Instream Flow Incremental Methodology

Kootenai River, Montana

Final Report

By:

Greg Hoffman
Don Skaar
Steve Dalbey
Jay DeShazer
Larry Garrow
Tom Ostrowski
Jim Dunnigan
Brian Marotz

Montana Department of Fish, Wildlife and Parks
475 Fish Hatchery Road
Libby, MT 59923

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INTRODUCTION

Regulated rivers such as the Kootenai River below Libby Dam often exhibit hydrographs and water fluctuation levels that are atypical when compared to non-regulated rivers. These flow regimes are often different conditions than those which native fish species evolved with, and can be important limiting factors in some systems. Fluctuating discharge levels can change the quantity and quality of aquatic habitat for fish. The instream flow incremental methodology (IFIM) is a tool that can help water managers evaluate different discharges in terms of their effects on available habitat for a particular fish species.

The U.S. Fish and Wildlife Service developed the IFIM (Bovee 1982) to quantify changes in aquatic habitat with changes in instream flow (Waite and Barnhart 1992; Baldridge and Amos 1981; Gore and Judy 1981; Irvine et al. 1987). IFIM modeling uses hydraulic computer models to relate changes in discharge to changes in the physical parameters such as water depth, current velocity and substrate particle size, within the aquatic environment. Habitat utilization curves are developed to describe the physical habitat most needed, preferred or tolerated for a selected species at various life stages (Bovee and Cochnauer 1977; Raleigh et al. 1984). Through the use of physical habitat simulation computer models, hydraulic and physical variables are simulated for differing flows, and the amount of usable habitat is predicted for the selected species and life stages.

The Kootenai River IFIM project was first initiated in 1990, with the collection of habitat utilization and physical hydraulic data through 1996. The physical habitat simulation computer modeling was completed from 1996 through 2000 with the assistance from Thomas Payne and Associates. This report summarizes the results of these efforts.

STUDY AREA

The Kootenai River, second largest tributary to the Columbia River, originates in Kootenay National Park near Banff, British Columbia. The river is 485 mi (780 km) long and drains approximately 19,300 mi^2 (50,000 km^2). It flows south into Montana near Rexford, between the Purcell and Salish Mountains into Lake Koocanusa, the reservoir created by Libby Dam. Below Libby, Montana (17 mi below the dam), the river flows northwest through a single, narrow channel and into a steep-sided canyon, over Kootenai Falls, into Idaho, then into Kootenay Lake in British Columbia, 128 mi (206 km) downstream of the falls. The river (spelled "Kootenay" in Canada) then flows southwest out of Kootenay Lake and enters the Columbia River at Castlegar, British Columbia.

The Kootenai River has an average annual discharge of 868 m^3/s (30,650 cfs). The drainage basin (Figure 1) is located within the Northern Rocky Mountain physiographic province, which is characterized by north to northwest trending mountain ranges separated by straight valleys parallel to the ranges (Woods and Falter 1982). As much as 90 percent of the Kootenai basin is coniferous forest; about 2 percent is agricultural land used mainly for pasture and forage production (Bonde and Bush 1982).

For the purposes of this study, we divided the Kootenai River into three sections. Section 1 encompassed the 25.17 mi between Libby Dam and the top of Kootenai Falls. Section 1 is more greatly influenced by Libby Dam operation than other river reaches downstream. Kootenai Falls was believed to be an impassible barrier to upstream fish migrations. Recently, however, radio tagged bull trout have ascended the falls (unpublished MFWP file data). Section 2 encompassed the 34.19 mi from Kootenai Falls downstream to approximately one mi upstream from Bonner's Ferry, Idaho. The lower boundary of Section 2 is the furthest upstream point influenced by Kootenay Lake water levels; gradient decreases from 0.6 m/km upstream of Bonner's Ferry to 0.02 m/km downstream of Bonners Ferry (Apperson and Anders 1990). Section 3 encompassed the 88.13 mi of low-gradient river within the zone influenced by Kootenay Lake.

The fish species assemblage in the Kootenai River drainage includes native and introduced species (Table 1). During the late 1940's, anglers caught primarily westslope cutthroat trout (*Oncorhynchus clarki lewisi)* and burbot (*Lota lota)* in Section 1 (Figure 2). Rainbow trout (*Onchorhynchus mykiss)*, bull trout (*Salvelinus confluentus)*, and mountain whitefish (*Prosopium williamsoni)* were seldom captured. Catch of burbot and westslope cutthroat trout declined in the 1950's, while rainbow trout and mountain whitefish catches increased (Bonde and Bush 1982). This trend continued following the completion of Libby Dam in 1972 (May and Huston 1979). Strong populations of rainbow trout, bull trout, and mountain whitefish currently exist, but the burbot fishery is no longer substantial. Torrent sculpins declined immediately following impoundment because of gas bubble disease; the extent of recovery is unknown (May and Huston 1979). Largescale suckers (*Catostomus macrocheilus)* remain numerous. Peamouth chubs (*Mylocheilus caurinus)* and northern pikeminnow (*Ptychocheilus oregonensis)* continue to be rare above Kootenai Falls, similar to conditions prior to impoundment.

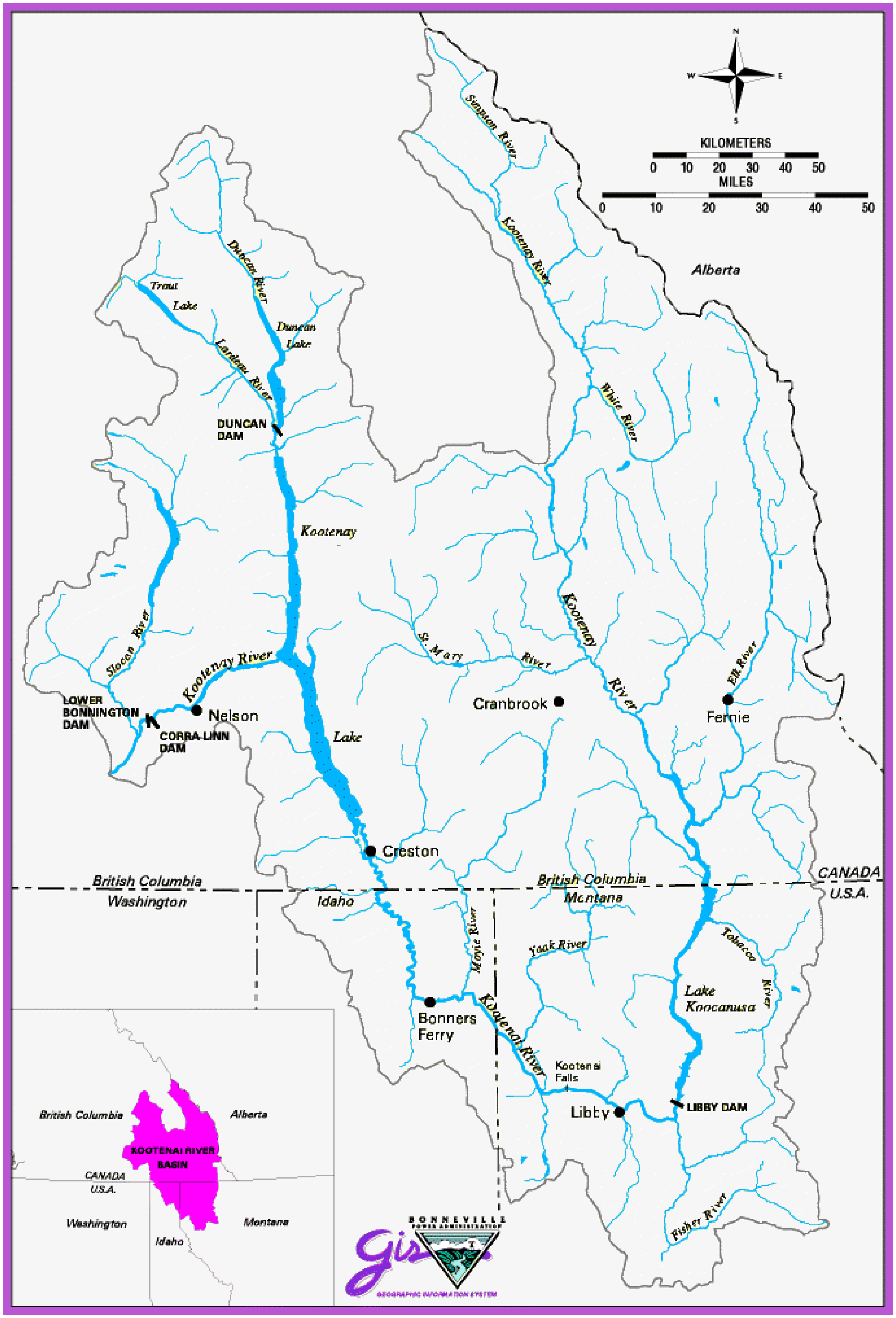

Figure 1. Kootenai River drainage, Montana, Idaho and British Columbia, Canada.

Table 1. Fish species present in the Kootenai River and their abundances (A=abundant, C=common, R=rare)

Common Name	Genus species	Abundance	Native
Westslope cutthroat trout	*Oncorhynchus clarki lewisi*	C	Yes
Rainbow trout	*Oncorhynchus mykiss*	A	Yes
Bull trout	*Salvelinus confluentus*	C	Yes
Brook trout	*Salvelinus fontinalis*	R	No
Brown trout	*Salmo trutta*	R	No
Kokanee salmon	*Oncorhynchus nerka*	C	Yes
Mountain whitefish	*Prosopium williamsoni*	A	Yes
Burbot	*Lota lota*	C	Yes
Largemouth bass	*Micropterus salmoides*	R	No
Northern pike	*Esox lucius*	R	No
Brown bullhead	*Ictalurus nebulosus*	R	No
Black bullhead	*Ictalurus melas*	R	No
Pumpkinseed sunfish	*Lepomis gibbosus*	R	No
Yellow perch	*Perca flavescens*	R	No
Redside shiner	*Richardsonius balteatus*	C	Yes
Peamouth chub	*Mylocheilus caurinus*	A	Yes
Northern pikeminnow	*Ptychocheilus oregonensis*	A	Yes
Largescale sucker	*Catostomus macrocheilus*	A	Yes
Longnose sucker	*Catostomus catostomus*	R	Yes
Longnose dace	*Rhinichthys cataractae*	R	Yes
Torrent sculpin	*Cottus rhotheus*	R	Yes
Slimy sculpin	*Cottus cognatus*	C	Yes
White sturgeon	*Acipenser transmontanus*	R	Yes

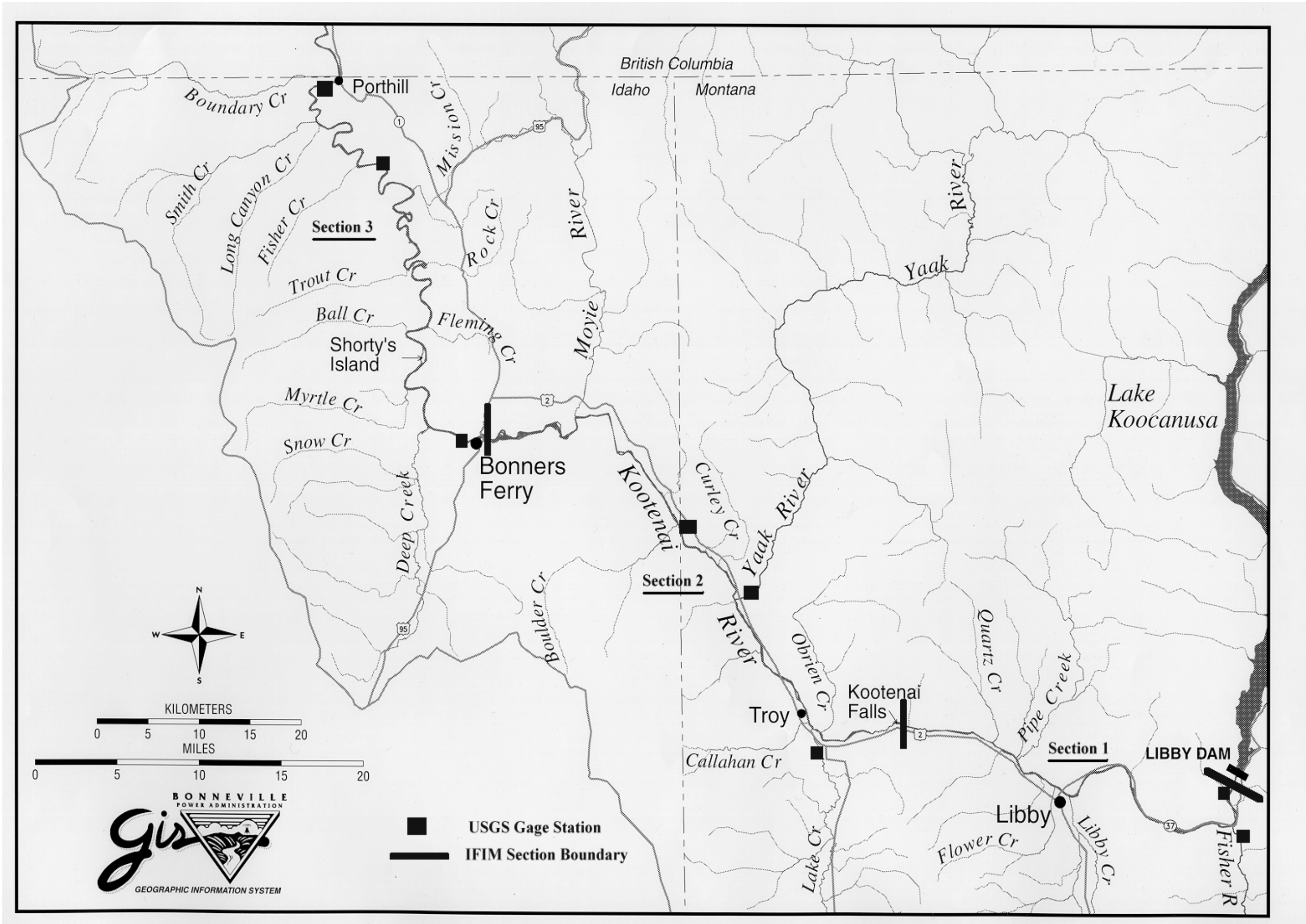

Figure 2. IFIM Section Boundaries and USGS Gauge Station locations on the Kootenai River, Montana and Idaho.

Bull trout, rainbow trout, and westslope cutthroat trout were not common in Section 2 (Kootenai Falls to one mile upstream of Bonners Ferry, Idaho; Figure 2) prior to impoundment, and remained uncommon following impoundment. This is likely due to a lack of spawning habitat (May and Huston 1979). Mountain whitefish became more numerous after impoundment in middle section of the Kootenai River, probably due to lower turbidity and warmer river temperatures during winter (Partridge 1982). Mountain whitefish are also more likely than trout to spawn successfully in the Kootenai River or in tributaries lacking suitable substrate for trout.

Anecdotal information from fishermen indicates that an excellent winter burbot fishery (fishing through the ice) existed from the 1950s through the early 1970s. Following impoundment, warmer water released by Libby Dam prevented ice formation on the Kootenai River and angler success decreased. Comparisons between IDFG hoop trap success rates in 1957 and 1958 with sampling by Partridge from 1979 through 1982 indicate a decline in burbot numbers. This may be due to a combination of factors including overexploitation, lack of spawning success due to flow alterations and warmer winter water temperatures, and poor fry survival resulting from a decrease in river productivity (Paragamian 1993).

Work performed by the Idaho Department of Fish and Game (IDFG) within Section 2 (near Rkm 262-265), found mountain whitefish, largescale sucker, redside shiner (*Richardsonius balteatus)*, and northern pikeminnow respectively to be the most abundant species in the electrofishing catch, constituting 39.7, 27.8, 13.9 and 8.8% respectively. However, largescale sucker, mountain whitefish, northern pikeminnow and longnose sucker (*Catostomus catostomus)* represented 70.0, 19.0, 3.8 and 3.4% of the biomass respectively (V. Paragamian, Idaho Department of Fish and Game, personal communication).

Bull trout are listed as threatened under the ESA. The population in the Canadian headwaters of Libby Reservoir is believed to be the strongest metapopulation in existence. The primary spawning stream for that population is in British Columbia in a drainage now undergoing logging. Libby Dam isolated bull trout populations above and below the dam. The strongest metapopulation in the U.S. spawns and rears in Grave Creek. The bull trout population below Libby Dam, which is now mainly supported by three tributaries upstream of Kootenai Falls, has too few sub-populations to be considered a stable metapopulation. Below the falls, only O'Brien Creek in Montana produces significant numbers of juvenile bull trout. In Idaho, juvenile bull trout are occasionally found in Boundary, Mission, Long Canyon, Boulder, Caribou, and Snow Creeks, while adults are occasionally captured in the lower mainstem section of the Kootenai River in Idaho during routine monitoring and evaluation of hatchery released white sturgeon juveniles (KTOI and IDFG, unpublished data).

Native interior redband, a subspecies of rainbow trout and a designated 'Species of Special Concern' in Montana, exist in only a few isolated Kootenai River tributaries. Callahan Creek in Montana is the only stream believed to provide spawning habitat for Kootenai River redband, although adult redband have been observed in the mouth of the Yaak River. The redband rainbow trout provides the most important fishery in the Kootenai River in Idaho. Although anglers were estimated to have caught over 1,000 trout in 1994, the total population numbers are thought to be down from pre-Libby Dam years. Research studies have shown that the recruitment of rainbow trout in the Idaho reach has come from two sources. Trout below Bonners Ferry rear in the Deep Creek drainage and mature in Kootenay Lake, B.C., while fish above Bonners Ferry are thought to recruit from a few tributaries in Idaho and Montana.

The headwaters of Libby Reservoir contain important, genetically pure stocks of fluvial and adfluvial westslope cutthroat trout. However, in the U.S., the species has been petitioned for ESA listing and has been designated a Species of Special Concern in Montana. Twenty-four years of population estimates show a population decline. In 1973, 44 percent of trout captured in the Kootenai River were westslope cutthroat, with angler catch rates recorded at 0.5 fish/hour, ranking the river among other Montana blue ribbon trout streams. Estimates in 1994 document significant population reductions, less than five percent of the trout captured were westslope cutthroat trout. In the Idaho reach of the Kootenai River, westslope cutthroat trout are not common and provide only a small portion of the salmonid harvest (Paragamian 1994).

Mountain whitefish abundance has declined in the Idaho reach of the Kootenai River since the early 1980s, despite what is considered to be ideal physical habitat for spawning (Partridge 1983; May and Huston 1983; Paragamian 1994; Downs 1998; Downs 1999). The 1980 and 1981 mountain whitefish estimates (Partridge 1983) in the Idaho reach of the Kootenai River upstream of Bonners Ferry were likely two-fold higher than pre-Libby Dam conditions. Partridge estimated 1,533 and 1,331 mountain whitefish per 305 m of river upstream of Bonners Ferry in 1980 and 1981, respectively. By 1994, mountain whitefish abundance had declined to an estimated 326 mountain whitefish per 305 m of river (Paragamian 1994). Mountain whitefish populations in the Montana portion of the Kootenai River have been stable.

Burbot in the Kootenai River in Idaho have been petitioned for ESA listing, and are Red Listed in B. C. They are designated as a “Species of Special Concern” in Idaho. In Montana burbot are still common, though recent trends in hoopnetting below Libby Dam have been downward (Greg Hoffman, MFWP, personal communication 2001), although they are listed as a species of special concern. It is believed that at one time, the burbot fishery in Idaho produced many thousands of fish each winter. The population provided a valuable social, sport, and commercial fishery, which collapsed soon after the completion of Libby Dam. Burbot were once very important to the anglers of Kootenay Lake, as well. Just as in Idaho, the fishery collapsed soon after Libby Dam began operations. Genetic analyses have indicated burbot in Idaho and B.C. are of the same genetic stock, while burbot in Montana are of a different stock.

An investigation initiated in 1993 was designed to assess burbot abundance, distribution, size, reproductive success, and movement, and to identify factors limiting burbot in the Kootenai River in Idaho and British Columbia. A total of only 17 burbot were caught in 1993 (CPUE one burbot/33 net days) and 8 in 1994 (CPUE of one burbot/111 net days). However, numerous age groups of fish were apparent in the net catch, indicating some burbot recruitment was occurring. Only one burbot was sampled between Bonners Ferry and the Montana border, and there was no evidence of reproduction in Idaho. Unspawned females have been caught (post-spawn) that were resorbing eggs, as have males (one month post-spawn) that were in various stages of gonadal maturity. This information suggests that a large segment of the adult burbot population is reproductively dysfunctional. Sampling for burbot during the winter of 1993 through 1994 at the mouths of Idaho tributaries was carried out in anticipation of intercepting a spawning run of fish from Kootenay Lake or the lower river, but no burbot were caught. Cooperative sampling in the British Columbia reach suggests that burbot are only slightly more abundant in the lower river. Telemetry studies have shown that the population is transboundary.

Fishing for white sturgeon (*Acipenser transmontanus)* in the Montana portion of Section 2 was unregulated until 1972. From 1972 through 1978, 5 to 18 sturgeon were legally harvested annually. The fishery was closed in 1979, when white sturgeon were designated "a species of special concern" in the state; the estimated population in Montana was five sturgeon. The last verified catch of a white sturgeon in Montana occurred in 1989 in "the sturgeon hole" below Kootenai Falls (Apperson and Anders 1990).

The white sturgeon population in the Kootenai River was listed as endangered in 1994. A lack of recruitment has been identified as the most critical limitation for Kootenai River white Sturgeon (Anders et al. 2000; USFWS 1999; Duke et al. 1999; Anders et al. 1994; Giorgi 1993; and Partridge 1983). Persistent natural recruitment failure in this endangered population appears to be due to intermittent female stock limitation (pre-spawning recruitment limitation) and/or one or more early life mortality factors (post-spawning recruitment limitation.

There has been very little juvenile recruitment since 1974. The most recent population estimate of adult Kootenai River white sturgeon (sturgeon $\geq$ 120 cm) indicated about 1,469 (95% C.I = 740 – 2,197) adult fish are present in the river and Kootenay Lake (Paragamian et al. 1996). The adult segment of the population was comprised primarily of fish of the 1972 year-class and older. The estimated number of wild, juvenile white sturgeon was substantially lower, about 87 individuals. The lower number of juveniles is evidence of the diminutive or lost year-classes of fish. Adults have spawned each year during flow augmentation experiments (initiated in 1991) as evidenced by the capture of fertilized eggs by the Idaho Department of Fish and Game (IDFG). Unfortunately, even with improved flow conditions since the ESA listing, few naturally produced juvenile sturgeon have been found.

Section 3 (Figure 2) has low water velocities, few riffles, and limited spawning habitat for salmonids. Non-game species predominate. The Kootenai Tribe of Idaho (KTOI) conducted electrofishing surveys at two locations (Rkm 170 and 230) in the lower Kootenai River in the fall of 2000 and found that largescale suckers, peamouth chubs, and northern pikeminnows respectively contributed the most biomass to the collective catch of all species (C. Holderman, KTOI, personal communication). Historically, this section supported a sport fishery for white sturgeon and a strong commercial and sport fishery for burbot. Both species have declined dramatically. At present, most of the remaining white sturgeon and burbot have been found in the deep, slow pools of Section 3. Tag returns and sonic telemetry data from IDFG show that burbot, as well as white sturgeon, move freely between Kootenay Lake and Section 3 of the Kootenai River (V. Paragamian, IDFG, personal communication).

WATERSHED CHARACTERISTICS

Prior to impoundment by Libby Dam, the Kootenai River followed a natural pattern of runoff designated "Rocky Mountain snowmelt-dominated" (Poff and Ward 1989). Flows were low from September through March, and increased with snowmelt towards maximum annual discharge during late May or June. Most severe flood events have occurred in May or June during rain on snow events.

The Kootenai River tributaries are primarily high gradient mountain streams with bed material consisting of various mixtures of sand, gravel, rubble, boulders and differing amounts of clay and silt, predominantly of glacio-lacustrine origin. Fine materials, due to their instability during periods of high stream discharge, are continually removed and re-deposited as gravel bars, forming alternating riffles and pools and braided reaches (May and Huston 1973). Interruption of high flow events by Libby Dam has affected the movement of river bottom sediments. Deltas are enlarging at the mouths of tributaries and fine sediments are embedding river cobble (Marotz et al. 1988). Hydropower, roads, logging, mining, agriculture and other human activities have contributed to the gradual decline in system health.

Environmental degradation to tributaries of the Kootenai River is well documented (Partridge 1983, Daley et al. 1981, Cloern 1976, and Northcote 1973). The largest tributary in the reach between Libby Dam and Kootenai Falls is the Fisher River, which originates on the west slopes of the Salish Mountains in Lincoln and Flathead counties and flows west into the Kootenai River approximately 3.4 mi (5.7 km) below Libby Dam. The Fisher River watershed is 838 mi^2 (2171 km^2); flows average about 485 cfs (13.7 cms). The Fisher River has been altered by road building, logging, and a railroad for much of it's length. Libby Creek is the second largest tributary between Libby Dam and Kootenai Falls and has a drainage area of 257 mi^2 (666 km^2; Hauer 1997). Libby Creek originates in the northern slopes of the Cabinet Mountains Wilderness and flows into the Kootenai River at the town of Libby. Flows ranged between 8.4 and 370 cfs (DosSantos 1985). Libby Creek has been altered by placer mining, logging, and roads, and is often dewatered during crucial summer months due to channel aggradation. Montana Department of Environmental Quality listed portions of Libby Creek impaired in accordance with Section 303(d) of the Clean Water Act, due to the overwidened and shallow condition of the stream channel. Sato (2000) indicates that spacing above mining sites is 750-2100 feet (2.5-7 pools per mile), versus 170-340 feet (16-31 pools per mile) below the mining sites. Other large tributaries in this reach are Dunn Creek, Pipe Creek, Bobtail Creek, Cedar Creek and Quartz Creek, all of which have experienced varying levels of alteration.

The Yaak River is the largest tributary to the Kootenai River in Section 2. It enters the Kootenai River about 8 mi downstream of Troy, Montana, and has a drainage area of 766 square mi (1985 km^2) and a mean annual flow of 888 cfs (25 cms; Hauer 1997). The Moyie River is nearly as large, with a drainage area of 755 square mi (1956 km^2) and a mean annual discharge of 886 cfs (24.9 cms; http://water.usgs.gov/id/nwis/sw). Other large tributaries in this reach are O'Brien Creek, Callahan Creek, Lake Creek, Star Creek, and Boulder Creek.

CONSTRUCTION AND OPERATION OF LIBBY DAM

Construction of Libby Dam began in 1966 and was completed in 1972. Libby Reservoir reached full pool elevation for the first time during July, 1974. The "selective withdrawal" system became operational in 1977. Libby Reservoir is a 145-km (90 mi) long storage reservoir with a surface area of 188 km^2 (46,500 A) at full pool (2,459 ft msl), and is operated by the U.S. Army Corps of Engineers (ACOE). The primary benefits of the project are power production (91.5 percent) and flood control (8.3 percent), as well as navigation and other benefits (0.2 percent; Storm et al. 1982). Water from Libby Dam passes through 13 downstream projects enroute to the Pacific Ocean. Libby Dam must be regulated in concert with the complex network of electrical energy producing systems, water consumption needs, and flood control requirements throughout the Columbia River Basin. Libby Dam is not currently equipped with fish passage facilities.

Surface elevation in Libby Reservoir ranges from 697.1 m (2,287 ft) to 749.5 m (2,459 ft, full pool). Mean maximum reservoir drawdown averaged 112.47 feet during water years 1974 through 1998. The deepest drafts occurred in 1991 (154 feet), 1988 (142 feet), and 1989 (138 feet). The 90-110 foot draft limit established in 1987 was exceeded in 1988, 1989, 1990, 1991, 1993, 1997 (MFWP and CSKT 1997), and 1999.

The reservoir stores water during spring runoff and rises towards full pool through the summer. Historically, the U.S. Army Corps of Engineers (ACOE) operated Libby Dam so that the reservoir reached full pool in July, and then began drafting in September to reach a minimum pool elevation by April. Present operations are dictated by a combination of power production, flood control, recreation, and special operations for the recovery of endangered species, including Kootenai River white sturgeon and Snake and Columbia river salmon and steelhead species (NMFS 1995, 1998 and 2000; USFWS 1999 and 2000).

The construction and operation of Libby Dam reversed the natural hydrograph (Figure 3); high flows occur during late fall and early winter and low flows occur during spring. Daily and weekly flows vary considerably from October through January. Since 1994, the USFWS has requested spring discharges in an attempt to restore natural recruitment to the endangered population of Kootenai River white sturgeon. A tiered flow strategy (USFWS 2000, Marotz et al. 1999) has been implemented to restore more natural flows during May and June.

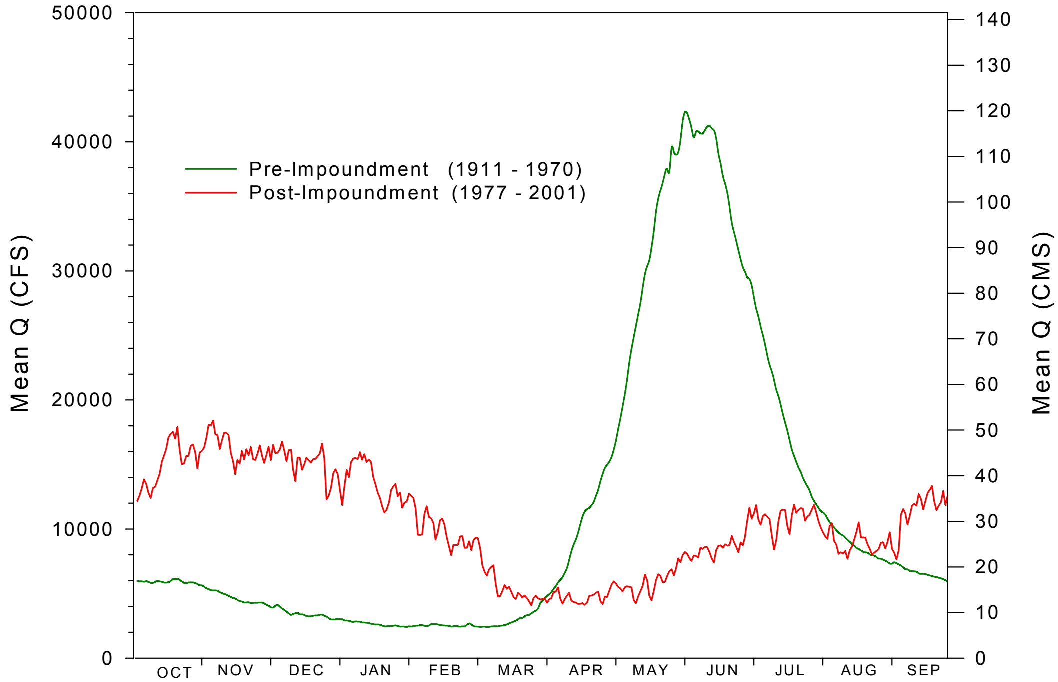

Figure 3. Hydrograph of Kootenai River flows before and after the construction of Libby Dam.

STUDY METHODS

Instream Flow Incremental Methodology (IFIM) was chosen as a study method because it was determined to be the best method with which to record available habitat and habitat use at varying discharges (Bovee 1986, Poff and Ward 1989). The principle objective in completing the study was to allow Montana Fish, Wildlife & Parks (MFWP) to make recommendations to the U.S. Army Corps of Engineers and Bonneville Power Administration for dam operations that would consider the needs of fishes inhabiting the Kootenai River below Libby Dam. The Northwest Power Planning Council Fish and Wildlife Program measure 10.3B.2 (NPPC 1994) clearly outlines MFWP's authority to make recommendations and states that the US Army Corps of Engineers (ACOE) shall "Implement the integrated rule curves for Libby Reservoir submitted to the Council in July 1994 by the CSKT and MFWP. Limits on drafting set in curves should be met in all years. However, exceeding the limits for local flood control is allowed provided that the Council, the CSKT and the State of Montana are notified prior to drafting, and the reservoirs are not incurring additional flood control responsibilities that have historically been provided by other projects. Exceeding the limits for power purposes is also allowed, but is contingent upon approval by the Council, CSKT and the State of Montana. Deviations from the limits will require mitigation as prescribed by the tribes and states, approved by the Council, and called for in measures 10.3B.5 and 10.3B.6". We chose to study the habitat use patterns of rainbow trout and mountain whitefish; rainbow trout provide an important sport fishery in the river below the dam, and mountain whitefish are native to the system.

Pools, riffles, glides, runs, rapids, and side channels were studied within each reach (Table 2). The rip-rap and dredge-cut areas below Libby Dam were excluded from habitat typing, as were the depositional zone above the Highway 37 bridge, the inaccessible section of Kootenai Falls and the canyon below the falls, and the mouth and side channel at Kootenay Lake. We determined habitat boundaries from a boat during low flows (4,000 to 8,000 cfs) using sonar-derived depths and visual cues, and marked them on enlarged sections of USFS quadrangle maps, and then measured the length of each habitat type unit from the maps.

Table 2. Total distance (mi) and percentages of each habitat type in IFIM Sections 1, 2, and 3 of the Kootenai River, Montana, Idaho, and British Columbia, Canada.

	SECTION 1		SECTION 2		SECTION 3	
	Distance	%	Distance	%	Distance	%
POOLS	5.87	23.3	10.87	31.8	28.02	31.8
RIFFLES	0.40	1.6	1.82	5.3	0.17	0.2
GLIDES	7.18	28.5	12.6	36.9	50.39	57.2
RUNS	3.87	15.4	4.16	12.2	0	0
RAPIDS	1.89	7.5	1.29	3.8	0	0
SIDE CHANNEL	4.40	17.5	1.60	4.7	0	0
EXCLUDED	1.56	6.2	1.85	5.4	9.55	10.8
TOTALS	25.17		34.19		88.13	

Velocity, surface turbulence, substrate composition, depth, and cover were the criteria used to determine habitat type. Velocity was generally characterized qualitatively as low, medium or high.

- **Pools** were characterized as having low velocities with the possibility of higher velocities occurring at the head, tail, or edges. The surface was smooth or slightly broken, and depth was such that if the river ceased flow, water would still be retained within the pool. Larger cover such as boulders or wood were usually evident.

- **Glides** had low velocity with little obvious flow, a flat surface, and would be mostly dry if river flow ceased. The substrate was often silty or sandy around larger substrate components.

- **Riffles** had medium to high velocities with cobbles and gravels obvious in the shallow, broken water.

- **Runs** also had medium to high velocities but were greater in depth than riffles. Velocity swirls were sometimes present and substrate composition was not obvious.

- **Rapids** had high velocity, and larger substrates such as boulders and cobbles were evident. Depth was greater than in riffles and the surface had turbulent, whitewater throughout the majority of the rapid.

Braided or side channel areas were studied as discrete units, because most of them contained more than one habitat type. The units were considered to be side channel habitats only if an island existed over a wide range of flows, and at least a portion of the island was vegetated. Although side channel areas posed some modeling problems, we elected to collect microhabitat information within these areas, because a fairly large portion of the river was identified as side channel habitat (17.5 percent of Section 1 and 5 percent of Section 2). We also found that a large proportion of our microhabitat observations associated with fish observations occurred in side channel areas. This was especially true for juvenile fish. Although we collected microhabitat observations within side channel areas, we were unable to incorporate side channel information into estimates of weighted usable area (WUA) due to modeling limitations. We identified two different types of side channel habitats: those that remained as two distinct channels during all flows, and those where the islands were submerged at high flows. However, each of the two types of side channels presented modeling challenges that were insurmountable. We were unable to estimate WUA in side channels because we found that discharge within side channels varied disproportionately to the total river discharge with varying flows. We felt this biased our state/discharge relationship, and therefore were unable to include side channel habitats in estimates of WUA. Since we did not include the side channels into the estimates of WUA, then the total estimate of WUA for the river will be somewhat of an underestimate, especially in Sections 1 and 2, since these sections had the highest occurrence of side channel habitats. This modeling bias may have been greatest at relatively low flows, when the frequency of occurrence of side channels was highest.

TRANSECT AND SURVEY SITE SELECTION

We assigned each river reach a classification of 'typical' or 'unique'. Typical reaches were portions of the river that encompassed no artificial structures such as bridges, rip-rap, dams, etc.; unique reaches contained man-made features that may have effected the channel and/or habitat characteristics. Survey sites were randomly selected within typical reaches. The number of transects measured in each habitat type in each section was approximately proportionate to the total linear length of that particular habitat type.

After a habitat series was chosen for measurements, each habitat type within the habitat series was marked at the upstream and downstream end with flagging. If an individual habitat contained more than one transect, the habitat was divided into similarly sized cells and marked with flagging and a labeled stake. Transects were placed as close to the center of each cell as possible, depending on the suitability of the river bank for placement of the cable stringing apparatus. If the center of the cell was not suitable, the closest suitable location upstream or downstream of the center of the cell was chosen. Transects were placed in locations which within each cell and marked with flagging and a labeled stake.

Hydraulic controls for each habitat series were identified and staked. The location was verified by using a hydroacoustic depth finder to identify the shallowest portion of the river channel below the habitat series. These hydraulic controls were typically heads of riffles and used as the stage of zero flow for the hydraulic model.

TRANSECT DATA COLLECTION

Transect Pin and Water Elevation Surveys

Vertical control benchmarks were established for each habitat series by driving a 5-6 ft fence-post into the ground above the high water mark, and identified with an aluminum tag indicating habitat series and number. Re-bar pins were placed as vertical and horizontal control points at both ends of each transect, above the high water level. Benchmarks and transect pin positions were surveyed using a *Trimble* global positioning unit. Positions were differentially corrected by referencing to base files from the U.S. Forest Service regional office in Missoula, Montana. The transect pin elevations were established by closing survey loops between each pin in a habitat series. We used a SOKIA transect level and graduated rod to survey elevations. We assigned the starting pin an elevation of 100.00' for the transect pin furthest upstream of a habitat series. We closed elevation loops using line of levels technique described by DeGROOT (1954). We surveyed at the accuracy of closure of the 3rd order of leveling using the equation:

$$E = 0.5\sqrt{M}$$

Where E denotes the permissible error of closure, in feet, in a survey loop; M denotes the length of the survey loop in miles.

We closed survey loops from a permanent benchmark to the closest transect pin for future reference Water elevations within each transect were surveyed at high (20,000-25,000 cfs), medium (12,000-15,000 cfs), and low (4,000-8,000 cfs) flows by closing loops from the respective transect pins to the waters edge. Ground elevations were also surveyed from the transect pin to the waters edge across the transect line at the medium flow stage. Ground elevations were measured at any ground feature changes across the transect line. Ground feature changes included significant changes in elevation or ground cover on each transect. We combined ground elevations to the water depths to complete an elevation cross section for the entire transect, left pin to right pin.

Transect Profile and Discharge Data Collection

Discharge and profile data were collected at each transect by measuring depth, flow velocity and cell width along the transect. Due to the size of the river, we had to take the measurements from a jet boat attached to a kevlar cable that was stretched across the river. The kevlar cable was 1,500 feet long and had a stress rating of 1,500 pounds. It was wound onto a heavy-duty steal hose reel that could be attached to the stream bank with fence posts. The boat was attached to the cable with a standard USGS suspension system that allowed the boat be pulled across a river and positioned at any location along the transect. To string the kevlar cable across the river we secured the hose reel with four fence posts to one bank and transported the end of the cable across the river with a jet boat. The end of the cable was then attached to a cable winch that was secured to the other bank with three fence posts. After affixing the cable to both banks it was tightened with the winch to absorb excess stretch and minimize sag. A B-56 sounding reel with a 75 lb bomb weight was attached to the suspension system and used for measuring depth and positioning a Price AA Flow Meter to collect velocity measurements.

Once the cable was setup we calculated the total transect length and determined cell widths and sampling locations. We divided each transect into a minimum of 20 within the wetted perimeter of the river. We measured depths, nose velocities and mean velocities at the mid-point of each cell. Mean velocities were taken at 60% of the measured depth in water less than 3 feet deep, and at 20 and 80% in water greater than three feet deep. For discharge calculation we used the 60% depth velocity areas less than three feet deep, and we averaged the 20 and 80% depth velocities in areas deeper than three feet. We installed a staff gauge in close proximity to the transect being measured to monitor any change in stage during the sampling period.

USGS gauge data were used to check the accuracy of measured discharges at each transect. Gauge stations on the Kootenai River are located in Montana just below Libby Dam, and near Leonia, at the Montana-Idaho border (http://water.usgs.gov/mt/nwis/sw), and in Idaho near Bonners Ferry and near Porthill (http://water.usgs.gov/id/nwis/sw). Data from gauged tributaries were used to approximate the inflows from tributaries that flow into the Kootenai River between the gauge stations. The difference between gauged and measured discharges was less than ten percent for all but one transect (Table 3). Section 1 had six transects that had differences of greater than ten percent when compared to gauged data. Measured discharges from Section 2 were very consistent with gauged discharges (Table 4). Discrepancies in measured flow data could be the result of human error or malfunctioning equipment. All measured discharges with greater than ten percent error occurred during the 1991 field season.

Table 3. Measured discharge related to gauged discharge, Section 1, Kootenai River.

Transect Type	Survey Date	Measured Q (cfs)	Gauged Q (cfs)	% Difference
Pool	9/26/91	13,016	14,125	7.7
Pool	9/25/91	13,043	14,125	7.7
Pool	9/25/91	11,590	14,125	17.4
Glide	9/24/91	12,470	14,125	12.0
Mid / Side Channel [a]	9/2/92	13,867	13,900	0.3
Mid / Side Channel [a]	9/14/92	13,957	13,980	0.2
Side Channel [a]	8/25/92	12,906	13,411	3.8
Side Channel [a]	8/31/92	12,843	12,890	0.4
Pool	10/11/91	13,519	14,120	4.3
Pool	10/11/91	13,203	14,120	6.5
Pool	10/9/91	12,264	14,120	13.2
Glide	9/30/91	12,167	14,120	13.8
Glide	10/9/91	11,802	14,120	16.4
Run	9/8/93	12,882	13,435	4.1
Glide	9/8/93	12,881	13,435	4.1
Glide	9/9/93	13,306	13,435	1.0
Glide	9/9/93	13,292	13,435	1.1
Pool	9/20/93	13,270	13,435	1.2
Pool	9/20/93	13,278	13,435	1.2
Pool	9/28/93	12,653	13,862	8.7
Run	9/29/93	13,840	13,862	0.8
Pool	9/21/93	13,118	13,339	1.7
Pool	9/22/93	13,909	13,339	4.1
Glide	9/22/93	12,711	13,339	4.7
Glide	9/24/93	12,639	13,339	5.3
Glide	9/24/93	10,902	13,339	18.3
Rapids	9/29/93	13,455	13,862	3.0
Rapids	10/1/93	13,586	13,862	2.0
Rapids	9/29/93	12,914	13,862	6.7
Run	9/30/93	13,318	13,862	4.0

a) Includes main channel and side channel discharges.

Table 4. Measured discharge related to gauged discharge, Section 2, Kootenai River.

Transect	Survey Date	Measured Q (cfs)	Gauged Q (cfs)	% Difference
Glide	8/19/91	12,950	13,050	1.0
Glide	8/19/91	12,706	13,050	3.0
Pool	8/20/91	13,102	13,250	1.1
Riffle	8/13/91	13,453	13,820	2.7
Riffle	8/12/91	13,626	13,810	1.3
Run	8/12/91	13,691	13,820	1.0
Run	8/7/91	14,423	13,960	3.2
Glide	8/7/91	12,671	13,960	9.2
Glide	8/6/91	13,473	13,980	3.6
Run [a]	8/14/91	13,857	13,790	0.5
Run [a]	8/15/91	13,138	13,790	4.7
Run	8/16/91	13,312	13,970	4.7
Glide	9/4/91	12,057	13,720	12.0
Glide	9/5/91	13,597	13,780	1.3
Pool	9/4/91	14,163	13,720	3.1
Pool	9/3/91	13,748	13,660	0.6
Pool	9/13/91	14,535	13,770	5.3
Pool	9/13/91	14,344	13,770	4.0
Pool	9/17/91	14,922	13,610	8.8
Run	9/17/91	13,328	13,610	2.0
Run	9/19/91	12,775	13,620	6.0
Pool	9/19/91	13,160	13,620	3.4
Pool	9/18/91	12,836	13,540	5.2
Glide	9/18/91	12,743	13,540	5.9

a) Includes main channel and side channel discharges.

MICROHABITAT SURVEYS

We collected microhabitat preference data for juvenile and adult rainbow and whitefish in the Kootenai River using snorkel and SCUBA techniques to locate and count fish by size and species. Data were collected from Sections 1 and 2 (between Libby Dam and Bonners Ferry, Idaho). Fish counts were collected from each habitat type (pool, glide, riffle, rapids, run, and side channel). Sampling distances in each habitat type totaled 20% of the total linear distances of each habitat type in each section of the river. The number of fish locations needed for each fish species and habitat type was determined based on the relative total availability of each habitat type in each section of river. The number of microhabitat measurements taken in each habitat type was determined from the proportion of fish observed in each (e.g., 100 adult mountain whitefish observed in the section, 40 of them in pools, so 40% of microhabitat measurement sites were gathered in pools). Fifty habitat measurements from each size class and each species were taken from each of section 1 and 2 of the river.

Microhabitat measurements consisted of snorkeling downstream in randomly selected lanes parallel to river channel (1-6) representing a position from right bank to left across the river, to locate fish and record microhabitat data (cover, substrate, depth, and velocity). Each of two surveyors was assigned a randomly selected lane to snorkel. Each surveyor counted the total number of juvenile and adult rainbow trout and whitefish and marked fish locations by dropping a color-coded (trout or whitefish) rock where a particular fish was located, and noted the size of the marked fish.

We used multiple anchors to secure the bow of the boat directly above the marked fish location. A flow meter was deployed to record mean and nose water velocities. We also recorded dominant substrate and available cover (Table 5) and percent of substrate embeddedness at each fish location, using a viewing tube when necessary.

Some habitat types, mainly pools, were too deep to effectively snorkel, so we utilized SCUBA equipment to collect microhabitat data, using the same methods described for transect velocity measurements. A diver equipped with a *Ocean Technology Systems Aquacom* sonic sideband 33 Khz transceiver mounted in a full face mask was lowered along with the bomb weight from the boat. The diver grasped a tether attached to the tail of the bomb weight, allowing the boat to guide the diver along a cross section of the habitat. An *Aquacom* surface sideband transceiver in the boat provided continuous communication between personnel in the boat and diver. When a whitefish or rainbow trout was observed along a transect, the diver would signal the boat to stop. The diver would then transmit substrate, available cover and substrate embeddedness observations. Personnel in the boat would mark the fish location on the tag line so we could return the boat to the same location and collect water velocities after the entire transect was surveyed.

Table 5. Substrate and cover types used to classify microhabitat in the Kootenai River, Montana. Nine classifications of substrate and cover were coded separately at each fish location.

Substrate Type	Substrate / Cover Value	Cover Type
Plant detritus	1	No cover
Clay/mud/silt	2	Rock: >6 in for juv, >12 in for adult
Sand (0.062-2.00 mm)	3	Velocity break
Small gravel (2-25 mm)	4	Submerged logs and root wads
Gravel (1-3 in)	5	Canopy (2 ft above water surface)
Small cobble (3-6 in)	6	Undercut bank: >0.5 ft juv, >1 ft adult
Large cobble (6-12 in)	7	Wood and brush (<6 in diameter)
Boulder (>12 in)	8	Turbulence
Bedrock	9	Submerged non-woody vegetation

DATA ANALYSIS

Data Calibration and Computer Analysis

Stage-discharge rating curves for all transects were calibrated using the *WSEI4S* program (a subroutine of IFG4) and a log-log graphics package by Thomas R. Payne & Associates). Representative transects were used to accurately estimate the river discharge within each sampling reach. The adequacy of the three point rating curves was assessed using patterns of slope, y-intercept, and depth to stage-of-zero-flow. After calibration, the stage-discharge relationship for each transect was within the acceptable mean error limit of five percent (with most less than three percent), and had consistent slope and intercept values.

Velocity simulations were refined within transect cells using minor velocity adjustments in shallow edge cells and in other cells that either significantly deviated from surrounding patterns or contributed to substantial errors in discharge calculations. Velocity adjustment factors for all non-deep-pool transects transitioned through 1.0 at or near the velocity calibration flow and are in the acceptable range (0.1 to 10.0) for a one-flow simulation within the bounds of extrapolation.

The microcomputer versions of PHABSIM computer programs (IFG4, WSEI4S, and HABTAT) most recently developed by the National Ecology Research Center, Aquatic Systems Branch (NERC/ASB) and adapted by TRPA were used in the computer analysis.

Physical Habitat Simulation

The relationship between stream discharge and an index to aquatic habitat (Weighted Usable Area or WUA) was developed using the Physical Habitat Simulation (PHABSIM) system under the overall framework of the IFIM. PHABSIM consists of hydraulic simulation (in this case the IFG4 computer model using a single high flow data set for velocity calibration and a minimum of two other stage-discharge rating measurements) and habitat simulation using the HABTAT computer model. The IFG4 model requires that transects be placed to record the range of existing physical conditions within each river reach. Depth and velocity data from the transects are regressed to develop rating curves and calibrate the computer model. Once IFG4 is calibrated, the output is combined with species habitat criteria on depth, velocity, substrate, and/or cover in the HABTAT model. The model calculates aquatic habitat suitability over the range of flows. The WUA index is described in terms of square feet of area per thousand linear feet of stream.

Habitat Suitability Curve (HSC) Development

The depth and velocity data were first stratified by fish species and size-class strata, then arranged into specified class intervals to generate frequency histograms. Class intervals used to generate histograms were 0.5 feet for depth (0.01-0.49 ft first interval) and 0.5 feet per second (0.00-0.49 fps first interval) for mean column velocity. Substrate data were arranged into 9 classes based on the dominant substrate observed at each fish location (Table 5). Cover data were collected based on the presence and number of 9 categories of cover at each fish location (Table 5).

HSC curves were constructed from the fish observation data by smoothing the frequency histograms for depth and mean column velocity using stepwise polynomial regressions. 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 variation (the significance was measured with an F-test), the stepwise procedure was terminated and all lower models were examined for aptness of fit by visual correlation with data, by F-statistics, and by serial correlation tests. The simplest model fulfilling these criteria was selected to describe habitat suitability. The maximum predicted value from the selected model was assigned a suitability of 1.0; then all other predicted values were normalized to the maximum.

Polynomials often do not perform well near the extreme ends of the distributions where sample sizes are small (e.g. in deep or fast water). To alleviate the unrealistic undulations that frequently result at the distribution tails, and to maximize the regression fit to the majority of the depth and velocity observations, we excluded all "outlying" observations in deeper or faster water prior to curve-fitting. For example, a series of consecutive zero observations (i.e. class intervals with a frequency of zero) were used to "bound" the fitted data set. The first zero interval on the tails of the non-zero observations were included in the curve-fitting, but the remaining zero intervals were not. All depth observations (zero or positive) >13.5 feet were treated as "outliers" and were not fitted with the polynomials. After fitting the polynomials to this restricted data set, we then adjusted the curves to fit the outlier observations in deeper water. All adjustments to the HSC curves were clearly identified in relation to the polynomial regressions in figures presented.

Using depth observations for adult whitefish as an example (Table 6), the "Observed" numbers were excluded from polynomial smoothing according to the above rules. Consequently, a polynomial was fit to the adult whitefish data from the range of 2.5 ft to 13.5 ft in depth; the multiple consecutive zeros at both ends of the distribution and some non-zero frequencies in deeper water (at >13.5 ft) were excluded from the regression analysis. The "outlier" observations in deeper water were then added to the HSC curve according to the following procedure.

The polynomial regression curve was plotted with the frequency data (all observations included). The following ratio was calculated for each *non-zero* observation beyond where the HSC curve declined to zero (at approximately 10.4 ft):

$$Depth\ Suit\ Ratio = \frac{\#FishObserved}{Max\#Fish\mathrm{P}redicted}$$

In the example data set (Table 7), the polynomial curve reached its maximum (suitability of 1.0) at 5.5 ft with a predicted value of 13.49 fish. The suitability ratios for the 5 non-zero observations in deeper water were thus 0.22 for the three "3's" (3/13.49), 0.44 for the 6 observations at 18.0 ft (6/13.49), and 0.15 for the observations at 18.5 ft (2/13.49). Ratios were not calculated using the intervening zero bins because it was assumed that those depths have positive suitability, but were empty simply due to low sample sizes.

The final deep-water suitability was the mean of each of these ratios, or 0.25 for the example shown. The deep-water suitability of 0.25 was then drawn as a line from its

Table 6. Example data set showing the calculation of deep water suitability ratios and overall suitabilities.

Depth	Observed	Predicted	Adjustment	Suitability
0.50	0			
1.00	0			
1.50	0			
2.00	0			
2.50	0	0.65		0.05
3.00	2	5.11		0.38
3.50	5	8.51		0.63
4.00	14	10.95		0.81
4.50	16	12.53		0.93
5.00	19	13.34		0.99
5.50	17	13.49		1.00
6.00	18	13.06		0.97
6.50	7	12.16		0.90
7.00	6	10.89		0.81
7.50	8	9.34		0.69
8.00	3	7.61		0.56
8.50	3	5.80		1.43
9.00	2	4.01		0.30
9.50	1	2.33		*0.25*
10.00	3	0.86		*0.25*
10.50	0	-0.30		*0.25*
11.00	3	-1.05	0.22	*0.25*
11.50	3	-1.29	0.22	*0.25*
12.00	0	-0.94		*0.25*
12.50	0	0.12		*0.25*
13.00	3	1.98	0.22	*0.25*
13.50	0	4.73		*0.25*
14.00	0			*0.25*
14.50	0			*0.25*
15.00	0			*0.25*
15.50	0			*0.25*
16.00	0			*0.25*
16.50	0			*0.25*
17.00	0			*0.25*
17.50	0			*0.25*
18.00	6		0.44	*0.25*
18.50	2		0.15	*0.25*

intersection with the polynomial curve to infinity for depth (shown in italics in the Table 6 "Suitability" column). This line is labeled as the "adjustment" on the figures showing observed and predicted habitat use with associated suitabilities.

This method of adjusting suitability at the extremes of the depth observations is not statistically rigorous. However, standardized procedures have not yet been developed which produce deep-water HSC values that are universally accepted by HSC researchers. Currently, the most frequently used methods of characterizing the suitability of deeper water are to: 1) assume the observation data (or a ratio of observed use to availability) reflect actual suitability and allow the curve to follow the data points (typically) to zero suitability after the last observation; 2) assume depth suitability remains at maximum into deeper water after the peak suitability is reached; 3) arbitrarily decide on an intermediate suitability value between the values given by choices 1 and 2 above, and 4) use regression to compare the relative changes in use and availability of habitat in deeper water (Gard 1997).

After discussions with divers who collected the deep-water data, we felt options 1 and 2 respectively under-estimated and over-estimated the suitability of deep water. Option 3 can be very arbitrary and easily subject to personal biases and debate. Option 4 shows promise but requires the use of habitat availability data at each of the HSC study sites, which we did not collect. Consequently, we developed the ratio method described above. The ratio method produced estimates of deep-water suitability that were felt to be realistic by the divers who collected the deep-water observations.

The treatment of "outlying" observations for mean column velocity was more straightforward. A straight adjustment line was drawn from the trailing edge of the polynomial curve at a suitability of 0.2 down to zero suitability at the velocity interval immediately beyond the last observation. This line is also labeled as the "adjustment" on the figures showing observed and predicted habitat use with associated suitabilities.

Polynomial regression was not used to derive HSC curves for the categorical substrate and cover data. Instead, HSC values were derived by normalizing the observation frequencies within each substrate category to the maximum observed frequency, which was set to a suitability of 1.0. Cover data were reduced from the frequencies of 9 cover types into 2 categories, cover present and cover absent, which were then normalized to a suitability of 1.0.

RESULTS

MICROHABITAT SURVEYS

Microhabitat (HSC) data were collected by direct observation of juvenile (<25.4 cm) and adult rainbow trout, and juvenile (<25.4 cm) and adult mountain whitefish, in the Kootenai River between August 1990 and September 1996. Underwater visibility ranged from 10 to 15 ft. Most observations (79%) were collected during August and September surveys, however data were also collected in July, October, and November (21%). Most HSC observations of adult fish were collected from pools and riffles, but juveniles were also commonly observed in rapids and runs (Table 7). Whitefish were typically more abundant in offshore mid-channel zones, whereas trout were common in both mid-channel and varial zones. Raw data are included in Appendix B.

Table 7. Number of microhabitat observations collected by section and habitat type for juvenile (<25.4 cm) and adult rainbow trout and mountain whitefish in the Kootenai River.

River Section	Habitat Type	Rainbow Trout # Juveniles	Rainbow Trout # Adults	Mountain Whitefish # Juveniles	Mountain Whitefish # Adults	HABITAT TOTALS:
1	*1 - Pools*	14	18	7	27	66
	2 - Riffles	8	14	12	29	63
	3 - Glides	0	6	6	11	23
	4 - Runs	0	0	2	2	4
	5 - Rapids	4	6	26	11	47
	6 - Side Channels	42	9	6	4	61
	SECTION TOTALS:	68	53	59	84	264
2	*1 - Pools*	15	8	25	20	68
	2 - Riffles	9	8	19	21	57
	3 - Glides	3	4	3	4	14
	4 - Runs	12	4	6	2	24
	5 - Rapids	6	4	11	7	28
	6 - Side Channels	6	4	13	3	26
	SECTION TOTALS:	51	32	77	57	217
	STUDY TOTALS:	119	85	136	141	481

Juvenile Rainbow Trout

Juvenile rainbow trout selected focal positions with a wide range of microhabitat characteristics (Table 7). The average depth at focal positions of juvenile trout (4.4 ft) was shallower than for adult trout or juvenile and adult whitefish. A 3rd –order polynomial was fit to the depth observations from the range of 0.5 ft to 10.5 ft; one observation at 15.2 ft was excluded from the polynomial fit (Figure 4). The 3rd –order model fit the histogram fairly well (R^2=0.63, P<0.001) with a peak suitability occurring between 3 ft and 4 ft, but the curve appears to overestimate suitability of depths between 1 ft and 2 ft. Adjusting the suitability of deep water using the methods described above resulted in a suitability value of 0.07 for depths greater than 7.5 ft (Table 8). Juvenile trout were rarely observed at depths exceeding 8 ft, even though SCUBA surveys were conducted in many deep-water pool habitats and whitefish were common at such depths.

The average mean column and focal velocities selected by juvenile trout (1.85 fps and 1.33 fps, respectively, Table 9) were very similar to those selected by adult rainbows, and only slightly lower than those selected by juvenile and adult whitefish. The broad frequency histogram for mean column velocity was accurately fit by a 3rd –order polynomial (R^2=0.80, P<0.001), between the range of 0.0 fps to 5.0 fps (Figure 5). The broad curve reflected the frequent use of velocities between 0.5 fps and 3.5 fps. A single observation at 6.11 fps was excluded from the polynomial, but was encompassed by the curve adjustment that extended from 4.5 fps to 7.0 fps (Table 8).

The dominant substrate and cover HSC were derived directly from the histograms by normalizing the observed frequencies to the maximum value (set to 1.0). Juvenile trout were rarely observed over substrates smaller than gravel, and 88% of observations occurred over cobble and boulder substrates. HSC values for small cobble, large cobble, and boulders were 0.64, 1.0, and 0.75, respectively (Tables 9, 10 and Figure 6). Gravel received a suitability of 0.25, but all finer substrate types and bedrock had suitabilities <0.05. The lack of observations over finer substrates was partly due to the predominance of coarser materials, and because relatively few juvenile trout were observed in pool habitats (Table 6) where most of the finer substrates occurred.

Juvenile trout appeared more strongly associated with instream cover than were adults or whitefish. Only 10% of juvenile positions were observed at locations lacking cover, whereas 20% to 40% of positions selected by adult rainbows and juvenile or adult whitefish lacked nearby cover (Table 8). The only cover types commonly observed at juvenile focal positions was rock substrate (81%) and velocity breaks (21%), however juveniles used turbulence cover to a greater degree (at 3.4%) than did other fish, possibly because of the proximity of turbulence to rock substrate and velocity breaks (Table 10). Normalized HSC scores for the presence or absence of cover were 1.0 and 0.11, respectively (Figure 7 and Table 8).

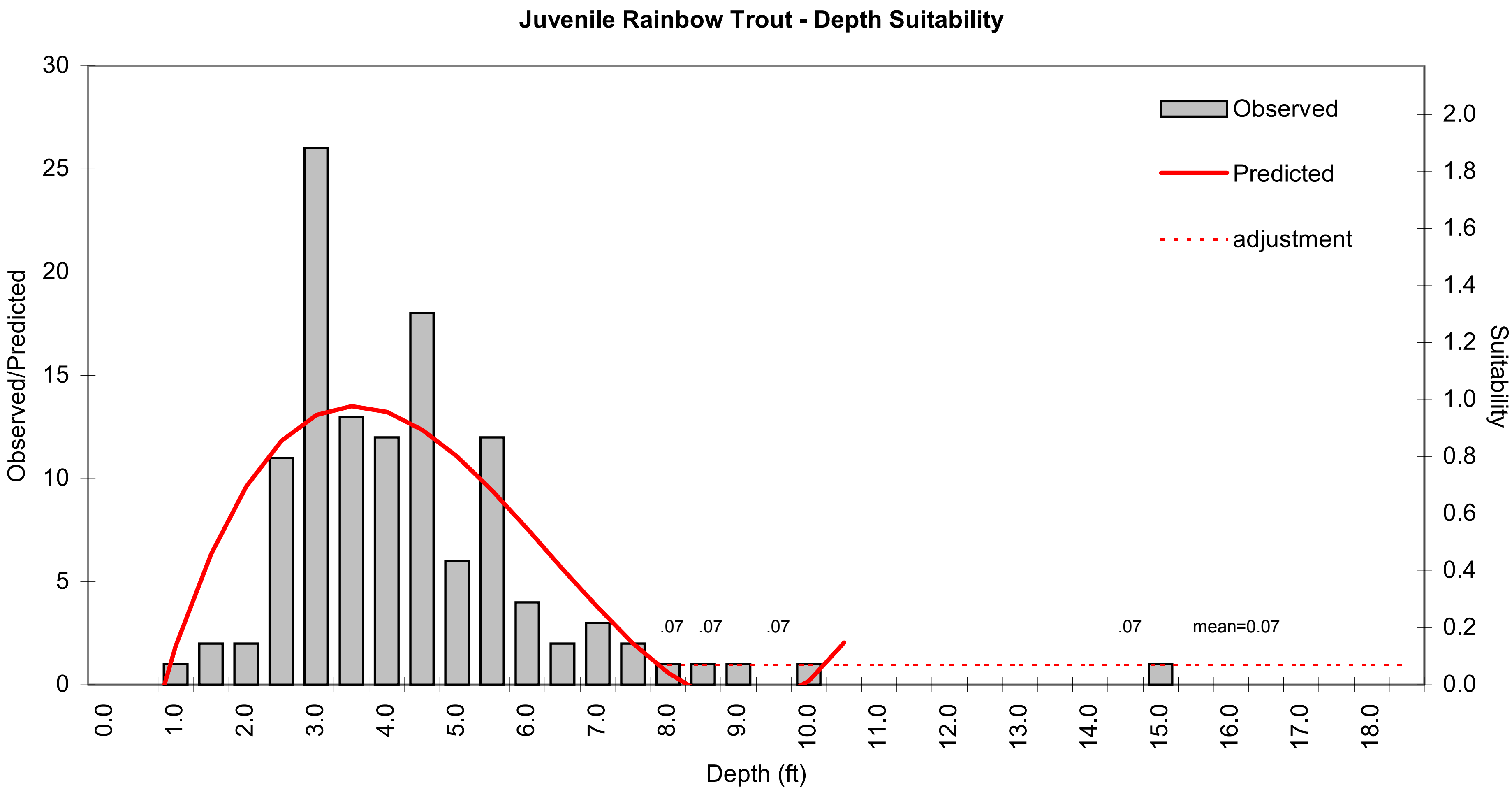

Figure 4. Depth habitat suitability for juvenile rainbow trout in the Kootenai River, Montana.

Table 8. HSC coordinate values for juvenile (<25.4cm) and adult rainbow trout in the Kootenai River.

Rainbow Trout Juvenile							
Depth	Suitability	Velocity	Suitability	Substrate	Suitability	Cover	Suitability
0.00	0.00	0.00	0.07	1	0.00	Not Present	0.11
0.82	0.00	0.50	0.54	2	0.02	Present	1.00
1.00	0.14	1.00	0.84	3	0.00		
1.50	0.47	1.50	0.98	4	0.00		
2.00	0.71	2.00	1.00	5	0.25		
2.50	0.88	2.50	0.92	6	0.64		
3.00	0.97	3.00	0.77	7	1.00		
3.50	1.00	3.50	0.58	8	0.75		
4.00	0.98	4.00	0.36	9	0.05		
4.50	0.92	4.50	0.20				
5.00	0.82	5.00	0.16				
5.50	0.70	5.50	0.12				
6.00	0.56	6.00	0.08				
6.50	0.42	6.50	0.04				
7.00	0.28	7.00	0.00				
7.50	0.15	100.00	0.00				
8.00	0.07						
100.00	0.07						
Rainbow Trout Adult							
Depth	Suitability	Velocity	Suitability	Substrate	Suitability	Cover	Suitability
0.00	0.00	0.00	0.00	1	0.04	Not Present	0.42
1.49	0.00	0.05	0.00	2	0.11	Present	1.00
2.00	0.40	0.50	0.49	3	0.00		
2.50	0.68	1.00	0.83	4	0.07		
3.00	0.87	1.50	0.99	5	0.25		
3.50	0.97	2.00	1.00	6	0.71		
4.00	1.00	2.50	0.90	7	0.82		
4.50	0.97	3.00	0.73	8	1.00		
5.00	0.89	3.50	0.51	9	0.04		
5.50	0.78	4.00	0.29				
6.00	0.65	4.50	0.20				
6.50	0.50	5.00	0.13				
7.00	0.34	5.50	0.07				
7.50	0.20	6.00	0.00				
8.00	0.10	100.00	0.00				
100.00	0.10						

Table 9. Microhabitat characteristics of focal positions selected by juvenile (<25.4cm) and adult rainbow trout and mountain whitefish in the Kootenai River (all sample areas combined). Variance statistics are only shown for continuous variables.

Species	Lifestage	Statistic	Water Depth	Mean Velocity	Focal Velocity	Dominant Substrate	% Embed-edness	# Cover Types
rainbow	juvenile	minimum	1.3	0.06	0	2	0-25	0
trout		maximum	15.2	6.11	4.31	9	75-100	3
	(n=119)	mode	3.0	1.12	1.41	7	0-25	1
		mean	4.4	1.85	1.33	6.8	-	1.2
		variance	3.4960	1.1110	0.6651	-	-	-
		std dev	1.8698	1.0541	0.8156	-	-	-
		95% C.I. for mean	0.3	0.19	0.15	-	-	-
rainbow	adult	minimum	2.5	0.12	0.02	1	0-25	0
trout		maximum	16.4	5.20	3.89	9	75-100	3
	(n=85)	mode	3.8	2.10	1.48	8	0-25	1
		mean	5.2	1.87	1.22	6.6	-	1.0
		variance	5.9444	0.9047	0.4921	-	-	-
		std dev	2.4381	0.9512	0.7015	-	-	-
		95% C.I. for mean	0.5	0.21	0.15	-	-	-
mountain	juvenile	minimum	0.8	0.09	0.05	2	0-25	0
whitefish		maximum	35.1	5.62	4.48	8	75-100	3
	(n=136)	mode	4.4	0.93	0.39	7	0-25	1
		mean	5.8	2.17	1.51	6.7	-	1.0
		variance	25.7053	1.3421	0.8406	-	-	-
		std dev	5.0700	1.1585	0.9168	-	-	-
		95% C.I. for mean	0.9	0.20	0.16	-	-	-
mountain	adult	minimum	2.7	0.19	0	1	0-25	0
whitefish		maximum	18.1	5.36	3.88	8	75-100	3
	(n=141)	mode	4.5	3.33	1.87	7	25-50	1
		mean	6.5	2.19	1.44	6.4	-	0.8
		variance	12.0284	1.2978	0.6949	-	-	-
		std dev	3.4682	1.1392	0.8336	-	-	-
		95% C.I. for mean	0.6	0.19	0.14	-	-	-

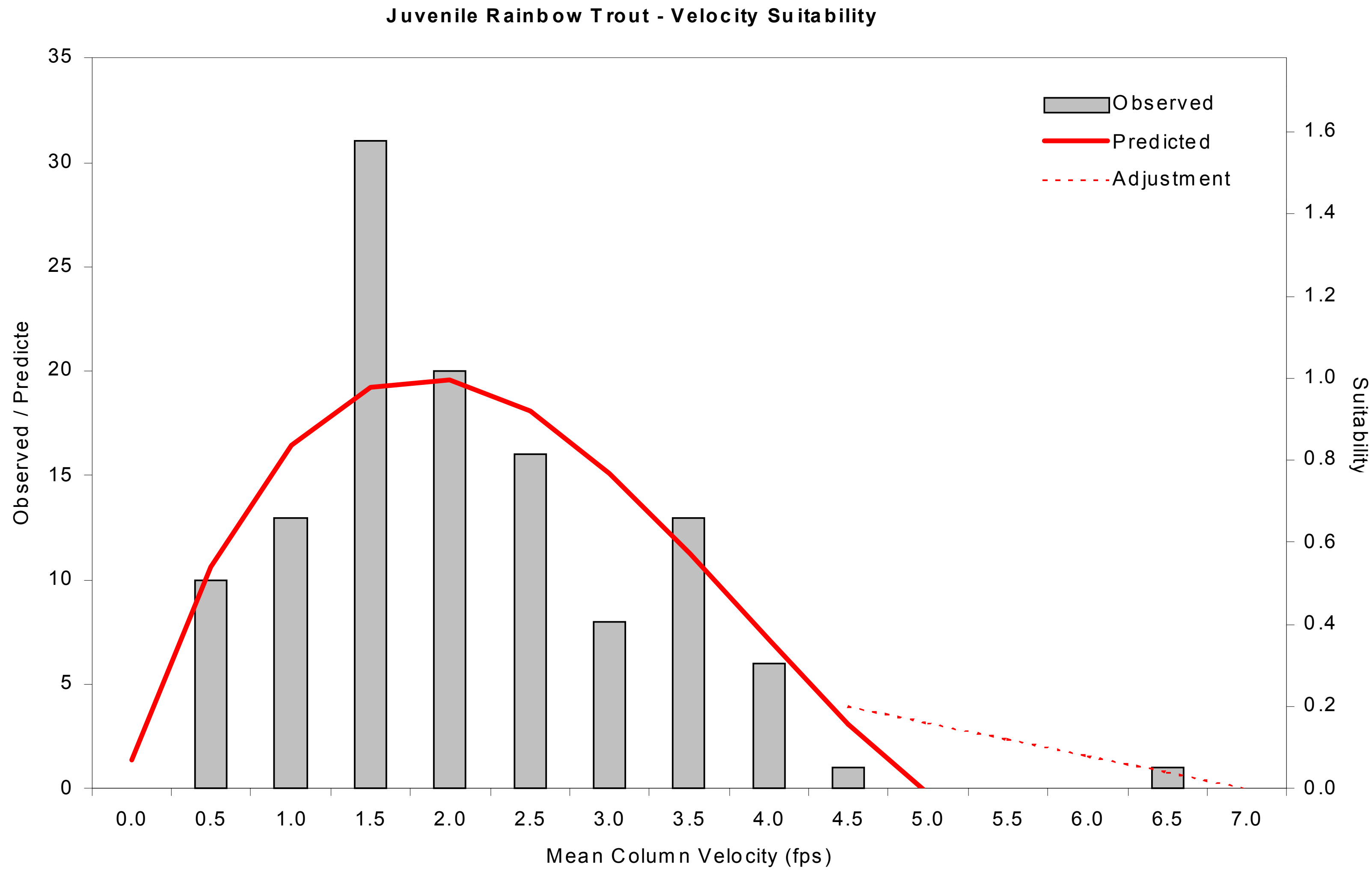

Figure 5. Velocity habitat suitability for juvenile rainbow trout in the Kootenai River, Montana.

Table 10. Percentage occurrence of cover types observed at focal positions selected by juvenile (<25.4 cm) and adult rainbow trout and mountain whitefish in the Kootenai River (all sample areas combined). See Table 6 for cover type descriptions.

	Rainbow Trout		Mountain Whitefish	
Cover Type	juvenile	adult	juvenile	adult
no cover	10.1%	29.4%	19.1%	39.7%
rock substrate	80.7%	57.6%	74.3%	41.8%
velocity break	21.0%	24.7%	11.0%	19.9%
logs/root wads	8.4%	3.5%	1.5%	5.7%
overhead canopy	0.0%	0.0%	0.0%	0.0%
undercut bank	0.0%	0.0%	0.0%	0.0%
small wood/brush	4.2%	1.2%	3.7%	2.1%
turbulence	3.4%	0.0%	1.5%	0.0%
non-woody vegetation	4.2%	15.3%	6.6%	9.2%

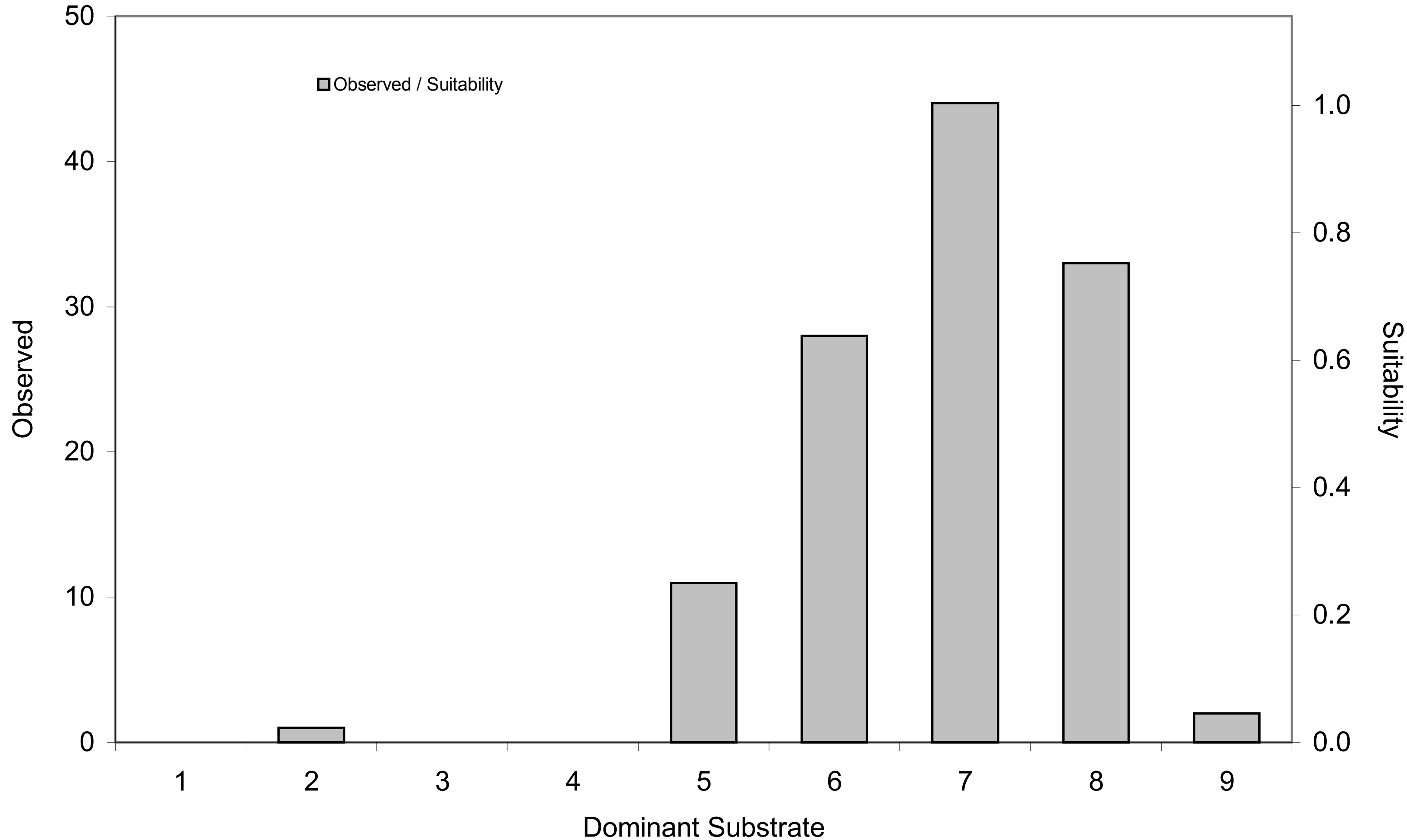

Figure 6. Substrate habitat suitability for juvenile rainbow trout in the Kootenai River, Montana.

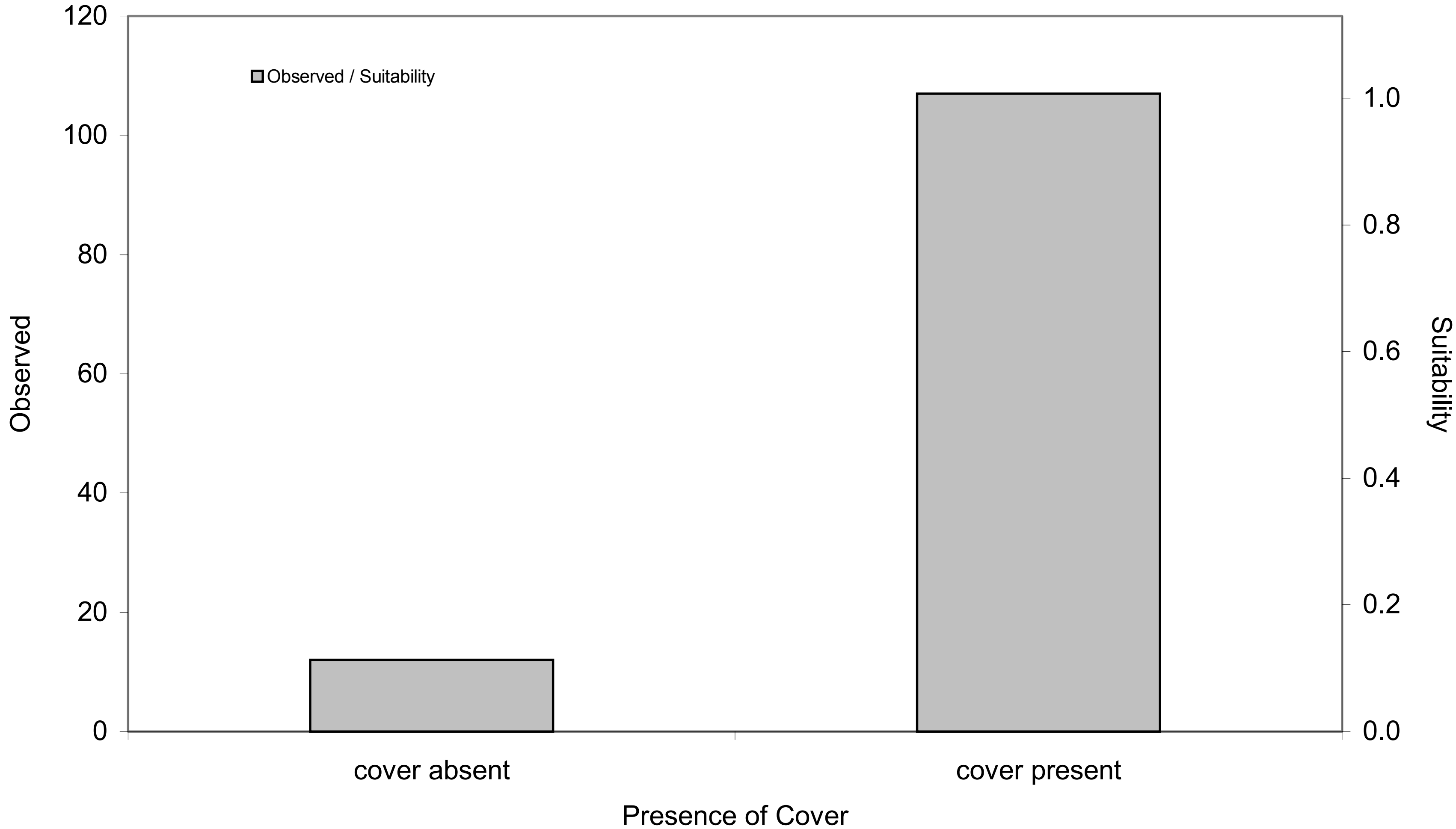

Figure 7. Cover habitat suitability for juvenile rainbow trout in the Kootenai River, Montana.

Adult Rainbow Trout

Adult rainbow trout were observed in both study sections and in all habitat types, but they were most frequently observed in pools and riffles (Table 7). Adult trout used a similar range of depths and velocities to those selected by juveniles, but mean and mode values were higher for adults (Table 9). Adult trout also exhibited a wider selection of substrate types and cover groupings than did juvenile trout (Figures 8,9 and Table 10).

A 3rd –order polynomial was fit to the depth observations from the range of 1.5 ft to 10.5 ft; 2 observations between 15.5 ft and 17.0 ft were excluded from the polynomial fit (Figure 10). The 3rd –order model fit the histogram fairly well (R^2=0.58, P=0.003), showing peak suitability between 3 ft and 5 ft. The deep-water adjustment for adult rainbows produced a suitability of 0.10 for depths greater than 8.0 ft (Table 8). Like juveniles, adult rainbows were not commonly observed in deeper water.

The frequency histogram for mean column velocity was fit with a 3rd –order polynomial (R^2=0.79, P=0.001) for observations between 0 fps and 4.0 fps (Figure 11). One observation at 5.2 fps was excluded prior to curve fitting, but was captured by the curve adjustment that extended from 4.0 fps to 6.0 fps. The HSC curve showed highest suitabilities for velocities between 1.0 fps and 3.0 fps. The adult velocity curve appeared much like the juvenile curve even though the data mode for adults was 1 ft deeper (at 2.5 fps) than the mode for juveniles (at 1.5 fps). Because the modes in both distributions were isolated peaks, the low-order polynomials did not capture that difference, but rather emphasized the broader, similar nature of the distributions.

The selection of cobble and boulder substrates by adult trout was also similar to the selections made by juveniles, although adults tended to hold over boulders and finer substrates more often (Figure 8). Calculated suitabilities for small cobble, large cobble, and boulder substrates were 0.71, 0.82, and 1.00, respectively (Table 8). Adult rainbow trout were commonly found in association with rock (58%) and velocity break (25%) cover, but many fish (29%) were also observed away from any predominant cover type (Table 10). Consequently, normalized HSC scores for the presence or absence of cover were 1.0 and 0.11, respectively (Figure 9 and Table 8).

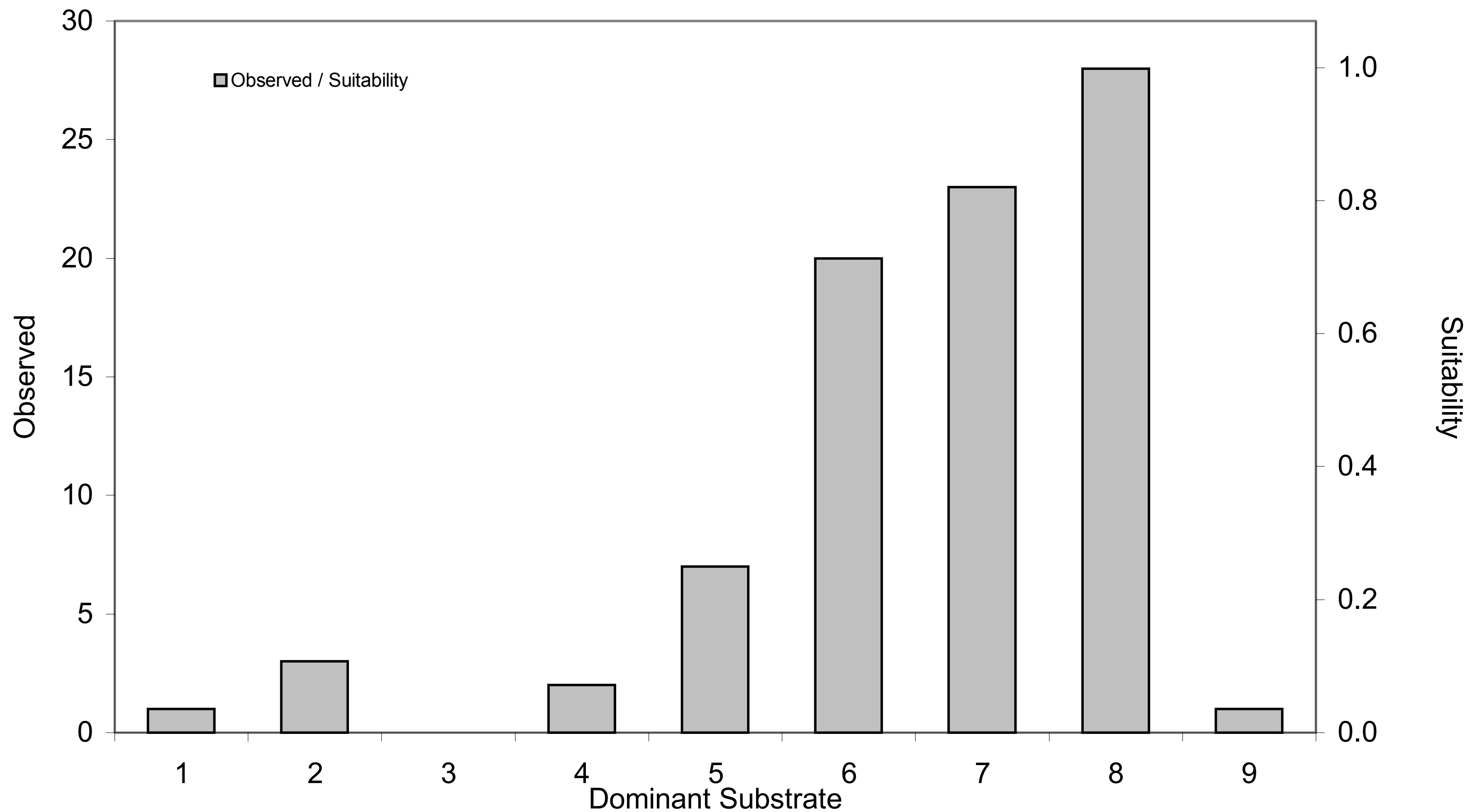

Figure 8. Substrate habitat suitability for adult rainbow trout in the Kootenai River, Montana.

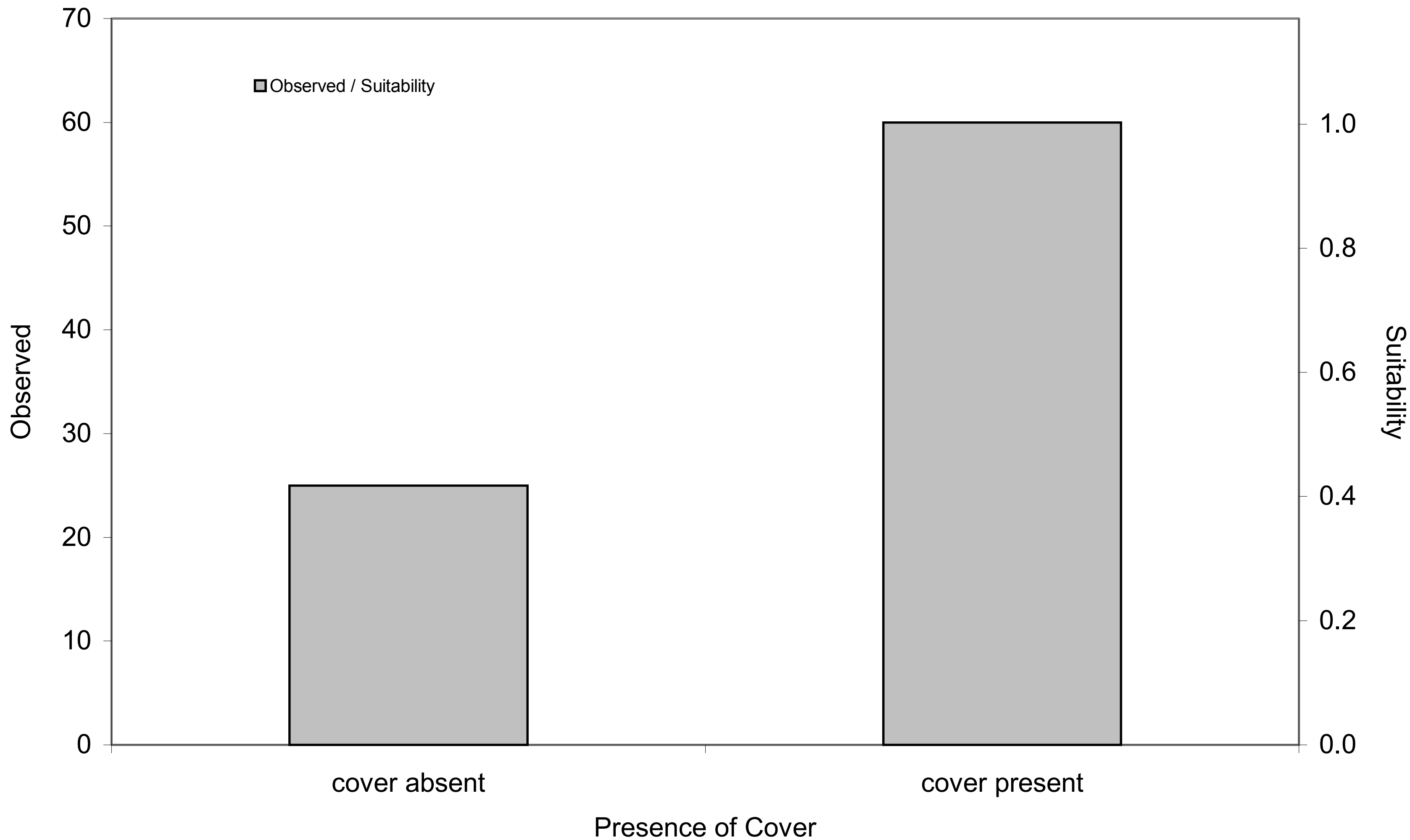

Figure 9. Substrate habitat suitability for adult rainbow trout in the Kootenai River, Montana.

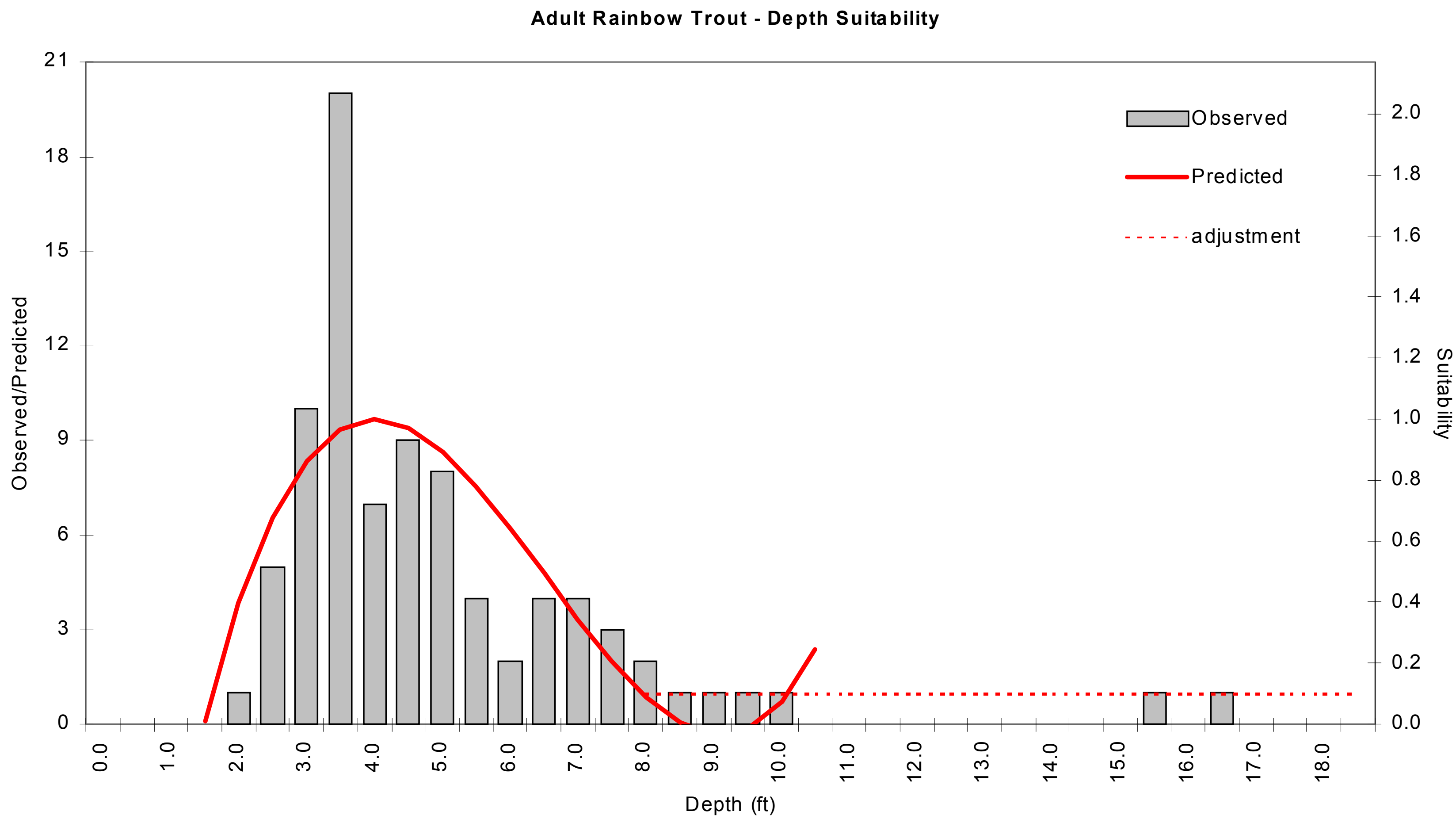

Figure 10. Depth habitat suitability for adult rainbow trout in the Kootenai River, Montana.

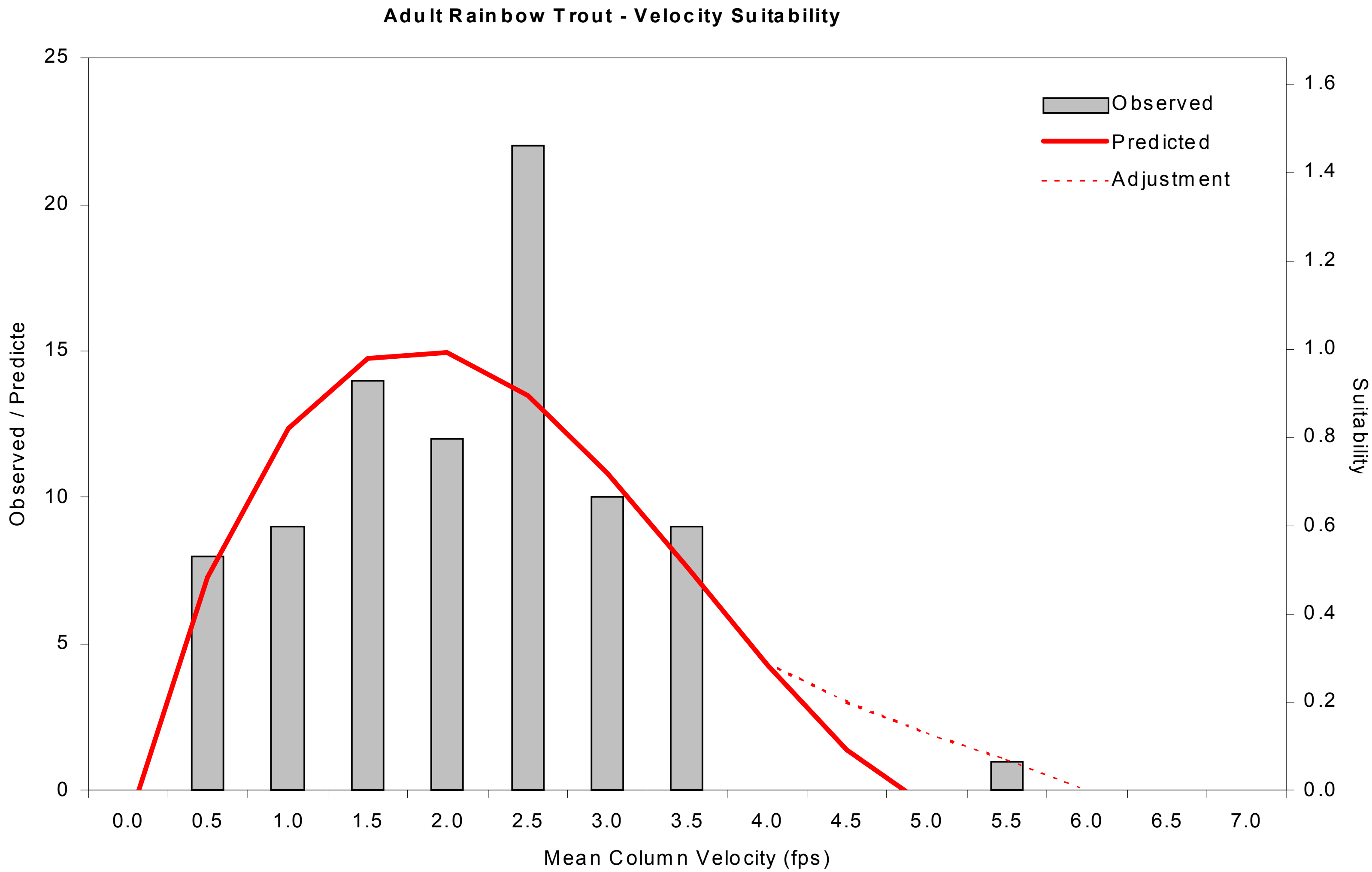

Figure 11. Velocity habitat suitability for adult rainbow trout in the Kootenai River, Montana.

Juvenile Mountain Whitefish

Juvenile whitefish were observed in a wide range of habitats (Table 7), including some of the deepest pools surveyed (two fish was observed at a depth of 35.1 ft, Appendix A). In general, juvenile whitefish occupied deeper depths and faster velocities than did either juvenile or adult rainbow trout (Table 9).

A 3rd –order polynomial was fit to the depth observations from the range of 0 ft to 13.0 ft, yet 11 observations between 14.5 ft and 35.1 ft were excluded prior to fitting with the polynomial fit (Figure 12). The polynomial model fit the histogram well (R^2=0.68, P<0.001), although the curve showed no suitability for observations over 10 ft. The deep-water adjustment accounted for the underestimated and the excluded observations, however, and produced a suitability of 0.18 for all depths greater than 8.0 ft (Table 11). The final curve showed peak suitability between 2 ft and 6 ft.

The broad, plateau-like frequency histogram for mean column velocity was also fit with a 3rd –order polynomial for observations between 0 fps and 6.5 fps (Figure 7). Although the statistical fit was good (R^2=0.85, P<0.001), the histogram suggested a higher, more constant suitability at velocities between 1.0 fps and 3.5 fps, rather than the narrower peak created by the polynomial. A fast water adjustment line extended from 4.5 fps to 6.5 fps. Juvenile whitefish were commonly observed to occupy positions having high mean column velocities, because their close association with the stream bottom (mean focal height ≤0.6’, Table 9) allowed them to remain in slower water underneath high velocities.

The histogram describing substrate types observed at focal positions of juvenile whitefish (Figure 7) appears nearly identical to that for juvenile rainbows (Figure 5), with calculated suitabilities of 0.40 for large gravel, 0.58 for small cobble, 1.0 for large cobble, and 0.72 for boulder (Table 10). Juvenile whitefish were rarely observed in association with fine substrates. Juvenile whitefish also utilized cover types similar to juvenile rainbows, where the vast majority of focal positions were in close proximity to rock cover and/or velocity breaks (Table 11). Unlike rainbows, focal positions lacking any nearby cover were approximately twice as common for juvenile whitefish (at 19%) than for juvenile rainbows (at 10%). Normalized suitability scores for presence and absence of cover were 1.0 and 0.24, respectively (Table 10).

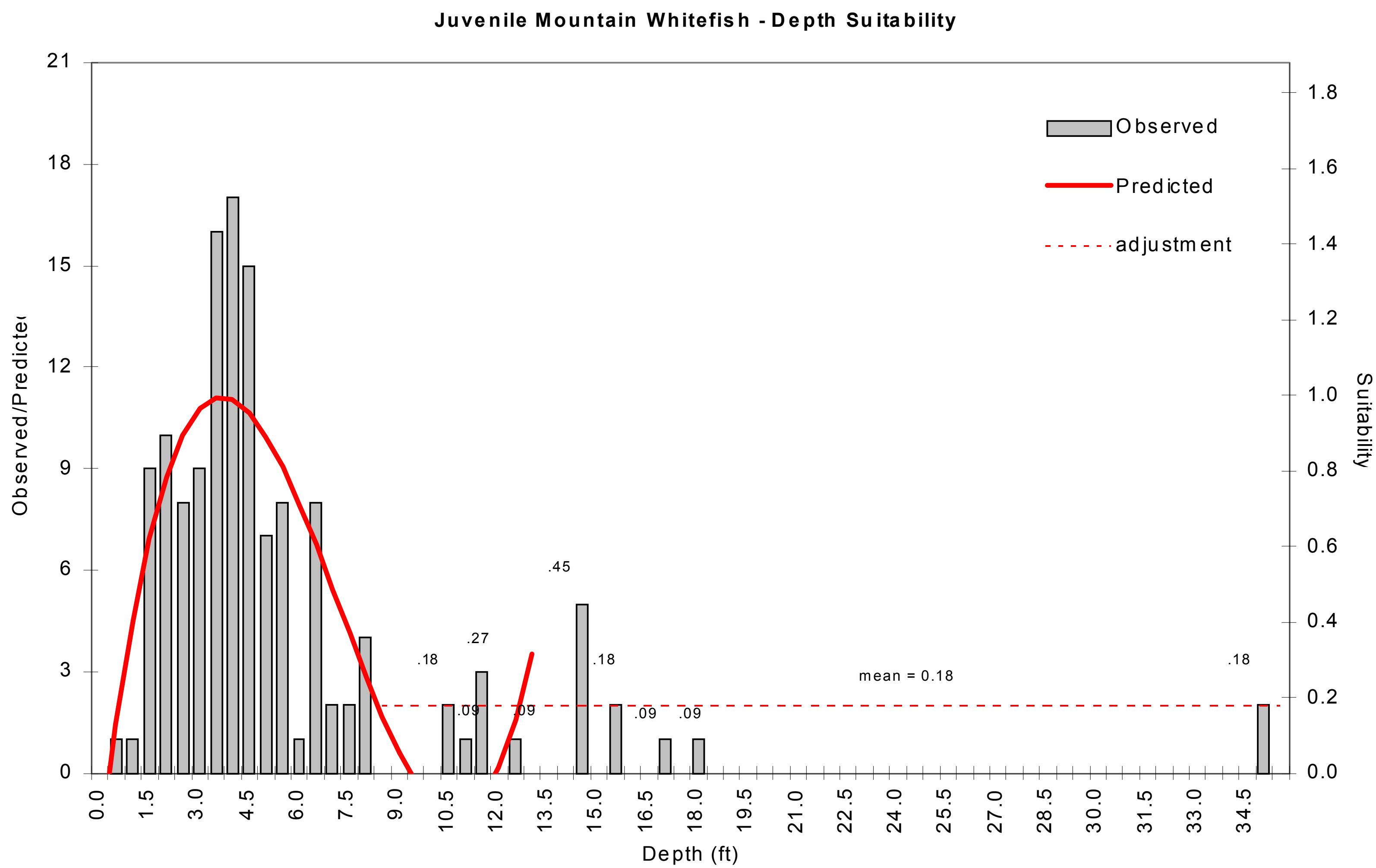

Figure 12. Depth habitat suitability for juvenile mountain whitefish in the Kootenai River, Montana.

Table 11. HSC coordinate values for juvenile (<25.4 cm) and adult mountain whitefish in the Kootenai River.

Mountain Whitefish Adult							
Depth	Suitability	Velocity	Suitability	Substrate	Suitability	Cover	Suitability
0.00	0.00	0.00	0.13	1	0.06	Not Present	0.66
2.43	0.00	0.50	0.44	2	0.08	Present	1.00
2.50	0.05	1.00	0.68	3	0.00		
3.00	0.38	1.50	0.86	4	0.04		
3.50	0.63	2.00	0.96	5	0.51		
4.00	0.81	2.50	1.00	6	0.53		
4.50	0.93	3.00	0.97	7	1.00		
5.00	0.99	3.50	0.87	8	0.65		
5.50	1.00	4.00	0.71	9	0.00		
6.00	0.97	4.50	0.47				
6.50	0.90	5.00	0.20				
7.00	0.81	5.50	0.10				
7.50	0.69	6.00	0.00				
8.00	0.56	100.00	0.00				
8.50	0.43						
9.00	0.30						
9.50	0.25						
100.00	0.25						

Mountain Whitefish Juvenile							
Depth	Suitability	Velocity	Suitability	Substrate	Suitability	Cover	Suitability
0.00	0.00	0.00	0.00	1	0.00	Not Present	0.24
0.30	0.00	0.50	0.47	2	0.02	Present	1.00
0.50	0.13	1.00	0.78	3	0.00		
1.00	0.41	1.50	0.95	4	0.00		
1.50	0.62	2.00	1.00	5	0.40		
2.00	0.79	2.50	0.95	6	0.58		
2.50	0.90	3.00	0.83	7	1.00		
3.00	0.97	3.50	0.66	8	0.72		
3.50	1.00	4.00	0.47	9	0.00		
4.00	0.99	4.50	0.28				
4.50	0.96	5.00	0.21				
5.00	0.90	5.50	0.14				
5.50	0.81	6.00	0.07				
6.00	0.72	6.50	0.00				
6.50	0.61	100.00	0.00				
7.00	0.49						
7.50	0.37						
8.00	0.26						
8.50	0.18						
100.00	0.18						

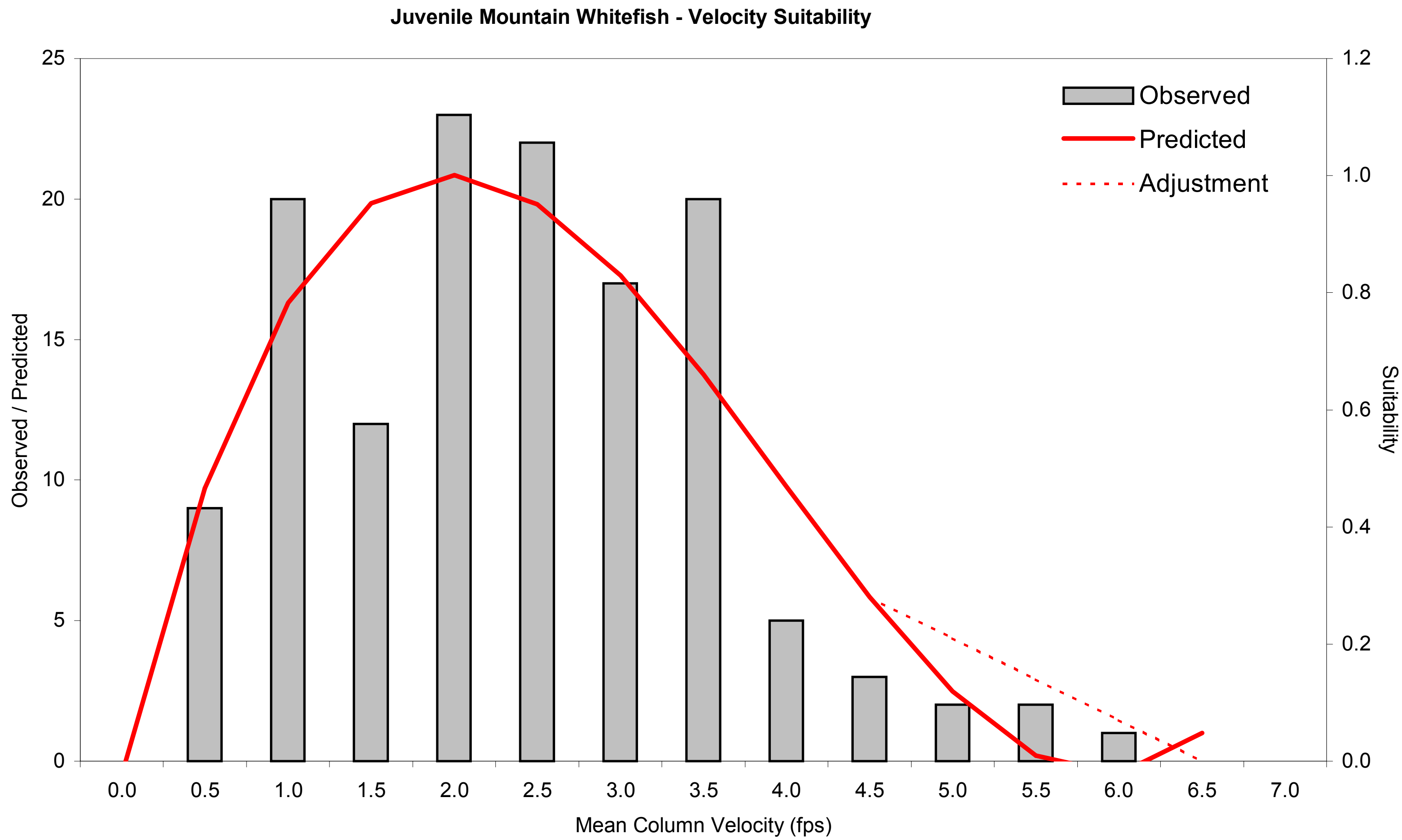

Figure 13. Velocity habitat suitability for juvenile mountain whitefish in the Kootenai River, Montana.

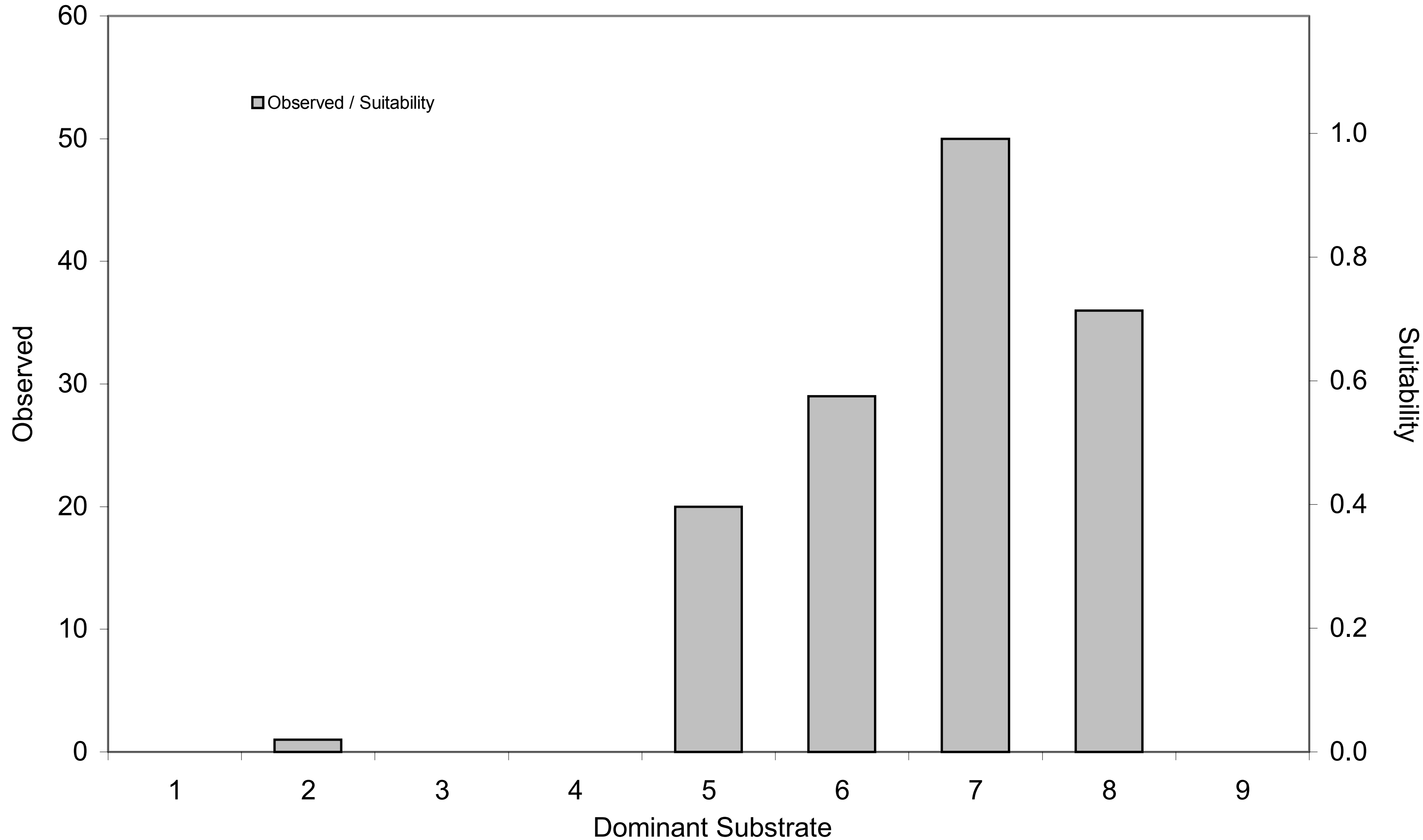

Figure 14. Substrate habitat suitability for juvenile mountain whitefish in the Kootenai River, Montana.

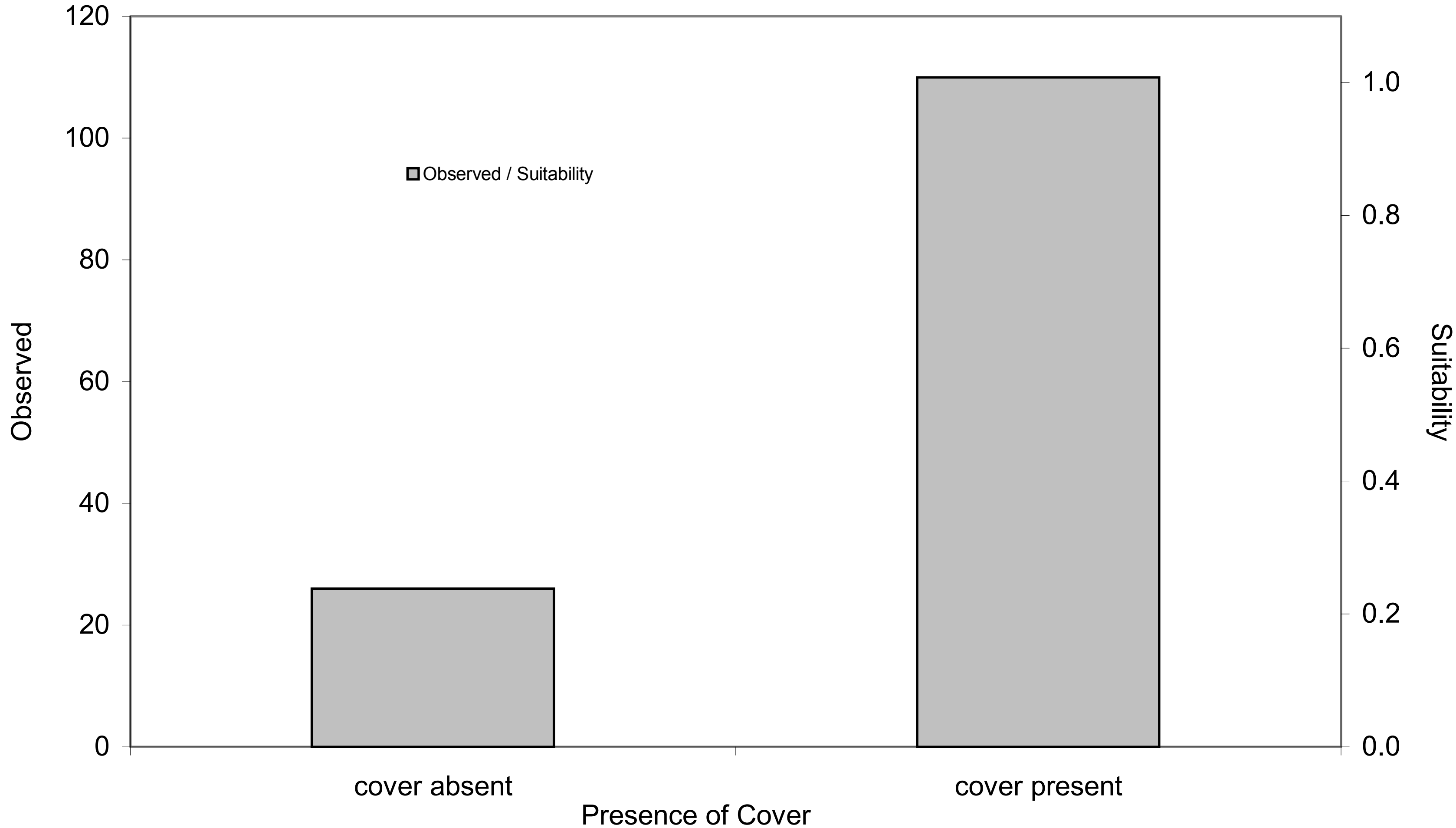

Figure 15. Cover habitat suitability for juvenile mountain whitefish in the Kootenai River, Montana.

Adult Mountain Whitefish

Adult mountain whitefish selected a broad range of depths, velocities, substrates, and cover types, and were observed in all habitat types (Table 7). The mean depth (6.5 ft) and mean velocity (2.19 fps) were greater for adult whitefish than for any other species or life stages (Table 9).

The depth histogram for adult whitefish was fit with a 3rd –order polynomial model between the depths of 2.5 ft and 13.5 ft (Figure 16). The overall fit was good (R^2=0.71, P<0.001), and showed highest suitabilities between 4.0 ft and 7.5 ft. The 8 observations at 18 ft to 19 ft that were excluded from the polynomial fit were accommodated with the deep water adjustment, which produced a suitability value of 0.25 for all depths greater than 9.0 ft (Table 11).

Adult whitefish commonly selected focal positions with mean column velocities between 0.5 fps and 3.5 fps (Figure 17). A 2nd-order polynomial produced the "best-fit" to the histogram data, according to the stepwise procedure (R^2=0.69, P=0.001). High suitabilities occurred at velocities between 1.5 fps and 3.5 fps, but the quadratic curve appeared to underestimate the suitability of slower velocities, and overestimate the suitability of higher velocities. A minor adjustment was made from 5.0 fps to 6.0 fps to encompass an observation at 5.5 fps.

Adult whitefish, like the other species and life stages, were most often observed over large gravel, small cobble, large cobble, and boulder substrates (Figure 18). Adult whitefish appeared to use fine sediments and large gravel more often than did the other fish, however. Calculated suitabilities for the 4 predominant substrate types were 0.51 for large gravel, 0.53 for small cobble, 1.0 for large cobble, and 0.65 for boulder (Table 10). All other substrates had suitabilities <0.10. Most focal positions (42%) occurred in close proximity to rock cover (Table 11), but positions lacking nearby cover were nearly as common (40%). Velocity breaks were also common (at 20%) at adult focal positions. Like rainbows, larger whitefish were more likely to be observed in the absence of cover than were smaller whitefish. HSC values for presence and absence of cover were 1.0 and 0.66, respectively (Table 10 and Figure 19).

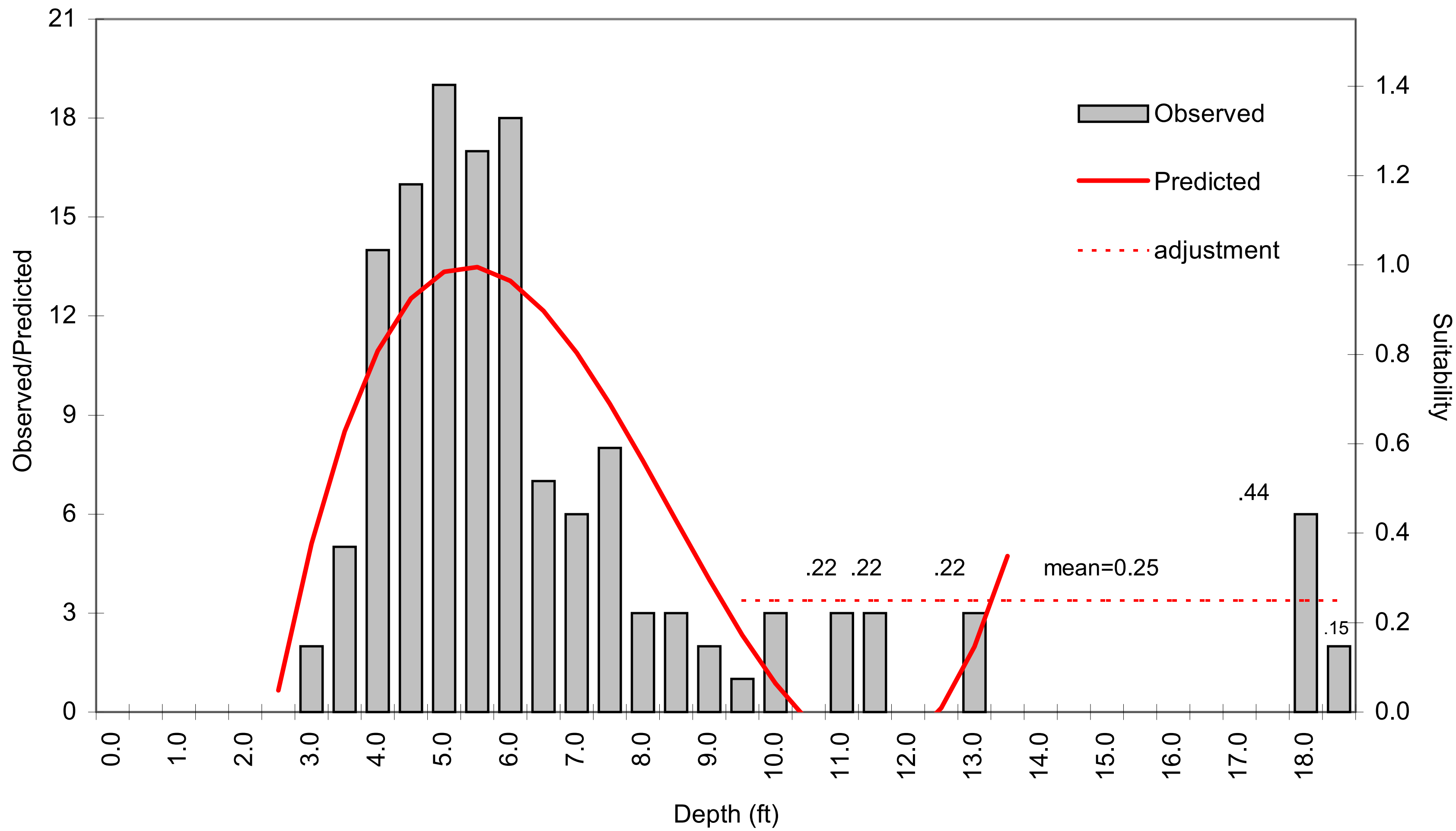

Figure 16. Depth habitat suitability for adult mountain whitefish in the Kootenai River, Montana.

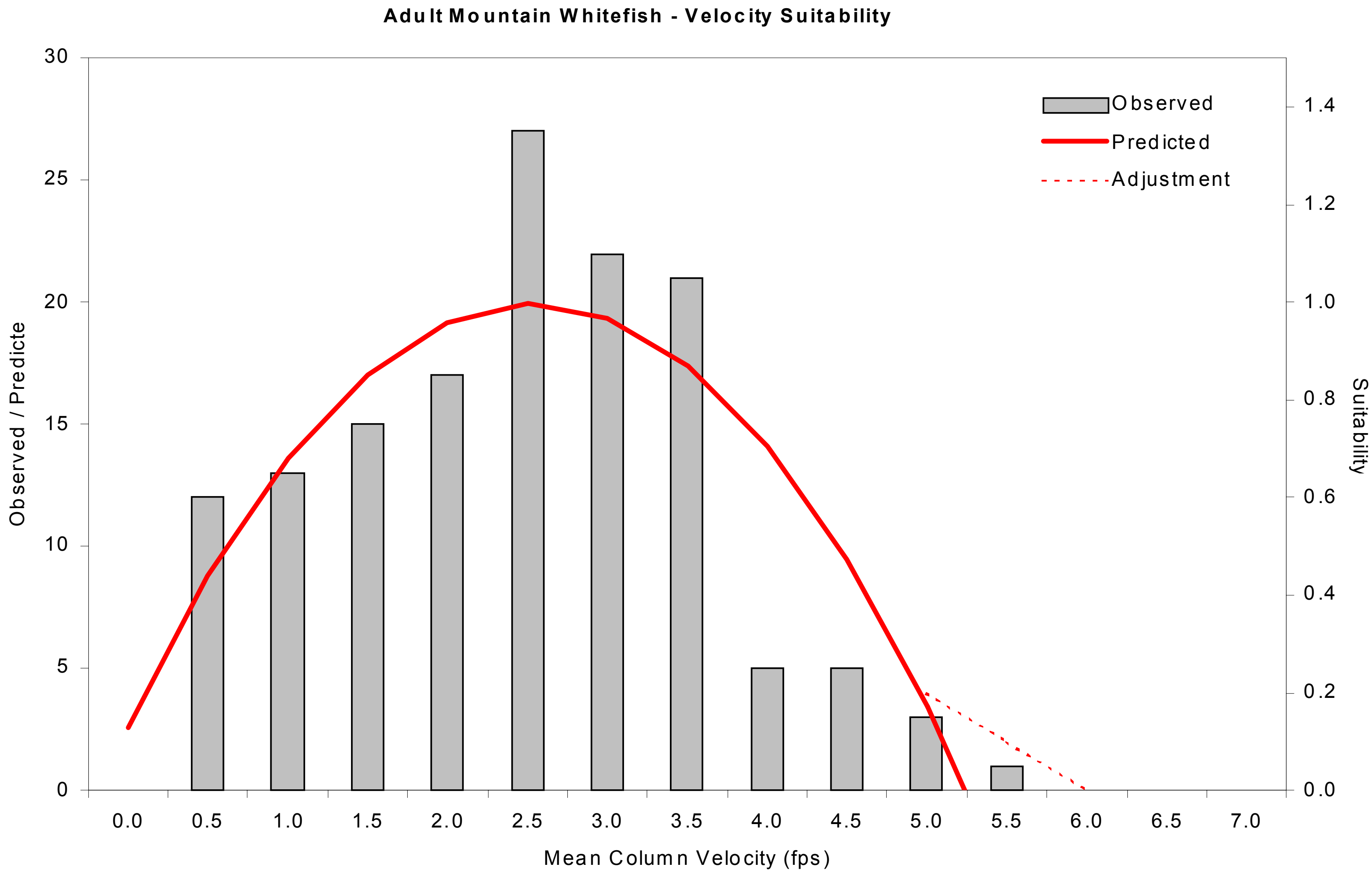

Figure 17. Velocity habitat suitability for adult mountain whitefish in the Kootenai River, Montana.

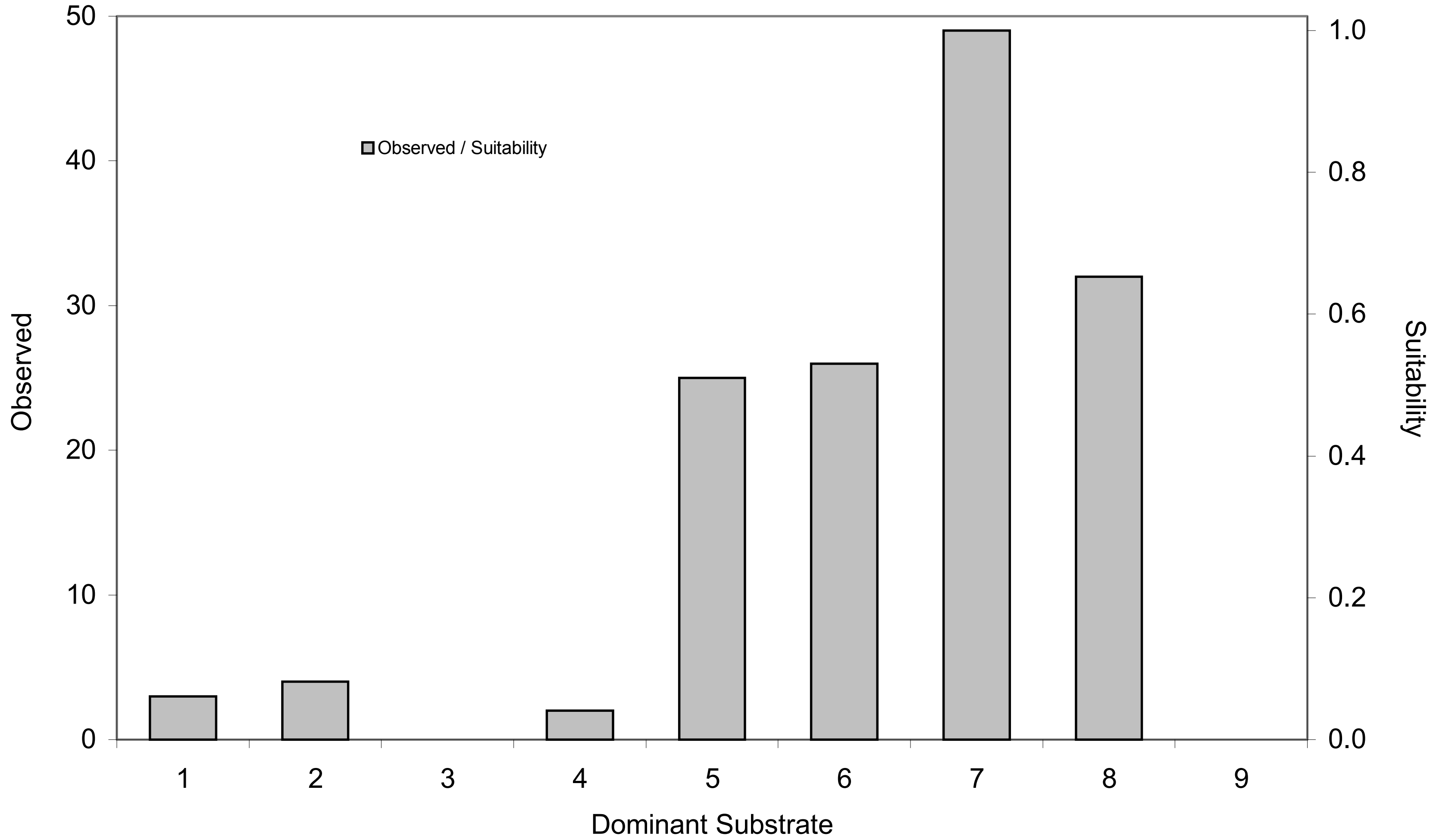

Figure 18. Substrate habitat suitability for adult mountain whitefish in the Kootenai River, Montana.

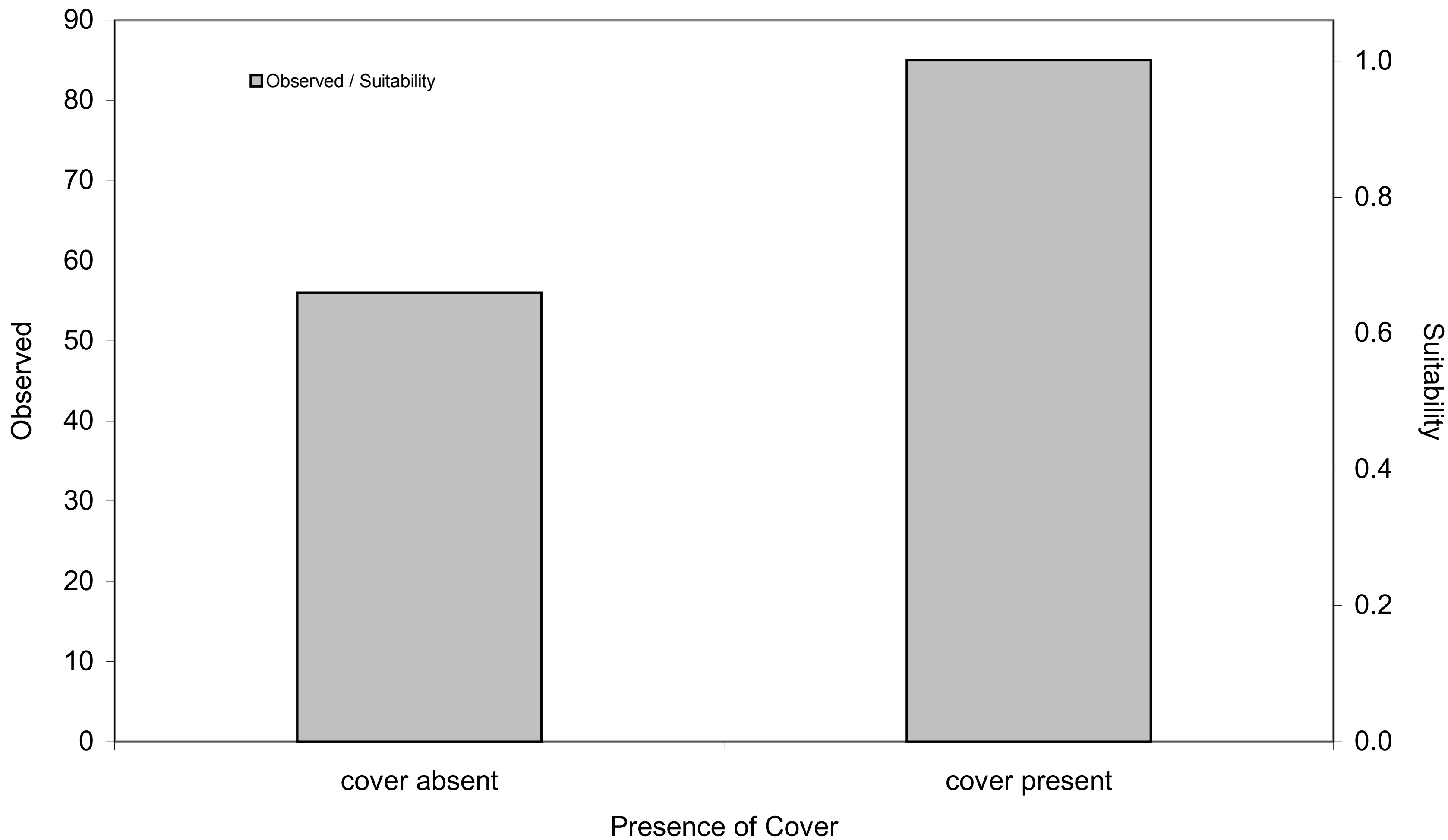

Figure 19. Cover habitat suitability for adult mountain whitefish in the Kootenai River, Montana.

DISCUSSION

Montana has resident fish at risk below Libby Dam, including Kootenai River white sturgeon, bull trout, and interior redband trout. These native fish have been designated *Species of Special Concern* by the American Fisheries Society. Kootenai River white sturgeon are listed as endangered under the Endangered Species Act (ESA), 59 Fed. Reg. 45989 (1994); interior redband trout, native to the Kootenai, is a candidate species (petitioned in April 1994); and bull trout are listed as threatened, 63 Fed. Reg. 31647 (1998). These fish can be adversely affected by how their environment in the Kootenai watershed, changed by Libby Dam, is managed.

Kootenai River White Sturgeon

The Kootenai River white sturgeon is a landlocked and genetically distinct population found in the Kootenai River from Kootenai Falls below Libby Dam downstream to Kootenay Lake in British Columbia. There has been no significant recruitment of juveniles into this population during the 25 years since the completion of Libby Dam. There are less than 2,000 individuals remaining.

Although the requirements for natural sturgeon spawning and recruitment remain largely unknown, evidence suggests that river flow and water temperature effect the movements and reproduction of Kootenai River white sturgeon. The operation of Libby Dam is critical to this species' recovery. As dams were installed on many Columbia River tributaries, the overall storage capacity of the Columbia River system increased, and spring flows were diminished. Loss of the spring freshet is believed to be a primary factor in the decline of anadromous and resident fish populations in the basin (ISG 1996, Apperson 1992, Apperson and Anders 1991). Although river discharge is but one of several environmental mechanisms suspected to influence early life survival, flow regulation effects all riverine trophic levels (Richards 1997, Poff and Ward 1989).

White Sturgeon Operations

In the Kootenai system, the IRC's include an experimental discharge scenario designed to aid in the recovery of the endangered Kootenai white sturgeon. The volume and shape of the spring freshet is based on water availability. These tiered flows were designed to encourage natural sturgeon reproduction, balance the effect of flow augmentation on reservoir refill and protect the needs of other fisheries resources in the Kootenai River system. Spring flows necessary for river channel maintenance and to re-sort and clean river substrate are presently limited by the physical structure of Libby Dam and flood control requirements. Libby Dam discharge is presently limited to maximum turbine capacity in five units (approximately 27,000 cfs). Flows from unregulated tributaries between Libby Dam and Kootenay Lake supplement dam discharge downstream. Maximum flows are regulated by maximum allowable flood stage (approximately 60,000 cfs) at Bonners Ferry, which eliminates the extremely high flows necessary to completely re-sort the river substrate. Flow regulation has resulted in substrate embeddedness and the build-up of deltaic materials at the mouths of tributary streams (Marotz and Fraley

1986; Marotz et al. 1988). Model simulations estimate that combined flows in excess of 50,000 cfs can be achieved at Bonners Ferry in approximately four out of every ten years (Marotz et al. 1996). Approximating the bankfull flow on this frequency is expected to reduce embeddedness and clean interstitial spaces in riffle areas. Since white sturgeon incubation, hatching and early fry stage historically coincided with gradually declining flows immediately after the spring runoff (Anders and Westerhof 1996), the flows may be shaped through in-season management to provide a normalized ramp down from the spring freshet. Unnatural flow fluctuations in the Kootenai River could directly effect sub-yearling white sturgeon if they use shallow, backwater areas (information on habitat requirements of these sturgeon during their first year of life is sparse because researchers have not been able to locate any subyearling white sturgeon in the Kootenai River to date).

Bull Trout

Bull trout are the largest native trout in Montana and require cold, clean water to reproduce and thrive. Bull trout numbers have been reduced by habitat degradation and negative interactions with non-native species throughout much of their historic range. When juvenile bull trout emigrate from their natal tributaries to the river, insects remain an important component of their diet. They then begin shifting to fish prey. Dam operation directly affects riverine habitat, insect production and the availability of fish prey.

The current distribution of bull trout in the Kootenai River between Libby Dam and Kootenai Falls is reduced from historic levels. Forestry practices rank as the highest risk, largely because it is the dominant land use in all core areas. This risk to the bull trout population is elevated due to the number of core areas (Quartz, Pipe and Libby Creek drainages) available due to fragmentation caused by Libby Dam. The threat from dam operations is considered high because of the biological effects associated with unnatural flow fluctuations and gas supersaturation problems that may arise from spilling water. The dam is a fish barrier, restricting this migratory population to 29 miles of river, which increases the likelihood of localized effects becoming a higher risk. Dam operations are considered a very high risk to the continued existence of the Kootenai drainage population of bull trout (Montana Bull Trout Scientific Group 1996).

Interior Redband

The interior redband trout is the only rainbow trout native to Montana and occurs only in the Kootenai drainage, which represents the furthest inland population in existence. Pure strain redband trout have been reduced to a fraction of their historic range in Montana, Idaho, eastern Washington and British Columbia. In Montana, redband occur only in five Kootenai River tributaries. At this time, only the Callahan Creek population is known to migrate to the Kootenai River where the availability food and habitat is directly related to dam operation. Interior redband are currently recognized as a category 2 subspecies, meaning that listing may be warranted but precluded due to lack of biological information in their present range.

Manipulating Kootenai River flows in a manner not consistent with the normative river concept has deleterious effects on the zoobenthos of the Kootenai River, and in turn the fish species of concern that inhabit the river. It is important to mimic natural conditions as much as possible, as the following excerpt from Hauer and Stanford (1997) reveals:

> *During the past two decades, the ecological effects of river regulation have received extensive scientific investigation. The theoretical predictions of the Serial Discontinuity Concept (see Ward and Stanford 1983) of regulated rivers have consistently been supported by ecological field studies (Hauer and Stanford 1982, Armitage 1984, Perry et al. 1986, Garcia de Jalon et al. 1988, Rader and Ward 1988, Stanford et al. 1988, Hauer et al. 1989, Hauer and Stanford 1991 and many others). The SDC hypothesizes either upstream of downstream shifts in physical, chemical and biological attributes of a river as functional resets of the River Continuum (sensu Vannote et al. 1980). Studies of regulated rivers have demonstrated changes in riverine algae, aquatic insects and fishes as a result of hydropower on large river systems. Large high-head dams on large rivers, such as Libby Dam on the Kootenai River, significantly alter flow regimes, diel channel flow, current speeds, substrata, nutrients, organic matter resources, and the dynamics of these variables in time and space. Unlike many large dams that have hypolimnial release, Libby Dam has a selective withdrawal system which allows dam operators to mimic the natural annual temperature regime in the dam discharge.*
>
> *The ecological consequences of these biophysical alterations are manifold; affecting virtually all aspects of the river's biota. Usually, hydropower regulation creates a broad expanse of river channel between maximum and minimum dam discharge that often may experience diel or day to day inundation and dewatering (Figure 20). This area, called the varial zone (see Stanford and Ward 1992), is dependent on local river channel morphometry and dam discharge flows and schedules (Jourdonnais and Hauer 1993). Frequently, the varial zone of the 5^{th} to 6^{th} order regulated rivers may be as narrow as 5-10 m along steep sided banks and > 100 m in less confined reaches. Zoobenthos in dam tail waters can only inhabit that portion of the channel that has remained inundated for the past 3-5 weeks. Studies of colonization rates show that typically several weeks are required for benthic organisms to invade newly wetted habitat and approach an equilibrium of community composition (Thorp et al. 1985, Fuchs and Statzner 1990). Thus, the varial zone of regulated rivers is often devoid of benthic organisms, particularly when there has been frequent flow fluctuation (Figure 21). There may also be significant mortality of zoobenthic organisms because of stranding if flows have remained high in dam tail water for an extended period, permitting colonization, followed by rapid decrease in discharge (Corrarino and Brusven 1983, Fisher and LaVoy 1972, Perry and Perry 1986).*

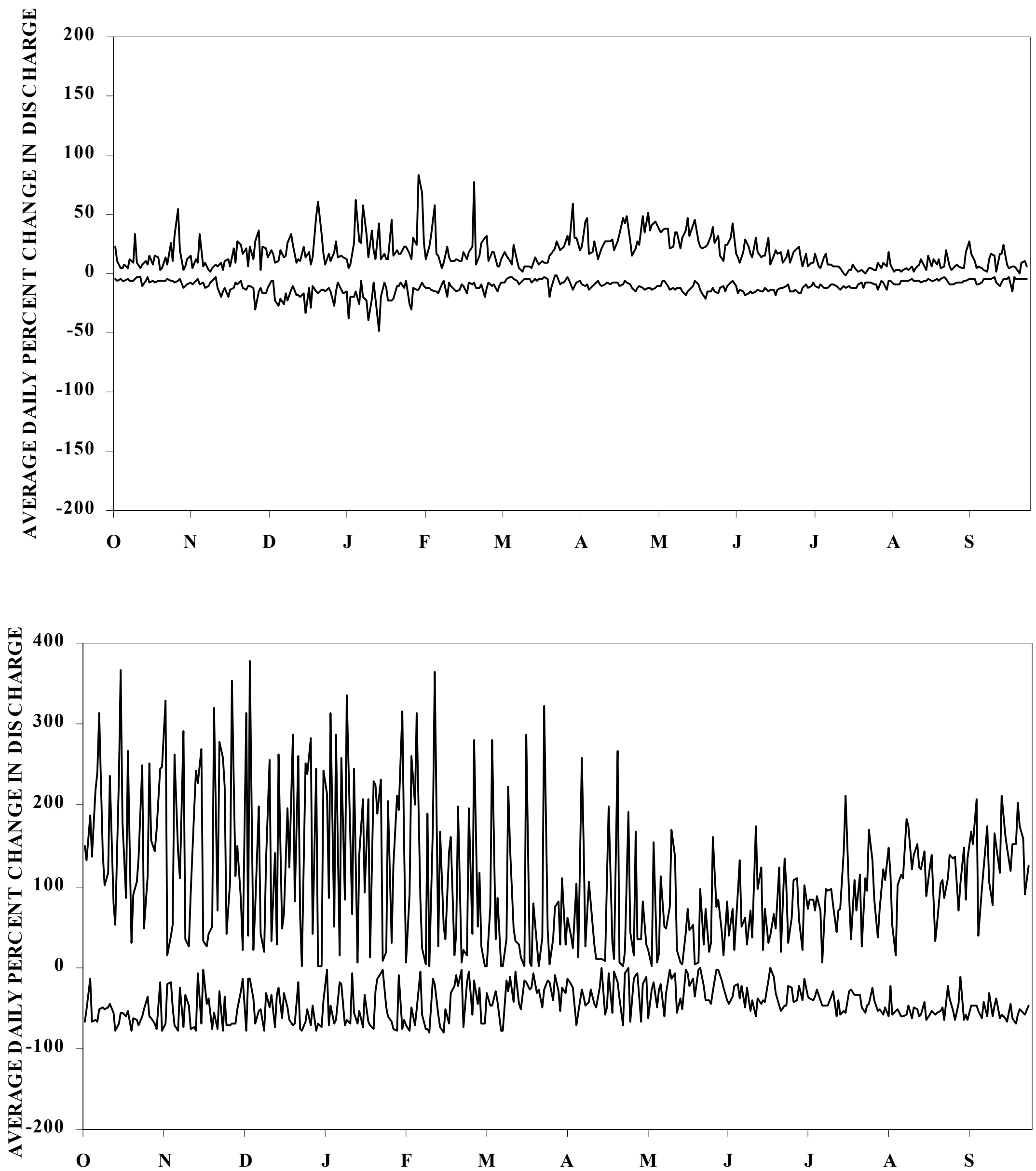

Figure 20. Range in daily change in discharge of the Kootenai River from water years 1952 through 1971 (top) and below Libby Dam from water years 1975 through 1995 (bottom) in Hauer (1997).

River regulation by Libby Dam has had numerous deleterious effects on river zoobenthos. With the exception of density of net-spinning caddisflies and blackflies in the dam tail waters, most species have reduced abundance when either comparing long-term trends... or between rivers in the region. The river downstream of the dam has an expansive varial zone that is essentially devoid of zoobenthos whenever the dam is operated with dramatic flow fluctuation. Dominant species present are those that emerge as adults off the surface of the *water column (e.g., trichoptera, diptera), rather than crawling out on the lateral margins of the river (e.g., plecoptera), where they must deal with the vararies of the varial zone as a consequence of Libby Dam operations.*

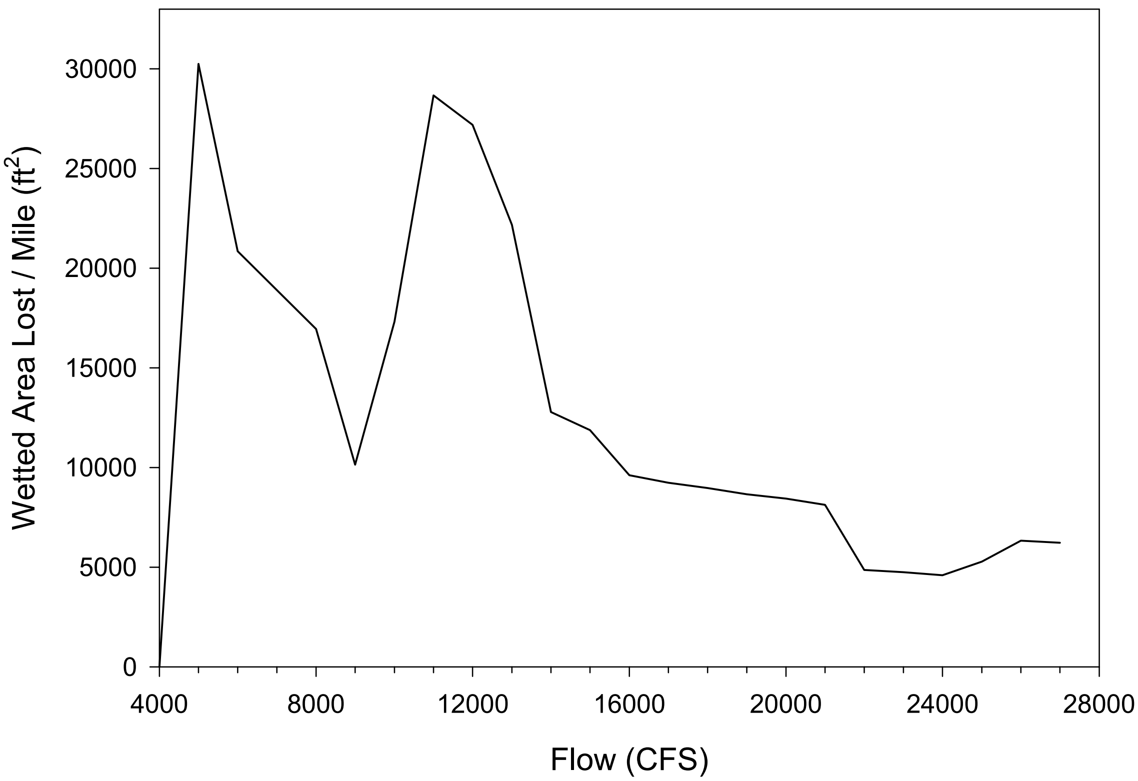

Figure 21. Average loss of varial zone in the Kootenai River following decreases in flow from Libby Dam.

Rainbow Trout

Habitat Suitability Curves (HSC's) constructed for juvenile and adult rainbow trout reveal that the most used depth for both life stages is 3.5 to 4.0 feet (Table 8, Figures 4 and 10), depths typically associated with the varial zone. When flows from Libby Dam are manipulated up and down, the varial zones are desiccated and inundated at varying rates, depending on the initial flow level. At flows of 11,000 cfs or less, the effects of dropping flow are much greater than the effects of reducing flows from higher levels (Figure 21). In a natural river environment, the nearshore habitat is productive and critical to fish. Fine sediments deposited on the river margins provide a fertile medium for water tolerant plants. Riparian vegetation reestablishes seasonally, providing secure habitat along river margins and reducing erosion of silt into the river. Fluctuating or abnormally high discharges disrupt this natural revegetation process.

Stabilizing flows and keeping varial zones inundated also has effects on spawning fish, as illustrated in Figure 22. Maintaining flat flows during the spring months prior to the freshet allows rainbow trout to build redds and spawn, and allows the eggs to develop and hatch without being desiccated. Variable flows during the spawning period has led to reduced redd numbers, and less-variable flows result in increased redd numbers.

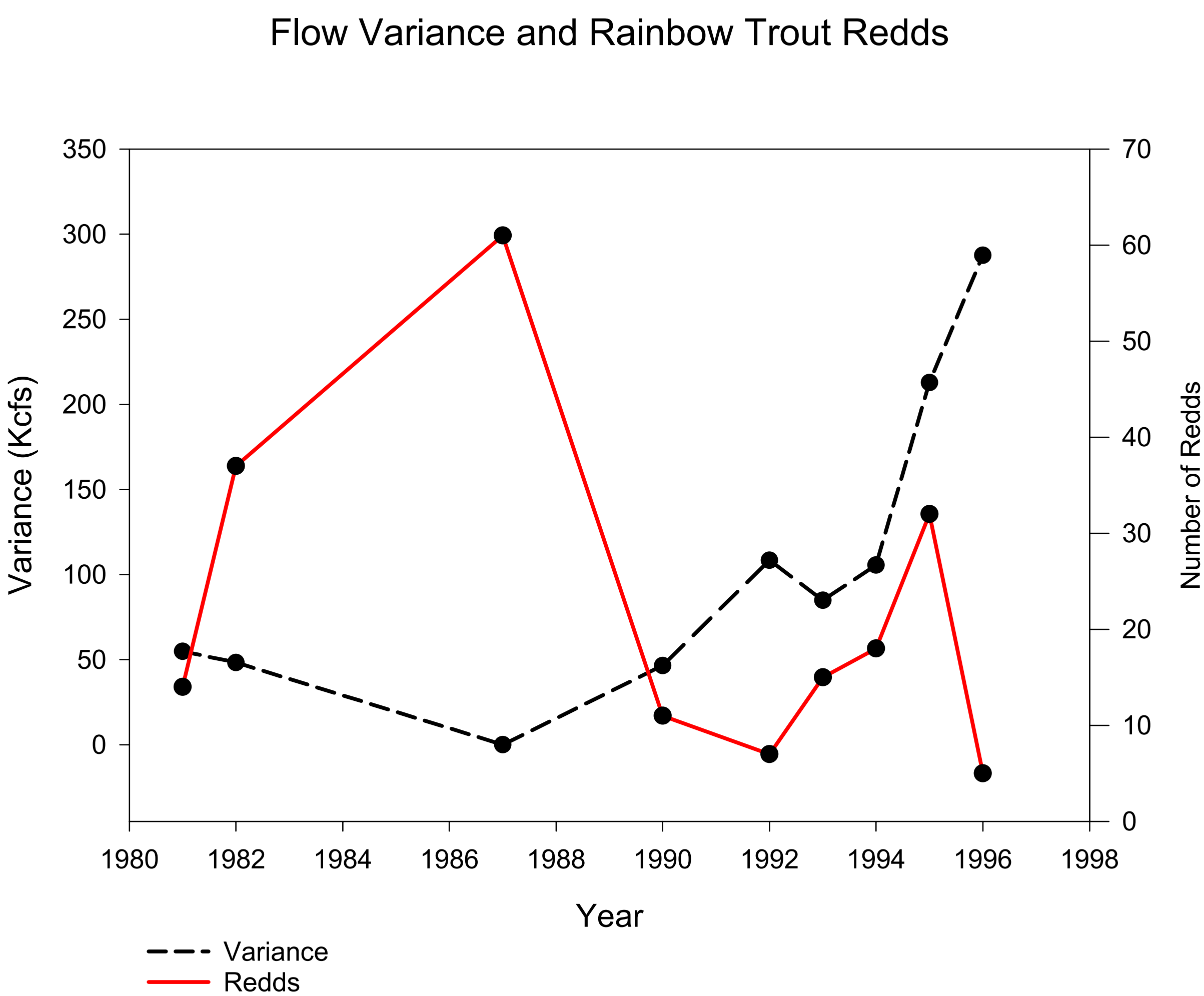

Figure 22. Number of rainbow trout redds counted below Libby Dam associated with variance in river flow during spring months (April through May).

Mountain Whitefish

Similar to rainbow trout, mountain whitefish prefer depths typically associated with the varial zone (Table 11). Juveniles prefer depths at or about 3.5 feet (Figure 12), and adults prefer depths at or about 5.5 feet (Figure 16). Mountain whitefish are often found where bull trout are present, and many scientists believe that the species co-evolved. Mountain whitefish are a component of bull trout diets when they are present.

Habitat Manipulation

While depth is the habitat component most easily manipulated in a regulated river environment, its effects are evident on the availability of other habitat variables, such as velocity and cover. Changes in releases from Libby Dam affect depth and coverage of critical varial zones, but also expose cover habitat features in those areas, making them unavailable for fish and other aquatic life. It is important to adhere to the normative river concept as it relates to flow variability within the constraints of the natural channel, or base flow areas. Creating flows above and beyond normal flow wetted perimeter often serve to create an artificial varial zone, one in which the habitat values are actually reduced compared to a bank full flow or slightly less than bank full. However, flows in excess of bank full on a seasonal basis serve to clean and re-sort substrates, and these flows should be part of seasonal operations in accordance with normative river concepts, and as discussed in the next section.

The importance of the varial zone fluctuates seasonally. The most productive periods are the warmer summer months, so it is therefore important to follow normative river concepts during these periods. The winter months are less productive, but it is still important to maintain a somewhat stable flow regime, as many aquatic macroinvertebrates have life cycles that encompass the winter months, and desiccating eggs and larvae during this period reduces important biomass. However, in general, there is more flexibility for operating Libby Dam to meet power demands during the winter months than in the summer months from a biological perspective.

Variable Flow models (VARQ) and Integrated Rule Curves were developed to provide water for reservoir refill and downstream fisheries needs while still allowing for power production and flood control. The models fit well with the normative river concept, and are discussed in the next section.

Integrated Rule Curve / VARQ Operations

Biological production in river reaches downstream of the dam can be protected by restoring a more naturally shaped hydrograph (as provided by the IRC's and VARQ). Prior to dam construction, the typical hydraulic cycle in the headwaters of the Columbia River included a high flow event during the spring melt of late May through early June and a stabilized low flow period throughout the remainder of the year. Hydropower operations reversed this natural flow pattern by storing water during the runoff and releasing water during the fall and winter when natural flows would be at their lowest (Figure 3).

Outflows from the dams affect the river ecology crucial to all life stages of aquatic organisms and tributary channel geomorphology. Spring flushing flows sort river gravel, define the channels, and remove tributary deltas, creating a healthy environment for fish and the food organisms that they depend on, and helps restore nutrient cycles and floodplain function. For the rivers below the dams, the intent of the IRC's and VARQ is to preserve the essential features of a natural hydrograph which are a period of runoff or freshet in the spring, tapering flows through the summer, and reduced peaking of flows during the low flow period (especially summer through late fall). This is consistent with normative conditions prior to dam construction when the Kootenai and Flathead Rivers flowed freely. Instream flows from both projects then continue downstream to aid juvenile anadromous salmon migration.

Flow fluctuations during the low flow period, especially the productive summer months, are harmful to aquatic life. The resulting zone of fluctuation, or *varial zone*, becomes biologically unproductive habitat, diminishing system health. A rapid flow reduction between flow peaks would dewater a large portion of the river margins (Figures 21 and 22), stranding insects, zooplankton, fish and fish eggs (Hauer and Stanford 1982; Perry 1984; Armitage 1984; Perry et al. 1986; Hauer et al. 1994; Hauer et al. 1997). Unnatural pulses of water, especially during the biologically productive summer months, are not consistent with the normative river concept described by the Independent Scientific Group (ISG 1996; ISAB 1997). In a natural river environment, the nearshore habitat is productive and critical to fish. Fine sediments deposited on the river margins provide a fertile medium for water tolerant plants. Riparian vegetation reestablishes seasonally, providing secure habitat along river margins and reducing erosion of silt into the river. Fluctuating or abnormally high discharges disrupt this natural revegetation process. Aquatic and terrestrial vegetation that would normally provide secure habitat along the river margins and stabilize soils cannot fully reestablish each summer, and fine sediment materials are more easily eroded and swept back into the channel. If dam discharges are gradually ramped down (as in the Integrated Rule Curves and VARQ), deleterious effects on biological production can be reduced.

LITERATURE CITED

Anders, P. J. 1994. Kootenai River white sturgeon studies. Report A, Natural spawning and rearing of white sturgeon (*Acipenser transmontanus*) in the Kootenai River, Idaho 1993. Kootenai Tribe of Idaho. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-64, Bonners Ferry, Idaho.

Anders, P.J. and R.E. Westerhof. 1996. Natural spawning of white sturgeon (Acipenser transmontanus) in the Kootenai River, Idaho, 1995. Preliminary Report of Research FY 95. Kootenai Tribe of Idaho and Bonneville Power Administration. Portland, Oregon. 14 pp.

Anders, P.J., S.C. Ireland, and JK. T. Siple. 2000. Conservation Aquaculture: An Adaptive Approach to Prevent Extinction of an endangered white sturgeon population (*Acipenser transmonanus*). *In*: Proceedings of the 130th Annual Meeting of the American Fisheries Society. August 20-24, 2000. St. Louis MO.

Anders, P. J., D.L. Richards, and M.S. Powell. 2000. The first endangered white sturgeon population (*Acipenser transmonanus*): Repercussions in an altered large river-floodplain ecosystem. *In*: Proceedings of the 130th Annual Meeting of the American Fisheries Society. August 20-24, 2000. St. Louis MO. 8.1-8.32 pp.

Apperson, K.A. 1992. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1991. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-AI79-88BP93497. Project No. 88-65. Portland, Oregon.

Apperson K.A. and P.J. Anders. 1990. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1989 prepared by Idaho Department of Fish and Game for Bonneville Power Administration, Portland, Oregon.

Apperson, K.A. and P.J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY 1990. Idaho Department of Fish and Game and Bonneville Power Administration. Contract No. DE-AI79-88BP93497. Project No. 88-65. Portland, Oregon. 67 pp.

Armitage, P.D. 1984. Environmental changes induced by stream regulation and their effect on lotic macroinvertebrate communities. Pages 139-165 in A. Lillehammer and S.J. Saltveit, editors. Regulated Rivers. University Press. Oslo, Norway.

Baldridge, J.E., and D. Amos. 1981. A technique for determining fish habita suitability criteria: a comparison between habitat utilization and availability. Pages 251-258 *in* N.B. Armantrout, editor. Acquisition and utilization of aquatic habitat inventory information. American Fisheries Society, Western Division, Bethesda Maryland.

Bonde, T.J.H. and R.M. Bush. 1982. Limnological investigations: Lake Koocanusa, Montana, Part 1: Pre-impoundment Study, 1967-1972. Seattle District, U. S. Army Corps of Engineers.

Bovee, K.D. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. U.S. Fish and Wildlife Service Biological Services Program FWS/OBS-82/26.

Bovee, K.D. 1986. Development and evaluation of habitat suitability criteria for use in the Instream Flow Incremental Methodology. In~stream Flow Information Paper 21. United States Fish and Wildlife Service, Biological Report 86(7). 235pp.

Bovee, K.D, and T. Cochnauer. 1977. Development and evaluation of weighted criteria, probability-of-use curves for instream flow assessments: fisheries. U.S. Fish and Wildlife Service Biological Services Program FWS/OBS-77/63.

Cloern, J.E. 1976. Recent limnological changes in southern Kootenay Lake, British Columbia. Canadian Journal of Zoology 54:1571-1578.

Corrarino, C.A. and M.A. Brusven. 1983. The effects of reduced stream discharge on insect drift and stranding of near-shore insects. Freshwater Invertebrate Biology 2:88-98.

Daley, R.J., E.C. Carmack, C.B. Grey, C.H. Pharo, S. Jasper, and R.C. Wiegland. 1981. The effects of upstream impoundments of Kootenay Lake, British Columbia, Canada Inland Waters Directorate, Research Institute, Scientific Series, British Columbia, Canada.

DeGROOT, A. M. 1954. Leveling Edition 2. International Textbook Company. Great Britain. 83p.

DosSantos, J.M. 1985. Comparative food habits and habitat selection of mountain whitefish and rainbow trout in the Kootenai River, Montana. M.S. Thesis. Montana State University, Bozeman, Montana.

Downs, C. 1998. Kootenai River Trout investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65. Portland OR.

Downs, C. 1999. Kootenai River Trout investigations. Idaho Department of Fish and Game. Prepared for Bonneville Power Administration. Annual Progress Report, Project 88-65. Portland OR.

Duke, S. P. Anders, G. Ennis, R. Hallock, J. Hammond, S. Ireland, J. Laufle, L. Lockard, B. Marotz, V. Paragamian, and R. Westerhof. 1999. Recovery plan for Kootenai River white sturgeon (*Acipenser transmonanus*). J. Applied Ichthyolo. (15):157-163.

Fisher, S.G. and A. LaVoy. 1972. Differences in littoral fauna due to fluctuating water levels below a hydroelectric dam. J. Fish. Res. Bd. Can. 29:1472-1476.

Fuchs, U. and B. Statzner. 1990. Time scales for the recovery potential of river communities after restoration: lessons to be learned from smaller streams. Regulated River 5:77-87.

Garcia de Jalon, D., Montes, Cl, Barcelo, E., Casado, C., and Menes, F. 1988. Effects of hydroelectric scheme on fluvial ecosystems within the Spanish Pyrenees. Regulated Rivers 4:479-491.

Gard, M. 1997. Technique for adjusting spawning depth habitat utilization curves for availability. Rivers 6:94-102.

Giorgi, A. 1993. The status of Kootenai River white sturgeon. Report prepared for the Pacific Northwest Utilities Conference Committee. September 1993. 58 pp. plus appendices.

Gore, J.A., and R.D. Judy, Jr. 1981. Predictive models of benthic macroinvertebrate density for use in instream flow studies and regulated flow management. Canadian Journal of Fisheries and Aquatic Sciences 38:1363-1370.

Hauer, F.R., Stanford, J.A., and Ward, J.V. 1989. Serial discontinuities in a Rocky Mountain River. II. Distribution and abundance of Trichoptera. Regulated Rivers 3:177-182.

Hauer, F.R., J.T. Gangemi and J.A. Stanford. 1994. Long-term influence of Hungry horse Dam operation on the ecology of macrozoobenthos of the Flathead River. Prepared for Montana Fish, Wildlife and Parks, Special Projects Bureau, Kalispell, Montana.

Hauer, F.R., J.B. Biby, J.T. Gangemi and J.A. Stanford. 1997. Long-term influence of Libby Dam operation on the ecology of macrozoobenthos of the Kootenai River. Report to Montana Fish, Wildlife & Parks. University of Montana, Yellow Bay Biological Station, Polson, Montana.

Hauer, F.R. and J.A. Stanford. 1982. Ecological responses of hydropsychid caddisflies to stream regulation. Canadian Journal of Fisheries Aquatic Science 39(9):1235-1242.

Hauer, F.R. and J.A. Stanford. 1997. Long-term influence of Libby Dam operation on the ecology of macrobenthos of the Kootenai River, Montana and Idaho. Report to Montana Fish, Wildlife & Parks. University of Montana, Flathead Lake Biological Station, Polson, Montana.

Independent Scientific Advisory Board. 1997. The Normative River. Independent Scientific Advisory Board report to the Northwest Power Planning Council and National Marine Fisheries Service. Portland, OR.

Independent Scientific Group. 1996. Prepublication Copy. Return to the River: Restoration of salmonid fishes in the Columbia River ecosystem. Development of an alternative conceptual foundation and review and synthesis of science underlying the Columbia River Basin Fish and Wildlife Program of the Northwest Power Planning Council Document 96-6.

Irvine, J.R., I.G. Jowett, and D. Scott. 1987. A test of the instream flow incremental methodology for underyearling rainbow trout, *Salmo gairdnerii*, in experimental New Zealand streams. New Zealand Journal of Marine and Freshwater Research 21:35-40.

Jourdonnais, J.H. and F.H. Hauer. 1993. Electrical frequency control and its effects on flow and river ecology in the lower Flathead River, Montana. Rivers 4(2):132-145.

Marotz, B.L., and J. Fraley. 1986. Instream flows needed for successful migration, spawning and rearing of rainbow and westslope cutthroat trout in selected tributaries of the Kootenai River. Montana Department of Fish, Wildlife and Parks. Prepared for Bonneville Power Administration. Project Number 85-6.

Marotz, B.L., B. Hansen, and S. Tralles. 1988. Instream flows needed for successful migration, spawning and rearing of rainbow and westslope cutthroat trout in selected tributaries of the Kootenai River. Montana Department of Fish, Wildlife and Parks. Prepared for Bonneville Power Administration. Project Number 85-6.

Marotz, B., D. Gustafson, C. Althen, and B. Lonon. 1996. Model development to establish Integrated Operation Rule Curves for Hungry Horse and Libby reservoirs, Montana. Montana Fish, Wildlife & Parks report to Bonneville Power Administration. DOE/BP-92452-1. Portland, Oregon. 114 p.

Marotz, B.L., D. Gustafson, C. Althen, and B. Lonon. 1999. Integrated operational rule curves for Montana reservoirs and application for other Columbia River storage projects. Ecosystem Approaches for Fisheries Management. Alaska Sea Grant College Program. AK-SG-99-01.

May, B. and J.E. Huston. 1973. Kootenai River fisheries investigations. Job Progress Report. Montana Fish, Wildlife & Parks in cooperation with U.S. Army Corps of Engineers.

May, B. and J.E. Huston. 1979. Kootenai River fisheries investigations. Job Progress Report. Montana Fish, Wildlife & Parks in cooperation with U.S. Army Corps of Engineers.

May B. and J. E. Huston 1983. Fisheries investigations. July 1972-September 1982. *In*: Kootenai River Fisheries Investigations: Final Completion Report. Montana Fish, Wildlife and Parks. Libby, MT

Montana Bull Trout Scientific Group. 1996. Middle Kootenai River drainage bull trout status report (between Kootenai Falls and Libby Dam). Montana Bull Trout Scientific Group, Helena, Montana.

NMFS. 1995. Endangered species Act – Section 7 Consultation. Biological Opinion: Reinitiation of consultation on 1994-1998 operation of the Federal Columbia River Power System and juvenile transportation program in 1995 and future years. Consultation by National Marine Fisheries Service, Northwest Region. US Army Corps of Engineers, Bonneville Power Administration, Bureau of Reclamation, National Marine Fisheries Service.

NMFS. 1998. Endangered species Act – Section 7 Consultation. Supplemental Biological Opinion on the operation of the Federal Columbia River Power System and juvenile transportation program: a supplemental to the Biological Opinion signed on March 2, 1995, for the same projects [Consultation number 10005]. Northwest Region Seattle, Washington, May 14,1998.

Northwest Power Planning Council. 1994. Columbia River Basin fish and wildlife program. NWPPC 94-95. Northwest Power Planning Council, Portland, Oregon.

Northcote, T.G. 1973. Some impacts of man on Kootenay Lake and its salmonids. Great Lakes Fishery Commission, Technical Report Number 25. Ann Arbor, MI.

Paragamian, V.L. 1993. Kootenai River Fisheries Investigation: Stock Status of Burbot and Rainbow Trout and Fisheries Inventory. Bonneville Power Administration Annual Report. Portland, Oregon. Project 88-65.

Paragamian, V. L. 1994. Kootenai River fisheries inventory: stock status of burbot and rainbow trout and fisheries inventory. Idaho Department of Fish and Game, Bonneville Power Administration, Project 88-65. Boise, ID.

Paragamian, V. L. 2000. The effect of variable flows on burbot spawning migrations in the Kootenai River, Idaho, USA, and Kootenay Lake, British Columbia, Canada, after construction of the Libby Dam. Pages 111-123 *in* V. L. Paragamian and D. W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda.

Paragamian, V. L., G. Kruse, and V. D. Wakkinen. 1996. Kootenai River white sturgeon investigation. Idaho Department of Fish and Game. Bonneville Power Administration, Annual Progress Report, Project 88-65, Boise, Idaho.

Paragamian, V. L., V. Whitman, J. Hammond, and H. Andrusak. 2000. Collapse of burbot fisheries in the Kootenai River, Idaho, USA, and Kootenay Lake, British Columbia, Canada. Pages 155-164 *in* V. L. Paragamian and D. W. Willis, editors. Burbot: biology, ecology, and management. American Fisheries Society, Fisheries Management Section, Publication Number 1, Bethesda, Maryland.

Partridge, F. 1982. Kootenai River fisheries investigations. Idaho Department of Fish and Game. Job Completion Report. Project F-73-R-5, Boise.

Partridge, F. 1983. Kootenai River fisheries investigations. Idaho Department of Fish and Game. Job Completion Report. Project F-73-R-5, Boise.

Perry, S.A. 1984. Comparative ecology of benthic communities in natural and regulated areas of the Flathead and Kootenai Rivers, Montana. North Texas State University. Denton, Texas.

Perry, S.A. and W.B. Perry. 1986. Effects of experimental flow regulation on invertebrate drift and stranding in the Flathead and Kootenai Rivers, Montana, USA. Hydrobiologia 134:171-182.

Perry, S.A., W.B. Perry and J.A. Stanford. 1986. Effects of stream regulation on density, growth, and emergence of two mayflies (Ephemeroptera: Ephemerellidae) and a caddisfly (Trichoptera: Hydropsychidae) in two Rocky Mountain rivers (U.S.A.). Canadian Journal of Zoology 64:656-666.

Poff, N. L. and J. V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: A regional analysis of streamflow patterns. Canadian Journal of Fisheries and Aquatic Science 46(10):1805-1818.

Rader, R.R. and J.V.Ward. 1988. Influence of regulation on environmental conditions and the macroinvertebrate community in the upper Colorado River. Regulated Rivers 2:597-618.

Raleigh, R.F., T. Hickman, R.C. Solomon and P.C. Nelson. 1984. Habitat suitability information: rainbow trout. U.S. Fish and Wildlife Service Biological Services Program FWS/OBS-84/10.60.

Richards, D. 1997. Kootenai River biological baseline status report. Kootenai Tribe of Idaho. Bonneville Power Administration, Portland, Oregon. Project 94-49.

Sato 2000. Upper Libby Creek Stability Analysis and Recommendations for The Montana Department of Fish, Wildlife & Parks. University of Montana. 132p.

Stanford, J.A., F.R. Hauer, and J.V. Ward. 1988. Serial discontinuity in a large river system. Verh. Internat.Verein. Limnol. 23:1114-1118.

Storm, P.C. et al. 1982. Limnological investigations: Lake Koocanusa, Montana, Part 3 basic data, post impoundment, 1972-1978. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington.

Thorp, J.H., McEwan, E.M., Flynn, M.G., and Haurer, F.R. 1985. Invertebrate colonization of submerged wood in a Cypress-Tupelo swamp and blackwater stream. American Midland Naturalist 113:56-68.

USFWS. 1999. Recovery Plan for the white sturgeon (*Acipenser transmontanus*): Kootenai River population. U.S. Fish and Wildlife Service. Portland, OR. 96 pp. Plus appendices.

Waite, I.R., and R.A. Barnhart. 1992. Habitat criteria for rearing steelhead: a comparison of site-specific and standard curves for use in the instream flow incremental methodology. North American Journal of Fisheries Management 12:40-46.

Ward, J.V. and J.A. Stanford. 1983. The serial discontinuity concept of lotic ecosystems. Pages 29-42 in T.D. Fontaine, S.M. Bartell, (eds) Dynamics of Lotic Ecosystems. Ann Arbor; Ann Arbor Science.

Woods, P.F. and C.M. Falter. 1982. Annual nutrient loadings, primary productivity, and trophic state of Lake Koocanusa, Montana and British Columbia, 1972-80. Geological Survey Professional Paper 1283, United States Government Printing Office.

APPENDIX A. Field Data Recording Forms.

IFIM TRANSECT DATA COLLECTION FORM

Habitat Series __________________ Section ____________________

Transect ________ of __________ (start at downstream end)

Discharge: 1) _______ 2) _______ 3) ________ 4) ________

Distance from Head Pin LB RB	Ground Elevation (ft)	#	Mean Velocity of Cell (fps)				Cover		Embeddedness
			1	2	3	4	Juv	Adt	

IFIM FISH HABITAT TRANSECT DATA COLLECTION FORM

Date____________________ Time____________________ Section_____________

Habitat Type/No.__________ Transect No.______________ Crew_______________

Distance from Head Pin	Depth	Nose velocity	Mean Velocity rev	Ft/s	Cell Width	Discharge Q	Substrate	Cover	
LB RB			V1(0.8)	V2(0.2)				Adult	Juv

Cell/line summary					
Cell	Line	Rainbow Trout		Mountain Whitefish	

KOOTENAI RIVER MICRO-HABITAT
SNORKEL OR SCUBA
Date____________
Time____________
Habitat Number__________________
Section Number__________________
Discharge___________
Crew_______________
Method_____________

UTILIZATION VALUES FOR INDIVIDUAL FISH

Species	Length (in)	Cell	Line	Depth (ft)	Velocity (ft/s) Nose	Mean 0.2	0.8	Substrate/ Embeddedness	Cover	Fish Activity	Comments

EMBEDDEDNESS:

1 0-25% embedded
2 25-50% embedded
3 50-75% embedded
4 75-100% embedded

FISH ACTIVITY:

1 on bottom
2 suspended
3 on surface

SUBSTRATE:

1 plant detritus
2 clay/mud/silt
3 sand (0.062-2 mm)
4 small gravel (2-25 mm)
5 gravel (1-3 in)
6 small cobble (3-6 in)
7 large cobble (6-12 in)
8 boulder (>12 in)
9 bedrock

COVER (juv. < 10 in. Adult 1 >10 in.)

1 no cover
2 rock: >6 in. for juv., >12 in. for adult
3 velocity break (can be outside cell)
4 submerged logs and root wads
5 canopy (2 ft above water surface)
6 undercut bank
7 wood and brush (<6 in diameter)
8 turbulence
9 submerged non-woody vegetation

* utilization sites (1 m diameter circle around fish)

APPENDIX B. Raw HSC data collected in the Kootenai River

Raw HSC data collected in the Kootenai River. See key for description of data categories and abbreviations.

KEY: Section (1-Libby Dam down to Kootenai Falls, 2-Falls down to Bonners Ferry)
Habitat Type (1=Pools; 2=Riffles; 3=Glides; 4=Runs; 5=Rapids; 6=Side Channels)
Species (RBT-rainbow trout, MWF-mountain whitefish)
Size Class (juv <25.4cm, adlt ≥25.4cm)
Substrate Type (1-plant detritus,2-clay/mud/silt,3-sand[0.062-2mm],4-sml grav[2-25mm],5-grav[1-3"],6-sml cobble[3-6"],7-lrg cob [6-12"],8-boulder[>12"],9-bedrock)
Embeddedness (1:0-25%, 2:25-50%, 3:50-75%, 4:75-100%)
Cover Types Present (1-none,2-rock[>6"juvs,>12"adults],3-veloc break,4-logs/root wads,5-canopy >2'abv WSEL, 6-UCB [>.5'juvs, >1'adult],7-wood/brush<6"diam,8-turb,9-subm veg)
Cover Code is the number of cover types present (ie 0 to 3)

Date	Section	Habitat Type	Species	Size Class	Depth	Focal Velocity	Mean Velocity	Substrate	Embed-dedness	Cover1	Cover2	Cover3	Cover Code
8/2/90	1	1	MWF	adult	3.9	.27	.69	8	1	3	9	0	2
8/2/90	1	1	MWF	adult	3.9	.27	.69	8	1	3	9	0	2
8/2/90	1	1	MWF	adult	4.5	.84	1.33	6	1	2	9	0	2
8/2/90	1	1	MWF	adult	4.5	.84	1.33	6	1	2	9	0	2
8/2/90	1	1	RBT	adult	4.3	1.44	2.10	8	1	3	0	0	1
8/2/90	1	1	RBT	adult	5.0	.39	.43	8	1	3	9	0	2
8/6/90	1	3	MWF	adult	3.4	.43	2.39	7	1	3	0	0	1
8/6/90	1	3	MWF	adult	4.5	.62	1.23	1	4	2	7	9	3
8/6/90	1	3	MWF	adult	4.5	.62	1.23	1	4	2	7	9	3
8/6/90	1	3	MWF	adult	4.5	.84	.67	1	4	3	0	0	1
8/6/90	1	3	MWF	adult	5.0	2.26	1.93	8	1	3	0	0	1
8/6/90	1	3	RBT	adult	2.9	.21	1.49	2	4	9	0	0	1
8/6/90	1	3	RBT	adult	3.9	1.00	2.36	8	1	9	0	0	1
8/6/90	1	3	RBT	adult	3.9	1.00	2.36	8	1	9	0	0	1
8/6/90	1	3	RBT	adult	4.0	.24	1.15	8	1	3	9	0	2
8/6/90	1	3	RBT	adult	4.5	1.11	2.02	1	4	3	9	0	2
8/8/90	1	2	MWF	juvenile	4.4	.05	.09	6	2	2	9	0	2
8/8/90	1	2	MWF	adult	4.5	.67	1.07	7	2	2	9	0	2
8/8/90	1	2	MWF	adult	5.0	.21	.61	5	2	9	0	0	1
8/8/90	1	2	RBT	juvenile	4.5	.54	1.27	5	1	2	0	0	1
8/8/90	1	2	RBT	adult	3.9	.73	1.87	5	1	3	9	0	2
8/9/90	1	3	MWF	adult	3.6	.46	2.88	5	1	1	0	0	0
8/10/90	1	2	RBT	juvenile	2.8	1.06	.82	8	1	3	0	0	1
8/10/90	1	2	RBT	juvenile	4.3	1.27	1.60	8	1	2	3	0	2
9/19/90	1	5	RBT	adult	4.6	.65	.80	7	2	9	0	0	1
9/20/90	1	2	MWF	juvenile	5.0	.07	.37	7	3	9	0	0	1
9/20/90	1	2	MWF	juvenile	5.0	.07	.12	6	2	9	0	0	1
9/20/90	1	2	MWF	adult	4.4	.14	.20	2	4	9	0	0	1
9/20/90	1	2	MWF	adult	4.4	.14	.20	2	4	9	0	0	1
9/20/90	1	2	MWF	adult	4.5	.12	.21	5	3	9	0	0	1
9/20/90	1	2	MWF	adult	4.5	.12	.21	5	3	9	0	0	1
9/20/90	1	2	RBT	adult	5.0	.07	.12	6	2	9	0	0	1
7/20/92	1	2	MWF	juvenile	12.7	.35	1.88	7	3	1	0	0	0
7/20/92	1	2	MWF	adult	5.0	2.20	1.98	6	1	1	0	0	0
7/20/92	1	2	MWF	adult	10.8	.47	.77	5	3	1	0	0	0
7/20/92	1	2	MWF	adult	11.1	.18	.38	7	2	2	0	0	1
7/20/92	1	2	RBT	juvenile	9.1	.35	.32	2	4	1	0	0	0
7/20/92	1	2	RBT	adult	11.1	.18	.38	7	2	2	0	0	1
7/21/92	1	1	MWF	adult	2.7	2.31	2.69	7	2	3	0	0	1
7/21/92	1	1	MWF	adult	4.5	1.91	2.85	7	1	3	0	0	1

Raw HSC data collected in the Kootenai River. See key for description of data categories and abbreviations.

7/21/92	1	1	MWF	adult	5.5	1.32	2.88	7	1	3	0	0	1
7/21/92	1	1	RBT	adult	5.5	1.67	2.53	8	1	2	3	0	2
7/21/92	1	5	MWF	adult	4.6	3.31	4.38	7	1	2	0	0	1
7/21/92	1	5	MWF	adult	4.9	2.02	3.64	7	1	2	0	0	1
8/6/92	2	4	MWF	juvenile	1.8	4.48	4.27	6	1	1	0	0	0
8/6/92	2	4	MWF	juvenile	3.9	3.73	5.40	6	1	1	0	0	0
8/6/92	2	4	MWF	juvenile	5.7	3.72	5.24	7	1	2	0	0	1
8/6/92	2	4	RBT	juvenile	2.6	1.13	1.22	7	1	2	3	0	2
8/7/92	2	1	MWF	juvenile	2.8	1.17	1.56	7	1	2	0	0	1
8/7/92	2	1	MWF	juvenile	5.6	3.99	4.94	6	1	1	0	0	0
8/7/92	2	1	MWF	juvenile	6.5	2.75	3.71	7	1	2	0	0	1
8/7/92	2	1	MWF	juvenile	7.0	2.23	3.49	6	2	2	0	0	1
8/7/92	2	1	MWF	adult	4.8	1.03	1.56	6	3	2	3	0	2
8/7/92	2	1	RBT	juvenile	4.5	1.74	2.22	8	2	2	0	0	1
8/10/92	1	1	MWF	juvenile	11.8	1.89	2.57	5	2	1	0	0	0
8/10/92	1	1	MWF	adult	5.1	1.83	2.80	6	1	1	0	0	0
8/10/92	1	1	MWF	adult	7.6	1.87	3.25	7	3	3	0	0	1
8/10/92	1	1	MWF	adult	10.0	1.74	2.80	5	2	1	0	0	0
8/10/92	1	1	MWF	adult	12.8	1.74	2.83	5	3	1	0	0	0
8/10/92	1	1	RBT	adult	7.3	1.03	1.48	6	4	1	0	0	0
9/24/92	1	6	RBT	juvenile	8.7	1.07	2.89	6	2	3	7	0	2
9/24/92	1	6	RBT	adult	5.1	1.58	2.66	6	3	1	0	0	0
7/8/93	1	6	MWF	juvenile	3.9	.82	1.35	7	2	2	0	0	1
7/8/93	1	6	MWF	juvenile	4.5	.76	.93	7	2	2	0	0	1
7/8/93	1	6	RBT	juvenile	2.1	.91	1.44	7	2	2	0	0	1
7/8/93	1	6	RBT	juvenile	2.3	1.55	2.19	5	2	1	0	0	0
7/8/93	1	6	RBT	juvenile	2.6	1.60	1.85	7	2	2	8	0	2
7/8/93	1	6	RBT	juvenile	2.8	.00	1.42	7	3	2	3	0	2
7/8/93	1	6	RBT	juvenile	8.1	.28	.50	8	1	2	3	7	3
7/8/93	1	6	RBT	adult	4.3	1.42	2.25	8	1	2	3	0	2
7/8/93	1	6	RBT	adult	8.1	.28	.50	8	1	2	3	7	3
7/9/93	1	2	MWF	adult	5.5	2.34	3.54	7	2	1	0	0	0
7/9/93	1	5	MWF	adult	3.0	1.36	1.94	7	2	1	0	0	0
7/9/93	1	5	MWF	adult	3.1	1.88	2.23	7	1	1	0	0	0
7/9/93	1	5	MWF	adult	3.4	3.66	4.37	7	2	1	0	0	0
7/9/93	1	5	MWF	adult	3.5	1.80	2.61	7	1	1	0	0	0
7/19/93	1	2	MWF	juvenile	4.5	1.25	1.78	7	2	2	3	0	2
7/19/93	1	2	MWF	adult	5.5	.94	1.79	8	2	3	0	0	1
7/19/93	1	2	MWF	adult	5.6	1.36	2.52	8	2	3	0	0	1
7/19/93	1	2	MWF	adult	5.7	1.53	3.17	8	2	1	0	0	0
7/19/93	1	2	MWF	adult	5.7	1.53	3.17	8	2	1	0	0	0
7/19/93	1	2	MWF	adult	5.7	1.53	3.17	8	2	1	0	0	0
7/19/93	1	2	MWF	adult	5.9	1.52	2.11	8	2	3	0	0	1
7/19/93	1	2	MWF	adult	7.4	1.90	3.62	7	2	1	0	0	0
7/19/93	1	2	RBT	juvenile	6.1	.71	1.48	8	2	3	0	0	1
7/26/93	1	1	MWF	adult	5.4	1.68	2.43	6	2	1	0	0	0
7/26/93	1	1	MWF	adult	5.5	1.67	2.63	7	2	2	0	0	1
7/26/93	1	4	MWF	adult	3.7	3.07	4.34	8	1	2	0	0	1
7/27/93	1	3	MWF	juvenile	4.9	.72	.55	7	3	2	3	0	2
7/27/93	1	3	MWF	adult	3.7	2.41	3.01	7	2	2	0	0	1
7/27/93	1	3	MWF	adult	4.9	.72	.55	7	3	2	3	0	2
7/27/93	1	3	RBT	adult	4.5	1.57	2.35	7	1	2	3	0	2
7/27/93	1	5	MWF	juvenile	1.5	.67	.67	8	3	2	3	0	2
7/27/93	1	5	MWF	juvenile	1.5	.67	.67	8	3	2	3	0	2
7/27/93	1	5	MWF	juvenile	1.5	.67	.67	8	3	2	3	0	2
7/27/93	1	5	MWF	juvenile	2.5	.84	1.98	8	4	2	9	0	2

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7/27/93	1	5	MWF	juvenile	2.5	.84	1.98	8	4	2	9	0	2
7/27/93	1	5	MWF	juvenile	2.5	.84	1.98	8	4	2	9	0	2
7/27/93	1	5	RBT	adult	5.5	.55	1.94	8	4	2	4	0	2
7/27/93	1	5	RBT	adult	5.7	.40	1.36	8	1	2	3	0	2
8/2/93	2	6	MWF	juvenile	1.8	.49	.49	6	2	2	3	0	2
8/2/93	2	6	MWF	juvenile	1.9	.93	1.09	5	4	1	0	0	0
8/2/93	2	6	MWF	juvenile	2.7	2.88	3.96	7	1	2	8	0	2
8/2/93	2	6	MWF	juvenile	3.6	3.17	4.11	7	1	2	0	0	1
8/2/93	2	6	MWF	adult	3.2	2.35	3.17	7	1	1	0	0	0
8/2/93	2	6	MWF	adult	4.0	1.72	2.55	7	1	1	0	0	0
8/2/93	2	6	RBT	juvenile	3.1	2.52	3.64	7	1	2	8	0	2
8/2/93	2	6	RBT	juvenile	3.2	1.83	2.81	7	1	2	8	0	2
8/2/93	2	6	RBT	juvenile	5.0	.40	.35	6	3	2	3	0	2
8/2/93	2	6	RBT	adult	3.5	.40	.79	7	2	2	3	0	2
8/3/93	2	6	MWF	juvenile	.8	1.60	1.93	5	3	1	0	0	0
8/3/93	2	6	MWF	juvenile	1.2	1.82	2.42	5	3	1	0	0	0
8/3/93	2	6	MWF	juvenile	1.7	1.27	1.44	6	2	2	0	0	1
8/3/93	2	6	MWF	juvenile	1.8	1.49	1.66	6	2	2	0	0	1
8/3/93	2	6	MWF	juvenile	1.8	1.49	1.66	6	2	2	0	0	1
8/3/93	2	6	MWF	juvenile	2.1	2.31	2.69	6	2	2	0	0	1
8/3/93	2	6	MWF	juvenile	2.1	1.49	2.69	6	2	2	0	0	1
8/3/93	2	6	MWF	juvenile	2.1	2.31	2.69	6	2	2	0	0	1
8/3/93	2	6	MWF	juvenile	2.6	.78	1.00	6	3	1	0	0	0
8/9/93	2	1	MWF	juvenile	4.4	.21	.36	6	4	4	0	0	1
8/9/93	2	1	MWF	juvenile	8.0	.32	2.32	7	2	2	0	0	1
8/9/93	2	1	MWF	juvenile	8.4	.45	.95	8	1	2	0	0	1
8/9/93	2	1	MWF	adult	4.6	.00	.19	5	4	4	9	0	2
8/9/93	2	1	MWF	adult	11.2	1.28	2.09	7	2	2	0	0	1
8/9/93	2	2	MWF	juvenile	4.0	.87	2.45	8	2	2	0	0	1
8/9/93	2	2	MWF	juvenile	4.1	1.91	2.72	7	2	2	0	0	1
8/9/93	2	2	MWF	adult	6.5	1.98	3.04	8	2	2	0	0	1
8/11/93	2	2	MWF	juvenile	5.7	.85	1.23	5	2	1	0	0	0
8/11/93	2	2	MWF	juvenile	6.4	.39	.96	8	2	2	0	0	1
8/11/93	2	2	MWF	adult	5.7	.85	1.23	5	2	2	0	0	1
8/11/93	2	2	MWF	adult	5.7	.85	1.23	5	2	1	0	0	0
8/11/93	2	2	RBT	juvenile	7.2	1.04	.88	8	1	2	3	0	2
8/11/93	2	5	MWF	juvenile	4.5	.39	.91	5	3	1	0	0	0
8/12/93	2	1	MWF	juvenile	3.9	.73	1.87	6	3	7	0	0	1
8/12/93	2	1	MWF	juvenile	3.9	.73	1.87	6	3	7	0	0	1
8/12/93	2	1	MWF	juvenile	4.7	.31	.55	2	4	7	0	0	1
8/12/93	2	2	MWF	juvenile	8.0	2.58	3.37	6	1	1	0	0	0
8/13/93	2	4	MWF	adult	4.1	2.77	4.13	7	2	2	0	0	1
8/13/93	2	4	RBT	juvenile	2.7	4.31	6.11	7	1	8	0	0	1
8/13/93	2	4	RBT	adult	3.7	3.89	5.20	6	1	1	0	0	0
8/13/93	2	5	MWF	adult	3.7	2.48	3.29	7	2	2	0	0	1
8/13/93	2	5	MWF	adult	3.9	1.85	2.66	7	2	2	0	0	1
8/13/93	2	5	MWF	adult	4.3	.64	1.07	6	3	3	2	0	2
8/13/93	2	5	RBT	juvenile	3.0	.57	1.55	7	2	2	0	0	1
8/13/93	2	5	RBT	juvenile	4.6	1.11	1.79	7	1	2	0	0	1
8/19/93	2	1	MWF	juvenile	2.5	.84	1.27	7	1	2	0	0	1
8/19/93	2	1	MWF	juvenile	3.4	.76	1.01	7	1	2	0	0	1
8/19/93	2	1	MWF	juvenile	5.7	1.26	2.10	7	2	2	0	0	1
8/19/93	2	1	MWF	juvenile	5.7	1.26	2.10	7	2	2	0	0	1
8/19/93	2	1	MWF	adult	4.6	2.60	3.02	6	3	1	0	0	0
8/19/93	2	1	MWF	adult	4.9	1.10	1.62	7	2	1	0	0	0
8/19/93	2	1	MWF	adult	4.9	1.10	1.62	7	2	1	0	0	0

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8/19/93	2	1	MWF	adult	5.0	1.52	1.87	7	2	1	0	0	0
8/19/93	2	1	MWF	adult	6.2	1.42	2.02	7	2	1	0	0	0
8/19/93	2	1	RBT	juvenile	3.4	1.20	1.49	7	1	2	0	0	1
8/19/93	2	1	RBT	juvenile	3.5	1.10	1.49	7	1	2	0	0	1
8/26/93	2	1	MWF	juvenile	7.5	2.71	3.36	6	2	2	0	0	1
8/26/93	2	1	MWF	adult	5.3	1.97	2.47	6	2	1	0	0	0
8/26/93	2	1	MWF	adult	5.6	1.63	2.62	5	2	1	0	0	0
8/26/93	2	1	MWF	adult	7.1	1.22	2.33	6	2	1	0	0	0
8/26/93	2	1	RBT	adult	6.8	1.22	2.50	6	2	1	0	0	0
8/26/93	2	1	RBT	adult	6.8	1.22	2.50	6	2	1	0	0	0
8/26/93	2	1	RBT	adult	7.1	1.69	2.71	6	2	1	0	0	0
8/30/93	1	2	MWF	adult	7.0	.64	.74	8	1	2	3	4	3
8/30/93	1	2	MWF	adult	7.8	.69	.92	6	2	1	0	0	0
8/30/93	1	2	MWF	adult	8.2	.27	.48	2	4	1	0	0	0
8/30/93	1	2	MWF	adult	8.2	.27	.48	2	4	1	0	0	0
8/30/93	1	2	RBT	juvenile	5.1	.72	.90	6	2	2	0	0	1
8/30/93	1	2	RBT	juvenile	7.1	.18	.17	8	2	2	3	0	2
8/30/93	1	2	RBT	adult	5.5	.31	.37	2	4	2	3	0	2
8/30/93	1	2	RBT	adult	8.0	.02	.27	2	4	9	0	0	1
8/30/93	1	2	RBT	adult	8.8	.24	.29	8	1	2	3	0	2
8/30/93	1	2	RBT	adult	10.0	.40	.70	6	2	1	0	0	0
9/1/93	1	6	MWF	juvenile	3.9	1.65	3.45	7	2	2	0	0	1
9/1/93	1	6	RBT	juvenile	2.7	1.86	1.87	7	2	2	0	0	1
9/1/93	1	6	RBT	juvenile	3.2	2.43	3.35	7	1	2	0	0	1
9/1/93	1	6	RBT	adult	3.1	2.79	3.42	7	1	1	0	0	0
9/1/93	1	6	RBT	adult	3.8	1.36	2.75	6	2	2	0	0	1
8/30/94	2	5	MWF	juvenile	4.2	1.13	1.71	8	1	2	0	0	1
8/30/94	2	5	MWF	juvenile	4.2	1.13	1.71	8	1	2	0	0	1
8/30/94	2	5	MWF	juvenile	4.2	1.13	1.71	8	1	2	0	0	1
8/30/94	2	5	MWF	juvenile	5.1	1.74	2.27	8	1	2	0	0	1
8/30/94	2	5	MWF	juvenile	5.9	1.62	3.16	8	1	2	0	0	1
8/30/94	2	5	MWF	juvenile	5.9	1.62	3.16	8	1	2	0	0	1
8/30/94	2	5	MWF	adult	4.6	2.35	3.14	6	1	2	0	0	1
8/30/94	2	5	MWF	adult	6.4	1.68	2.66	6	2	1	0	0	0
8/30/94	2	5	MWF	adult	6.7	.15	.48	6	2	2	0	0	1
8/30/94	2	5	RBT	juvenile	3.4	1.91	2.18	6	2	1	0	0	0
8/30/94	2	5	RBT	adult	4.9	.89	1.42	6	2	1	0	0	0
8/31/94	2	1	MWF	juvenile	2.2	.43	.42	7	3	2	7	0	2
8/31/94	2	1	MWF	juvenile	2.3	.76	.90	8	1	2	0	0	1
8/31/94	2	1	MWF	juvenile	2.3	.76	.90	8	1	2	0	0	1
8/31/94	2	1	MWF	juvenile	4.2	1.80	2.35	7	2	2	0	0	1
8/31/94	2	1	MWF	juvenile	10.5	1.47	2.18	5	1	1	0	0	0
8/31/94	2	1	RBT	juvenile	3.2	.48	.96	7	2	2	0	0	1
8/31/94	2	1	RBT	juvenile	3.8	2.04	2.76	7	2	2	0	0	1
8/31/94	2	1	RBT	adult	3.1	1.48	1.67	7	1	2	0	0	1
8/31/94	2	2	MWF	juvenile	3.1	1.91	1.78	7	2	2	0	0	1
8/31/94	2	2	MWF	juvenile	3.2	1.99	2.35	7	2	2	0	0	1
8/31/94	2	2	MWF	juvenile	3.2	1.99	2.35	7	2	2	0	0	1
8/31/94	2	2	MWF	juvenile	3.2	1.82	2.57	7	1	2	0	0	1
8/31/94	2	2	RBT	juvenile	4.9	.92	1.07	7	3	1	0	0	0
8/31/94	2	2	RBT	adult	4.8	2.04	3.35	7	2	2	0	0	1
8/31/94	2	2	RBT	adult	5.9	.66	3.35	7	3	2	0	0	1
9/1/94	2	5	MWF	juvenile	4.1	1.20	2.05	6	2	2	0	0	1
9/1/94	2	5	MWF	juvenile	4.5	.76	1.64	8	1	2	0	0	1
9/1/94	2	5	MWF	juvenile	5.0	1.54	1.98	7	2	2	0	0	1
9/1/94	2	5	MWF	juvenile	7.5	.28	1.00	8	2	2	3	7	3

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9/1/94	2	5	MWF	adult	6.0	.99	1.74	7	1	2	0	0	1
9/1/94	2	5	RBT	juvenile	4.6	.67	1.71	8	1	2	0	0	1
9/1/94	2	5	RBT	adult	4.8	1.24	2.10	8	1	2	0	0	1
9/1/94	2	5	RBT	adult	4.8	1.24	2.10	8	1	2	0	0	1
9/1/94	2	5	RBT	adult	5.4	.95	1.56	7	2	1	0	0	0
9/2/94	2	1	MWF	juvenile	3.8	.88	.79	7	3	2	0	0	1
9/2/94	2	1	MWF	juvenile	5.0	1.02	1.38	8	2	2	0	0	1
9/2/94	2	1	MWF	adult	8.9	1.62	2.86	8	2	2	0	0	1
9/2/94	2	1	RBT	juvenile	7.2	.58	1.72	8	2	2	3	0	2
9/2/94	2	1	RBT	adult	6.7	.82	1.51	8	2	2	3	0	2
9/21/94	1	5	MWF	juvenile	3.1	1.43	2.27	7	1	2	0	0	1
9/21/94	1	5	MWF	juvenile	4.4	1.18	2.71	7	1	2	0	0	1
9/21/94	1	5	MWF	juvenile	4.7	2.13	3.67	8	1	2	0	0	1
9/21/94	1	5	MWF	juvenile	4.7	2.13	3.67	8	1	2	0	0	1
9/21/94	1	5	MWF	adult	5.3	.25	.45	8	2	2	7	0	2
9/21/94	1	5	MWF	adult	5.8	.43	.58	7	2	2	0	0	1
9/21/94	1	5	MWF	adult	7.1	.97	2.56	8	2	2	0	0	1
9/21/94	1	5	MWF	adult	7.1	.97	2.56	8	2	2	0	0	1
9/21/94	1	5	RBT	juvenile	2.6	.64	.87	7	2	2	0	0	1
9/21/94	1	5	RBT	juvenile	3.2	1.60	2.21	7	1	2	0	0	1
9/21/94	1	5	RBT	juvenile	3.4	1.68	2.38	8	1	2	0	0	1
9/21/94	1	5	RBT	juvenile	4.0	1.91	3.13	7	2	2	0	0	1
9/21/94	1	5	RBT	adult	3.6	2.30	3.45	8	1	2	0	0	1
9/21/94	1	5	RBT	adult	3.6	2.32	3.18	7	1	2	0	0	1
9/21/94	1	5	RBT	adult	7.5	1.00	2.17	7	2	2	0	0	1
11/2/94	1	2	MWF	juvenile	14.5	1.02	1.58	5	3	1	0	0	0
11/2/94	1	2	MWF	juvenile	14.5	1.02	1.58	5	3	1	0	0	0
11/2/94	1	2	MWF	juvenile	14.8	1.06	1.95	8	2	2	4	0	2
11/2/94	1	2	MWF	juvenile	15.8	1.20	2.01	5	3	1	0	0	0
11/2/94	1	2	MWF	juvenile	15.8	1.20	2.01	5	3	1	0	0	0
11/2/94	1	2	MWF	adult	17.8	1.87	3.33	5	3	3	4	0	2
11/2/94	1	2	MWF	adult	17.8	1.87	3.33	5	3	3	4	0	2
11/2/94	1	2	MWF	adult	17.8	1.87	3.33	5	3	3	4	0	2
11/2/94	1	2	MWF	adult	17.8	1.87	3.33	5	3	3	4	0	2
11/2/94	1	2	MWF	adult	17.8	1.87	3.33	5	3	3	4	0	2
11/2/94	1	2	MWF	adult	17.8	1.87	3.33	5	3	3	4	0	2
11/2/94	1	2	RBT	juvenile	10.3	.00	.06	8	2	9	0	0	1
11/3/94	1	2	MWF	juvenile	14.8	.80	1.88	8	2	2	0	0	1
11/3/94	1	2	MWF	juvenile	14.9	1.32	2.47	5	2	2	0	0	1
7/25/95	1	1	MWF	juvenile	8.2	1.16	2.31	7	2	2	0	0	1
7/25/95	1	1	MWF	adult	6.8	1.30	2.13	7	2	2	0	0	1
7/25/95	1	2	MWF	adult	6.1	1.87	2.21	6	3	1	0	0	0
7/25/95	1	2	MWF	adult	6.1	1.40	2.02	6	2	1	0	0	0
7/26/95	1	3	MWF	adult	3.7	.31	.29	7	1	2	0	0	1
7/26/95	1	3	MWF	adult	5.8	.67	1.24	8	1	2	3	0	2
7/26/95	1	3	MWF	adult	8.1	.79	1.67	7	2	2	0	0	1
7/26/95	1	5	MWF	adult	4.7	3.20	4.74	7	2	1	0	0	0
7/27/95	2	2	MWF	juvenile	10.7	2.50	2.99	6	1	2	0	0	1
7/27/95	2	2	MWF	juvenile	11.3	2.55	3.37	6	1	2	0	0	1
7/27/95	2	2	MWF	juvenile	35.1	1.34	1.48	5	1	1	0	0	0
7/27/95	2	2	MWF	juvenile	35.1	1.34	1.48	5	1	1	0	0	0
7/27/95	2	2	MWF	adult	6.6	2.61	3.46	5	1	1	0	0	0
7/27/95	2	2	MWF	adult	10.7	2.50	2.99	6	1	2	0	0	1
8/2/95	1	1	MWF	juvenile	4.1	3.84	5.62	7	3	2	0	0	1
8/2/95	1	1	MWF	adult	5.1	3.88	5.36	7	2	1	0	0	0
8/30/95	2	2	MWF	juvenile	11.8	2.63	3.36	5	1	2	0	0	1

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8/30/95	2	2	MWF	juvenile	11.8	2.63	3.36	5	1	2	0	0	1
8/30/95	2	2	MWF	adult	9.6	2.72	3.97	5	1	1	0	0	0
10/5/95	1	1	MWF	adult	5.4	.53	.65	4	3	1	0	0	0
10/5/95	1	1	MWF	adult	11.0	.24	.19	4	3	1	0	0	0
10/5/95	1	1	RBT	adult	5.4	.54	.65	4	3	1	0	0	0
10/5/95	1	1	RBT	adult	6.1	.66	.72	4	3	1	0	0	0
10/5/95	1	2	RBT	adult	5.1	1.18	1.53	7	1	2	3	0	2
10/5/95	1	2	RBT	adult	5.5	.78	1.41	8	1	2	0	0	1
10/5/95	1	2	RBT	adult	5.6	.74	1.11	7	1	2	4	0	2
10/5/95	1	4	MWF	juvenile	2.4	2.42	3.44	7	1	2	0	0	1
10/9/95	2	1	MWF	adult	3.8	1.83	2.14	8	2	2	0	0	1
10/9/95	2	1	MWF	adult	3.8	1.83	2.14	8	2	2	0	0	1
10/9/95	2	1	MWF	adult	5.1	1.46	1.96	6	2	2	0	0	1
10/9/95	2	1	MWF	adult	5.1	1.46	1.96	6	2	2	0	0	1
10/9/95	2	1	MWF	adult	5.2	1.16	1.47	8	2	2	0	0	1
10/9/95	2	1	RBT	juvenile	2.9	1.70	1.42	6	2	2	0	0	1
10/9/95	2	1	RBT	juvenile	3.6	.80	1.27	6	2	3	0	0	1
10/9/95	2	1	RBT	juvenile	4.1	.82	.93	8	2	2	0	0	1
10/9/95	2	1	RBT	juvenile	4.2	.21	.72	8	2	2	3	0	2
10/9/95	2	1	RBT	juvenile	5.8	.17	1.39	9	1	3	0	0	1
10/9/95	2	1	RBT	adult	2.9	1.70	1.42	6	2	2	0	0	1
10/9/95	2	1	RBT	adult	3.6	1.71	1.86	8	2	2	0	0	1
10/9/95	2	1	RBT	adult	3.8	1.83	2.14	8	2	2	0	0	1
9/5/96	1	1	MWF	adult	5.8	1.47	2.28	7	1	2	0	0	1
9/5/96	1	1	MWF	adult	5.8	1.47	2.28	7	1	2	0	0	1
9/5/96	1	1	MWF	adult	5.8	2.30	2.52	7	1	2	0	0	1
9/5/96	1	1	RBT	adult	7.4	1.32	1.86	7	1	1	0	0	0
9/5/96	1	2	RBT	adult	5.9	1.72	2.22	7	2	2	0	0	1
9/5/96	1	2	RBT	adult	7.8	1.45	2.32	7	3	1	0	0	0
9/5/96	1	2	RBT	adult	8.0	.92	1.67	6	2	1	0	0	0
9/6/96	2	2	MWF	juvenile	3.1	1.14	1.33	6	2	2	0	0	1
9/6/96	2	2	MWF	juvenile	17.0	1.20	2.67	7	2	2	0	0	1
9/6/96	2	2	MWF	juvenile	18.1	1.89	3.41	7	2	2	0	0	1
9/6/96	2	2	MWF	adult	4.0	.35	1.14	8	3	2	0	0	1
9/6/96	2	2	MWF	adult	4.0	.35	1.14	8	3	2	0	0	1
9/6/96	2	2	MWF	adult	4.0	.35	1.14	8	3	2	0	0	1
9/6/96	2	2	MWF	adult	4.6	1.08	1.57	7	3	1	0	0	0
9/6/96	2	2	MWF	adult	7.1	.71	1.26	8	2	2	0	0	1
9/6/96	2	2	MWF	adult	7.6	1.71	2.25	5	3	1	0	0	0
9/6/96	2	2	MWF	adult	9.0	1.44	1.66	6	2	1	0	0	0
9/6/96	2	2	MWF	adult	9.1	1.90	2.48	7	2	1	0	0	0
9/6/96	2	2	MWF	adult	9.8	2.32	2.66	6	2	1	0	0	0
9/6/96	2	2	MWF	adult	11.4	2.30	3.18	6	2	1	0	0	0
9/6/96	2	2	MWF	adult	12.6	.55	2.35	7	2	1	0	0	0
9/6/96	2	2	MWF	adult	12.6	.55	2.35	7	2	1	0	0	0
9/6/96	2	2	MWF	adult	18.1	1.89	3.41	7	2	2	0	0	1
9/6/96	2	2	MWF	adult	18.1	1.89	3.41	7	2	2	0	0	1
9/6/96	2	2	RBT	juvenile	15.2	1.94	3.40	5	1	1	0	0	0
9/6/96	2	2	RBT	adult	15.2	1.94	3.40	5	1	1	0	0	0
9/6/96	2	2	RBT	adult	16.4	1.47	2.22	8	2	2	0	0	1
9/7/96	2	3	MWF	juvenile	2.1	2.80	3.17	6	1	1	0	0	0
9/7/96	2	3	MWF	juvenile	2.1	2.80	3.17	6	1	1	0	0	0
9/7/96	2	3	MWF	juvenile	5.7	.30	.22	6	1	1	0	0	0
9/7/96	2	3	MWF	adult	4.1	2.01	2.57	6	1	1	0	0	0
9/7/96	2	3	MWF	adult	4.1	2.01	2.57	6	1	1	0	0	0
9/7/96	2	3	RBT	juvenile	4.6	.24	.40	6	1	1	0	0	0

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9/7/96	2	3	RBT	adult	3.4	2.13	2.83	6	1	1	0	0	0
9/7/96	2	4	MWF	juvenile	2.0	3.34	3.74	6	1	1	0	0	0
9/7/96	2	4	MWF	juvenile	4.8	.53	.47	6	1	1	0	0	0
9/7/96	2	4	MWF	juvenile	4.8	.53	.47	6	1	1	0	0	0
9/9/96	2	1	MWF	juvenile	3.6	1.28	1.62	8	1	2	0	0	1
9/9/96	2	1	MWF	juvenile	4.6	2.29	3.03	8	2	2	0	0	1
9/9/96	2	1	MWF	juvenile	5.0	1.74	2.54	8	1	2	0	0	1
9/9/96	2	1	MWF	adult	5.1	.76	1.39	8	2	2	0	0	1
9/9/96	2	1	MWF	adult	5.5	1.65	2.26	8	2	1	0	0	0
9/9/96	2	1	MWF	adult	6.0	1.60	2.37	8	2	2	0	0	1
9/9/96	2	1	RBT	juvenile	3.3	.99	1.45	8	1	2	0	0	1
9/9/96	2	1	RBT	juvenile	3.7	1.16	1.44	8	1	2	0	0	1
9/9/96	2	1	RBT	juvenile	4.6	.66	.87	8	2	2	0	0	1
9/9/96	2	1	RBT	juvenile	4.6	.70	2.21	7	1	2	0	0	1
9/10/96	2	4	MWF	adult	5.6	1.18	2.38	7	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	2.9	1.53	1.71	7	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	3.1	2.55	3.12	7	1	1	0	0	0
9/10/96	2	4	RBT	juvenile	3.6	.18	.28	7	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	3.7	2.12	3.08	6	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	3.9	2.12	3.28	6	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	4.1	1.93	3.01	7	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	4.8	.27	.23	7	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	4.8	.27	.23	7	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	4.8	.27	.23	7	1	2	0	0	1
9/10/96	2	4	RBT	juvenile	5.6	1.48	3.62	7	2	2	3	0	2
9/10/96	2	4	RBT	adult	2.6	1.91	2.57	6	2	1	0	0	0
9/10/96	2	4	RBT	adult	3.1	1.42	2.34	7	1	1	0	0	0
9/10/96	2	4	RBT	adult	4.8	2.64	3.47	7	1	1	0	0	0
9/10/96	2	5	RBT	juvenile	1.3	1.64	1.64	7	2	2	0	0	1
9/10/96	2	5	RBT	juvenile	3.0	3.34	3.64	6	1	1	0	0	0
9/10/96	2	6	MWF	adult	5.6	2.25	3.77	7	1	1	0	0	0
9/10/96	2	6	RBT	juvenile	4.3	1.95	2.46	7	2	2	0	0	1
9/10/96	2	6	RBT	juvenile	4.5	.49	.64	9	1	2	0	0	1
9/10/96	2	6	RBT	juvenile	4.8	2.42	3.12	7	1	2	0	0	1
9/10/96	2	6	RBT	adult	2.6	1.47	2.08	6	1	2	0	0	1
9/10/96	2	6	RBT	adult	3.5	1.44	1.53	5	1	1	0	0	0
9/10/96	2	6	RBT	adult	3.8	2.01	3.20	7	2	2	0	0	1
9/11/96	2	2	MWF	juvenile	6.5	.56	1.60	8	1	2	3	0	2
9/11/96	2	2	MWF	adult	5.3	.36	.58	8	1	2	3	0	2
9/11/96	2	2	RBT	juvenile	4.5	1.83	2.17	8	1	2	0	0	1
9/11/96	2	2	RBT	juvenile	4.7	1.72	2.37	8	1	2	0	0	1
9/11/96	2	2	RBT	juvenile	4.8	.65	1.06	8	1	2	0	0	1
9/11/96	2	2	RBT	juvenile	6.5	.56	1.60	8	1	2	3	0	2
9/11/96	2	2	RBT	juvenile	7.9	.08	1.34	8	2	2	0	0	1
9/11/96	2	2	RBT	juvenile	7.9	.08	1.34	8	2	2	0	0	1
9/11/96	2	2	RBT	adult	3.9	.92	1.56	9	1	2	0	0	1
9/11/96	2	2	RBT	adult	4.4	.68	1.00	8	1	2	0	0	1
9/11/96	2	2	RBT	adult	4.4	.95	1.30	6	2	2	0	0	1
9/11/96	2	2	RBT	adult	8.1	.54	1.04	8	1	2	0	0	1
9/11/96	2	3	MWF	adult	4.1	2.22	3.19	7	1	1	0	0	0
9/11/96	2	3	MWF	adult	5.1	1.52	2.49	7	1	1	0	0	0
9/11/96	2	3	RBT	juvenile	3.3	.35	.69	7	1	2	0	0	1
9/11/96	2	3	RBT	juvenile	6.0	1.32	2.33	5	1	1	0	0	0
9/11/96	2	3	RBT	adult	2.5	.76	.43	7	1	2	0	0	1
9/11/96	2	3	RBT	adult	3.9	1.42	1.51	5	1	1	0	0	0
9/11/96	2	3	RBT	adult	6.5	.80	1.16	8	2	2	0	0	1

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9/13/96	1	6	MWF	juvenile	4.6	3.41	4.75	5	1	1	0	0	0
9/13/96	1	6	MWF	juvenile	5.3	1.14	1.30	5	1	9	0	0	1
9/13/96	1	6	MWF	juvenile	7.2	.97	.85	5	2	3	0	0	1
9/13/96	1	6	MWF	adult	4.6	3.41	4.75	5	1	1	0	0	0
9/13/96	1	6	MWF	adult	4.6	3.41	4.75	5	1	1	0	0	0
9/13/96	1	6	MWF	adult	7.2	.97	.85	5	2	3	0	0	1
9/13/96	1	6	MWF	adult	7.2	.97	.85	5	2	3	0	0	1
9/13/96	1	6	RBT	juvenile	1.8	2.63	2.76	6	1	2	0	0	1
9/13/96	1	6	RBT	juvenile	3.0	2.98	3.05	5	1	1	0	0	0
9/13/96	1	6	RBT	juvenile	3.2	2.66	3.35	5	1	1	0	0	0
9/13/96	1	6	RBT	juvenile	3.7	.40	.53	5	2	9	0	0	1
9/13/96	1	6	RBT	juvenile	3.8	3.15	4.30	7	1	2	0	0	1
9/13/96	1	6	RBT	juvenile	4.7	.80	.59	7	1	2	7	9	3
9/13/96	1	6	RBT	juvenile	5.2	1.00	1.61	5	2	3	7	0	2
9/13/96	1	6	RBT	juvenile	5.3	1.14	1.30	5	1	9	0	0	1
9/13/96	1	6	RBT	juvenile	6.2	.65	.81	5	2	9	0	0	1
9/13/96	1	6	RBT	adult	3.3	1.55	2.09	5	1	1	0	0	0
9/13/96	1	6	RBT	adult	3.9	1.41	1.25	5	2	2	4	9	3
9/13/96	1	6	RBT	adult	4.4	1.84	.75	6	1	2	9	0	2
9/13/96	1	6	RBT	adult	6.7	.57	.67	6	1	2	9	0	2
9/16/96	1	1	MWF	juvenile	4.0	2.27	3.15	7	1	2	0	0	1
9/16/96	1	1	MWF	juvenile	4.4	1.72	2.56	7	1	2	0	0	1
9/16/96	1	1	MWF	juvenile	4.4	1.72	2.56	7	1	2	0	0	1
9/16/96	1	1	MWF	juvenile	4.4	1.72	2.56	7	1	2	0	0	1
9/16/96	1	1	MWF	adult	4.6	1.91	2.22	8	1	2	0	0	1
9/16/96	1	1	MWF	adult	4.8	1.05	1.94	7	1	2	0	0	1
9/16/96	1	1	MWF	adult	5.7	1.64	2.37	8	1	2	0	0	1
9/16/96	1	1	MWF	adult	6.2	1.64	2.37	8	1	2	0	0	1
9/16/96	1	1	MWF	adult	6.3	1.32	2.20	8	1	2	0	0	1
9/16/96	1	1	MWF	adult	6.7	1.51	1.58	6	3	2	3	0	2
9/16/96	1	1	MWF	adult	6.7	1.51	1.58	6	3	2	3	0	2
9/16/96	1	1	RBT	juvenile	2.9	1.53	2.25	7	2	2	0	0	1
9/16/96	1	1	RBT	juvenile	3.0	1.38	1.58	8	1	2	3	0	2
9/16/96	1	1	RBT	juvenile	3.0	1.38	1.58	8	1	2	3	0	2
9/16/96	1	1	RBT	juvenile	3.0	1.38	1.58	8	1	2	3	0	2
9/16/96	1	1	RBT	juvenile	3.0	1.23	1.95	8	1	2	0	0	1
9/16/96	1	1	RBT	juvenile	3.3	1.21	1.99	7	2	2	0	0	1
9/16/96	1	1	RBT	juvenile	3.3	1.34	2.04	7	2	2	0	0	1
9/16/96	1	1	RBT	juvenile	3.4	1.75	2.13	8	1	2	7	0	2
9/16/96	1	1	RBT	juvenile	3.5	2.19	3.26	7	2	2	0	0	1
9/16/96	1	1	RBT	juvenile	3.8	.38	1.16	8	1	2	3	0	2
9/16/96	1	1	RBT	juvenile	4.0	1.48	2.23	8	1	2	3	0	2
9/16/96	1	1	RBT	juvenile	4.1	2.08	2.76	7	2	2	0	0	1
9/16/96	1	1	RBT	juvenile	4.1	2.55	3.20	7	2	2	0	0	1
9/16/96	1	1	RBT	juvenile	5.0	.90	2.73	8	1	2	0	0	1
9/16/96	1	1	RBT	adult	3.3	1.89	2.54	7	1	2	3	0	2
9/16/96	1	1	RBT	adult	3.3	1.89	2.54	7	1	2	3	0	2
9/16/96	1	1	RBT	adult	3.8	2.08	2.79	6	1	2	0	0	1
9/16/96	1	1	RBT	adult	3.8	.67	1.02	8	1	2	3	0	2
9/16/96	1	1	RBT	adult	3.8	.62	1.11	8	1	2	3	0	2
9/16/96	1	1	RBT	adult	4.0	1.48	2.23	8	1	2	3	0	2
9/16/96	1	1	RBT	adult	4.0	1.62	2.30	6	1	2	0	0	1
9/16/96	1	1	RBT	adult	4.0	1.48	2.23	8	1	2	3	0	2
9/16/96	1	1	RBT	adult	5.0	.90	2.73	8	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	1.5	1.21	1.98	6	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	2.6	1.70	1.98	5	1	1	0	0	0

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9/17/96	1	6	RBT	juvenile	3.0	2.95	3.67	7	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	3.0	2.95	3.67	7	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	3.0	2.48	2.36	8	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	3.4	2.60	2.86	6	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	3.5	2.05	3.99	7	2	2	3	0	2
9/17/96	1	6	RBT	juvenile	3.8	1.91	2.91	6	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	4.2	1.52	1.70	6	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	4.2	.92	1.36	6	1	2	0	0	1
9/17/96	1	6	RBT	juvenile	4.3	.89	1.46	8	1	2	3	0	2
9/17/96	1	6	RBT	juvenile	4.5	.92	1.94	7	1	2	3	0	2
9/17/96	1	6	RBT	juvenile	5.3	2.23	3.47	8	3	2	0	0	1
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	5.7	1.41	1.12	6	2	2	4	0	2
9/17/96	1	6	RBT	juvenile	6.4	.72	1.27	6	2	2	0	0	1
9/17/96	1	6	RBT	juvenile	6.5	1.05	2.04	6	1	2	0	0	1
9/18/96	1	1	RBT	adult	3.3	2.78	3.28	7	1	1	0	0	0
9/18/96	1	1	RBT	adult	9.1	1.41	2.01	5	1	1	0	0	0
9/18/96	1	2	RBT	adult	2.9	.78	.97	8	1	2	0	0	1
9/18/96	1	3	MWF	juvenile	6.6	.39	.93	8	1	2	3	0	2
9/18/96	1	3	MWF	juvenile	6.6	.39	.93	8	1	2	3	0	2
9/18/96	1	3	MWF	juvenile	6.6	.39	.93	8	1	2	3	0	2
9/18/96	1	3	MWF	juvenile	6.6	.39	.93	8	1	2	3	0	2
9/18/96	1	3	MWF	juvenile	6.6	.39	.93	8	1	2	3	0	2
9/18/96	1	4	MWF	juvenile	6.8	2.94	4.29	5	1	8	0	0	1
9/18/96	1	4	MWF	adult	7.3	2.59	4.06	5	1	1	0	0	0
9/18/96	1	5	MWF	juvenile	3.6	2.13	2.35	8	1	2	3	0	2
9/19/96	1	5	MWF	juvenile	2.9	2.78	3.15	7	2	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.0	2.75	3.45	7	1	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.2	1.81	2.98	7	1	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.5	2.24	2.85	7	1	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.5	1.81	2.23	7	2	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.5	1.81	2.21	7	2	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.5	2.24	2.85	7	1	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.5	1.81	2.23	7	2	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.6	1.89	3.21	7	1	2	0	0	1
9/19/96	1	5	MWF	juvenile	3.7	1.15	1.50	7	3	2	0	0	1
9/19/96	1	5	MWF	juvenile	4.2	2.14	2.36	7	1	2	9	0	2
9/19/96	1	5	MWF	juvenile	4.2	2.14	2.36	7	1	2	9	0	2
9/19/96	1	5	MWF	juvenile	4.5	2.03	3.27	8	1	2	0	0	1
9/19/96	1	5	MWF	juvenile	4.5	2.03	3.27	8	1	2	0	0	1
9/19/96	1	5	MWF	juvenile	4.9	1.66	2.67	7	3	2	0	0	1

APPENDIX C. HSC Development Tables

Kootenai River HSC Data - Depth and Velocity

Rainbow Trout Adult

Depth	Suitability
0.00	0.00
1.49	0.00
2.00	0.40
2.50	0.68
3.00	0.87
3.50	0.97
4.00	1.00
4.50	0.97
5.00	0.89
5.50	0.78
6.00	0.65
6.50	0.50
7.00	0.34
7.50	0.20
8.00	0.10
100.00	0.10

Mean Column Velocity	Suitability
0.00	0.00
0.05	0.00
0.50	0.49
1.00	0.83
1.50	0.99
2.00	1.00
2.50	0.90
3.00	0.73
3.50	0.51
4.00	0.29
4.50	0.20
5.00	0.13
5.50	0.07
6.00	0.00
100.00	0.00

Rainbow Trout Juvenile

Depth	Suitability
0.00	0.00
0.82	0.00
1.00	0.14
1.50	0.47
2.00	0.71
2.50	0.88
3.00	0.97
3.50	1.00
4.00	0.98
4.50	0.92
5.00	0.82
5.50	0.70
6.00	0.56
6.50	0.42
7.00	0.28
7.50	0.15
8.00	0.07
100.00	0.07

Mean Column Velocity	Suitability
0.00	0.07
0.50	0.54
1.00	0.84
1.50	0.98
2.00	1.00
2.50	0.92
3.00	0.77
3.50	0.58
4.00	0.36
4.50	0.20
5.00	0.16
5.50	0.12
6.00	0.08
6.50	0.04
7.00	0.00
100.00	0.00

Whitefish Adult

Depth	Suitability
0.00	0.00
2.43	0.00
2.50	0.05
3.00	0.38
3.50	0.63
4.00	0.81
4.50	0.93
5.00	0.99
5.50	1.00
6.00	0.97
6.50	0.90
7.00	0.81
7.50	0.69
8.00	0.56
8.50	0.43
9.00	0.30
9.50	0.25
100.00	0.25

Mean Column Velocity	Suitability
0.00	0.13
0.50	0.44
1.00	0.68
1.50	0.86
2.00	0.96
2.50	1.00
3.00	0.97
3.50	0.87
4.00	0.71
4.50	0.47
5.00	0.20
5.50	0.10
6.00	0.00
100.00	0.00

Whitefish Juvenile

Depth	Suitability
0.00	0.00
0.30	0.00
0.50	0.13
1.00	0.41
1.50	0.62
2.00	0.79
2.50	0.90
3.00	0.97
3.50	1.00
4.00	0.99
4.50	0.96
5.00	0.90
5.50	0.81
6.00	0.72
6.50	0.61
7.00	0.49
7.50	0.37
8.00	0.26
8.50	0.18
100.00	0.18

Mean Column Velocity	Suitability
0.00	0.00
0.50	0.47
1.00	0.78
1.50	0.95
2.00	1.00
2.50	0.95
3.00	0.83
3.50	0.66
4.00	0.47
4.50	0.28
5.00	0.21
5.50	0.14
6.00	0.07
6.50	0.00
100.00	0.00

Kootenai River HSC Data - Depth Adjustments

	Adult Mountain Whitefish					Juvenile Mountain Whitefish				Adult Rainbow Trout				Juvenile Rainbow Trout		
Depth	Observed	Predicted	Adjustment		Depth	Observed	Predicted	Adjustment	Depth	Observed	Predicted	Adjustment	Depth	Observed	Predicted	Adjustment
0.00	0			1	0.00	0	-2.32		0.00	0			0.00	0		
0.50	0			1	0.50	1	1.45		0.50	0			0.50	0	-3.97	
1.00	0			1	1.00	1	4.51		1.00	0			1.00	1	1.87	
1.50	0			1	1.50	9	6.92		1.50	0	0.12		1.50	2	6.34	
2.00	0			1	2.00	10	8.73		2.00	1	3.86		2.00	2	9.62	
2.50	0	0.65		1	2.50	8	10.00		2.50	5	6.57		2.50	11	11.82	
3.00	2	5.11		1	3.00	9	10.77		3.00	10	8.36		3.00	26	13.07	
3.50	5	8.51		1	3.50	16	11.10		3.50	20	9.35		3.50	13	13.49	
4.00	14	10.95		1	4.00	17	11.03		4.00	7	9.66		4.00	12	13.22	
4.50	16	12.53		1	4.50	15	10.64		4.50	9	9.38		4.50	18	12.36	
5.00	19	13.34		1	5.00	7	9.96		5.00	8	8.64		5.00	6	11.05	
5.50	17	13.49		1	5.50	8	9.04		5.50	4	7.56		5.50	12	9.40	
6.00	18	13.06		1	6.00	1	7.96		6.00	2	6.24		6.00	4	7.56	
6.50	7	12.16		1	6.50	8	6.74		6.50	4	4.79		6.50	2	5.62	
7.00	6	10.89		1	7.00	2	5.45		7.00	4	3.33		7.00	3	3.73	
7.50	8	9.34		1	7.50	2	4.14		7.50	3	1.98		7.50	2	2.01	
8.00	3	7.61		1	8.00	4	2.87		8.00	2	0.84	0.10	8.00	1	0.57	0.07
8.50	3	5.80		1	8.50	0	1.68	0.18	8.50	1	0.04	0.10	8.50	1	-0.46	0.07
9.00	2	4.01		1	9.00	0	0.63	0.18	9.00	1	-0.33	0.10	9.00	1	-0.94	0.07
9.50	1	2.33	0.25	1	9.50	0	-0.23	0.18	9.50	1	-0.14	0.10	9.50	0	-0.77	0.07
10.00	3	0.86	0.25	1	10.00	0	-0.85	0.18	10.00	1	0.73	0.10	10.00	1	0.19	0.07
10.50	0	-0.30	0.25	1	10.50	2	-1.17	0.18	10.50	0	2.37	0.10	10.50	0	2.05	0.07
11.00	3	-1.05	0.25	1	11.00	1	-1.14	0.18	11.00	0		0.10	11.00	0		0.07
11.50	3	-1.29	0.25	1	11.50	3	-0.71	0.18	11.50	0		0.10	11.50	0		0.07
12.00	0	-0.94	0.25	1	12.00	0	0.18	0.18	12.00	0		0.10	12.00	0		0.07
12.50	0	0.12	0.25	1	12.50	1	1.57	0.18	12.50	0		0.10	12.50	0		0.07
13.00	3	1.98	0.25	1	13.00	0	3.53	0.18	13.00	0		0.10	13.00	0		0.07
13.50	0	4.73	0.25	1	13.50	0		0.18	13.50	0		0.10	13.50	0		0.07
14.00	0		0.25	1	14.00	0		0.18	14.00	0		0.10	14.00	0		0.07
14.50	0		0.25	1	14.50	5		0.18	14.50	0		0.10	14.50	0		0.07
15.00	0		0.25	1	15.00	0		0.18	15.00	0		0.10	15.00	1		0.07
15.50	0		0.25	1	15.50	2		0.18	15.50	1		0.10	15.50	0		0.07
16.00	0		0.25	1	16.00	0		0.18	16.00	0		0.10	16.00	0		0.07
16.50	0		0.25	1	16.50	0		0.18	16.50	1		0.10	16.50	0		0.07
17.00	0		0.25	1	17.00	1		0.18	17.00			0.10	17.00	0		0.07
17.50	0		0.25	1	17.50	0		0.18	17.50			0.10	17.50	0		0.07
18.00	6		0.25	1	18.00	1		0.18	18.00			0.10	18.00	0		0.07
18.50	2		0.25	1	18.5-34.5	0		0.18	18.50			0.10	18.50	0		0.07
					35.00	2		0.18								
					35.50	0		0.18								

Notes: All predicted values are based on 3rd order polynomials over the range of depths indicated by the predicted values

Predicted values are scaled to suitability values on the right axis

Calculated suitability values for deep water observations are shown on figures, along with mean suitability value (denoted by dashed line)

Kootenai River HSC Data - Velocity Adjustments

	Adult Rainbow Trout				Juvenile Rainbow Trout		
MC Vel	Observed	Predicted	Adjustment		Observed	Predicted	Adjustment
0.00	0	-1.09		1	0	1.37	
0.50	8	7.27		1	10	10.64	
1.00	9	12.39		1	13	16.42	
1.50	14	14.77		1	31	19.24	
2.00	12	14.96		1	20	19.62	
2.50	22	13.48		1	16	18.07	
3.00	10	10.85		1	8	15.12	
3.50	9	7.60		1	13	11.29	
4.00	0	4.27	0.29	1	6	7.11	
4.50	0	1.38	0.20	1	1	3.08	0.20
5.00	0	-0.54	0.13	1	0	-0.27	0.16
5.50	1	-0.96	0.07	1	0	-2.41	0.12
6.00			0.00	1	0	-2.82	0.08
6.50				1	1	-0.99	0.04
7.00				1			0.00

	2nd order Adult Whitefish			Juvenile Whitefish		
MC Vel	Observed	Predicted	Adjustment	Observed	Predicted	Adjustment
0.00	0	2.60		0	-0.47	
0.50	12	8.77		9	9.71	
1.00	13	13.59		20	16.32	
1.50	15	17.06		12	19.85	
2.00	17	19.18		23	20.85	
2.50	27	19.94		22	19.82	
3.00	22	19.35		17	17.29	
3.50	21	17.40		20	13.77	
4.00	5	14.11		5	9.78	
4.50	5	9.46		3	5.84	0.28
5.00	3	3.45	0.20	2	2.48	0.21
5.50	1	-3.90	0.10	2	0.20	0.14
6.00			0.00	1	-0.46	0.07
6.50				0	1.00	0.00
7.00						

Notes: All predicted values are based on 3rd order polynomials (except 2nd for WF adult)
Predicted values are scaled to suitability values on the right axis

Substrate & Cover HSC Data

		Juvenile Rainbow		Adult Rainbow		Juvenile Whitefish		Adult Whitefish	
Substrate Type		Observed	Suitability	Observed	Suitability	Observed	Suitability	Observed	Suitability
plant detritus	1	0	0.00	1	0.04	0	0.00	3	0.06
clay/mud/silt	2	1	0.02	3	0.11	1	0.02	4	0.08
sand	3	0	0.00	0	0.00	0	0.00	0	0.00
small gravel	4	0	0.00	2	0.07	0	0.00	2	0.04
gravel	5	11	0.25	7	0.25	20	0.40	25	0.51
small cobble	6	28	0.64	20	0.71	29	0.58	26	0.53
large cobble	7	44	1.00	23	0.82	50	1.00	49	1.00
boulder	8	33	0.75	28	1.00	36	0.72	32	0.65
bedrock	9	2	0.05	1	0.04	0	0.00	0	0.00
		119		85		136		141	

		Juvenile Rainbow		Adult Rainbow		Juvenile Whitefish		Adult Whitefish	
Cover Group		Observed	Suitability	Observed	Suitability	Observed	Suitability	Observed	Suitability
no cover	1	12	0.17	25	0.71	26	0.30	56	0.90
1 type	2	71	1.00	35	1.00	87	1.00	62	1.00
2 types	3	34	0.48	23	0.66	22	0.25	20	0.32
3 types	4	2	0.03	2	0.06	1	0.01	3	0.05
		119		85		136		141	

		Juvenile Rainbow		Adult Rainbow		Juvenile Whitefish		Adult Whitefish	
Cover Group		Observed	Suitability	Observed	Suitability	Observed	Suitability	Observed	Suitability
cover absent	1	12	0.11	25	0.42	26	0.24	56	0.66
cover present	2	107	1.00	60	1.00	110	1.00	85	1.00