Hungry Horse Mitigation Program

Investigations of the Flathead River Native Species Project

Annual Report
2003 - 2004

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Hungry Horse Mitigation Program
2003 Annual Progress Report
Investigations of the Flathead River Native Species Project

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Bonneville Power Administration 2002 Progress Report
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TABLE OF CONTENTS

Hybridization between Native Westslope Cutthroat Trout and Non-native Rainbow Trout in the Upper Flathead River System

The upper Flathead River system in northwest Montana is recognized as a regional stronghold for migratory (e.g., adfluvial and fluvial) westslope cutthroat trout (WCT) throughout their historic range (Figure 1; Liknes and Graham 1988; Shepard et al. 1984; Shepard et al. 1997). Migratory forms are important life-history strategies for maintaining genetic diversity and dispersal among populations (Rieman and McIntyre 1995), which is critical to the long-term persistence and preservation of a species (Allendorf and Leary 1988). Populations of migratory life-history forms, however, have declined due to genetic introgression (hybridization), habitat fragmentation and degradation, and migration barriers such as dams, irrigation diversions and culverts (Liknes and Graham 1988; Behnke 1992). Consequently, westslope cutthroat trout currently inhabit about 27.4% of their original range in Montana, and genetically pure populations occupy only 2.5% of their historic range (Liknes and Graham 1988). In response to population declines, Montana Fish, Wildlife & Parks (MFWP) and the American Fisheries Society (AFS) classified westslope cutthroat trout as a species of special concern and the U.S. Forest Service classified them as a sensitive species.

Hybridization between native westslope cutthroat trout (WCT) and non-native rainbow trout (RBT) is a leading factor contributing to the decline of genetically pure cutthroat trout populations in the upper Flathead River system. In 1998, we initiated a study to examine spatial and temporal patterns of hybridization between native WCT and non-native RBT in streams of the upper Flathead River system (Hitt 2002; Hitt et al. 2003). We detected hybridization at 24 of 42 (57%) sites sampled from 1998 to 2001. New *O. mykiss* introgression was documented in 8 of 11 (73%) sites that were determined to be non-hybridized in 1988. The spatial distribution of hybrid populations (e.g., patterns of spatial autocorrelation) and patterns of genetic inheritance (e.g., and linkage disequilibrium) indicated that hybridization is spreading among sites and is advancing primarily by post-F_1 hybrids. Although hybridized sites were distributed widely throughout the study area, the amount of admixture from *O. mykiss* decreased with increasing upstream distance from the Flathead River main stem, suggesting that *O. mykiss* introgression is spreading in an upstream direction. Similarly, recent radiotelemetry studies (Muhlfeld et al. 2001; Muhlfeld et al. 2002; Muhlfeld et al. 2003) have also documented movements of hybrid (WCT x RBT) spawners into North Fork tributaries historically inhabited by WCT.

Little information exists regarding the demographics of WCT x RBT hybrid populations in the upper Flathead River drainage. Recent concern has arisen that genetically pure WCT populations are at high risk of further declines primarily due to hybridization with non-native RBT (Hitt et al. 2003). The specific distribution, population structure, abundance, and seasonal movements of hybrid trout populations are largely unknown. These unknown life-history preferences warrant immediate research and mitigation to protect the remaining endemic WCT for further population declines in the Flathead River system.

The 2003 objectives for restoration and protection of westslope cutthroat trout are to:

1. Examine spatial patterns of hybridization between westslope cutthroat trout and rainbow trout in the upper Flathead River system, Montana;

2. Quantify summer distribution, abundance, size-class structure, and genetic composition of known hybrid populations in the upper Flathead River system;

3. Assess movements and spawning locations of adult rainbow and hybrid trout in the upper Flathead River system;

4. Assess the population abundance of spawning rainbow and hybrid trout in Abbot Creek and continue a suppression program to prevent rainbow and hybrid spawners from ascending the stream; and

5. Monitor population dynamics of trout populations inhabiting the main stem Flathead River during winter.

Hybrid Population Surveys

We conducted fish population and genetics surveys in 22 tributaries of the main stem and North Fork Flathead River during the summer and fall of 2003 (Figure 1). Surveys were completed to estimate population abundance, age and size-class structure, and genetic composition of expanding and recently invaded hybrid (WCT x RBT) populations. Information gained from this study will be used to identify source hybrid populations and to prioritize and evaluate hybrid suppression efforts implemented by the Hungry Horse Mitigation Program.

From mid July through the first week in September 2003, wildfire conditions in the Flathead drainage prevented fisheries sampling in the North Fork. Consequently, population surveys were conducted in the fall, and work was redirected to upper basin streams in the United States and British Columbia, Canada, that had not been previously sampled.

Methods

Abbot Creek

We conducted population estimates in two spawning and rearing areas (an upper and lower site) in Abbot Creek, a tributary to the Flathead River near Coram, Montana. Abundance data were collected to evaluate the effectiveness of hybrid trout suppression efforts by the Hungry Horse Mitigation Program (see below). Population estimates were conducted on 23 and 24 October 2003 using a three-pass application of the removal method (Ricker 1975). Crews used a backpack electrofishing unit (pulsed DC)

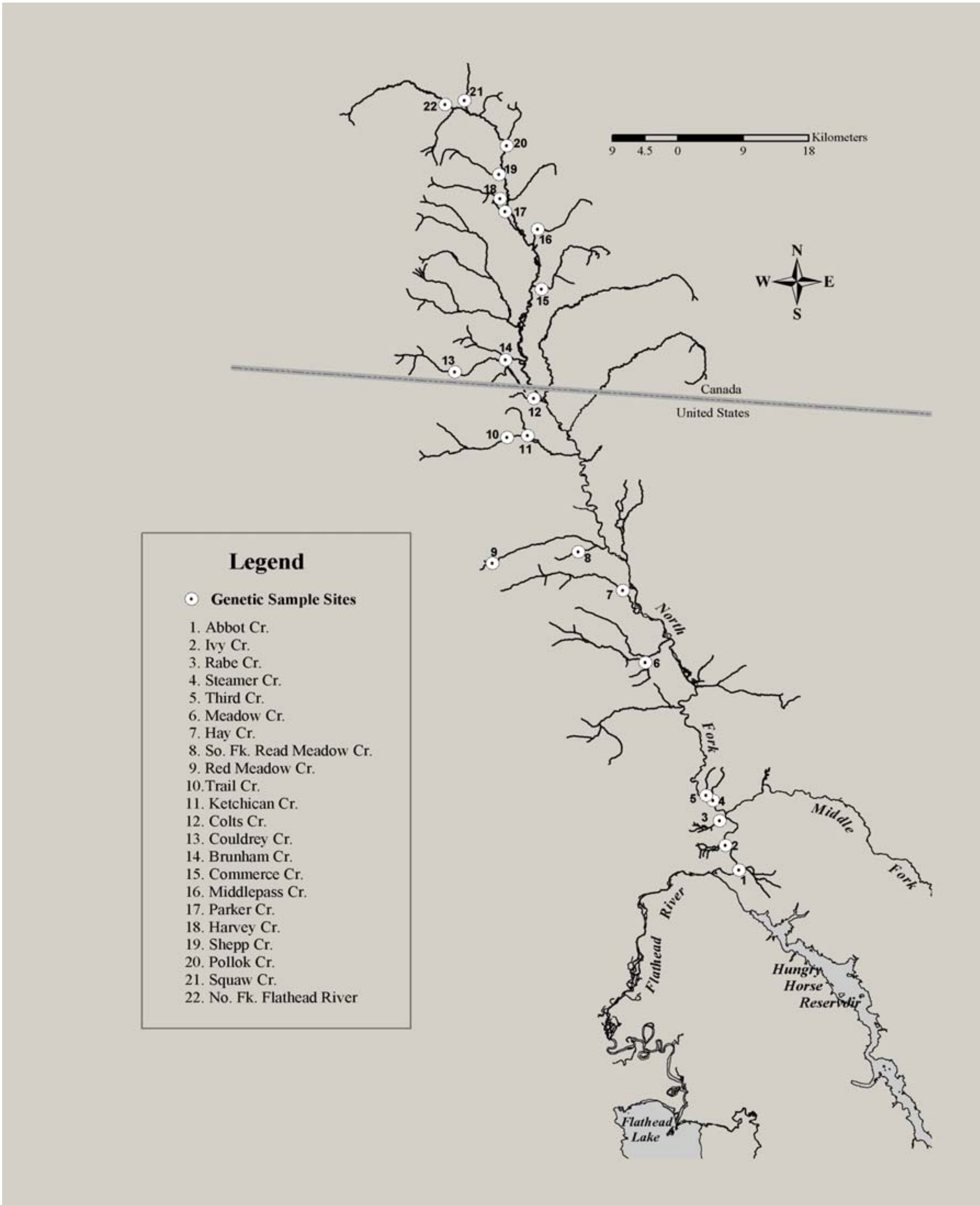

Figure 1. Fish sampling locations in the upper Flathead River system in 2003.

in each 75 m section. The lower electrofishing section was located approximately 200 m upstream of the mouth at the Flathead River, about 110 m upstream of the migrant trap (see below). The sample section had an average width of 3.1 m, and a wetted area of 232 m^2. The upper monitoring section was located on private property approximately 350 m upstream of Highway 2 in a low-gradient spawning reach, which is upstream of the fish barrier that was installed in February 2003 to prevent hybrid spawners from accessing the spawning reach. The upper section had an average width of 2.9 m, and a wetted area of 217 m^2.

Due to dramatic river stage fluctuations during spring runoff, adult fish are able to migrate into Abbot Creek and spawn in the lower 90 m between the trap and the main stem Flathead River. Backwater effects from the main stem cause river stage changes of up to 5 feet at the mouth of Abbot Creek during high water years, as experienced in the spring of 2003. Consequently, we were unable to operate a migrant trap closer than 90 m upstream of the mouth, which allowed hybrid spawners to successfully construct several redds downstream of the trap. Therefore, we conducted weekly electrofishing depletion estimates in July and August 2003 to ascertain hybrid trout fry production in the 90 m spawning reach.

For each sampling section, we established a habitat break to begin the upper boundary and a block net was placed across the channel at the lower boundary. At least 10 stream width measurements were systematically taken throughout each the section to estimate the sampling area. Multiple passes were conducted with a backpack electrofishing unit (Smith-Root Model 15 – D) moving in a downstream direction. All captured fish greater than 75 mm were identified, measured (total length), and fish less than 75 mm were enumerated. Fin clips were taken from a random sample of fish for genetic molecular analysis. Water temperature and GPS coordinates were also recorded.

North Fork Tributaries

We also completed base-line population surveys in several unnamed tributaries to the main stem, Middle Fork and North Fork Flathead River during the fall of 2003 (Figure 1). Base-line fish population surveys were conducted to determine occurrence (presence/absence), species composition, size and age-class structure, and genetic composition of WCT and bull trout *Salvelinus confluentus* populations. Surveys were conducted with a backpack electrofishing unit at access locations along the North Fork Road. Fish were identified, measured (total length), and sampled for genetics (fin clip). Water temperature and GPS coordinates were also recorded.

Results and Discussion

Abbot Creek

Lower section-The upper section of Abbot Creek was dominated by RBTxWCT hybrids (N = 97; 76%) and eastern brook trout (*Salvelinus fontinalis*; EBT; N = 30; 24%). Most of the hybrid trout were age-0 fish (<75 mm), with a few age-1 and 2 fish present in the sample (Figure 2). The population estimate for hybrid trout fry was 86 fish (SE = 1.6; lower 95% CI = 85, upper 95% CI = 89) in the lower section of Abbot Creek (Table 1).

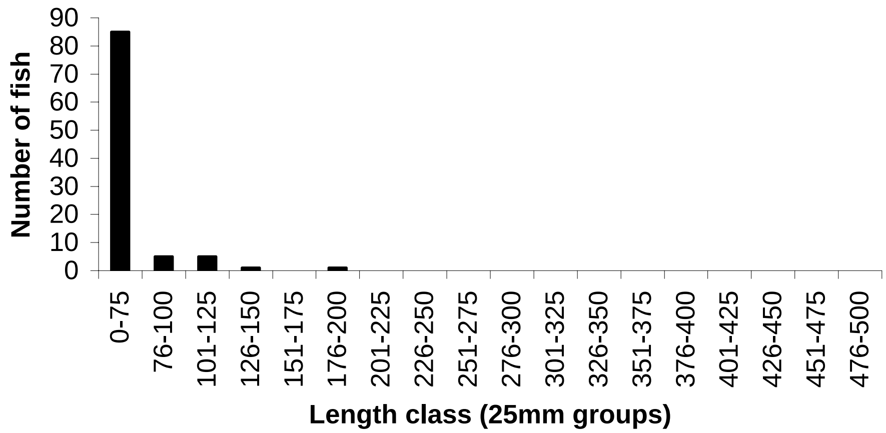

FIGURE 2. Length frequency distribution (*N* = 97) of hybrid (RBTxWCT) trout captured in the lower section of Abbot Creek (downstream of Highway 2) on 23 October 2003.

Upper section- The upper section of Abbot Creek (upstream of Highway 2) contained EBT (*N* = 94; 80%) and hybrid trout (*N* = 23; 20%). Hybrid fish *O. spp.* were age-1 and 2 fish, with no age-0 fish present in the sample (Figure 3). The population estimate for hybrid fish in this section was 23 fish (SE = 0.92; lower 95% CI = 23, upper 95% CI =25).

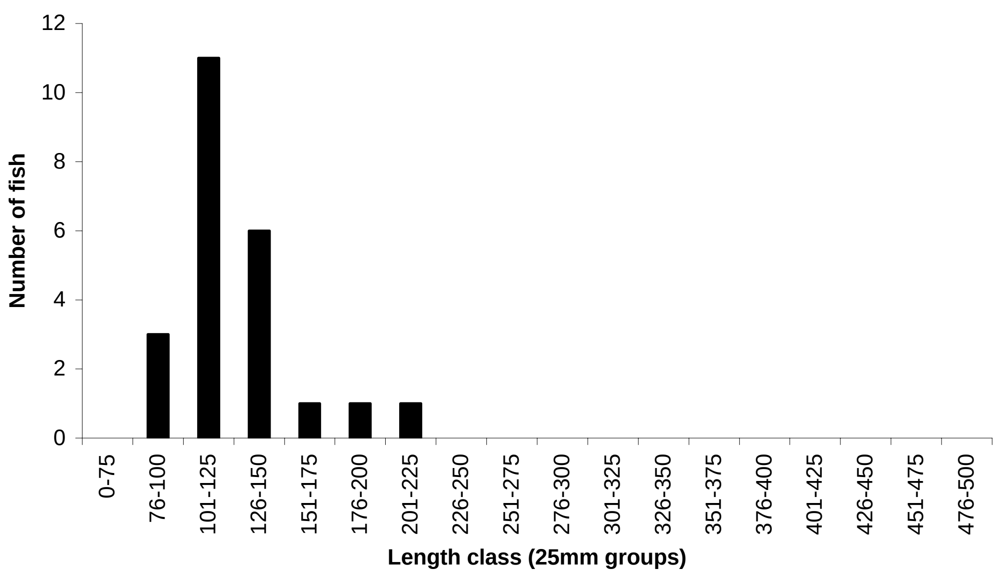

FIGURE 3. Length frequency distribution (*N* = 23) for *Onc. spp.* sampled in Abbot Creek (upper section) on 24 October 2003.

TABLE 1. Summary of population estimates for *Onc. spp.* (< 75 mm) sampled in Abbot Creek (upper and lower sites) from 2001 through 2003.

	2001		**2002**		**2003**	
	Lower	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**
Total number of fish	46	92	102	90	85	23
Number of fish <75 mm	41	84	98	87	72	0
Mean length (mm)	122	95	121	111	111	128
SD	28	5	44	27	25	27
Range	(106 – 172)	(88 – 105)	(76 – 180)	(78 – 144)	(90 – 176)	(95 – 205)
Population Estimate	79	84	104	99	86	23
SE	44	1.1	4.1	7.3	1.6	0.9
Lower 95% C.I.	41	84	98	87	85	23
Upper 95% C.I.	167	86	112	113	89	25

Our 2003 results indicate no hybrid recruitment in the upper section of Abbot Creek. Indeed, no fish less than 75 mm were captured upstream of the fish migration barrier that we installed in the Highway 2 culvert in February 2003. Previous surveys have yielded sample sizes of 84 total fry in 2001 and 87 in 2002 (Table 1). Thus, our data suggest that the recently installed barrier halted hybrid production in the most productive spawning habitat available in Abbot Creek, which is the largest source population of WCT x RBT hybrids in the upper Flathead River system.

We did not detect a significant reduction, however, in recruitment of age-0 fish in the lower monitoring section of Abbot Creek. These data suggest that some adult hybrids circumvented the trap and successfully spawned below the barrier. Further, we removed a total of 1,575 RBT fry on 9 sampling dates (population estimate = 1,987 fry) in the 90 m section downstream of the migrant trap at the mouth (Figure 4), suggesting that fish successfully spawned below our trap. Future suppression efforts will include moving the trap closer to the mouth (barring any backwater effects from the main stem) and installing a fish barrier near the mouth to preclude spawning in the entire stream.

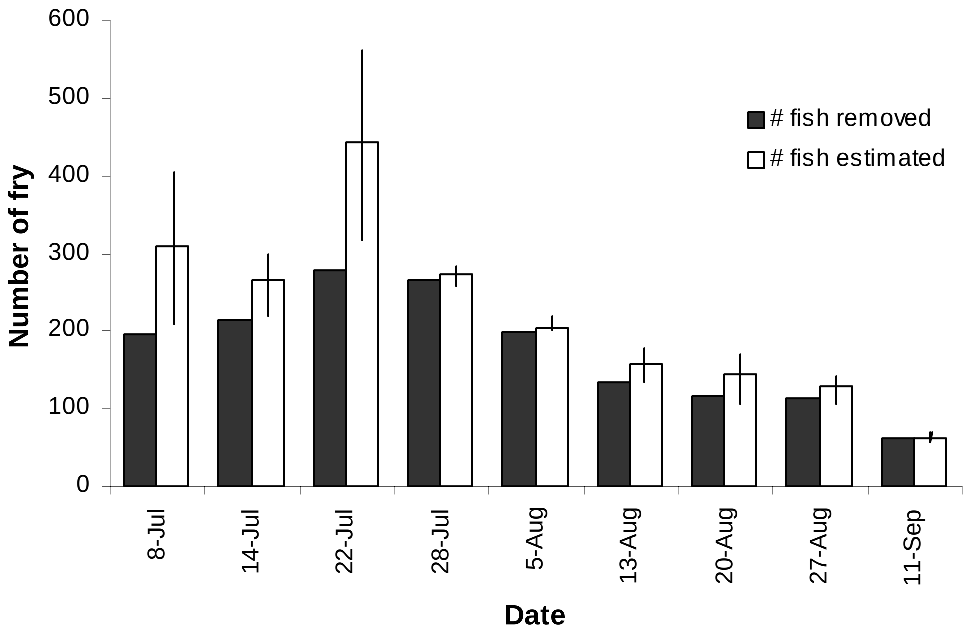

FIGURE 4. Number of fish removed and estimated on nine sampling dates on a 90m section of lower Abbot Creek, 2003.

Migrant trapping

Hybridization is perhaps the primary threat facing westslope cutthroat trout; however, the distribution of hybridized populations and the factors associated with the spread of hybridization remain poorly understood. In this study, we examined spatial and temporal patterns of hybridization between westslope cutthroat trout and rainbow trout and the population dynamics of hybrid swarms in the upper Flathead River system. This information will be used to quantify the relative production and assess life history characteristics of recently introgressed cutthroat populations (Hitt et al. 2003) for suppression efforts.

Crews deployed migrant traps in four tributaries of the upper Flathead River system during the spring and summer of 2003 to collect hybrid spawners. Upstream traps were deployed in Abbot Creek and Taylor's Outflow (tributaries to the main-stem) to assess adult escapement during spring high flows and bi-directional traps were deployed in Cyclone Creek (tributary to Coal Creek in the North Fork) and Langford Creek (tributary to Big Creek in the North Fork) to assess adult escapement and juvenile outmigration during the spring and summer.

Abbot Creek

Two adult migrant traps were deployed in Abbot Creek on 1 April 2003. One trap was placed upstream of Highway 2 (herein referred to as the upper trap) to assess the effectiveness of the fish screen barrier that was installed in the highway culvert in February 2003. The second trap (herein referred to as the lower trap) was placed downstream of the barrier, approximately 90 m upstream of the confluence with the main stem. Both traps were checked at least twice a week (each day during spring high flows), and all captured fish were measured (total length), weighed, and a tissue sample (fin clip) was removed for genetic analysis. All captured spawners were transported to a kids fishing pond (Dry Bridge Slough) in Kalispell. Both traps were operated continuously from 1 April 2003 to 2 July 2003, for a total of 91 d.

During peak spring flows, the Flathead River creates a backwater effect in the lower section of Abbot Creek that can submerge the trap and render it ineffective, which occurred in late May and early June 2003. Therefore, we used boat electrofishing to capture fish in the backwater area below the trap.

We captured and removed a total of 53 adult hybrids and 4 juvenile fish from the lower Abbot Creek trap during spring 2003. No fish were captured in the upper trap that was located upstream of the recently installed fish barrier. Twelve fish were captured in the lower trap, and 45 fish were captured by boat electrofishing near the mouth on 6 May, 28-29 May, and 3 June 2003 (Table 2). Mean length of the captured fish was 352 mm (Figure 5; range, 94 – 590 mm). Ripe spawners consisted of 24 males and 21 females. Hybrid adults entered Abbot Creek as temperature and discharge increased during the rising limb of the hydrograph (Figures 6 and 7).

TABLE 2. Abbot Creek trap data from 2000 through 2003.

	2000	2001	2002	2003
# of RBTxWCT captured	77	140	74 (114*)	12 (43*)
# of WCT captured	3	0	2	2*
Mean total length (mm)	357	362	358	352
Total length range (mm)	138 - 549	71 – 540	83 - 505	94 – 590
# Ripe males	40	33	79	24
# Ripe females	35	27	71	21
Trap dates	31 Mar - 2 Jun	2 Apr – 8 Jun	28 Mar – 20 May	1 Apr – 2 Jul
# Trap days	64	68	54	91
CPUE	1.2	2.1	1.4	0.6
Run length	3 Apr – 2 Jun	17 Apr – 6 Jun	1 May – 28 May	18 Apr – 5 Jun
Mean run date	3 May	12 May	14 May	12 May
Discharge range (m^3/s)	156.2 – 931.1	99.1 – 687.7	305.6 – 1171.6	258.9 – 645.2
Mean discharge (m^3/s)	491.8	331.0	608.0	509.3
Temperature range (^oC)	1.5 – 8.5	4.5 – 11.0	4.0 – 7.0	5.3 – 9.1
Mean temperature (^oC)	6.1	7.3	5.4	6.5

* Fish captured by electrofishing.

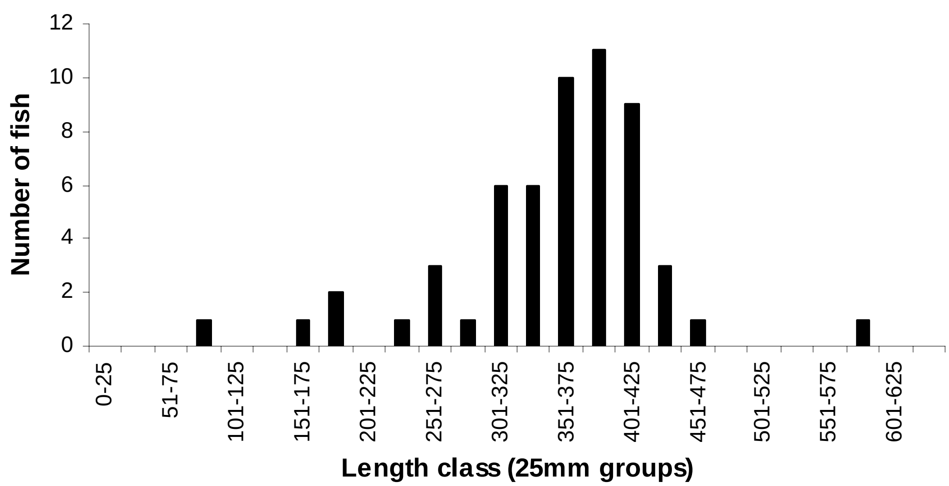

FIGURE 5. Length frequency distribution (*N* =55) of WCT x RBT hybrids captured in the Abbot Creek trap during the spring of 2003.

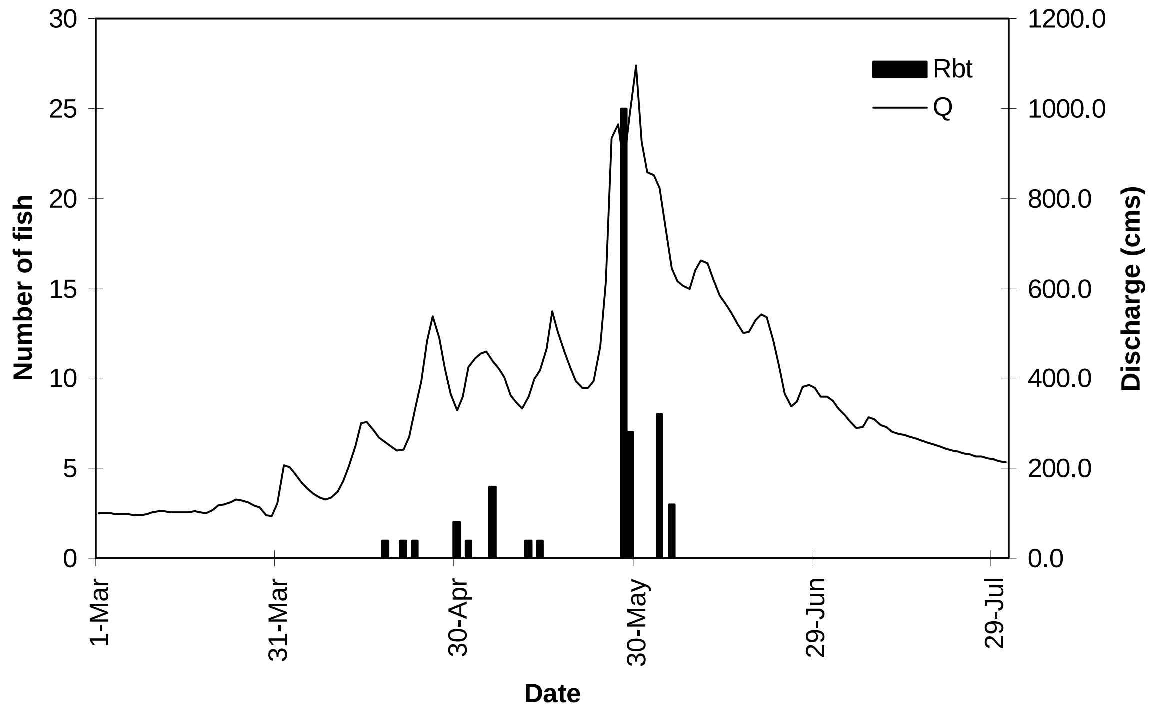

FIGURE 6. Number of RBTxWCT hybrids (*N* = 55) captured in the lower Abbot Creek trap as related to the Flathead River hydrograph during spring 2003.

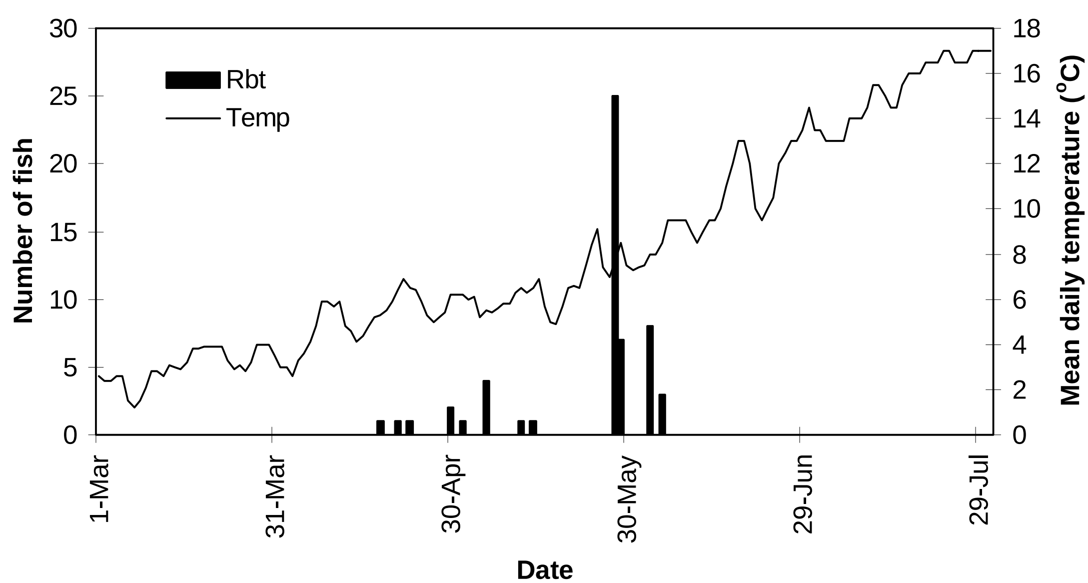

FIGURE 7. Number of RBTxWCT hybrids (*N* = 55) captured in the lower Abbot Creek trap as related to Flathead River mean daily temperature (^{o}C) during the spring of 2003.

Taylor's Outflow

Recent telemetry studies have demonstrated that hybrid fish use Taylor's Outflow for spawning (Muhlfeld et al. 2002; Muhlfeld et al. 2003). Therefore, in order to evaluate and attempt to suppress this source hybrid population, we installed a migrant trap approximately 25 m upstream of the confluence with the Flathead River on 31 March 2003. A total of 3 fish (210, 365, and 190 mm) were captured during the 72 d deployment period. Length, weight, scale samples, and fin clips were taken from all fish, and all captured fish were relocated to Dry Bridge Slough in Kalispell.

Cyclone and Langford Creeks

We operated migrant traps in Cyclone and Langford Creeks during spring 2003 to assess population dynamics of these recently invaded hybrid streams (Figure 8). Field crews checked each trap every other day pre and post run-off and every day during peak flows. Length, weight, fin clips, scales samples, and digital photographs were taken from each fish. Additionally, we implanted PIT tags (Biomark Inc., Boise, Idaho) in juvenile outmigrants to monitor movements and estimate survival.

We installed a one-way adult migrant trout near the mouth of Cyclone Creek on 15 April. The adult trap was operated for 64 d during peak spring flows. On 19 June, the one-way trap was replaced with a bi-directional trap (as flows subsided) and subsequently operated for 32 d. Fifty-one adult spawners (*Onc. spp.*; mean length, 253 mm; range, 165 – 435) were captured in the upstream trap of Cyclone Creek (Figure 9). Ripe spawners consisted of 25 males and 10 females (Table 3). The spawning run began on 21 April and ended on 6 June (Figures 10 and 11). Mean daily temperatures in the Flathead River ranged from 4.9 to 9.5 ^{o}C, and discharge ranged from 242 to 1,095.2 m^3/s.

FIGURE 8. Migrant traps deployed in Langford and Cyclone Creeks during 2003.

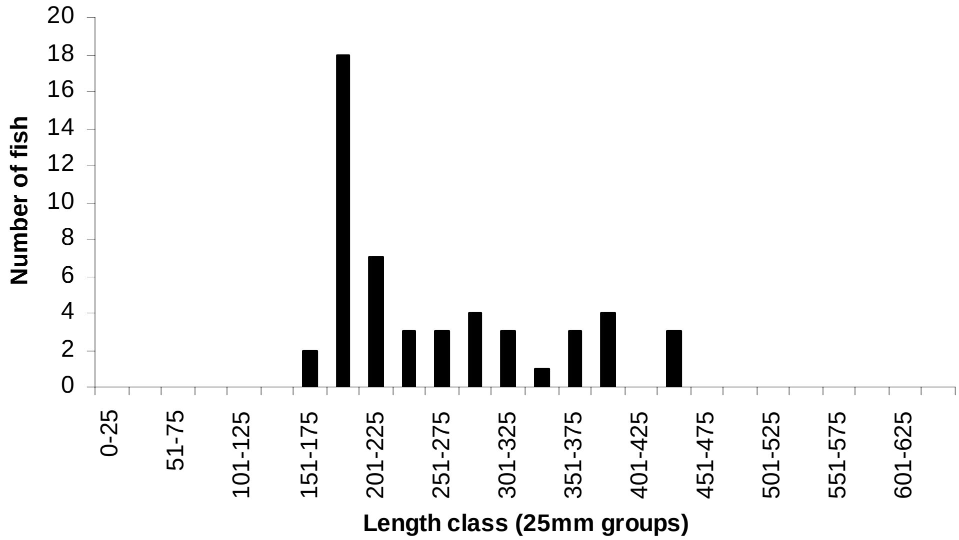

FIGURE 9. Length frequency distribution of adult hybrids (*Onc. spp*.; *N* = 51) captured in the Cyclone Creek trap during spring 2003.

TABLE 3. Summary of trapping data collected in Cyclone and Langford Creeks during 2003.

	Upstream trap Cyclone Cr.	Langford Cr.
# of spawners	51	28
Mean length (mm)	253	329
Range (mm)	165 – 435	179 – 610
S.D.	80	120
# of males	25	20
# of females	10	4
Run length	21 Apr – 6 Jun 2003	16 Apr – 16 May 2003
Mean run date	14 May	1 May
	Downstream trap	
# of adults	6 (5 recaptures)	4 (2 recaptures)
# of juveniles	21	13
Mean length (mm)	159	140
Range (mm)	105 – 182	97 – 213
S.D.	19	33
Run length	20 Jun – 21 Jul 2003	23 May – 21 Jul 2003
Mean run date	5 Jul 2003	22 Jun 2003

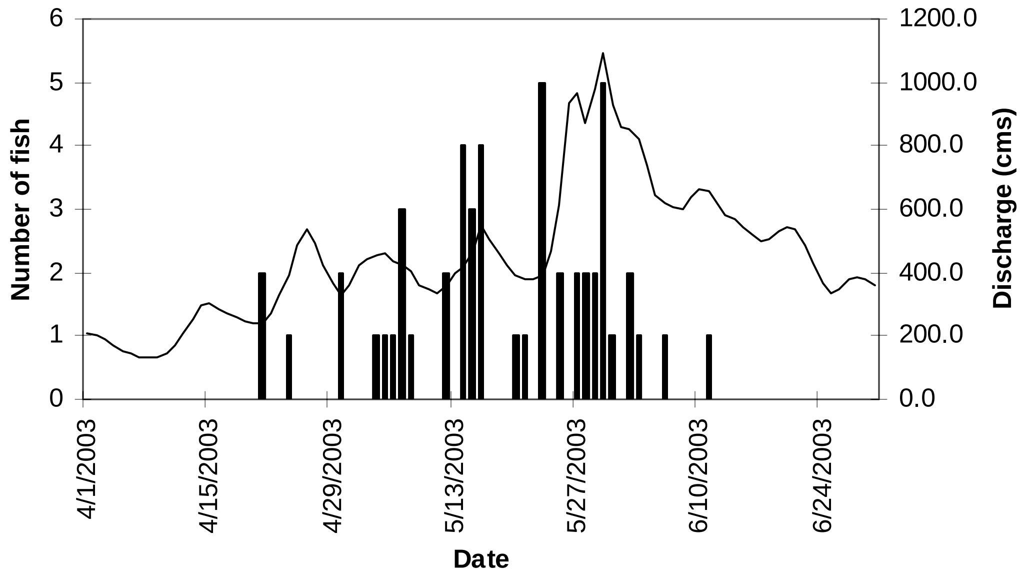

FIGURE 10. Number of trout *Onc. spp*. (*N* = 51) captured in the upstream trap in Cyclone Creek as related to the Flathead River hydrograph from 1 April through 30 June 2003.

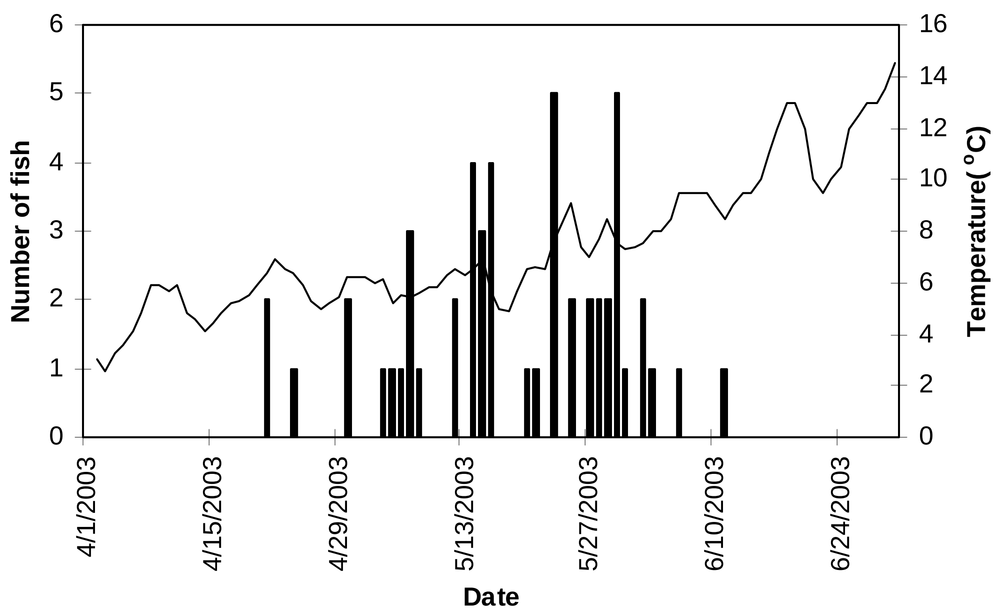

FIGURE 11. Number of trout *Onc. spp*. (*N* = 51) sampled in the upstream trap in Cyclone Creek as related to the Flathead River mean daily temperature (^{o}C) from 1 April – 30 June 2003.

Twenty-seven fish were captured in the downstream trap. Five of these fish were recaptured spent adults and 1 was an unmarked adult, while the remaining fish were unmarked juvenile migrants. Average length of the juvenile trout was 159 mm (range, 105 – 182 mm; Figure 12). Outmigrating fish were captured from 20 June to 21 July (mean, 5 July; Figures 13 and 14). Mean daily temperatures in the main-stem Flathead River ranged from 9.5 – 16.5 °C, and river discharge ranged from 244 to 534.9 m^3/s.

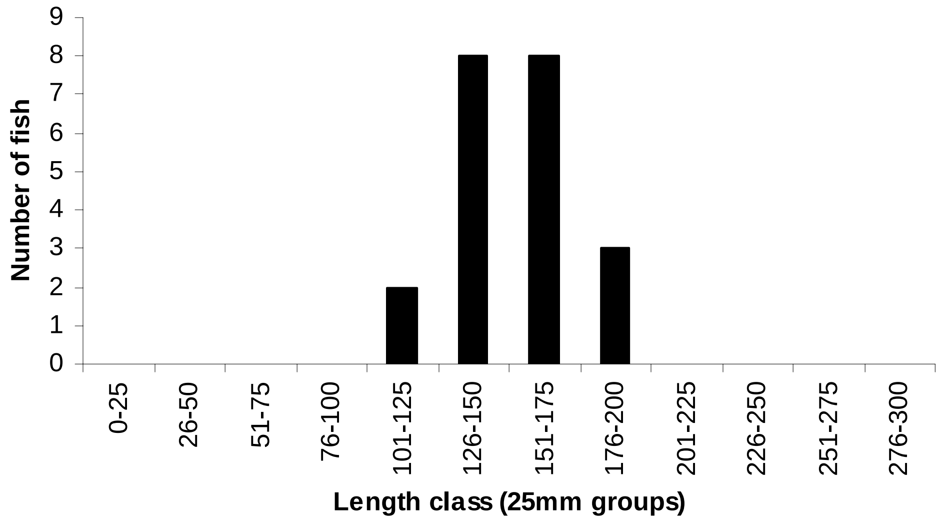

FIGURE 12. Length frequency distribution of juvenile trout *Onc. spp*.(N = 21) captured in the Cyclone Creek downstream trap during the spring of 2003.

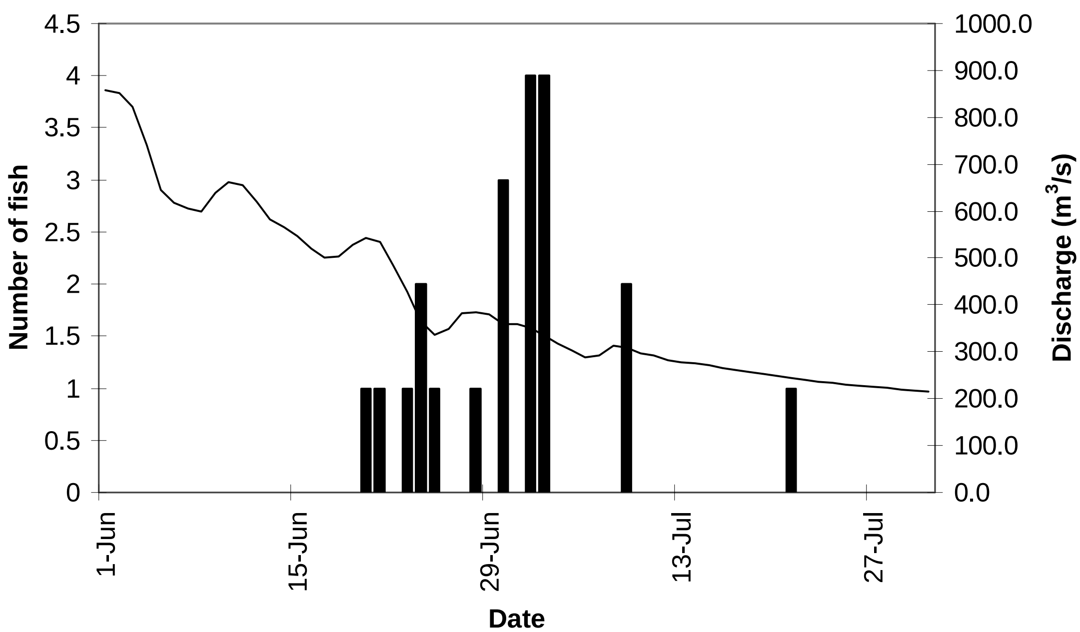

FIGURE 13. Number of juvenile trout *Onc. spp*.(N = 21) captured in the downstream Cyclone Creek trap as related to Flathead River hydrograph from 1 June to 31 July 2003.

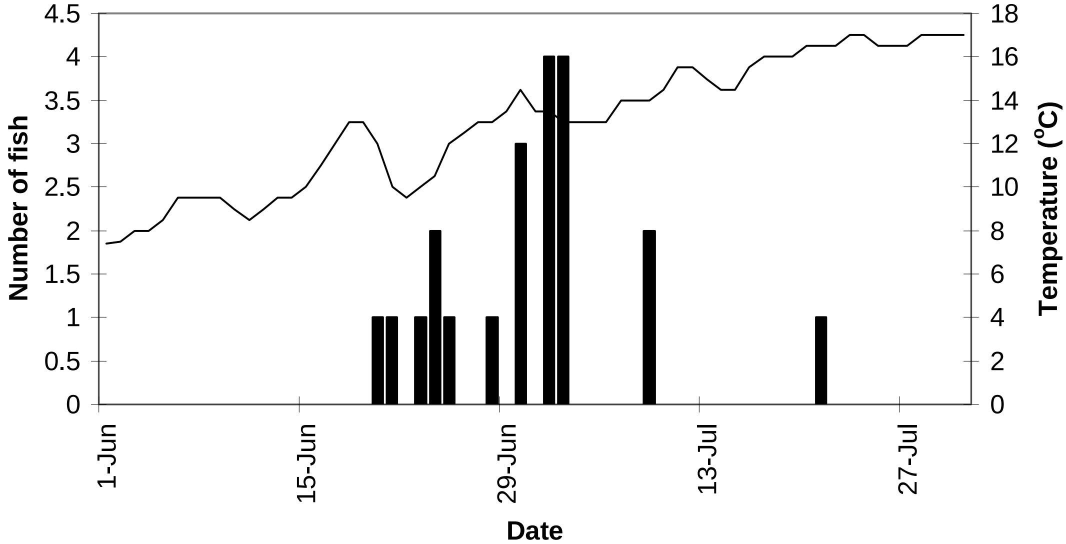

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FIGURE 14. Number of juvenile trout *Onc. spp*.(*N* = 21) captured in the downstream Cyclone Creek trap as related to Flathead River mean daily temperature (^{o}C) from 1 June to 31 July 2003.

We installed an upstream migrant trap near the mouth of Langford Creek on 8 April, which was deployed during peak flows for 42 d. As discharge subsided, the upstream trap was removed and replaced with a bi-directional trap on 20 May for an additional 61 d. Twenty-eight adult fish *Onc. sp.* were captured in the upstream migrant trap in 2003 (Figure 15). Mean length of the adult spawners was 329 mm (range, 179- 610 mm). Ripe spawners consisted of 20 males and 4 females (Table 4). The upstream migration period ranged from 16 April to 16 May (Figures 16 and 17). Mean daily temperatures at the USGS station on the main stem Flathead River ranged from 4.8 to 6.9 ^{o}C, and discharge ranged from 239.7 – 549.0 m^3/s.

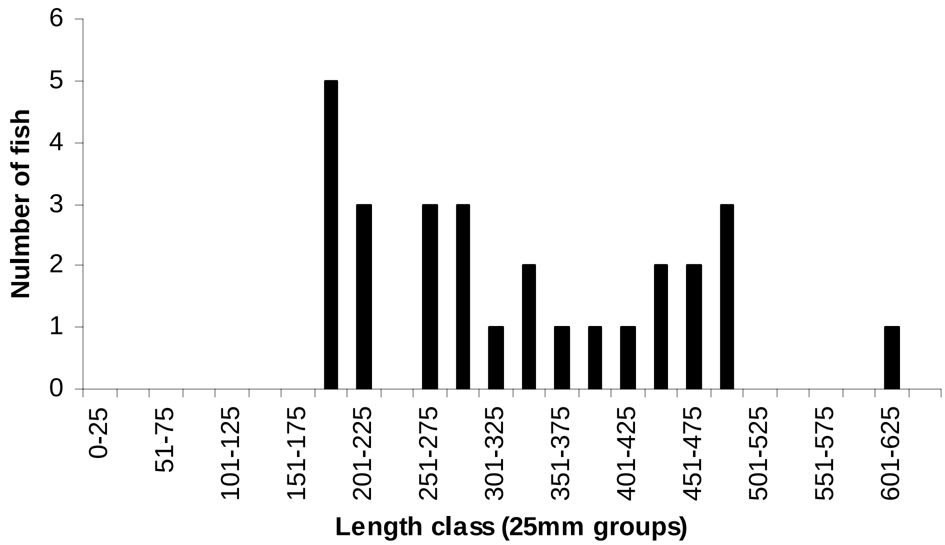

FIGURE 15. Length frequency distribution of adult fish (*Onc. spp*.; *N* = 28) captured in the upstream trap in Langford Creek during spring 2003.

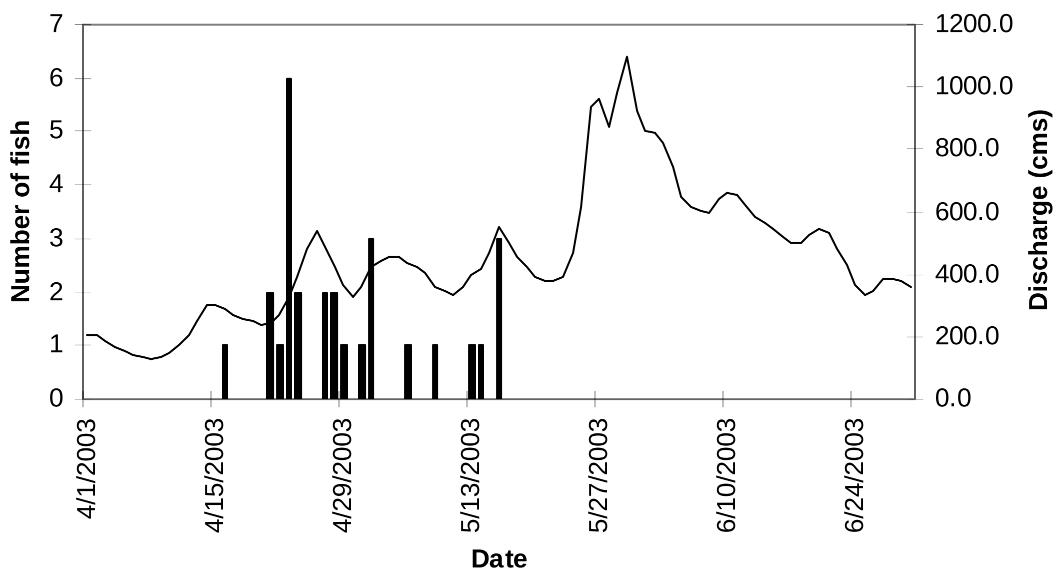

FIGURE 16. Number of adult fish (*Onc. spp*.; *N* = 28) captured in the upstream trap in Langford Creek as related to the Flathead River hydrograph from 1 April to 30 June 2003.

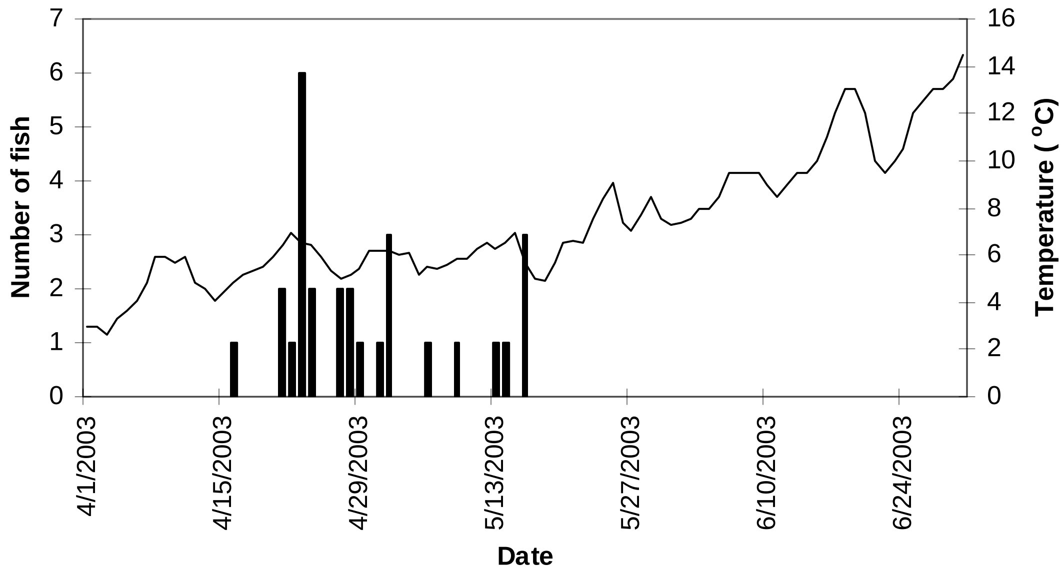

FIGURE 17. Number of adult fish *Onc. spp.* (*N* = 28) sampled in the upstream Langford Creek trap as related to the Flathead River mean daily water temperature (°C) from 1 April – 30 June 2003.

Seventeen fish *O. spp.* were sampled in the downstream trap in Langford Creek, including 2 marked and 2 unmarked adults. Average length of the 13 juvenile fish was 140 mm (range, 97 – 213 mm; Figure 18). The downstream migration ranged from 23 May to 21 July (mean, 22 June; Figures 19 and 20).

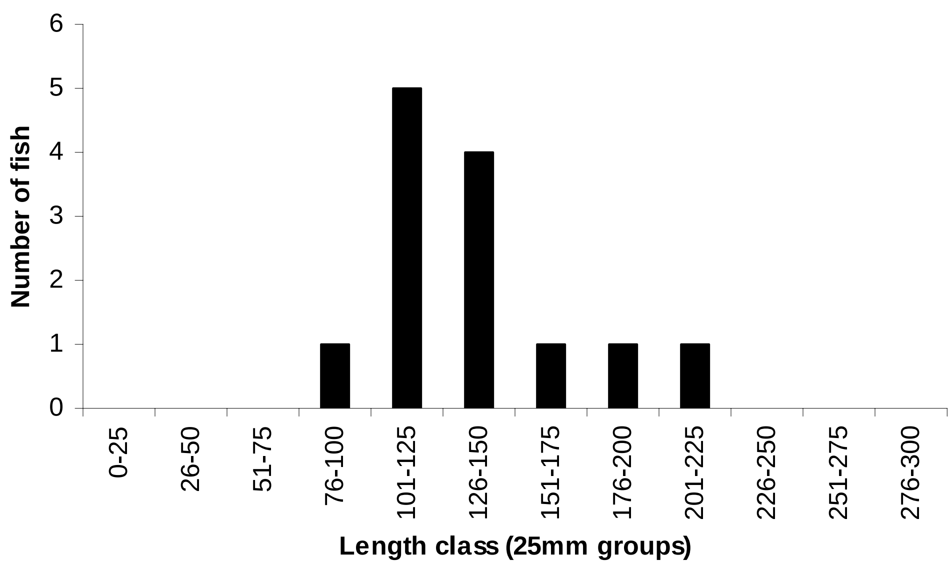

Figure 18. Length frequency distribution for juvenile *Onc. spp.* (*N* = 13) captured in the downstream Langford Creek trap during the spring of 2003.

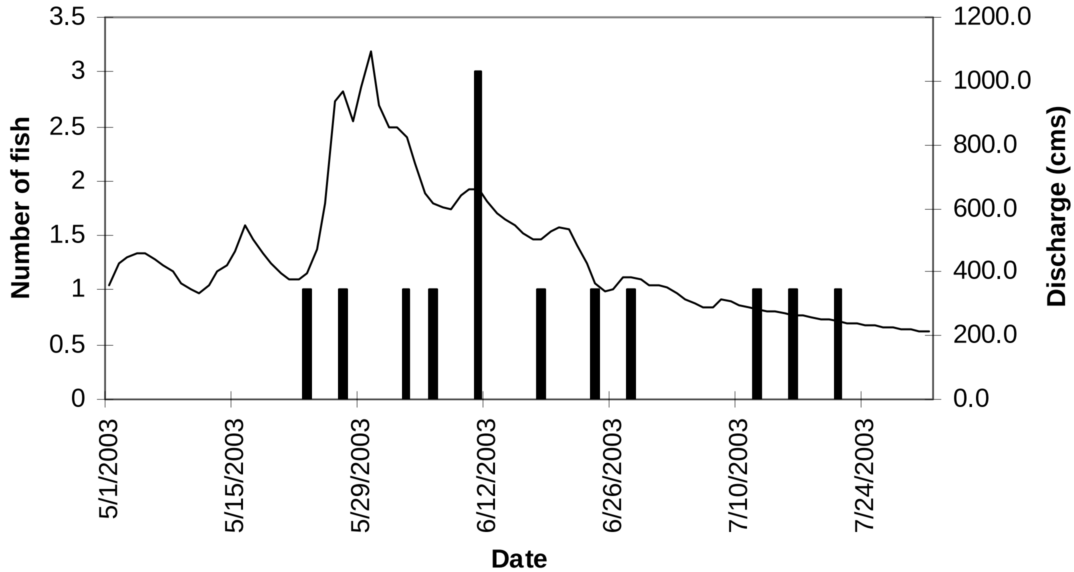

FIGURE 19. Number of juvenile *Onc. spp*. (*N* = 13) captured in the downstream Langford Creek trap as related to Flathead River hydrograph from 1 May – 31 July 2003.

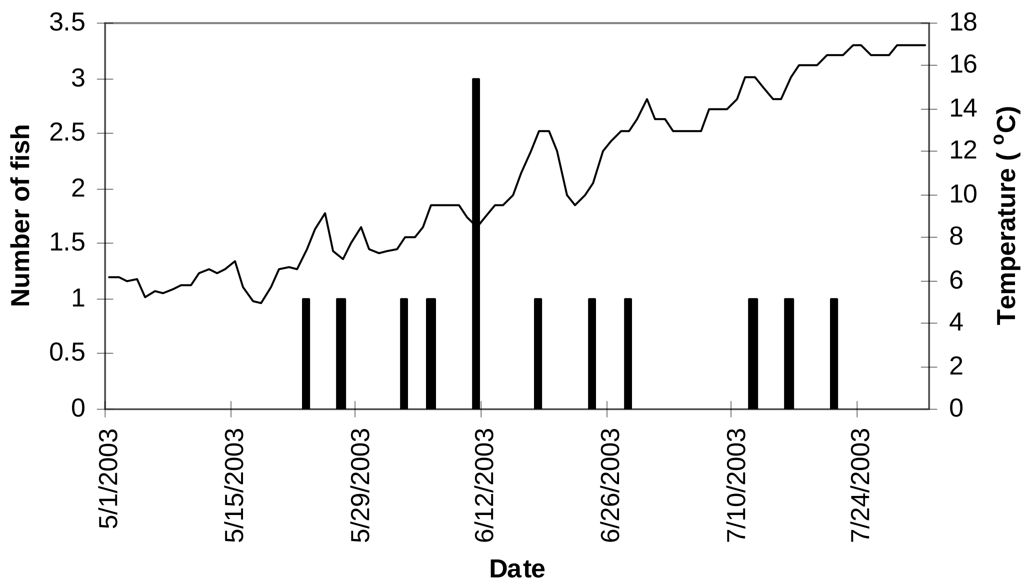

FIGURE 20. Number of juvenile *Onc. spp*. (*N* = 13) captured in the downstream Langford Creek trap as related to Flathead River mean daily temperature (^{o}C) from 1 May – 31 July 2003.

Trapping data collected in the North Fork streams will be used to assess the potential of removing the hybrid components of these expanding populations. Discharge measurements and gauge heights were also taken at various flows throughout the spring freshet in Cyclone and Langford Creeks to determine a gauge-discharge relationship for each stream. Tissue samples were sent to the University of Montana for molecular genetic analyses. Future work will include trapping pure cutthroat trout streams to compare relative production, survival, and life history characteristics. Additionally, a PIT tag monitoring system will be incorporated into the study to monitor fish movements and estimate survival in hybrid and pure cutthroat streams.

Timing and Location of Spawning by Rainbow Trout and Westslope Cutthroat Trout x Rainbow Trout Hybrids

Hybridization between non-native rainbow trout and native westslope cutthroat trout is prevalent in the Flathead River upstream of Flathead Lake (Deleray et al. 1999; Hitt et al. 2003). Despite recognition of apparent population declines, however, little is known about the spatial and temporal distribution of native westlope cutthroat trout and non-native rainbow trout during spawning. An understanding of fish movements during spawning will allow managers to identify mechanisms responsible for genetic introgression and identify streams containing hybrids for removal or suppression programs by the Hungry Horse Mitigation Program.

Methods

Telemetry

Radiotelemetry was used to monitor movements of 25 adult rainbow trout and WCT x RBT hybrids (317-561 mm) during the spring of 2003. Fish were captured by boat electrofishing, surgically implanted with radio transmitters, and released near their capture location. Transmitters weighed 6.7 g (air weight) and emitted a unique code in the 148.780 MHZ frequency range.

Fish were relocated five times per week during the spawning period and three times per week during the migration phases of the spawning period. We located fish using a Lotek (model SRX-400) scanning receiver equipped with an ATS 3-element Yagi antenna from a jet boat and from vehicle access points along the stream. Fixed wing aerial telemetry was used to survey remote and inaccessible areas throughout the upper portions of the Flathead River system. When possible, observers walked spawning tributaries to gain a more accurate location and to document redd construction. Four permanent telemetry ground stations were installed near the mouths of the North Fork, Middle Fork, mainstem (near Hungry Horse), and at the mouth of the main stem Flathead River. The telemetry ground stations were used to continuously monitor (24 hours/7 days a week) fish movements when fish came within 250 m of stations. Each ground station consisted of a Lotek data-logging receiver equipped with a 3-element directional Yagi antenna powered by a 12-volt deep cycle marine battery.

Due to high spring flows and turbid stream conditions during the spawning period, we were sometimes unable to physically document exactly where and when the fish spawned. Therefore, we established a set of criteria to estimate the location and timing of spawning. All fish that moved into tributaries during the spawning period were assumed to have spawned. All fish that remained in close proximity to their respective capture and release locations in the main stem Flathead River were classified non-spawners. Fish that made pronounced migrations, were relocated several times near the same tributary mouth and then migrated back to their pre-spawn tagging locations were assumed to have spawned. We assumed that fish spawned within their furthest upstream or downstream location during the fish's migration.

Molecular Genetics

Tissue samples were collected from each fish during surgery, preserved in 95% ethanol, and later sent to the Wild Salmon and Trout Genetics Laboratory at the University of Montana, Missoula. We used molecular analyses using 10 diagnostic markers produced from random amplified polymorphic DNA to determine the genetic composition of each study fish. We also estimated the taxonomic identity of each fish using meristic characteristics. Visual techniques relied on the spotting pattern, body coloration, and the presence or absence of coloration (e.g. red slashes) below the gill covers. Although success at visually differentiating between RBT and hybrids is at best marginal, past studies have shown excellent success at identifying pure WCT. This suggests that removal efforts using visual examination may prove to be successful in reducing the abundance of RBT and hybrids in the system.

Results and Discussion

Genetic analyses confirmed that we radio tagged 14 RBT and 9 hybrids in the main stem Flathead River near Kalispell and Columbia Falls (mean T.L.= 413mm; range 317-561mm). Radiotagged fish were relocated an average of 23 times (range, 9-36).

Of the 25 RBT and hybrids, 4 fish did not exhibit pronounced movements during the study period. Of the 21 remaining fish, 18 were relocated at the mouth of or within spawning tributaries (spawners) and 2 fish made significant upstream migrations but were not tracked to spawning streams (probable spawners). The remaining fish was caught by an angler and found dead along the bank during its migration; therefore, we did not include this fish in our analysis due to insufficient data.

Spawning behavior

Fish began spawning migrations between 11 March and 13 May 2003 (median = 9 April; Figure 21) as water temperatures increased and ranged from 2 to 7^{o} C. Fish entered spawning tributaries between 27 March and 30 May (median = 29 April). Fish staged at tributary mouths from 1-26 d (mean = 9 d). The median spawn date was 3 May (range, 13 April to 3 June; Figure 22). The average amount of time spent in spawning streams was 6 d (range, 1-33 d).

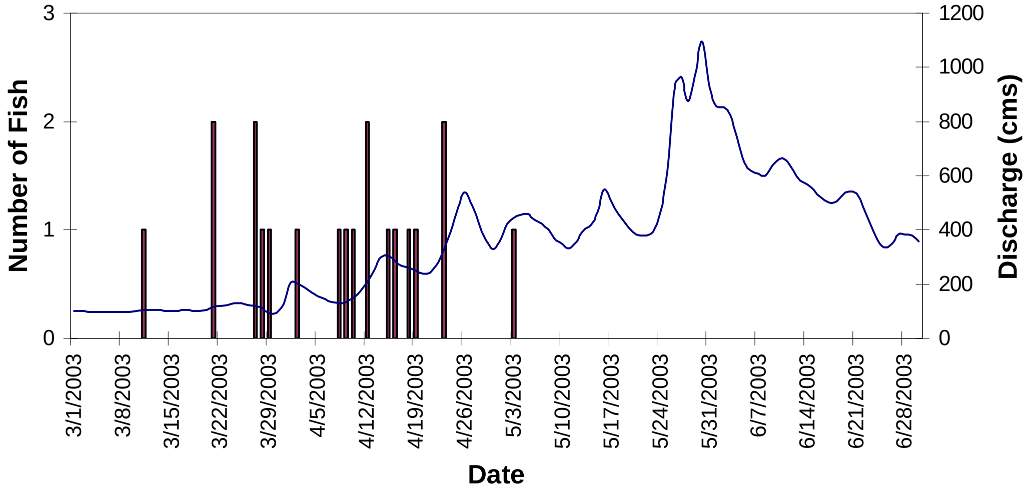

FIGURE 21. Number of rainbow and RBT x WCT hybrids (*N* = 20) beginning spawning migrations as related to the main stem Flathead River hydrograph in 2003.

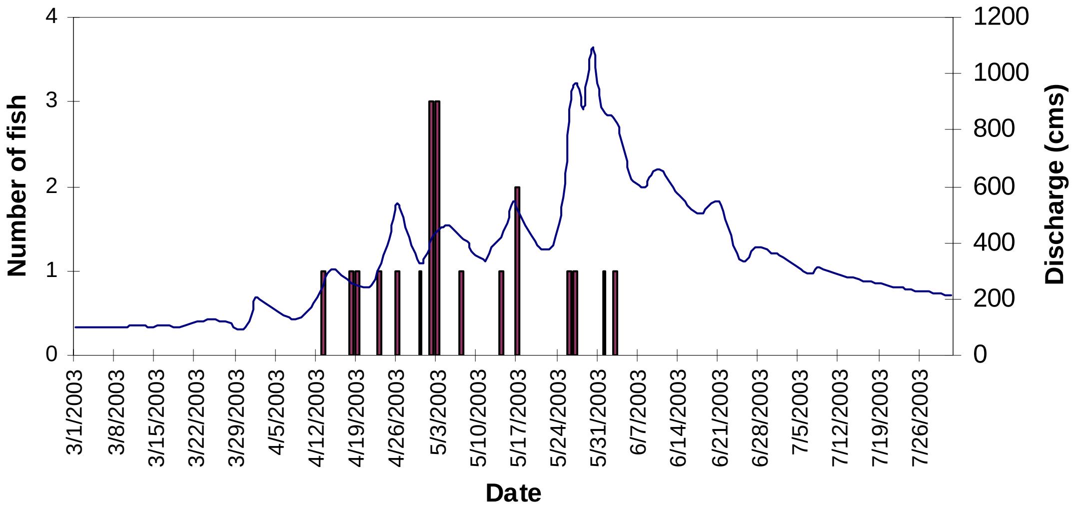

FIGURE 22. Number of rainbow and RBT x WCT hybrids (*N* = 20) and dates each fish spawned as related to the main stem Flathead River hydrograph in 2003.

Spawning locations

In 2003, 8 radiotagged fish (40%) spawned in Abbot Creek. These data and our previous findings indicate that Abbot Creek is a major hybrid stream in the upper Flathead River system. Suppression efforts are currently underway to eliminate this source hybrid population. Crews have been manually removing adult spawners during their migration into the creek (see previous section), and preliminary results suggest that hybrid abundance has declined in the main stem (*see Flathead River Winter Trout Abundance*). Further, we installed a permanent fish barrier in the Highway 2 culvert on 19 February 2003 to preclude hybrid spawners from ascending the stream (see next section). Additionally, we plan to install another migration barrier near the mouth at the Flathead River to prevent hybrids from using the lower reaches downstream of Highway 2.

Other radiotagged fish (40%) spawned in small, spring-fed tributaries to the Flathead River, including Taylor's Outflow, Ivy Creek, Rabe Creek, and Mill Creek. Three RBT spawned in Taylor's Outflow (two fish on 2 May and one on 13 April), a small spring creek located approximately 300 m upstream of the Highway 2 Bridge in Columbia Falls. One fish entered "Ivy Creek", a small-unnamed tributary that enters the Flathead River approximately 8.1 km downstream of the confluence of the Middle and North Forks. This fish was found dead 233 m upstream from the mouth of Ivy Creek. In addition, two fish were consistently located near the mouth of Ivy Creek during the spawning period and were assumed to have spawned in Ivy Creek, although we did not document these fish in the creek. One trout was located in "Rabe Creek" on 3 May. Rabe Creek flows into "Blankenship Creek" which is an unnamed tributary that enters the Flathead River from the west just below the confluence of the North and Middle Forks. Finally, one hybrid fish migrated 46 km downriver and spawned in Mill Creek. Mill Creek is a small spring creek that flows into the lake-influenced portion of the Flathead River upstream of Flathead Lake. Hitt et al. (2003) reported that Mill Creek supports a WCT x RBT hybrid population (Hitt et al. 2003). Interestingly, Creston National Fish Hatchery, a rainbow trout production facility, is located in the headwaters of Mill Creek and is likely leaking fish into the stream system.

The remaining 4 fish spawned in tributaries to the North Fork Flathead River. One fish spawned in 1st Creek on 14 May and another in 3rd Creek on 1 June. Both of these unnamed tributaries are located on the west side of Glacier National Park approximately 5 km upstream of the confluence with the Middle Fork. One fish spawned in Coal Creek on 27 May. This fish spent most of its time staging near the mouths of Cyclone and Meadow Creeks, but an exact spawning location was not determined. The remaining fish spawned immediately downstream of the mouth of Dutch and Camas Creeks in Glacier National Park on 17 May.

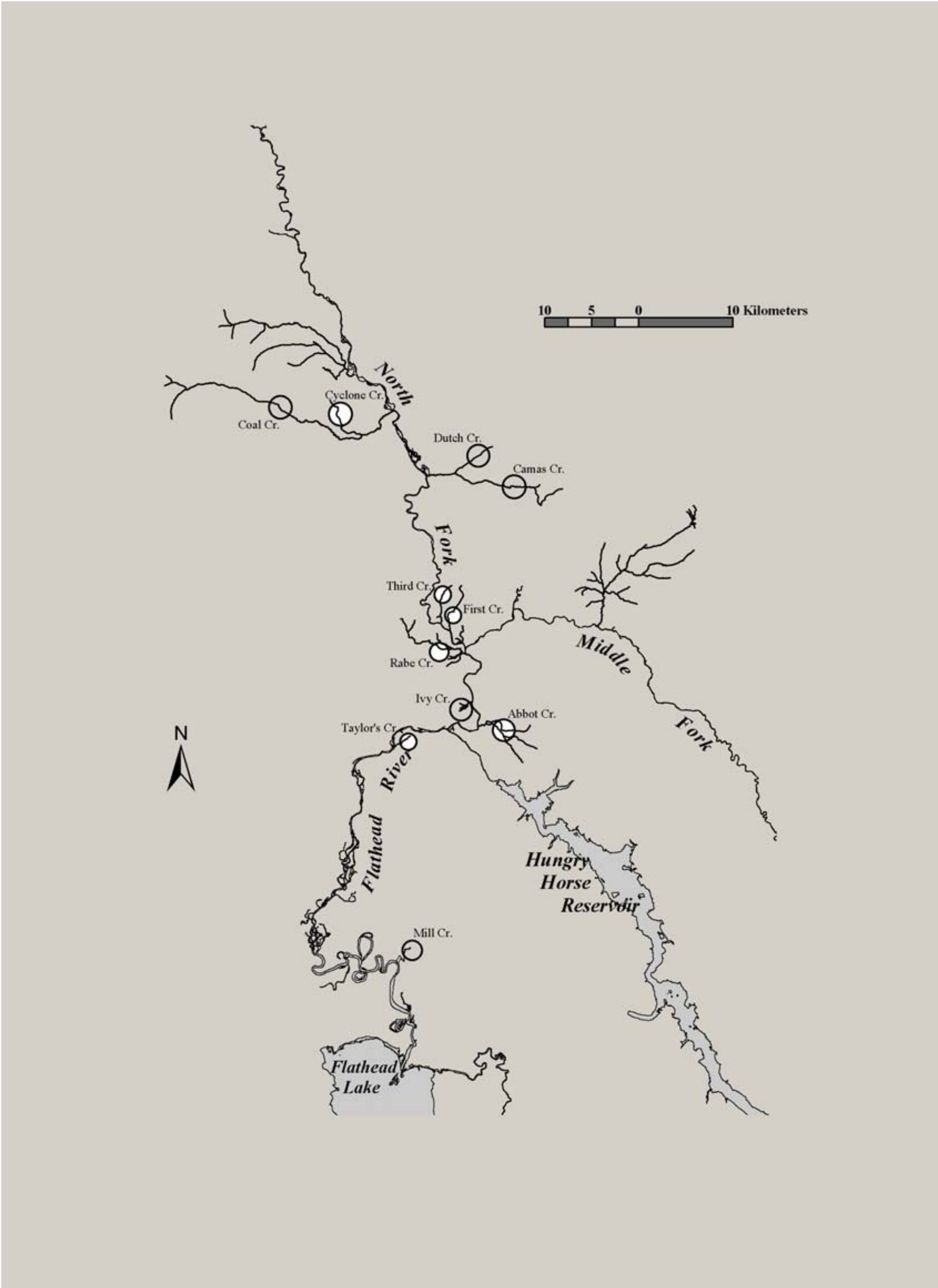

Figure 23. Spawning locations of rainbow and rainbow x cutthroat trout hybrids in the upper Flathead River system in 2003.

Abbot Creek Fish Barrier Project

Previous research has shown that Abbot Creek is a major source of hybridization between non-native rainbow trout and native westslope cutthroat trout in the upper Flathead River system (Muhlfeld et al. 2000; Muhlfeld et al. 2001; Muhlfeld et al. 2002; Muhlfeld et al 2003). Therefore, a permanent fish passage barrier (screen) was installed in the Highway 2 culvert in February 2003 to prevent hybrid adult fish from using the stream as a spawning area (Figure 24). In addition, we will operate a fish trap downstream of the barrier for 6-10 consecutive years to manually remove hybrid spawners from the population. We also plan to install an additional migration barrier near the mouth at the Flathead River to prevent hybrids from using the lower reaches downstream of Highway 2. Removal of rainbow trout and hybrids from the stream will eradicate the existing hybrid population spawning in Abbot Creek and ultimately reduce the threat of hybridization in the Flathead River system. Electrofishing surveys completed in October 2003 above the barrier yielded no age-0 trout (e.g., *Onc. spp.*; see above). These data suggest that the barrier will prevent hybrids from spawning in the upper low gradient reach of Abbot Creek.

Figure 24. Downstream view of the Abbot Creek fish screen barrier placed in the Highway 2 culvert in February 2003.

Flathead River Winter Trout Abundance

Salmonid populations exhibit complex movement patterns throughout the upper Flathead River system. The migrational behaviors of native bull trout and westslope cutthroat trout populations are critical to maintain genetic diversity and dispersal among populations, which is critical to the long-term persistence of each species (Allendorf and Leary 1988; Rieman and McIntyre 1995). Determining population status for these species is difficult in the upper Flathead River system due to the timing of seasonal migrations and overlapping habitat use by the different life histories. Further, within a species, individual fish of one life history are generally not visually distinguishable from those of another life history.

Native westslope cutthroat and bull trout display both fluvial and adfluvial life histories, whereas nonnative rainbow appear to be primarily fluvial. Therefore, at any time of the year, different salmonids, life histories, and age groups are migrating throughout the river system. These migrations compromise general assumptions of mark-recapture methodologies (i.e., closed population assumption) and complicate standardizing the timing of annual monitoring surveys. This is especially true for the cutthroat and bull trout populations, but not for rainbow trout.

Native bull trout and westslope cutthroat trout populations have declined throughout their range due to human impacts on the environment. Hybridization between native westslope cutthroat trout and nonnative rainbow trout is a leading factor contributing to the decline of genetically pure cutthroat trout populations in the upper Flathead River system. Therefore, we have initiated several projects to suppress and eradicate rainbow trout and hybrid source populations in the lower Flathead River system upstream of Flathead Lake (i.e., Abbot Creek). Monitoring population trends for rainbow trout and hybrids in the main stem Flathead River will provide managers the proper long-term information to determine the effectiveness of westslope cutthroat trout recovery and conservation efforts.

From 1979-1981 catch per unit effort (CPUE) electrofishing surveys were conducted in two sections of the Flathead River (McMullin and Graham 1981). In an effort to assess fish populations and avoid the above constraints, monitoring efforts were spread out over an extended time period (months) to encapsulate the migration periods. Past methods attempted to describe the relative abundance of these fishes and specific size groups at a number of different times throughout the year. It was believed that repeated sampling (biweekly) would account for annual variation in the timing of seasonal migrations. As a result, in 1997 and 1998 Deleray et al. (1999) followed the methodology of previous surveys (McMullin and Graham 1981) to assess changes over the last two decades in cutthroat, rainbow, and bull trout abundances in the main stem Flathead River near Columbia Falls and Kalispell. The authors recommended that future population surveys should focus on estimating rainbow trout abundance to document population trends as related to suppression programs. Therefore, our 2000-2003 objectives were: (1) to continue monitoring trout catch during winter months in two sections of the main stem

Flathead River; and (2) to estimate the abundance of juvenile and adult rainbow trout and hybrids overwintering in the Flathead River.

Methods

We conducted fish population surveys in the main stem Flathead River following the methodology of previous surveys (McMullin and Graham 1981; Deleray et al. 1999). Two sections of the Flathead River were sampled at one-week intervals; the Kalispell section (2.6 km) near Montana Highway 35 Bridge and the Columbia Falls section (2.0 km) near the Montana Highway 2 Bridge. In 2000, the Kalispell section was shortened (2.95 to 2.6 km) to reduce sampling effort and in 2001 and 2002 we decided to reduce the frequency of sampling in each section to two sampling surveys at least one week apart to obtain a more accurate population estimate (e.g. mark-recapture) for rainbow trout and hybrids. In 2003, we only completed one survey in the Kalispell section due to inclement weather conditions that precluded nighttime sampling. Therefore, a population estimate was not completed for the Kalispell section.

Surveys started after sunset and continued until two passes were completed on each bank (four passes total) in each section per night. We electrofished from a jet boat rigged with fixed-boom anodes. The Coffelt M22 produced straight DC at 3 to 5 amperes. McMullin and Graham (1981) did not specify the wave form or type and power levels used during electrofishing sampling. Most likely, a pulsed DC waveform (60 Hz per second) was used. In recent years, MFWP has established electrofishing policy that mandates use of straight DC or pulse rates ≤ 30 Hz per second when sampling waters with native fishes. This variance in methodology could affect CPUE comparisons between the two sampling periods. Passes began at the upstream boundary of each section and progressed downstream along one of the banks to the lower boundary. We netted all trout, measured total length and weight, and collected scales and genetic samples from cutthroat trout and rainbow trout. All rainbow trout and hybrids were marked (fin clip) to complete a mark-recapture abundance estimate in 2000 (Schnabel multiple census; Ricker 1975), and from 2001 to 2003 (Peterson mark-recapture; Ricker 1975).

We calculated CPUE in two ways. First, we calculated CPUE as the as the number of a fish species or size group captured divided by the time (hr) spent electrofishing and the length of the sample section (km). McMullin and Graham (1981) graphically displayed CPUE values for surveys conducted in 1997 and 1998. The second method used to calculate CPUE was to divide the number of a fish species or size group captured by the time (hr) spent electrofishing. Catch per hour was reported only for rainbow trout in the 1980s report.

Results and Discussion

Westslope cutthroat trout, rainbow trout, and bull trout dominated the trout and char catch during the winter of 2003. In both sections combined, we captured 124 rainbow trout or hybrids (39%), 175 westslope cutthroat trout (54%), and 22 bull trout (7%). In the Columbia Falls section, rainbow trout dominated the total catch (n = 113; 52%) followed by westslope cutthroat trout (n = 99; 45%), and bull trout (n = 7; 3%).

In the Columbia Falls section we caught cutthroat trout in a wide range of sizes, ranging from 173 to 469 mm (TL) during the winter of 2003 (Figure 25). For rainbow trout and hybrids, we caught a wide range of sizes with good representation of many size groups (Figure 26). Rainbow trout and hybrids ranged from 82 to 563 mm in length. Captured bull trout ranged from 213 to 252 mm, indicating a sub-adult life history stage (Figure 27).

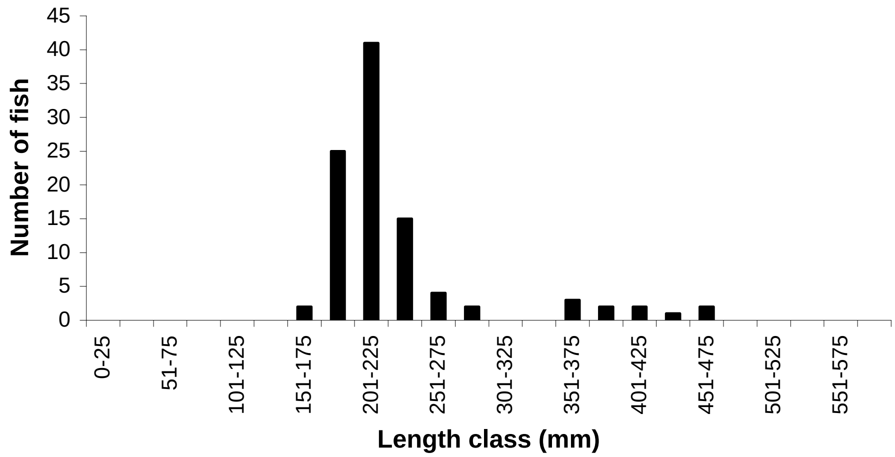

Figure 25. Length frequency distribution of westslope cutthroat trout captured during electrofishing surveys in the Columbia Falls section of the main stem Flathead River in March 2003 (N = 99).

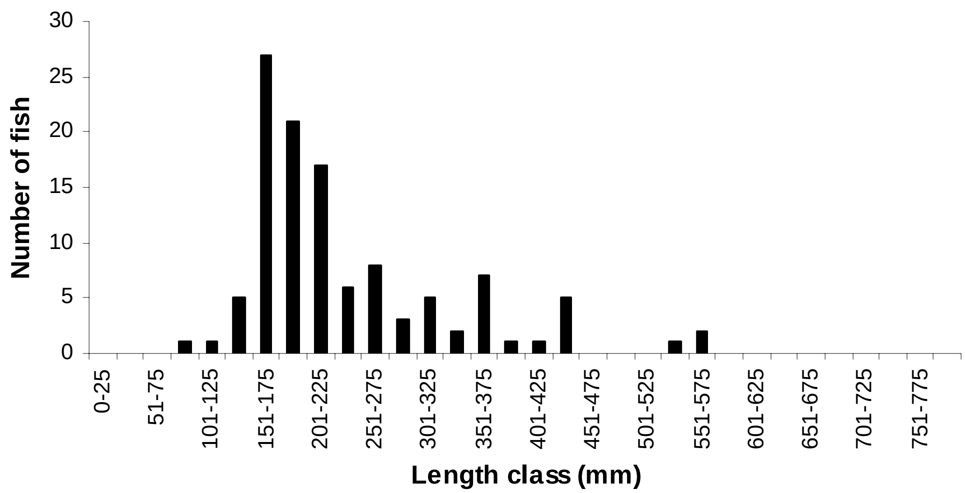

Figure 26. Length frequency distribution of rainbow trout captured during electrofishing surveys in the Columbia Falls section of the main stem Flathead River in March 2003 (N = 113).

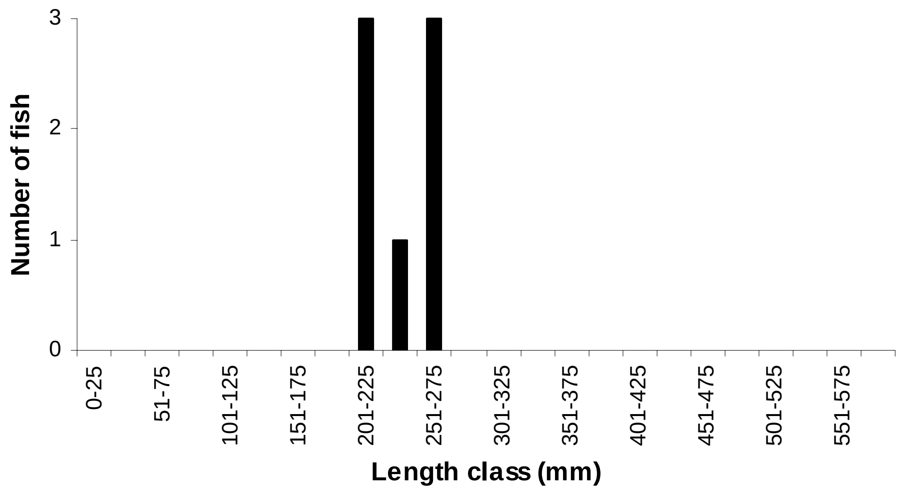

Figure 27. Length frequency distribution of bull trout captured during electrofishing surveys in the Columbia Falls section of the main stem Flathead River in March 2003 (N = 7).

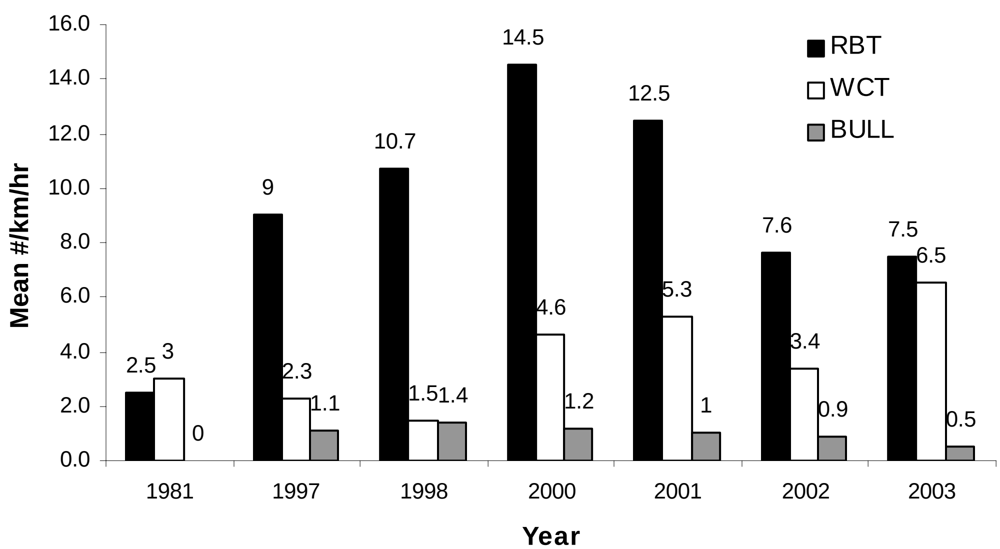

Figure 28. Mean catch per unit effort (CPUE) for rainbow, westslope cutthroat, and bull trout captured during winter electrofishing surveys in the Columbia Falls section of the Flathead River in 1981, 1997, 1998, and 2000 – 2003.

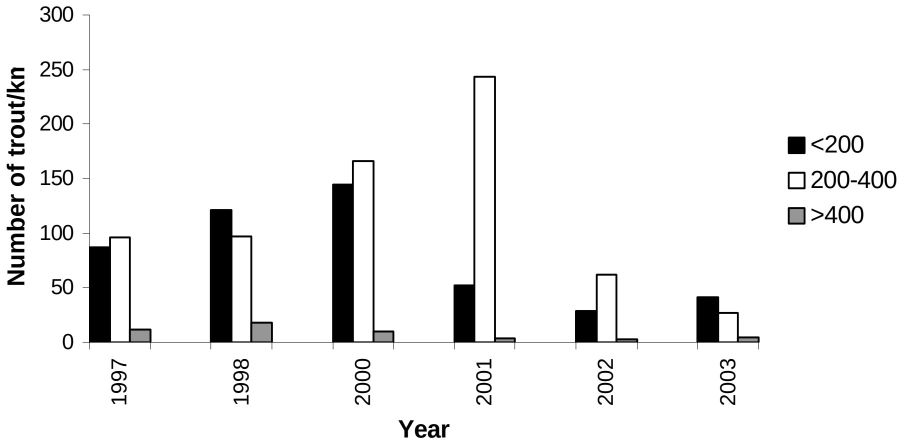

Figure 29. Abundance estimates for rainbow and hybrid trout in the Columbia Falls section of the Flathead River during the winters of 1997, 1998, 2000 (Schnable; Ricker 1975), and 2001–2003 (Peterson; Ricker 1975).

Our abundance data indicate that hybrid abundance has declined in the main stem Flathead River since 2001 (Figures 28 and 29). Rainbow and hybrid trout abundance steadily increased from 1997 to 2001, averaging about 125 fish (<400 mm) per kilometer. In contrast, juvenile (<200 mm) abundance declined to below 50 fish per kilometer in 2002 and 2003. Potential reductions in hybrid abundance may be related to hybrid suppression efforts in Abbot Creek or sampling limitations.

Mill Creek Brown Trout Suppression Program

In 1999, we discovered a population of non-native brown trout inhabiting Mill Creek, a tributary to the Flathead River near Creston, Montana. To our knowledge, Mill Creek supports the only known brown trout population in the upper Flathead River system upstream of Kerr Dam. Genetic analyses conducted by Robb Leary (University of Montana Wild Trout and Salmon Genetics Laboratory) revealed that the brown trout population in Mill Creek likely derived from hatchery brown trout held at Creston National Fish Hatchery in the early 1990s. Expansion of the brown trout population inhabiting Mill Creek may lead to further population declines of native bull trout and westslope cutthroat trout due to negative non-native species interactions, such as competition and predation.

In response to this threat to native fishes, Hungry Horse Mitigation personnel have seasonally removed adult and juvenile brown trout from the Gattis Gardens section of Mill Creek in an effort to eradicate this predacious non-native species (Table 4). In addition, multiple spawning habitat and redd surveys were completed throughout the fall seasons to monitor adult escapement. Results of the spawning habitat surveys indicated that suitable spawning habitat is limited to a few gravel sections of the stream (approximately 50 m of stream channel), primarily in the Gattis Garden section and directly downstream of Creston National Fish Hatchery. Identification and removal of brown trout redds is, therefore, a feasible option to eliminate reproduction in the stream. Therefore, all identified redds were thoroughly excavated and eggs were discarded from 1999 to 2003.

Since fall 1999, we have removed a total of 187 brown trout and eliminated 19 redds from Mill Creek. No brown trout were captured during electrofishing surveys from October 2001 through August 2003; however, electrofishing surveys on 19 December 2003 turned up 3 juvenile brown trout. Electrofishing and redd removal efforts will continue for several years to eradicate brown trout from Mill Creek and the upper Flathead River system.

Table 4. Summary of brown trout eradication efforts in Mill Creek from 1999 to 2003.

Survey dates	**Electrofishing**		**Redds Found**	**Notes**
	Juveniles	Adults		
10-6-99	5			
10-8-99	6	2		
10-12-99	46	8	yes	
10-25-99	32	7		
10-26-99			yes	
10-28-99	13	1		
11-4-99			yes	
11-12-99	10	0	yes	Excavated 10 redds
4-8-00	6	0	yes	
5-26-00	3	0		
8-4-00	23	0		
9-15-00			no	

10-20-00	2	3	yes	
10-23-00	6	1		
11-3-00	4	1	yes	Excavated 5 redds
7-6-01	2	0		
10-2-01	0	3	yes	Excavated 3 redds
10-22-01	0	0	no	
11-7-01	0	0	yes	
2-6-02	0	0		
6-28-02	0	0		
10-1-02	0	0	no	
11-12-02	0	0		
12-12-02			yes	Excavated 1 redd
8-6-03	0	0		
10-21-03			no	
11-4-03			no	
11-13-03			no	
12-19-03	3	0		No redds found
Total	161	26		

A Bioenergetics Approach to Investigate the Interactions between Non-native Northern Pike and Native Salmonids in the Lower Flathead River

Northern pike *Esox lucius* were illegally introduced and have become self-sustaining in the lower Flathead River above Flathead Lake, Montana. In 1953, non-native northern pike were illegally planted into Lone Pine Reservoir (near Hot Springs, Montana) from Lake Sherburne, Glacier National Park (MFWP, unpublished data, Kalispell, Montana). In the early 1970's, northern pike were illegally introduced to the upper Flathead River drainage (upstream of Flathead Lake) and became a popular sport fishery beginning in the 1980's. Northern pike abundance probably peaked in the 1980's, a time of peak bull trout abundance on record (Deleray et al. 1999). The current distribution of northern pike in the upper Flathead River system includes Flathead Lake, the Flathead River downstream of the Stillwater River, and the Stillwater, Whitefish and Swan River drainages.

The Flathead River drainage harbors migratory populations of native bull trout and westslope cutthroat trout. Currently, the American Fisheries Society and Montana Fish, Wildlife & Parks recognize bull trout as a threatened species under the Endangered Species Act (ESA) and westslope cutthroat trout are classified as a species of special concern. Due to apparent declines in native trout populations, concerns have arisen that the pike may be adversely impacting native trout populations (Muhlfeld et al. 2001 and 2002). Increasing local popularity of the northern pike fishery and the potential adverse effects on native species has prompted fisheries managers to collect baseline ecological information (i.e. movements, abundance, size-class structure, food habits etc.) on the northern pike population in the upper Flathead River system.

The 2003 project objectives are to:

1. Estimate the abundance of piscivorous size-classes of northern pike; and to

2. Quantify the predatory effects of northern pike on juvenile bull trout and westslope cutthroat trout.

Study area

The study area includes the lower section of the Flathead River (above Kerr Dam) that begins at the confluence of the Stillwater River and main stem Flathead River and flows in a southerly direction for 32 km before entering the north end of Flathead Lake, Flathead County, Montana. The lower Flathead River is a low-gradient (< 0.4 m/km) sinuous channel dominated by deep run habitat in the main channel with connected slough habitats present in lateral areas of the floodplain. This reach is characterized by sand, silt and gravel substrates and dominated by rooted and floating aquatic vegetation in the sloughs. Maximum recorded depth of the lower Flathead River is 27.5 m. This portion of the river is influenced by seasonal backwater affects (vertical fluctuations of approximately 3 m) caused by the impoundment of Flathead Lake by Kerr Dam.

Because Flathead Lake is held near full pool for water storage from June through September, water levels in the lower portion of the Flathead River increase during summer transforming the lower river from a lotic to a lentic aquatic environment. When Flathead Lake is at full pool, approximately 35 km of the Flathead River becomes a backwater. The main stem Flathead River is regulated by water releases from Hungry Horse Dam downstream of the confluence with the South Fork Flathead River. Dam operations have essentially reversed the natural hydrograph resulting in the storage of spring melt during spring and summer and releasing water in the fall and winter when flows were historically low**.**

Methods

Objective 1: Estimate the abundance of piscivorous size-classes of northern pike.

Field crews deployed fyke nets throughout sloughs and in the lower river above Flathead Lake from February through June 2003. The average number of nets deployed was 13 per d and ranged from 7 to 13 per day depending on net repairs and maintenance. Trapping occurred in the spring (February-June) during runoff and will resume in late winter and early spring 2004. However, no nets were set in March 2003 due to ice formation in sloughs and river. Custom fyke nets were made with two rectangular frames at the mouth to prevent the net from rolling on the bottom. The frames were made of metal conduit tubing, measuring 1.2 x 1.8 m. Following the rectangular frames are three fiberglass hoop frames with a 1.2 m diameter, which funnel fish into a holding area. A custom-built escape hatch was attached to the trap to allow otters to exit the trap. One lead was attached to the center of the trap mouth and extended approximately 20 m to shore. All mesh was 1" in diameter. Traps were set with the lead anchored with rebar near shoreline extending to center of trap mouth. A jet boat was used to pull traps so leads were stretched perpendicular to the shoreline. Thus, fish moving in either direction along shoreline intersect lead net and are directed into the holding area.

Traps were fished 24-hours per day and 7 d per week. Field crews checked traps everyday or every other day during the spawning period (April-June). We identified and enumerated each captured fish. For each captured pike, we measured length (to the nearest mm) and weight (grams), obtained tissue and scale samples, and removed stomach contents using a gastric lavage technique. Each captured pike was marked with an external spaghetti tag by inserting it through the base of the dorsal finite. All recaptured fish were recorded and released. Each tag was individually numbered and printed with a return address that included a $5.00 reward statement to increase the probability of tag returns from anglers. A few pike were not tagged due to size or if determined unfit to survive.

Annual pike abundance (by size-class) will be estimated using a mark-recapture estimator (Ricker 1975). Catch per unit effort (CPUE) was calculated as the total number of pike per month captured, divided by the total number of trapping hours per month. Stream temperature and discharge information was obtained from Columbia Falls USGS monitoring site on the Flathead River. Mean daily slough temperatures were recorded using Onset Stowaway thermographs (Onset Computer Corp., Pocasset, MA).

Objective 2: Quantify the predatory effects of northern pike on juvenile bull trout and westslope cutthroat trout.

Food Habits- To quantify the predatory effects of northern pike on juvenile bull trout and westslope cutthroat trout by northern pike, stomach samples were collected from northern pike by angling (volunteer anglers), netting, and creel surveys. Stomachs were collected from harvested fish by removing the entire stomach from the body. Stomachs were collected from live fish in the fyke traps using a non-lethal gastric lavage technique (Light et al. 1983). All samples were preserved in 95% ethanol and labeled with species, location of catch, length of predator, and date. Fish prey items will be identified from stomachs to the lowest practical taxonomic level, enumerated, and weighed by trained technicians at the University of Idaho.

Predatory Impact- The total annual consumption of fish species by northern pike will be estimated using the computer model Fish Bioenergetics 3.0 (Hanson et al. 1997). Consumption estimates will be obtained from the food habits data, and consumption will be estimated by fitting a known growth curve. Parameters used in the model will include: estimates of northern pike size-classes, mortality estimates (from growth curves), weight at age estimates, temperature availability, and dietary composition. Dr. David H. Bennett (University of Idaho) will assist the project biologist with model development.

Results

Objective 1

Fyke traps were deployed in Halfmoon, Church, Fennon and Rose Creek sloughs for a total of 25,511 trapping hours, and in the mainstem for 4,036 trapping hours (Table 5). We captured a total of 224 northern pike at 35 different trap locations (mean T.L. = 505mm; range, 263-960; Figure 30). Of the 224 pike, 207 were captured in sloughs and 17 were captured in the main river (Table 5). A total of 184 pike were tagged with spaghetti tags. The remaining 40 pike were not tagged due to size, condition factor, or because the individual was a recapture.

We tagged 184 pike during 2003 and 295 fish in 2002. Of the 379 tagged pike, 21 were recaptured in fyke nets during 2003 (9 fish tagged in 2003 and 12 in 2002). The number of captured pike was greatest in early spring, April (n = 135; 60 % of total catch) and decreased in late spring, May (n = 30; 13 % of total catch) and June (n = 54; 24 % of total catch). Monthly CPUE followed similar trends as observed in the total catch information (Table 5, Figure 31). Interestingly, northern pike captured in 2002 were significantly larger compared to those tagged in 2003. Mean length of the tagged pike in 2002 was 605 mm (range: 200 - 1045 mm) as compared to a mean length of 505 mm (range: 263-960) in 2003 (Figure 32).

TABLE 5. Monthly catch information for northern pike sampled in fyke nets in the Flathead River sloughs and main-stem during 2003.

Sample month	Total trap Hours	Number of captured pike	Number of tagged pike	Number of 2002 recaptured pike	Number of 2003 recaptured pike	Pike not tagged	Mean TL (mm)	Pike CPUE
				Slough Catch				
Feb	24	0	0	0	0	0	0	0.000
Mar	0	0	0	0	0	0	0	na
April	7446	123	101	11	1	10	514	0.017
May	8631	30	21	1	1	7	420	0.003
Jun	9410	54	47	0	7	0	505	0.006
Total	25511	207	169	12	9	17		0.008
				River catch				
Feb	1503	5	5	0	0	0	425	0.003
Mar	0	0	0	0	0	0	0	na
April	2032	12	10	0	0	2	628	0.006
May	122	0	0	0	0	0	0	0.000
Jun	380	0	0	0	0	0	0	0.000
Totals	4036	17	15	0	0	2		0.004

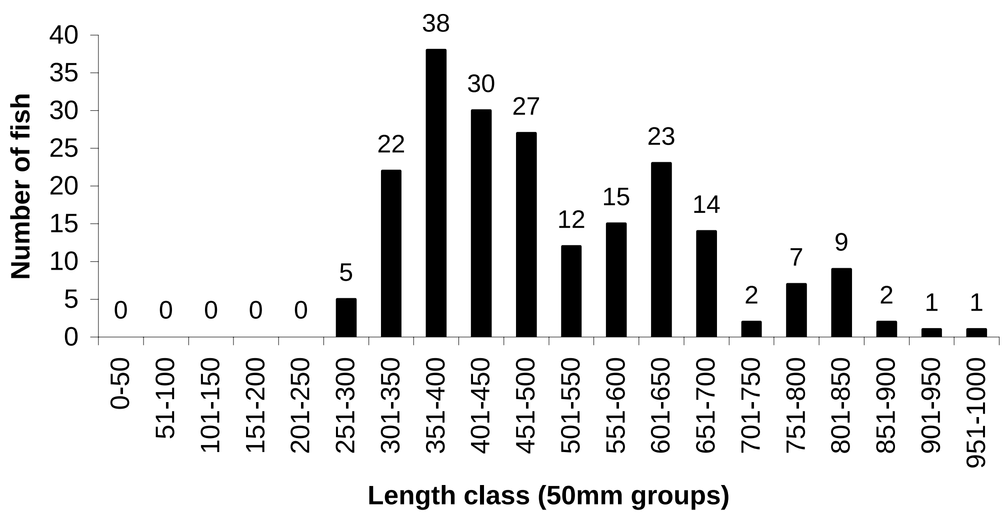

FIGURE 30. Length frequency distribution of northern pike (N = 208) captured in fyke traps in the Flathead River and sloughs in 2003.

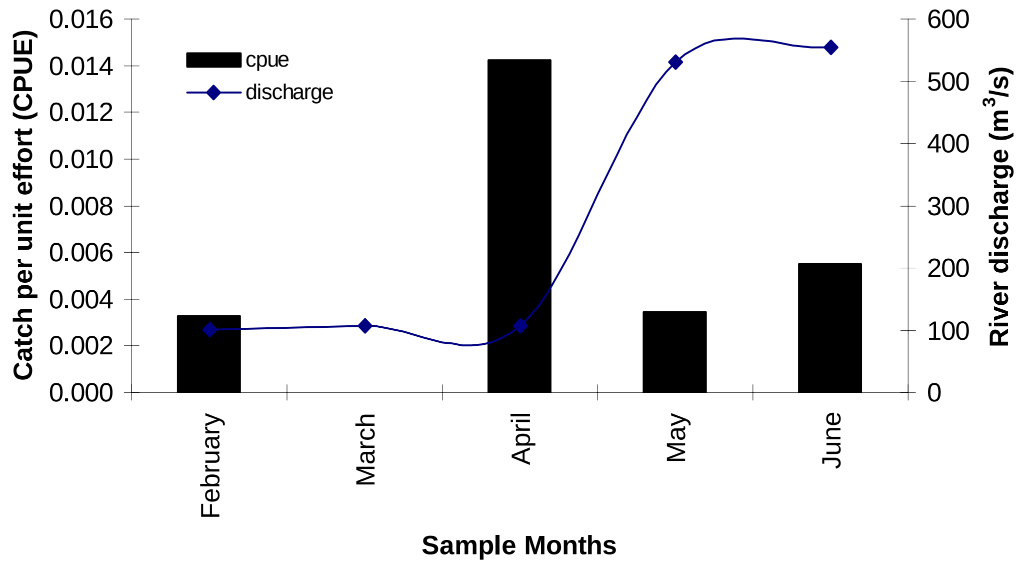

FIGURE 31. Catch per unit effort (CPUE) for northern pike captured in fyke traps in the main stem Flathead River and sloughs as related to the Flathead River hydrograph in 2003.

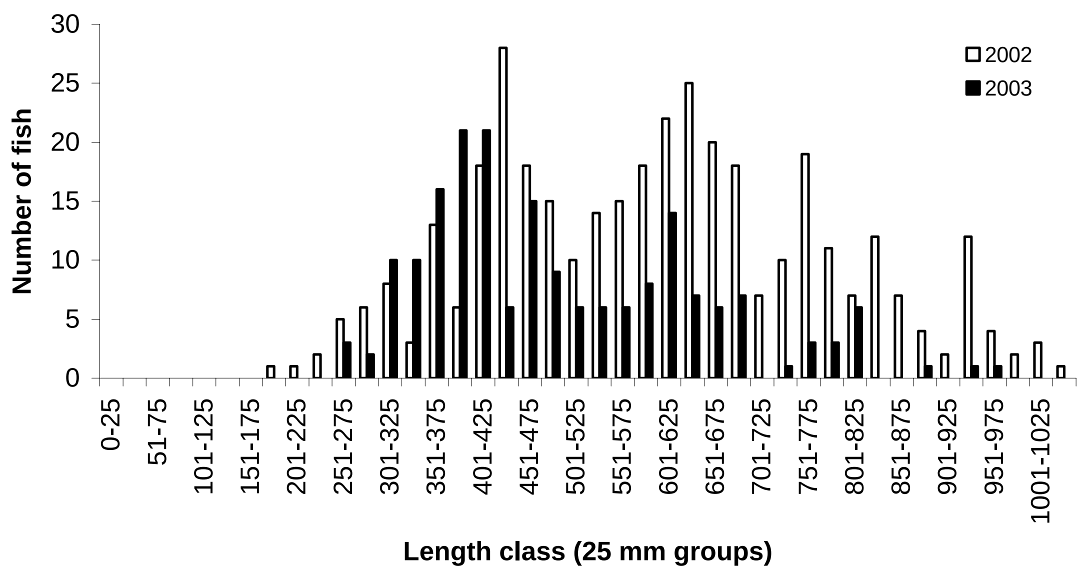

FIGURE 32. Length frequency comparison of northern pike in captured in 2002 (*N* =367) and 2003 (*N* = 208) in the Flathead River and sloughs.

Objective 2

Food Habits – One hundred and thirty northern pike stomachs were sent to University of Idaho for dietary analysis. Eighty-three percent of these samples (n = 108) were collected from fyke traps. The other samples were collected from anglers during creel surveys. Results from stomach samples collected in 2002 and 2003 will be reported together when analyses are completed.

Predatory Impacts – Continued data collection is needed in 2004 to provide a minimum of 3 years data for population estimation.

Flathead River Instream Flow Incremental Methodology Project

The installation of Hungry Horse Dam in 1952 changed the physical and biological characteristics of the Flathead River downstream of the dam (Appert and Graham 1982; Fraley and Graham 1982; Fraley et al. 1989; Fraley and Decker-Hess 1987; Fraley et al. 1989; Hauer et al. 1994). Hypolimetic releases from the dam artificially cooled the river from 1952 through 1996. Therefore, a selective withdrawl system was installed in August 1996 that allowed dam operators to control temperatures in the tailrace and restored temperatures to near pre-dam conditions (Christenson 1996; Marotz et al. 1999). However, power production and flood control operations have reversed the annual hydrograph, resulting in storing water derived from spring runoff and releasing it during the fall and winter months when flows were historically low (Figure 33; Marotz et al. 1996). In addition, summer flow augmentation for recovery of anadromous salmon stocks has caused rapid flow fluctuations during biologically productive summer months (Figure 33). Short-term sporadic releases in the tailwater resulted in an exposed unproductive varial zone, higher substrate embeddedness, and a less diverse and less productive aquatic invertebrate community (Hauer et al. 1994).

In the Flathead River system, native salmonid populations have declined throughout their range because of human impacts on the environment such as habitat degradation and fragmentation, introductions of aquatic organisms, and the installation and operation of Hungry Horse Dam (Liknes and Graham 1988; Fraley and Shepard 1989; Deleray et al. 1999). The Flathead River upstream of Flathead Lake provides critical overwintering areas for native bull trout and westslope cutthroat trout populations (Shepard et al. 1984; Fraley and Shepard 1989). Hydropower and flood control operations from Hungry Horse Dam regulate the lower 69 km of the Flathead River. Sporadic flow fluctuations during winter and summer may adversely impact the growth and survival of native fishes inhabiting the dam influenced reaches of the river.

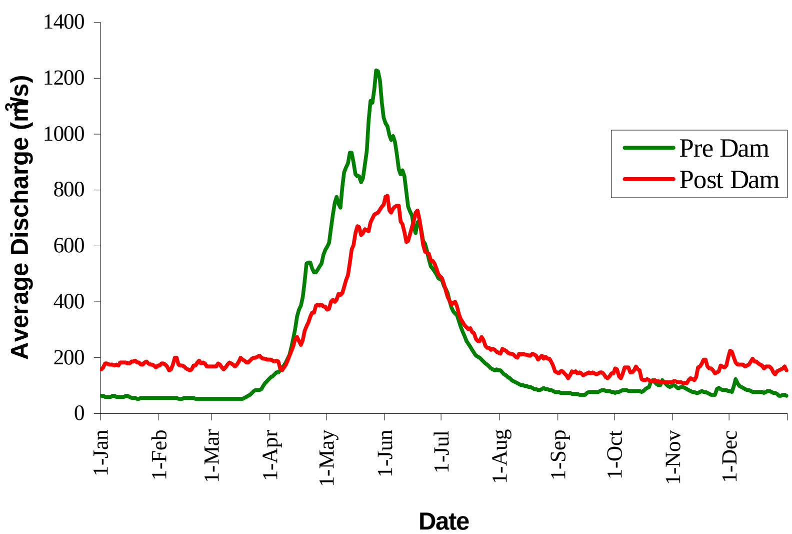

Figure 33. Pre- and post-dam annual average discharge of the Flathead River downstream from Hungry Horse Dam, Montana.

Work Completed

In 1999, we initiated a study to determine how changes in river discharge (e.g. seasonal flow regimes and discharge change rates) influence the availability of suitable habitat to native salmonids, using a modified version of the Instream Flow Incremental Methodology (IFIM; Bovee 1982; Miller et al. 2003). The Instream Flow Incremental Methodology (IFIM) is the most widely applied methodology for developing instream flow recommendations in North America (Reiser et al. 1989). The IFIM model uses a combination of empirical physical and biological data to quantify the total availability of various habitats for selected life stages of native fishes (Miller et al. 2003; Muhlfeld et al. 2003). Physical aspects of the IFIM project were directly contracted by BPA (project 199502500) to Miller Ecological Consultants Inc., Fort Collins, Colorado. The two-dimensional hydrodynamic modeling approach that overcomes many limitations related to classical physical habitat simulation modeling (1-D; Leclerc et al. 1995). Additionally, the Flathead River Native Species Project collected site-specific biological data to quantify impacts on critical bull trout and westlope cutthroat trout habitat to ensure meaningful and accurate habitat characterizations.

Habitat use and movement data were collected for each native target species (bull trout and westslope cutthroat trout) and life stage (juvenile and adult) by use of radiotelemetry and snorkel surveys in reaches affected by dam operations downriver of Hungry Horse Dam (Muhlfeld et al. 2001, 2002, 2003ab). Habitat suitability functions were developed using these data to ensure that the suitability criteria accurately reflected the habitat requirements of the species and life stage of interest in the tailwater. Further, radiotelemetry allowed researchers to accurately characterize selection of specific habitats during day and night surveys (Muhlfeld et al. 2003b). Calculation of habitat suitability criteria required use of a bivariate analysis of depth-velocity paired data to calculate fish presence for depth and velocity in the stream reach (Figure 34). Indeed, Muhlfeld et al. (2003) found that depth and velocity were the most important habitat variable influencing habitat selection of subadult bull trout in the Flathead River. Habitat utilization curves were developed using hundreds of observations on radio-tagged fish from summer 1999 to winter 2002 in the Flathead River. Observations were stratified by species, size-class, and season. Suitability curves were then combined with two-dimensional hydraulic simulations of river hydraulic characteristics (i.e., streambed elevations, mean column velocity, habitat type) in a GIS analysis format to determine habitat area as a function of discharge (Miller et al. 2003).

Results of the IFIM studies showed that habitat area for native bull trout and westslope cutthroat trout is more available at lower discharges than higher discharges (Miller et al. 2003). Comparison of the pre and post-dam hydrology demonstrated that stable flows during both summer and winter base-flow periods provided more habitat than the highly variable flow regime caused by hydropower operations. Variation in weekly and daily flows under post-dam conditions first floods then dewaters stream margins, which forces subadult bull trout to move from their habitat used during day and night. Further, channel margin habitats that are intermittently wet and dry (called the *varial zone*) provide little productivity for lower trophic levels and also become unproductive for fish, especially bull trout that use those areas at night and as flows increase. Muhlfeld et al. (2002) found that subadult bull trout moved from deep, mid-channel areas during the day, to shallow low-velocity areas along the channel margins without overhead cover at night. The authors recommended that resource managers who wish to protect overwintering habitat features preferred by subadult bull trout should employ natural flow management strategies that maximize and stabilize channel margin habitats.

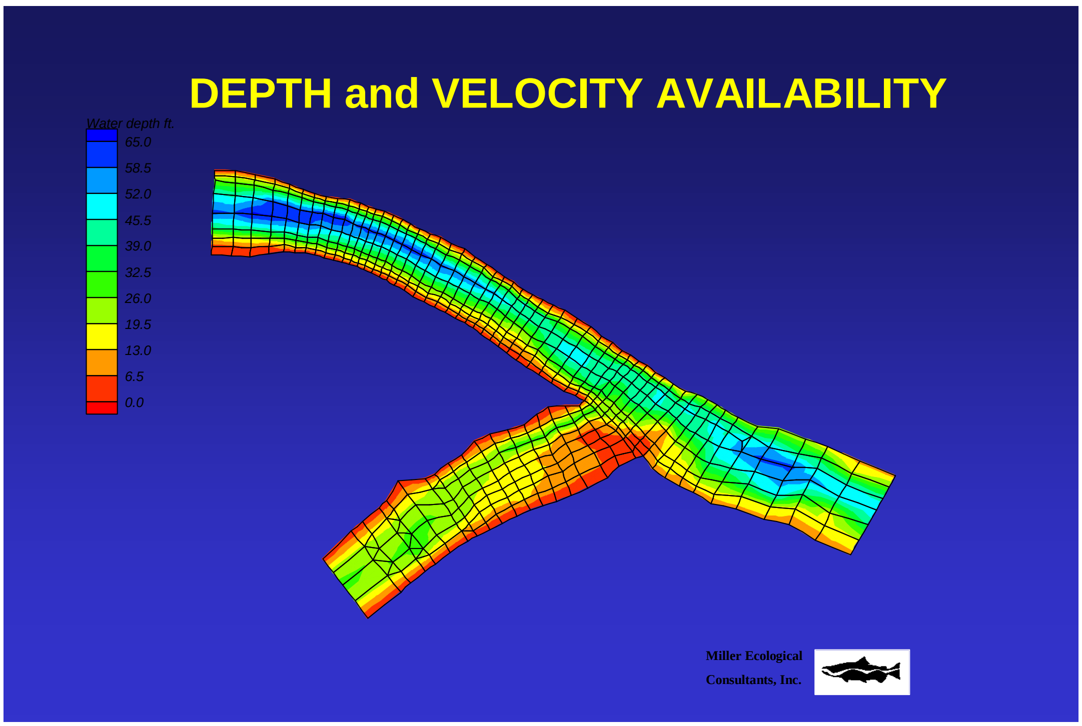

Figure 34 Example of depth and velocity availability for subadult bull trout in Reach 1 of the main stem Flatehead River.

Future Work

The Independent Scientific Advisory Board (ISAB 1997 and 1997b) recommended that restoration of the most natural flow regime possible under the current management constraints will protect key ecosystem processes and maintain or restore bull trout populations in Montana and elsewhere in the Pacific Northwest (Independent Scientific Group 1999). Our IFIM research supports previous literature showing that stable flow regimes are more productive than flow regimes with high weekly variation. The highly variable flows apparently stress native salmonids as they move from day to night habitat locations based on depth and velocity characteristics. Miller et al. (2003) provided a visual characterization of habitat and Arcview project data.

In December 2000, the U.S. Fish and Wildlife Service (USFWS) published their Biological Opinion (USFWS 2000) that addresses impacts of the Federal Columbia River Power System operations on bull trout and Kootenai white sturgeon, including terms and conditions for flow ramping rates for Hungry Horse Dam. The Biop also requires that action agencies, in consultation with the USFWS, conduct a 10-year study to assess the biological effectiveness of these prescribed ramping rates. Using the IFIM models, estimates of total usable area will be obtained for each species and life stage for three specific operational strategies: historic (pre-dam), water budget flow augmentation for anadromous fish recovery, and the proposed Mainstem Amendments. Regression and time-series analyses will be used to correlate total usable area under various operational strategies as related to river discharge. For each operational strategy, five representative water years will be selected to quantify suitable habitat at low (lowest 20th percentile), medium, and high flow conditions, which will provide a mean and range of conditions. Historic flow records will be obtained from the U.S. Geological Survey, which will represent conditions with low variability in habitat on a weekly, daily, and seasonal basis. Operations since water budget for flow augmentation for anadromous fish recovery was implemented will be quantified with specific emphasis of more recent years where flow augumentation was released in the second half in August, creating a double peak. Finally, suitable habitat availability will be estimated for conditions following the proposed Mainstem Amendment strategy, which is designed to release stable flows from July through September. The Mainstem Amendments follow a sliding scale for flat flows at low, medium and high water years. Water releases will be calculated by adding the volume within top 10 ft of each reservoir and reservoir inflow (tributaries) divided by number of days during the period of July and September. ANOVA (mixed model) will be used to test the null hypothesis that suitable habitat availability does not differ between control (historic) and treatment groups for each flow regime. Regression analyses will assess the relationship between habitat availability (dependent variable) and river discharge (independent) for each operational strategy and flow regime to identify flows that maximize critical habitat. Model results will be verified with radio telemetry relocations to ensure meaningful and defensible instream flow analyses. Estimations of usable habitat from the calibrated IFIM models will be used to rank the alternative operating strategies based on the amount of available habitat for each target species and lifecycle stage of salmonids in the Flathead and Kootenai Rivers.

Aquatic Nuisance Species (ANS) Progress Report

The threat of Zebra Mussels and other Aquatic Nuisance Species (ANS) pose an immense threat to aquatic ecosystems throughout the United States. Preventing or delaying the spread and establishment of ANS will help protect and conserve important aquatic organisms and will help save millions of dollars spent annually for the restoration of infested areas.

Anglers traveling westward from ANS- infested areas for sportfishing and recreational fishing purposes can spread ANS. For example, participants in bass and walleye tournaments often travel between zebra mussel- infested waters (e.g., Great Lakes) into uninfected waters (e.g., Washington, Oregon, Idaho, Montana, and Wyoming). Therefore, Montana Fish, Wildlife & Parks, the Pacific States Marine Fisheries Commission, and the U.S. Fish and Wildlife Service initiated a cooperative effort to install three Traveler Information Systems (TIS) in Montana to help prevent the westward spread of zebra mussels and other ANS related species into Montana.

Project Progress

Montana Fish, Wildlife & Parks is in the process of installing three Traveler Information Stations (TIS; low frequency radio) throughout Montana (Figure 35). Each station will have signs posted along the highway that alert travelers to tune into a specific radio station that will have an ANS related message. Each TIS system message will target recreational anglers and boaters and will contain educational and preventative information on the spread and prevention of ANS.

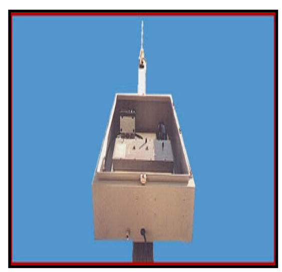

FIGURE 35 Example of a Traveler Information System (TIS) in Montana.

The locations and status of the TIS systems in Montana are as follows (Figure 36):

1. Southwestern Montana- Gallatin County, Madison River, Montana

    - An electrician has been contracted and site location has been confirmed for the radio station power supply, pole installation, and highway sign location.
    - The power supply and radio station equipment will be housed at a Montana Fish, Wildlife & Parks (MFWP) wardens residence.

- The location is 400 hundred yards east of Highway 191 adjacent to the Madison River in Gallatin County. Signs will also be located in this area.
- This area of the Madison has an infestation of New Zealand Mud Snails and is used extensively by anglers in this area. The threat also exists for anglers and aquatic recreationists traveling from Yellowstone National Park transporting New Zealand Mud Snails to other bodies of water outside the park.

2. Eastern Montana location Highway 2, Culbertson, Montana

   - Located at the Montana Department of Transportation (MDOT) Weigh Station.
   - Electronic equipment has been installed and highway signs will be installed this spring

3. Eastern Montana, I94, Wibaux, Montana

   - Located at the Montana Department of Transportation (MDOT) Weigh Station.
   - Electronic equipment has been installed and highway signs will be installed this spring

4. Missouri Headwaters State Park, Montana

   - Located at Missouri River near Townsend, MT
   - System will be installed Spring 2004
   - System was cost shared with MFWP Parks Division and Pacific States Marine Fisheries Commission

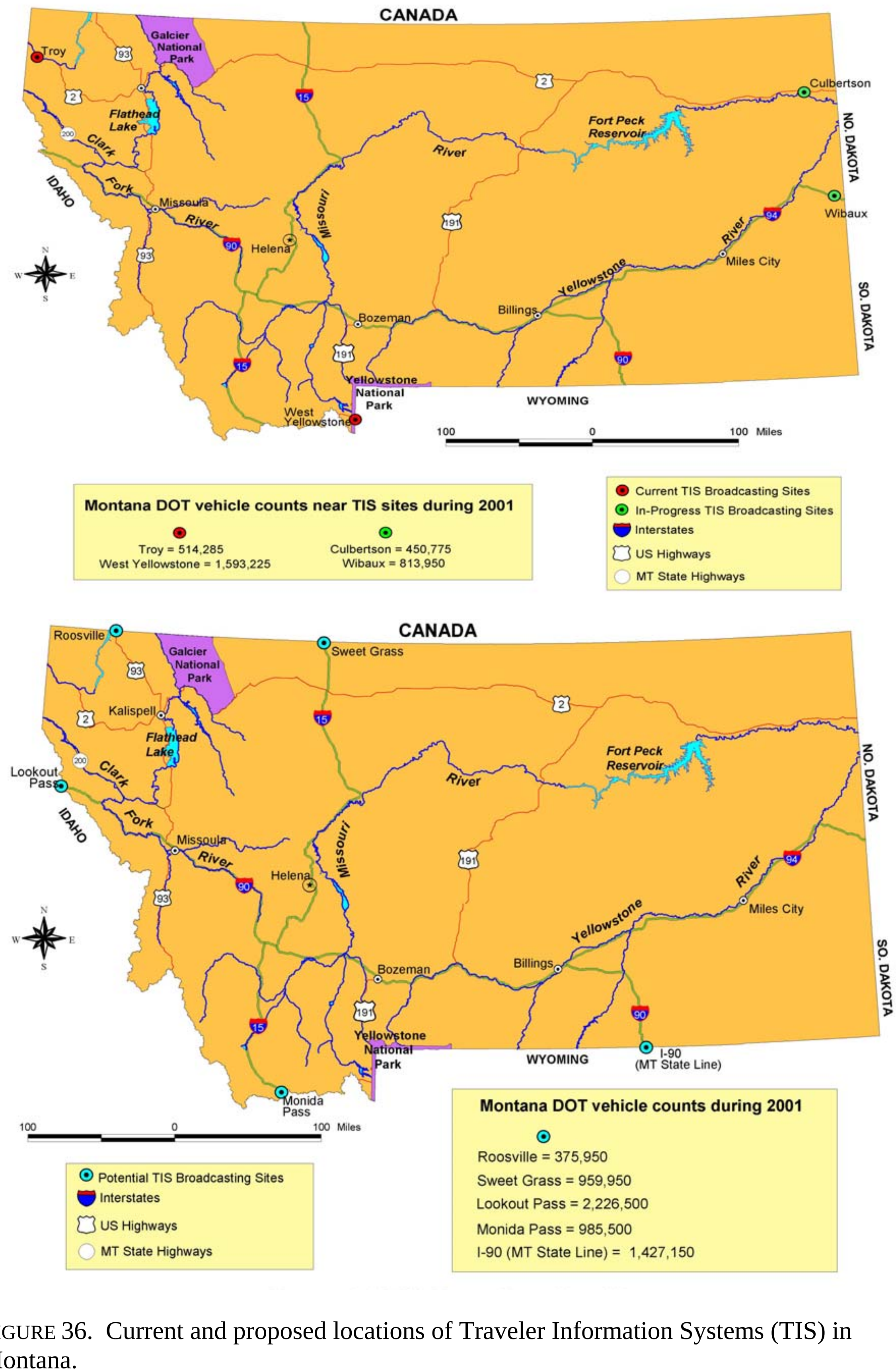

FIGURE 36. Current and proposed locations of Traveler Information Systems (TIS) in Montana.

Signs

To help prevent a mixed message being sent to travelers into Montana and to stay consistent with the U.S. Fish & Wildlife Service "Stop Aquatic Hitchhikers" Program, signs that will be installed for all three (TIS) Systems will read as follows:

STOP AQUATIC HITCHIKERS!
ANGLERS & BOATERS
TUNE RADIO TO AM XXXX KHZ

Note: Signs will meet the (MDOT) standards for highway speeds, colors, and size.

Other ANS related projects:

Other projects that have been carried out through the course of the 2003 calendar year include:

- Produced a Public Radio Public Service Announcement (PSA) in the Kalispell area and also in the Polson area. MFWP and the Salish & Kootenai tribe cost –shared this project. Also worked with Flathead Salish & Kootenai tribal fisheries biologist with signs and brochures regarding ANS information and education for tribal lands.
- Worked with Tri- State Water Quality Council (Sandpoint, ID) and Avista Corp. to cost share a TIS system on Highway 200 on the border of Montana and Idaho. Work is still in progress.
- Produced an ANS message regarding cleaning boats and equipment in the 2004 FWP fishing regulations.
- Pursued an ANS hot link to MFWP web page.
- Provided information on ANS species to a MFWP Lewis & Clark Bicentennial web site. The information will provide readers with boat and equipment cleaning information regarding Zebra Mussels as well as an explanation of what a Zebra Mussel looks like.
- Worked with the Columbia River Basin ANS Group to identify and support ongoing ANS projects in the Columbia River basin.
- Worked with the 100th Meridian Initiative to prevent the further spread of zebra mussels. The 100th Meridian Initiative is a comprehensive prevention partnership that includes State and Federal agencies, private industries, and user groups.
- Presented information regarding the (TIS) project for Montana, in Pierre, SD at the 100 Meridian Initiative Missouri River Team Meeting (March 10-12, 2003).
- Attended the 100th Meridian Team Meeting in Atchinson, Kansas (June 4 –6th, 2003).
- Presented a presentation at the 12th Annual International Invasive Species Conference, Windsor, Canada (June 9-12, 2003).

- Completed a standardized sign regarding Zebra Mussels and other aquatic nuisance species (ANS) for the Missouri River basin in preparation for the Lewis and Clark Bicentennial.
- Completed Montana Fish, Wildlife & Parks (MFWP) “ Traveler Information Systems project” quarterly report for the Pacific States Marine Fisheries Commission Portland, OR.
- Worked with MFWP Region 3 (Ennis, MT) to install a TIS system in the West Yellowstone area of Montana. The system will inform motorists regarding New Zealand Mud snails, Zebra Mussels, and what precautions need to be taken to prevent the spread of (ANS).
- Published an article entitled “ Stop Aquatic Hitchhikers” for (MFWP) Fishing Log Newsletter.
- Attended the 100th Meridian Columbia River Basin Team Meeting Boise, Id. December 2-3, 2003.

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