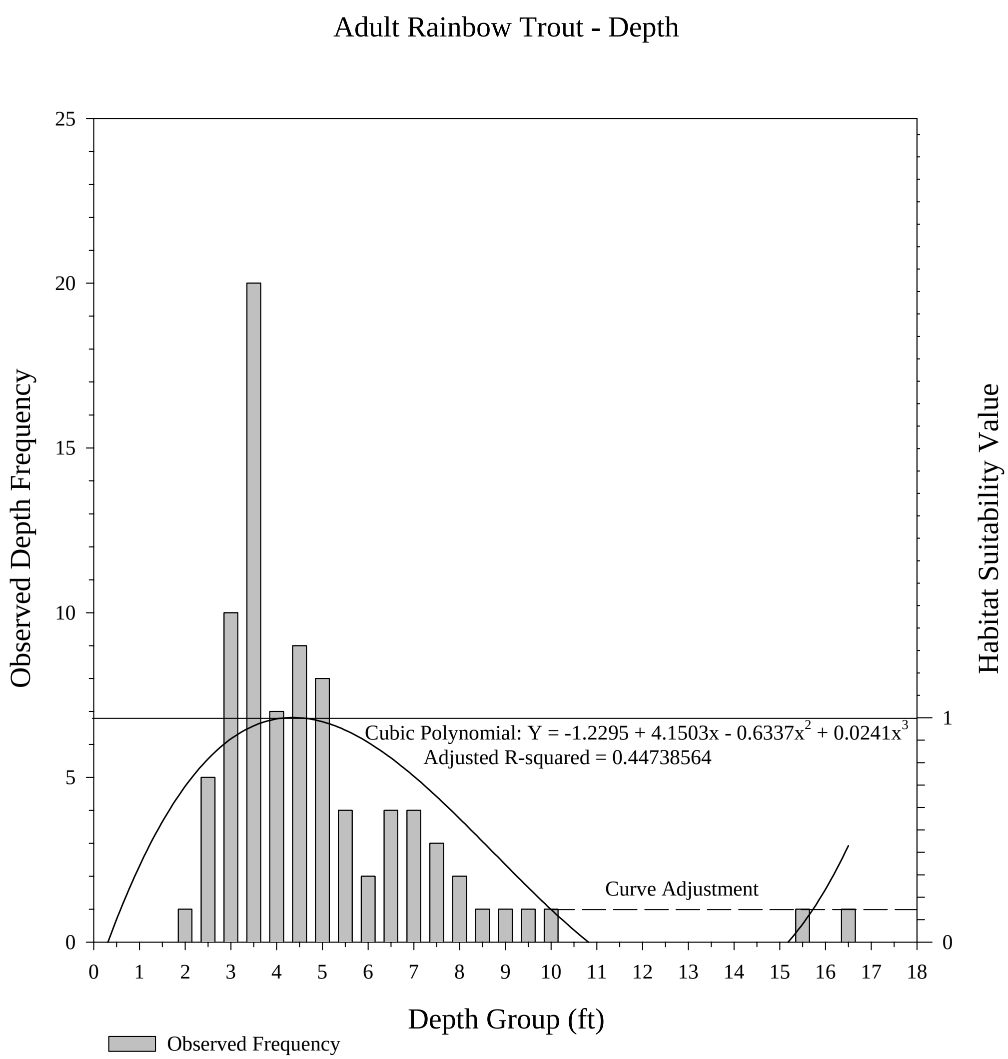


Figure 1. Depth habitat suitability curve for adult rainbow trout in Sections 1 and 2 of the Kootenai River between Libby Dam, Montana and Bonners Ferry, Idaho.

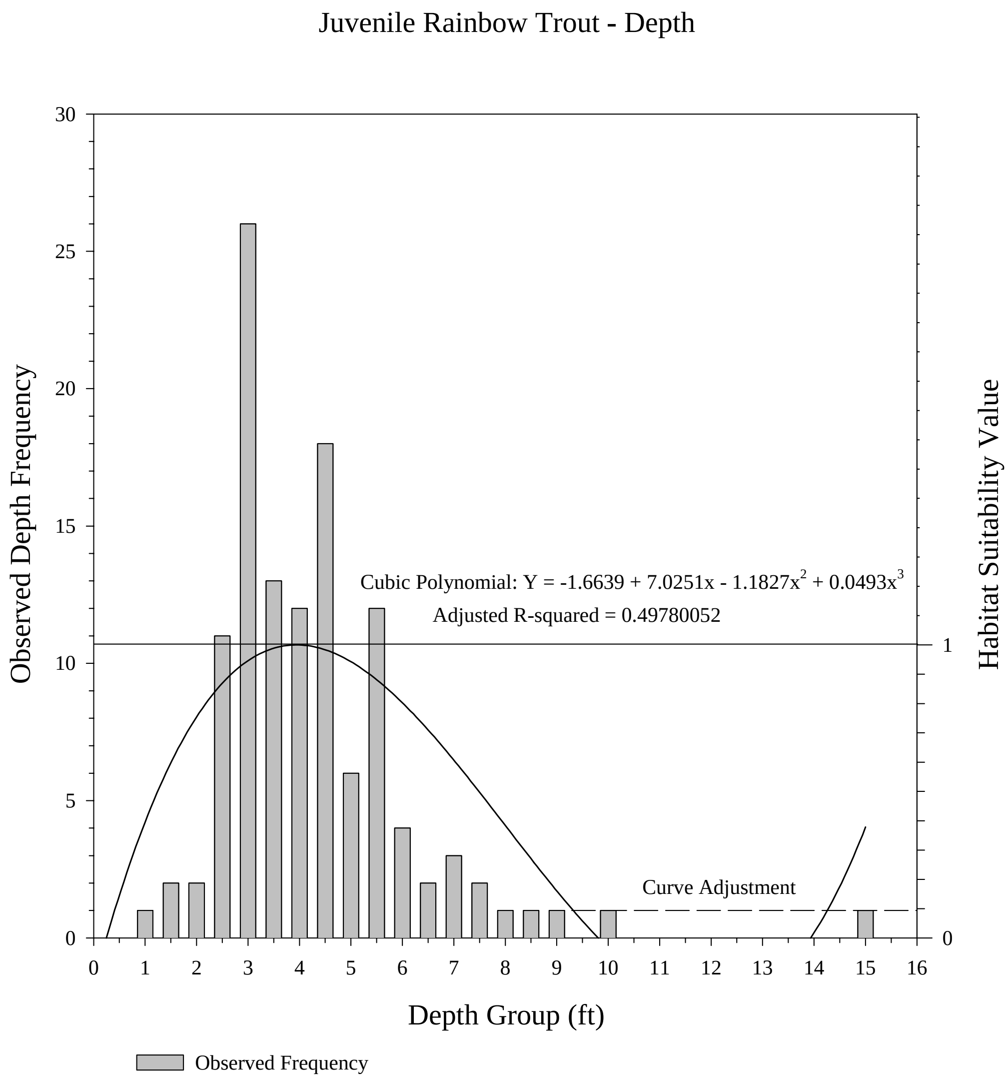


Figure 2. Depth habitat suitability curve for juvenile rainbow trout in Sections 1 and 2 of the Kootenai River between Libby Dam, Montana and Bonners Ferry, Idaho.

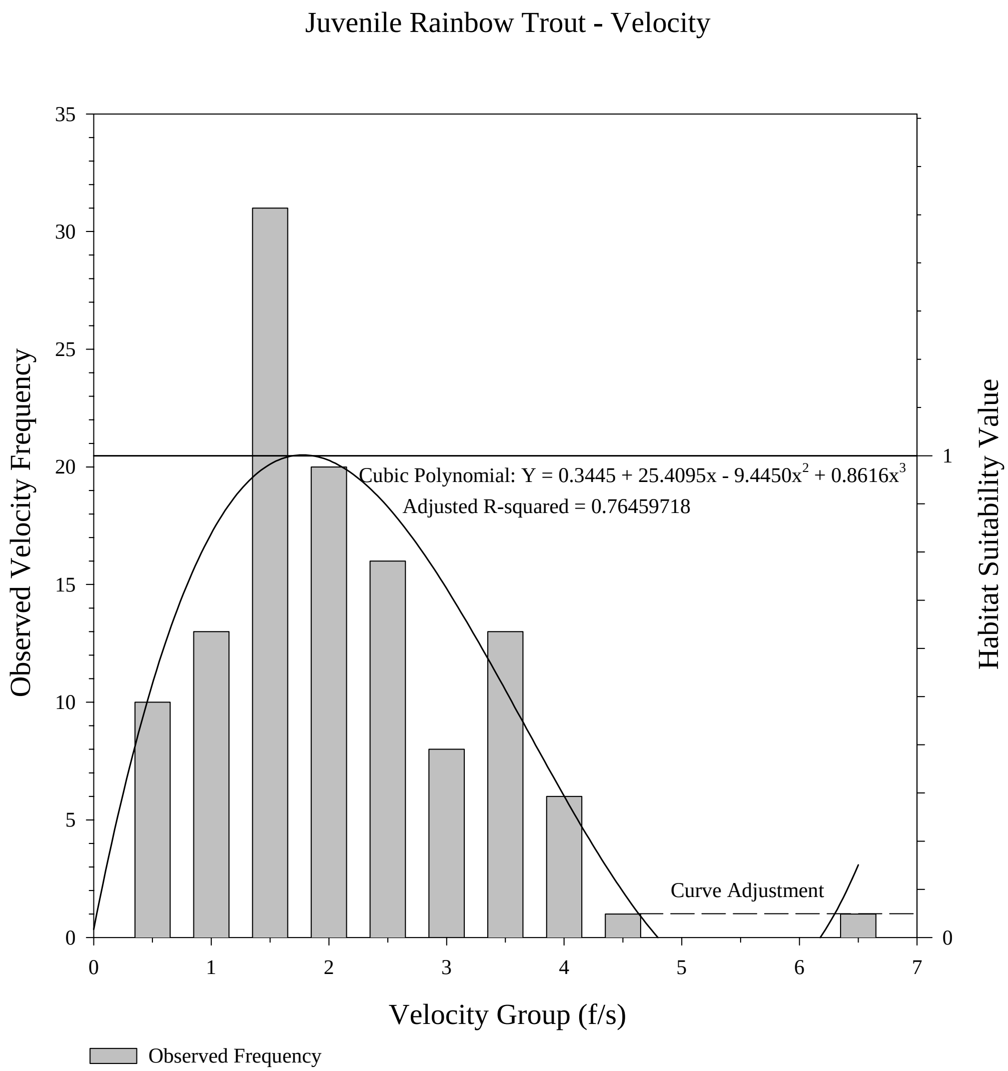


Figure 3. Velocity habitat suitability curve for juvenile rainbow trout in Sections 1 and 2 of the Kootenai River between Libby Dam, Montana and Bonners Ferry, Idaho.

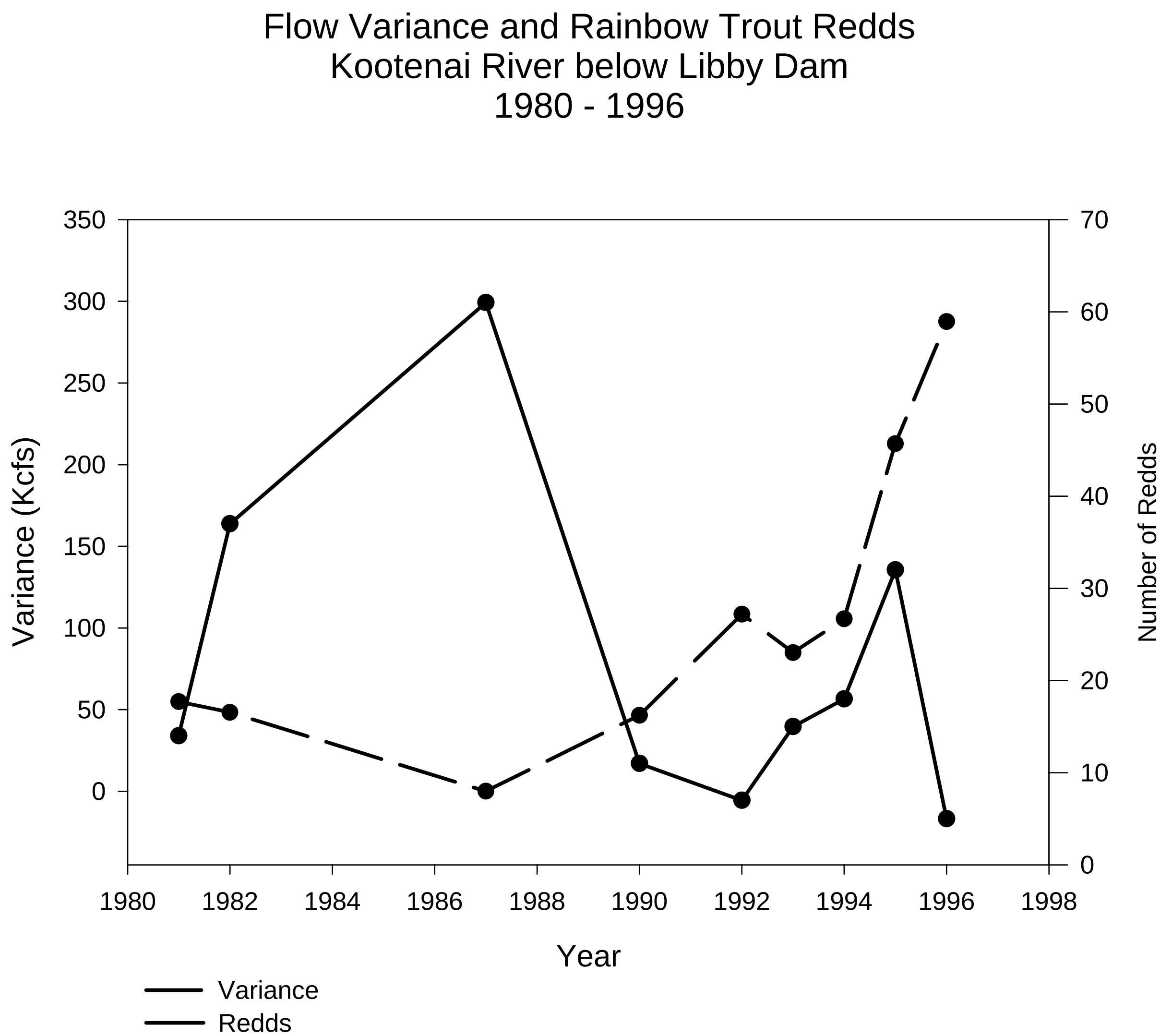
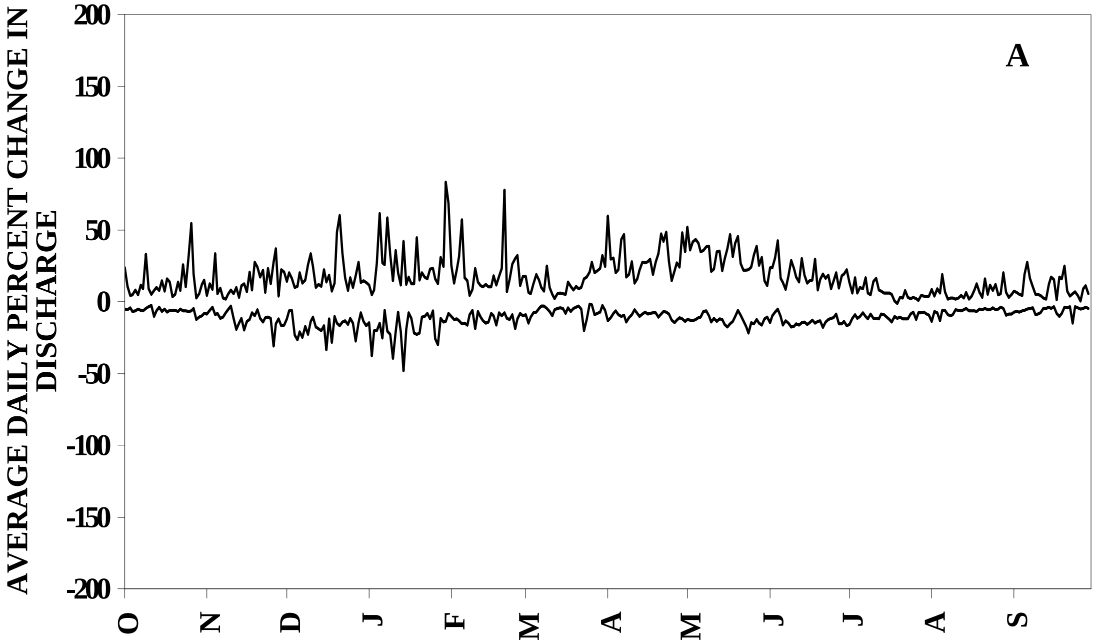
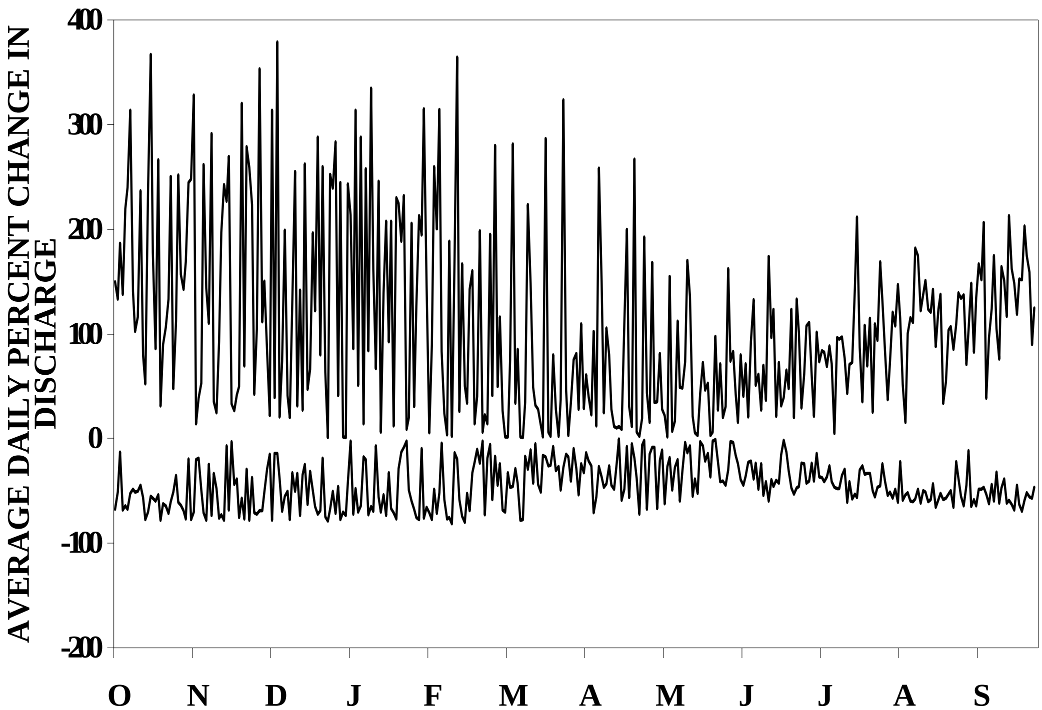

Flow Variance and Rainbow Trout Redds
Kootenai River below Libby Dam
1980 - 1996
Variance (Kcfs)
350
300
250
200
150
100
50
0
Number of Redds
70
60
50
40
30
20
10
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Variance
Redds

Table 1. Loss of varial zone area and depth with changes in Q-out from Libby Dam in Section 1 of the Kootenai River (Dam to Falls).

Qout	avg maxdepth	change/1kcfs	Cumulative	avg maxwidth	change/1kcfs	Cumulative	ft2/mile	mean of ft2/mile
4000	8		0	396		0	0	441619
5000	8.21	0.46	0.46	411.18	15.61	15.61	82421	
6000	8.61	0.4	0.86	424.05	12.87	28.48	150374	
7000	8.98	0.37	1.23	434	9.95	38.43	202910	
8000	9.32	0.34	1.57	441.02	7.02	45.45	239976	
9000	9.64	0.32	1.89	446.27	5.25	50.7	267696	
10000	9.94	0.3	2.19	450.69	4.42	55.12	291034	
11000	10.22	0.28	2.47	455.06	4.37	59.49	314107	
12000	10.49	0.27	2.74	459.22	4.16	63.65	336072	
13000	10.75	0.26	3	463.05	3.83	67.48	356294	
14000	11	0.25	3.25	466.86	3.81	71.29	376411	
15000	11.24	0.24	3.49	470.87	4.01	75.3	397584	
16000	11.47	0.23	3.72	475.11	4.24	79.54	419971	
17000	11.69	0.22	3.94	479.35	4.24	83.78	442358	
18000	11.9	0.21	4.15	484.51	5.16	88.94	469603	
19000	12.11	0.21	4.36	489.94	5.43	94.37	498274	
20000	12.31	0.2	4.56	495.68	5.74	100.11	528581	
21000	12.51	0.2	4.76	500.11	4.43	104.54	551971	
22000	12.7	0.19	4.95	504.54	4.43	108.97	575362	
23000	12.89	0.19	5.14	506.89	2.35	111.32	587770	
24000	13.07	0.18	5.32	508.92	2.03	113.35	598488	
25000	13.25	0.18	5.5	510.84	1.92	115.27	608626	
26000	13.43	0.18	5.68	512.67	1.83	117.1	618288	
27000	13.6	0.17	5.85	514.45	1.78	118.88	627686	

Figure 4. Range in daily percent change in discharge of the Kootenai River from water year 1952 through 1971 (A) and below Libby Dam from water year 1975 through 1995 (B) *in* Hauer and Stanford (1997).





Flathead River below Hungry Horse Dam

The installation of Hungry Horse Dam in 1952 changed the physical and biological characteristics of the Flathead River downstream of the dam. Therefore, in 1999 Montana Fish, Wildlife and Parks (FWP) initiated a three-year IFIM study to assess the available physical habitat and fish habitat use relative to changes in river discharge for native species (i.e. bull trout and westslope cutthroat trout) inhabiting the Flathead River, Montana. The overall goal of the project will be to allow FWP to make flow recommendations to the Bureau of Reclamation (BOR) for Hungry Horse Dam operation that will mutually benefit power production, flood control and native fish species in the Flathead system. The following habitat use information was collected during the first year of the study from August 1999 through March 2000 in Reach 1 of the mainstem Flathead River.

Study Area

The overall study area encompasses the Flathead River from the confluence of the South Fork Flathead River downstream to the river mouth at Flathead Lake, Flathead County Montana. The Flathead River was stratified into three reaches based on changes in river morphology. Reach 1 begins at the confluence of the mainstem and the South Fork Flathead River and flows in a southerly direction approximately 12.4 miles to a gradient break near Presentine Bar, Kalispell, Montana. The study reach is classified as a Rosgen C3/4 channel characterized by run dominated habitat with pool and riffle inclusions.

Methods

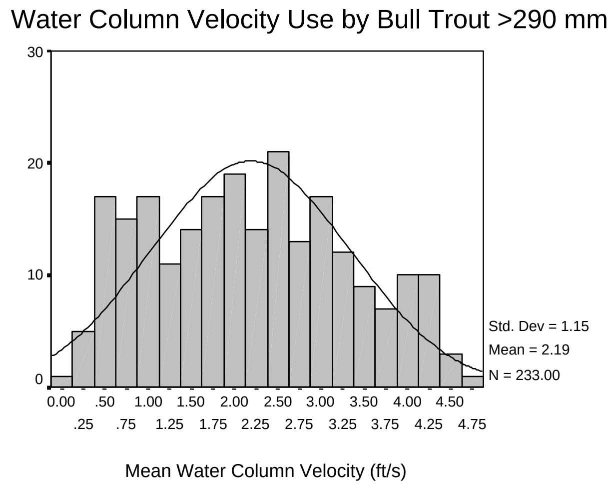
The following habitat use data were collected following standard IFIM random sampling methods (e.g. snorkeling) and radio-telemetry. Snorkel surveys were conducted during August and September 1999 and telemetry surveys from August through March 2000. Data were combined for subsequent analyses and reported for westslope cutthroat trout (>75 mm; n = 193), juvenile bull trout (<290 mm; n = 15), and sub-adult and adult bull trout (>290 mm; n = 233). In addition, we conducted 24-tracking surveys on one sub-adult and one adult bull trout in the mainstem Flathead River below Hungry Horse Dam on September 22-23, 1999.

Preliminary Results

Habitat use- Frequent flow fluctuations that sporadically influence the varial zone of the river will affect the habitat used by westslope cutthroat trout and juvenile, sub-adult and adult bull trout in the Flathead River below Hungry Horse Dam. In general, westslope cutthroat trout and all size-classes of bull trout used low-velocity areas of the stream. Mean water column velocity used by westslope cutthroat trout and juvenile, sub-adult/adult bull trout was 1.27 ft/sec (S.D.= 0.88), 2.6 ft/sec (S.D.=1.76), and 2.19 ft/sec (S.D. = 1.15), respectively (Figure 5). In addition, cutthroat trout and all size-classes of bull trout commonly used areas of the channel with moderate water depths. Mean water depth used by cutthroat trout, juvenile and sub-adult and adult bull trout (Figure 6) was 7.7 ft (S.D.= 4.37), 8.2 ft (S.D.=2.84), and 8.2 (S.D. = 3.94), respectively. Furthermore, our results suggest that both target species and size-classes, in particular cutthroat trout, used channel margins more than expected. Approximately 79.1%, 56.2%, and 44.9 % of the observations for cutthroat trout, juvenile bull trout and sub-adult and adult bull trout, respectively, were located in lateral, near-shore areas of the channel. Thus, our preliminary results show that cutthroat trout and all size-classes of bull trout commonly used low velocity areas with moderate depths located in lateral margins of the river channel. Completion of the IFIM model will allow us to relate habitat use to availability to quantify the amount of suitable habitat for each target species and size-class at various flow regimes.

Diel surveys- Preliminary diel movement and habitat use surveys revealed that bull trout (>290 mm) used various habitat types throughout well-defined home ranges in the Flathead River below Hungry Horse Dam. Bull trout were active both day and night, and we observed them commonly occupying a variety of deep (i.e. pools) and shallow (i.e. shoals) habitat types; 34% of the relocations were in pools, 44% in runs and 22% in shoals. The observed variable habitat use and movements were probably related to feeding behavior. During night, bull trout were commonly associated with shallow shoal habitats where mountain whitefish are concentrated and readily available as prey. Therefore, our preliminary data suggests that shallow areas located in lateral margins of the channel and deep, low-velocity resting habitats are important to bull trout on a daily basis. Similarly, electrofishing surveys in the Flathead River revealed that juvenile bull trout are commonly found in shallow, low-velocity habitats located in the channel margins.

Radio-telemetry- Reservoir operations may affect fluvial bull trout that inhabit the mainstem Flathead River below Hungry Horse Dam. Our preliminary movement results reveal that a component of the migratory bull trout population may adhere to a fluvial life-history strategy that was previously undocumented in the Flathead system. Bull trout #32 was originally captured and released on April 1 1998 near Eleanor Island, approximately 6.5 km downstream of Columbia Falls. Spring surveys revealed that the study fish remained within the vicinity of Eleanor Island (± 3.6 km) during April and May. On June 22, it passed through the North Fork permanent telemetry ground station (at Glacier Rim) moving a total distance of 37 km upstream of Eleanor Island. On September 28, the study fish passed through the North Fork ground station and 8 days later returned to Eleanor Island. It was consistently relocated near Eleanor Island through June 6, 1999 until battery expiration. Thus, the pronounced summer to fall upstream and subsequent downstream migration by bull trout #32 coincides with typical spawning migrations reported for migratory bull trout in the Flathead system.



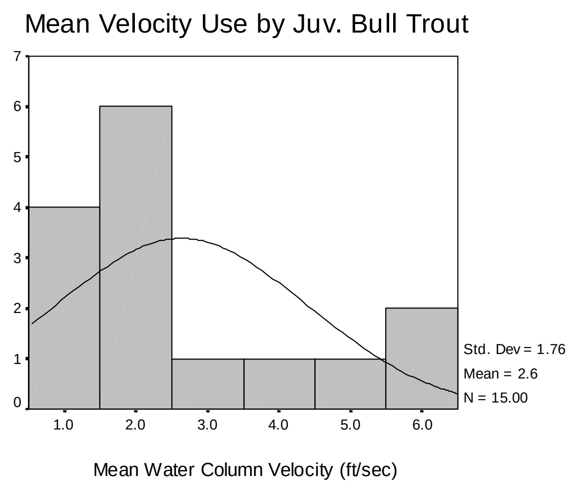
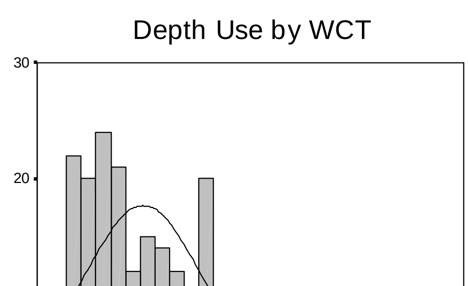
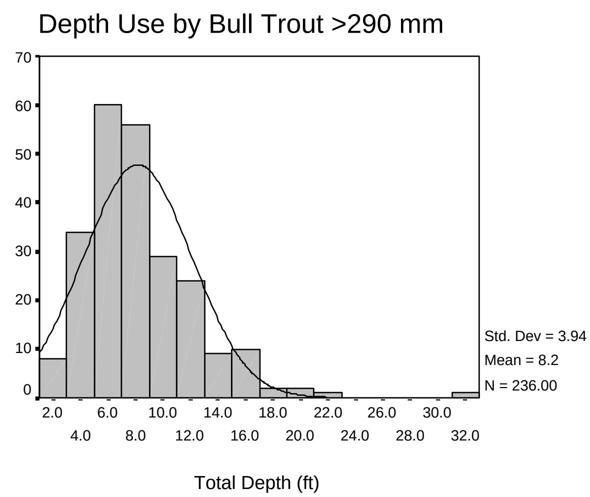


Figure 1. Mean water column velocity use by westslope cutthroat trout (>75 mm), juvenile bull trout (< 280 mm) and sub-adult and adult bull trout (>280 mm) in the Flathead River from August 1999 through March 2000.





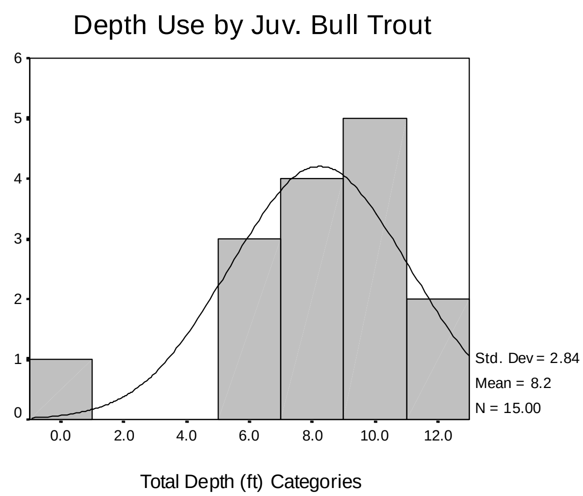


Figure 2. Total depth use (m) by westslope cutthroat trout (>75 mm), juvenile bull trout (< 280 mm) and sub-adult and adult bull trout (>280 mm) in the Flathead River from August 1999 through March 2000.