estigations of Bull Trout (*Salvelinus confluentus*) in the St. Mary River Drainage, Montana

Report for 2006

Based on Field Investigations Conducted During 1997–2006

Prepared By

Jim T. Mogen and Lynn R. Kaeding

U.S. Fish and Wildlife Service
Montana Fish and Wildlife Management Assistance Office
Branch of Native Fishes Management
4052 Bridger Canyon Road
Bozeman, Montana 59715

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EXECUTIVE SUMMARY

The bull trout (*Salvelinus confluentus*) inhabits mainly freshwater environments in western North America, primarily west of the Continental Divide. The historic decline of bull trout led to its classification as a "threatened" species, under the U.S. Endangered Species Act, in 1999. As part of that designation, bull trout were said to collectively exist as five "distinct population segments," only one of which occurred east of the Continental Divide, in the St. Mary River and Belly River drainages in Montana and Alberta (*Federal Register* 64: 58910 [1 November 1999]). The study described here, conducted between 1997 and 2006, determined key characteristics of bull trout populations in St. Mary River tributaries in Montana, including locations of spawning areas, sizes of spawning stocks, and the extent that bull trout move among tributaries; identified factors that may unduly limit the populations; and recommended management actions to eliminate or ameliorate the effects of those factors.

Electrofishing showed bull trout were widely distributed and often abundant in St. Mary River tributaries. Moreover, the species remained in all of the waters that it historically inhabited in the drainage in Montana. The occurrence of age-0 bull trout indicated recent spawning and reproduction in each creek in which the species was found, except lower Otatso and Divide creeks, and annual reproduction was indicated by multiple age-classes of young fish. In contrast, the occurrence of redds revealed major bull trout spawning areas in only Boulder and Kennedy creeks, as well as above the Slide Lakes in upper Otatso Creek. Recaptures of tagged fish revealed bull trout movements among most creeks, as well as movements both upstream and downstream over the St. Mary River Diversion dam and downstream over the rockslide that forms the Slide Lakes. Although both migratory and non-migratory bull trout remained in the St. Mary River drainage, migratory fish were most obvious because they were caught in traps or moved between creeks. Resident (i.e., non-migratory) bull trout also occurred in some creeks but were less conspicuous that migratory fish.

Results of our study and concurrent investigations supported some previous U.S. Fish and Wildlife Service conclusions that bull trout in the St. Mary River drainage are negatively affected by operation of water-storage and delivery systems that are part of the Milk River Irrigation Project (*Federal Register* 64: 58910). A concurrent study, described in a separate report (Mogen and Kaeding 2002), showed that bull trout are entrained in the St. Mary Canal and thereby lost from the reproducing population. In addition, our results from radio telemetry, also described in separate reports (e.g., Mogen and Kaeding 2005b), suggested the acute reductions in discharge from Sherburne Dam in the fall produced low-flow conditions downstream in Swiftcurrent Creek that led to the death of bull trout. On the other hand, results from that study showed movements of bull trout past the St. Mary Diversion dam, which had previously been thought to be a major barrier to such movements. Timing of those movements is not precisely known but probably occurred when the dam was open, usually between October and April. Brook trout (*S. fontinalis*) constituted a small portion of the fish communities in St. Mary River tributaries. We found no evidence that brook trout had displaced bull trout or that hybridization with brook trout was an emerging threat to the bull trout genome.

Recommended actions that would benefit bull trout in the St. Mary River drainage include: (1) facilitation of year-round movement of adult bull trout over the St. Mary Diversion dam; (2) release of water from Sherburne Dam to provide adequate winter habitat for bull trout downstream in Swiftcurrent Creek; (3) prevention of bull trout entrainment in the St. Mary Canal; and (4) assessment and remediation, if necessary, of the effects of water diversion into the St. Mary Canal (i.e., the removal of water from the drainage) on bull trout habitat in the St. Mary River downstream from the diversion, in Montana and Alberta.

INTRODUCTION

The bull trout (*Salvelinus confluentus*) is a char (i.e., Genus *Salvelinus*) that inhabits mainly freshwater environments in western North America. Bull trout historic range (Cavender 1978, Haas and McPhail 1991, Nelson and Paetz 1992) extends from northern areas of California and Nevada to upstream regions of the Yukon River in Alaska and the Yukon, and encompasses Puget Sound and major coastal river systems in Washington, British Columbia, and southeast Alaska. Inland, bull trout inhabit rivers and lakes of the Columbia River basin, including headwater areas in Idaho, Montana, and British Columbia, as well as the Klamath River basin in Oregon. Bull trout also occur east of the Continental Divide, in the upper MacKenzie River basin (Arctic drainage) in the Northwest Territories, British Columbia, and Alberta; the upper Peace, Athabasca, North Saskatchewan, and South Saskatchewan River basins (Hudson Bay drainage) in Alberta; and the upper South Saskatchewan River basin in Montana. Bull trout apparently colonized the waters east of the Continental Divide from refugia in the MacKenzie and Columbia River basins and elsewhere, soon after the Pleistocene glaciation (~12,000 years ago; Haas and McPhail 2001).

Bull trout usually mature when 5 to 7 years old and spawn entirely in coldwater streams, primarily small (second- to fourth-order) tributaries, between late summer and late fall (Fraley and Shepard 1989, Mogen and Kaeding 2005a; for reviews, see Goetz 1989 and Rieman and McIntyre 1993). Like most inland salmonids, bull trout have been broadly categorized into two life-history forms on the basis of their migratory behaviors (Rieman and McIntyre 1993, McCart 1997, Northcote 1992, 1997). Non-migratory bull trout move little and spend their lives entirely within their natal stream, whereas migratory fish spawn in small streams but their resultant young eventually move downstream to either rivers or lakes, where the fish mature. After spawning, migratory adult bull trout return to the rivers or lakes. Anadromy – characterized in part by residence of the fish in the sea for a substantial period (McDowall 1987) – has also been reported for bull trout (Brenkman et al. 2007).

Both non-migratory and migratory bull trout may occur in a single drainage (Fitch 1997, Jakober et al. 1998, Mogen and Kaeding 2005a) and it is unknown whether those life-history forms represent heritable (i.e., genetically based) traits, conditional behaviors whose individual expressions are dependent upon the variety of accessible aquatic habitats (i.e., phenotypic plasticity), or a combination of those factors (Rieman and McIntyre 1993, McCart 1997, Nelson et al. 2002; see also Northcote 1992 and Jonsson and Jonsson 1993). Within the non-migratory form, McCart (1997) distinguished the "resident" type from the "isolated" type, which occurs upstream from a natural or man-made physical barrier (e.g., waterfall or dam) that prevents the return of fish that move downstream. The resident type is not confined by such barriers.

Like the young of other salmonids, young bull trout in both streams and lakes are opportunistic feeders that mainly eat macro-invertebrate organisms. Adult bull trout, however, feed predominantly on other fishes (Boag 1987, Fraley and Shepard 1989, Donald and Alger 1993). Because lakes and large rivers are often more

biologically productive than headwater streams, migratory bull trout usually attain larger size and, accordingly, exhibit more frequent piscivory than resident bull trout (Fraley and Shepard 1989, Donald and Alger 1993).

Today, bull trout have been extirpated from areas near the southern limit of their historic range in California and all but one river system in Nevada, and have declined in many other areas in the contiguous United States (*Federal Register* 64: 58910). That decline is broadly attributed to adverse, human-caused modifications of the aquatic environment, including population fragmentation resulting from blockage of migration routes by dams and other barriers; hybridization or competition with introduced, nonnative brook trout (*S. fontinalis*), lake trout (*S. namaycush*), and brown trout (*Salmo trutta*); and excessive harvest by anglers. The bull trout decline led the U.S. Fish and Wildlife Service (Service) to formally classify (i.e., "list") the species as "threatened" throughout its historic range in the contiguous United States, under the U.S. Endangered Species Act, in 1999 (*Federal Register* 64: 58910).

In reaching its decision to list bull trout, the Service concluded that the species now occurs as five "distinct population segments" (DPSs) in the contiguous United States (*Federal Register* 64: 58910). Only one of those DPSs lies east of the Continental Divide, in the St. Mary River and Belly River drainages of the upper South Saskatchewan River basin in Montana and Alberta. The Service also concluded that the St. Mary River-Belly River DPS consisted of four bull trout subpopulations, each of which inhabits a separate geographic region. Subpopulation designation was based on the assumption that bull trout were reproductively isolated among subpopulations. Furthermore, a subpopulation was considered at risk of extirpation from natural events if it was: (1) unlikely to be reestablished by fish from another subpopulation; (2) limited to using a single spawning area; (3) characterized by low numbers of fish or spawning adults; or (4) primarily consisted of fish of a single life-history form. The Service also acknowledged, however, that historic information on bull trout in the St. Mary River-Belly River DPS was largely anecdotal and definitive, contemporary information was meager.

Objectives of the ongoing study described here, begun in 1997, were to: (1) determine key characteristics of bull trout populations in St. Mary River tributaries in Montana, including locations of spawning areas, sizes of spawning stocks, and the extent that bull trout move among tributaries; (2) identify factors that may unduly limit the populations; and (3) recommend management actions to eliminate or ameliorate the effects of those factors. Those objectives were closely tied to the previously described factors that were thought to make a bull trout subpopulation at risk of extirpation from natural events (*Federal Register* 64: 58910). Also as part of the present study, the status of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in the drainage was determined. That subspecies declined appreciably across its natural range during the twentieth century (Behnke 1992). The small part of the Belly River drainage that lies in the United States is entirely within Glacier National Park and was not investigated as part of this study.

The present report provides a comprehensive description of the results of investigations, except for our trapping and radiotelemetry study, performed on the major tributaries of the St. Mary River in Montana between 1997 and 2006. Results of the trapping program and radiotelemetry investigation are presented in Mogen and Kaeding (2004, 2005a) and Mogen and Kaeding (2005b), respectively.

STUDY AREA

Aquatic Habitats

Detailed descriptions of the study area are provided in Mogen and Kaeding (2004). In brief, the St. Mary River begins at Gunsight Lake, in Glacier National Park, and flows northeast 13 km before entering St. Mary Lake, just after the river had passed over a 10-m-high fall (Figure 1). After leaving that 16-km-long lake, the river flows northeast 2 km before entering Lower St. Mary Lake (9 km long), on the Blackfeet Reservation. From that lake, the river meanders northerly 25 km to the international border, then continues north through mainly shrub-grassland habitat ~55 km to St. Mary Reservoir, a large (storage capacity, ~395 M m^3), man-made impoundment whose 62-m-high dam was closed in 1951.

Each of the 11 tributaries of the St. Mary River or its intervening lakes investigated during the study begins at high elevation (> 1,800 m) in the park, flows mainly through coniferous forest, and has one or more natural, year-round or seasonal barriers to fish movement somewhere along its length (Figure 1).

Between 1906 and 1924, the U.S. Bureau of Reclamation (Bureau) built several water-control and delivery structures in the St. Mary River drainage, as part of the Milk River Irrigation Project. Along with the dam on Swiftcurrent Creek that created Lake Sherburne, those structures included the 2-m-high, concrete, St. Mary Diversion dam, 1.2 km downstream from Lower St. Mary Lake (Figure 1). Annually between about April and October, that dam deflects water (~18.4 m^3/s [650 ft^3/s]) into the St. Mary Canal, which conveys the water 46 km to the North Fork Milk River, in the Missouri River basin. In addition, the lower reach of Swiftcurrent Creek, which historically flowed into the St. Mary River downstream from Lower St. Mary Lake, was channeled into the lake itself. That allowed water released from Lake Sherburne to be diverted into the St. Mary Canal.

Fish Species

Detailed descriptions of the fishes of the St. Mary drainage are provided in Mogen and Kaeding (2004). In brief, the historic distribution of native fishes in the St. Mary River drainage was delimited by the many natural, year-round barriers to fish movement. Waters that were upstream from such barriers and historically barren of fish included the entire upper Red Eagle, Swiftcurrent, Kennedy and Otatso Creek watersheds, and the headwaters of the St. Mary River itself (Figure 1).

Among the fishes indigenous to the drainage, bull trout, westslope cutthroat trout, and mountain whitefish (*Prosopium williamsoni*) are believed to have occurred in all of the streams and lakes to which they had access, including the Slide Lakes, while lake trout inhabited only St. Mary and Lower St. Mary lakes (Brown 1971). Nowhere else in the contiguous United States are bull trout naturally sympatric with lake trout (Donald and Alger 1993). Also indigenous to the drainage are northern pike (*Esox lucius*), burbot (*Lota lota*), and perhaps

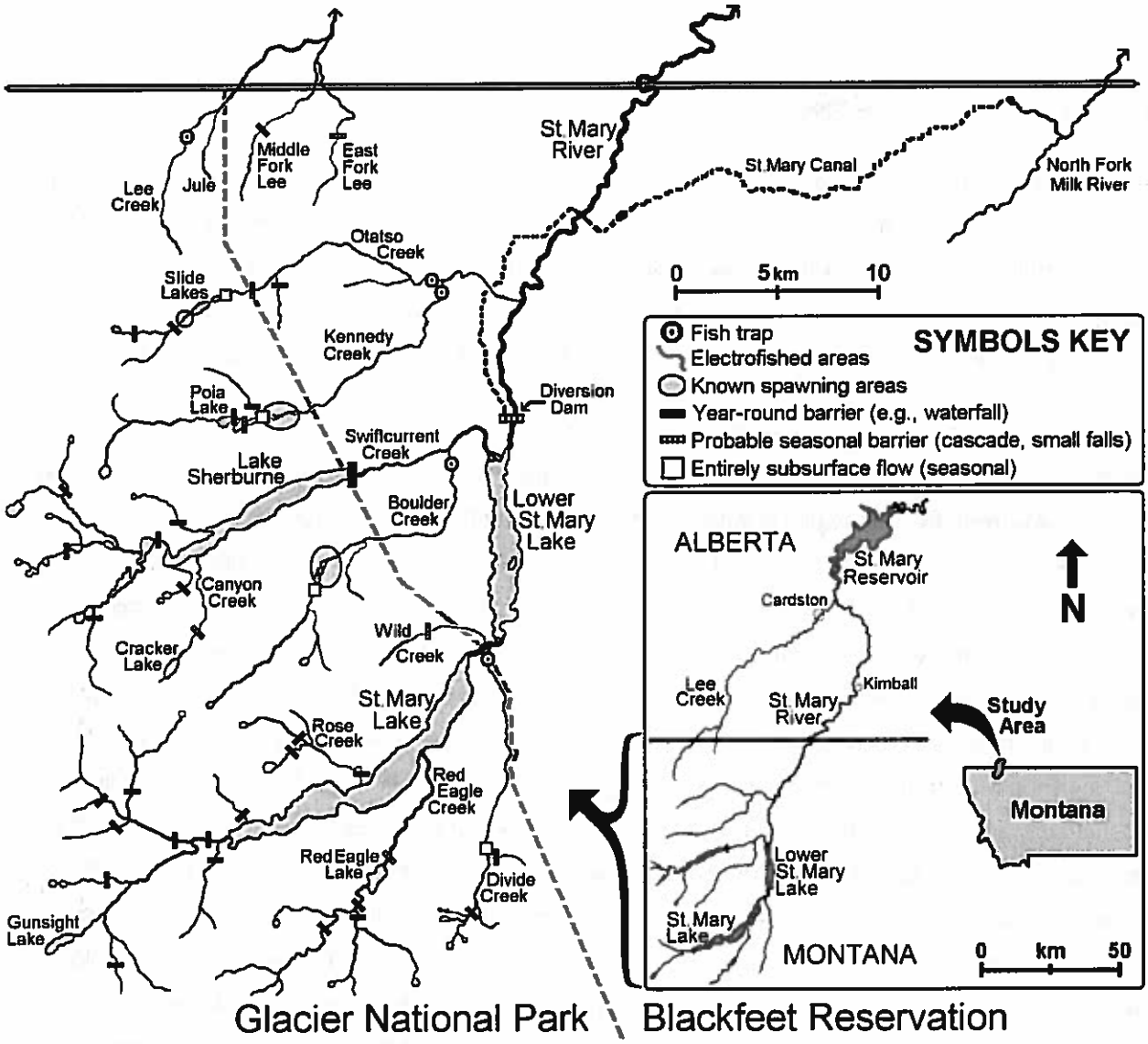

Figure 1. Study area, St. Mary River drainage, Montana and Alberta.

lake whitefish (*Coregonus clupeaformis*), all of which inhabit the St. Mary lakes, and white sucker (*Catostomus commersoni*), longnose sucker (*Catostomus catostomus*), mountain sucker (*Catostomus platyrhynchus*), lake chub (*Couesius plumbeus*), trout-perch (*Percopsis omiscomaycus*), longnose dace (*Rhinichthys cataractae*), pearl dace (*Margariscus margarita*), mottled sculpin (*Cottus bairdi*), and spoonhead sculpin (*Cottus ricei*), which inhabit many of the streams and lakes to which the fish had natural access (Brown 1971).

Nonnative fishes that have established self-sustaining populations at various locations in the drainage include brook trout, as well as rainbow trout (*O. mykiss*), Yellowstone cutthroat trout (*O. clarki bouvieri*), and especially the genetic intergrades (i.e., "hybrids") among those two fishes and westslope cutthroat trout.

METHODS

Electrofishing Surveys (1998–2006)

Electrofishing was performed between mid-July and late August to broadly characterize the bull trout populations and fish communities in the creeks. Because the creeks were mainly accessible only by foot, it was not possible to annually electrofish entire creeks. We therefore established in each creek an approximate sampling reach that contained a variety of mesohabitats and, where present, bull trout of a broad range of size-classes, as determined by creek-wide, reconnaissance electrofishing conducted during 1998 and 1999.

Electrofishing occurred annually, unless otherwise noted (Table 1), in: (1) a 2-km reach of Divide Creek that extended downstream from the region of entirely subsurface flow; (2) a 4- to 7-km reach of Boulder Creek that extended downstream from the region of entirely subsurface flow; (3) a 6- to 9-km reach of Kennedy Creek that extended downstream from the region of entirely subsurface flow; (4) Otatso Creek's 3 reaches, i.e., (a) lower Otatso, a 1- to 3-km reach that extended downstream from the fall ~13 km upstream from the creek's mouth; (b) middle Otatso, from the fall upstream 1.9 km to the rockslide that forms Slide Lakes; and (c) Slide Lakes, the subsequent 2.5-km reach to the fall above the lakes, except the lakes themselves were not sampled; and (5) a 4-km reach of Lee Creek that extended upstream from Chief Mountain International Highway. In addition, periodic electrofishing occurred in (6) a 2- to 3-km reach of Canyon Creek that encompassed the small fall but mainly extended downstream; (7) the lowermost 2 km of Rose Creek; (8) a 1-km reach of Wild Creek that extended upstream from the park boundary; and (9) Jule, (10) Middle Fork Lee, and (11) East Fork Lee creeks, each within ~0.5 km upstream and downstream from their crossings with the highway. Except for the few, additional creeks subsequently described in this report, remaining creeks (except Red Eagle Creek) appeared too small or to have gradients too steep to support substantive fish communities and were not electrofished. Red Eagle Creek was not examined because the creek was difficult to access and too large for our electrofishing equipment.

We used a battery-powered, backpack electrofisher (Smith-Root Model 15-B) operated at 500–800 volts, pulsed (25–30 Hz) direct current to capture fish. During electrofishing, a single, upstream-moving pass was made through each reach. Creek flows were seasonally low and clear and we selectively netted bull trout and other char and trout. Although small, age-0 fish were not specifically sought during 1998 and 1999 and often passed through our nets, beginning in 2000 we also caught representative samples of age-0 bull trout.

Captured char and trout were identified to species and counted, whereas the occurrences of mountain whitefish and the sculpins (the two species not distinguished) were only noted. Accordingly, all char and trout caught from a creek (or each Otatso Creek reach) in a single year constituted an electrofishing sample.

Table 1. Dates and locations of electrofishing in the St. Mary River drainage, Montana, 1998–2006.

Creek	1998	1999	2000	2001	2002	2003	2004	2005	2006
Divide Creek	7/8	8/5	—	—	8/22	8/12, 16	8/23	8/18	10/11
Boulder Creek	7/28	8/23	7/17 & 8/9,23	8/13,14	8/7,9,15	8/14,17	8/16,17	8/26	8/16,18
Kennedy Creek	7/15,29 & 8/12	7/26-27 & 8/9,25	7/12,16,26,30 & 8/8,13,25	8/7-8	8/11,20,22	8/18,21	8/12,13,24	8/11,16	8/9,10,15
Otatso Creek									
Lower Otatso	—	8/6	7/28 & 8/22	8/9-10	8/13,29	8/19	8/19	8/23	8/22
Middle Otatso	7/22-21	8/19-20	7/27 & 8/11	—	8/12-13	8/19-20	8/20	8/17	8/21-22
Slide Lakes	7/21	8/19	7/27	—	8/13	8/20	8/19	8/22	8/21
Lee Creek	8/18	7/24 & 8/24	7/13,15 & 8/10,24	8/11-12	8/8,21	8/13	8/14	—	8/13-14
Jule Creek	8/11	7/13	—	—	—	—	—	—	—
Middle Fork Lee Creek	8/11	7/13	—	—	—	—	—	—	—
East Fork Lee Creek	—	7/12	—	—	9/26	—	—	—	—
Canyon Creek	—	—	—	—	8/28	8/26	8/11	8/21	9/11
Wild Creek	7/27	7/23	—	—	7/25	—	—	—	8/11
Rose Creek	—	—	7/25	—	8/10	8/15	8/10	8/9	—
St. Mary River	—	—	—	—	—	—	—	7/27	8/3,8,12

Because it was not practical for us to distinguish the hybrids or genetic intergrades of rainbow trout and cutthroat trout from their parent species or subspecies on the basis of external morphological characteristics evident in the field and such interbreeding appeared widespread, all of those fishes were assigned to a single taxon (i.e., cutthroat × rainbow intergrades), except when they plainly appeared to be westslope cutthroat trout. When an apparent westslope cutthroat trout population was found, specimens were collected for subsequent biochemical genetic (allozyme) analysis at the University of Montana's Wild Trout and Salmon Genetics Laboratory.

Bull trout were measured to total length (TL, mm), weighed (g), and (through 2002) scales were taken from an area just posterior to the dorsal fin and above the lateral line of many fish longer than ~75 mm TL. We did not distinguish between sexes. Passive integrated transponder (PIT) tags, each uniquely coded, were injected into skeletal muscle directly below the dorsal fin of bull trout $\geq$ 200 mm TL. The adipose fin was removed from tagged fish and some fins were kept for subsequent molecular genetic (microsatellite) analysis, also at the University of Montana. All bull trout were examined for previously applied tags. For analyses of data taken from recaptured bull trout, a recapture event consisted of a recapture that occurred at least one field season after the previous capture. Thus multiple recaptures of individual fish within years were collectively treated as a single recapture event.

St. Mary River Electrofishing Surveys (2005–2006)

In 2005 and 2006 (Table 1), electrofishing surveys were also conducted on representative reaches of the mainstem St. Mary River downstream from the diversion structure to broadly characterize the bull trout populations, fish community, and habitat conditions in the river and to gather baseline information useful to evaluation of future project modifications on the river's habitat and fisheries. During the river surveys, a four-man crew utilized a PVC raft (14 ft long) equipped with an electroshocking system consisting of two boom-mounted electrodes and a Coffelt Mark-22 variable voltage pulsator (pulsed DC current) powered by a Honda 3500-watt generator. Typical surveys consisted of a single-pass, free-float down the channel while continually shocking, particularly in probable fish-holding habitat such as deep pools, undercut banks, and debris jams. Generally, one crew member controlled the shocking equipment and manned the oars from the center of the raft while two persons in the bow netted fish. The final member usually walked behind the raft, holding on to the raft to slow and guide it. River flows were seasonally low and clear and we attempted to net all observed fish, except small fish, which could not be effectively sampled and included sculpins, dace, and juveniles of various species. All captured bull trout were processed in the manner described above. All other captured fish were weighed and measured to total length.

Lake Sherburne Gillnetting Surveys (2006)

Gillnetting was conducted in Lake Sherburne in fall 2006 to characterize the fish community in the reservoir and the adfluvial bull trout population that spawns in Canyon Creek, the only lake tributary used by spawning bull trout. From 10-12 October, during low-pool conditions, seven gillnet sets were made at various locations along the lake's southwest shore. Experimental-mesh sinking gillnets that were 38 m long, 1.5 m deep and contained five 7.6 m long, graduated-mesh panels of 19, 25, 32, 38, and 51 mm mesh (bar measure) netting. Bull trout were handled as described above, whereas remaining fish were identified and measured to total length.

Redd Surveys (1997–2006)

During October or November 1997, a single visual reconnaissance was conducted along the entire length of Divide, Boulder, Kennedy, and lower Otatso creeks, to identify bull trout spawning areas on the basis of the occurrence of redds. To monitor trends in annual bull trout spawning effort, those spawning areas alone were surveyed for redds in subsequent years, mainly during mid-October. When searching for redds, crew members wore polarizing sunglasses, walked creek banks, and proceeded upstream until an obvious barrier to the upstream movement of fish was encountered. Validity of potential redds was decided on the basis of their visual characteristics and consensus among crew members. Locations of redds and general characteristics of spawning areas were recorded.

Statistical Analyses

Statistical analyses were performed using the Number Cruncher Statistical System (Hintze 2001), after tests had been conducted to assure that the routine assumptions of normality and equal variance in the error term had been met. When necessary, transformations of appropriate variables were performed to meet those assumptions (Neter et al. 1996). Bonferroni's All-Pairwise, Multiple-Comparison Test was used to reveal which treatment-population means differed statistically.

RESULTS

Distribution of Bull Trout and other Fishes

Bull trout were found in each of the creeks, except East Fork Lee and Rose creeks. They constituted more than half of the fish in each electrofishing sample from Boulder, Lee (except 2004), and Canyon creeks and the Middle Otatso and Slide Lakes reaches, as well as many of the samples from Kennedy and Lower Otatso creeks (Figure 2). Average size of the 68 electrofishing samples was 104 fish (range, 2 to 434 fish); samples did not exceed 48 fish for first-order creeks. Collectively, 88% of the other fishes in samples were cutthroat × rainbow intergrades (including a few westslope cutthroat trout, described in a subsequent section of this report). Brook trout were found in Divide, Boulder, Kennedy, Rose and Canyon creeks, where they averaged 7% (range, 0% to 25%) of samples. Sculpins were found in Divide, Boulder, Kennedy and lower Otatso creeks, as were mountain whitefish, which were also found in Rose Creek.

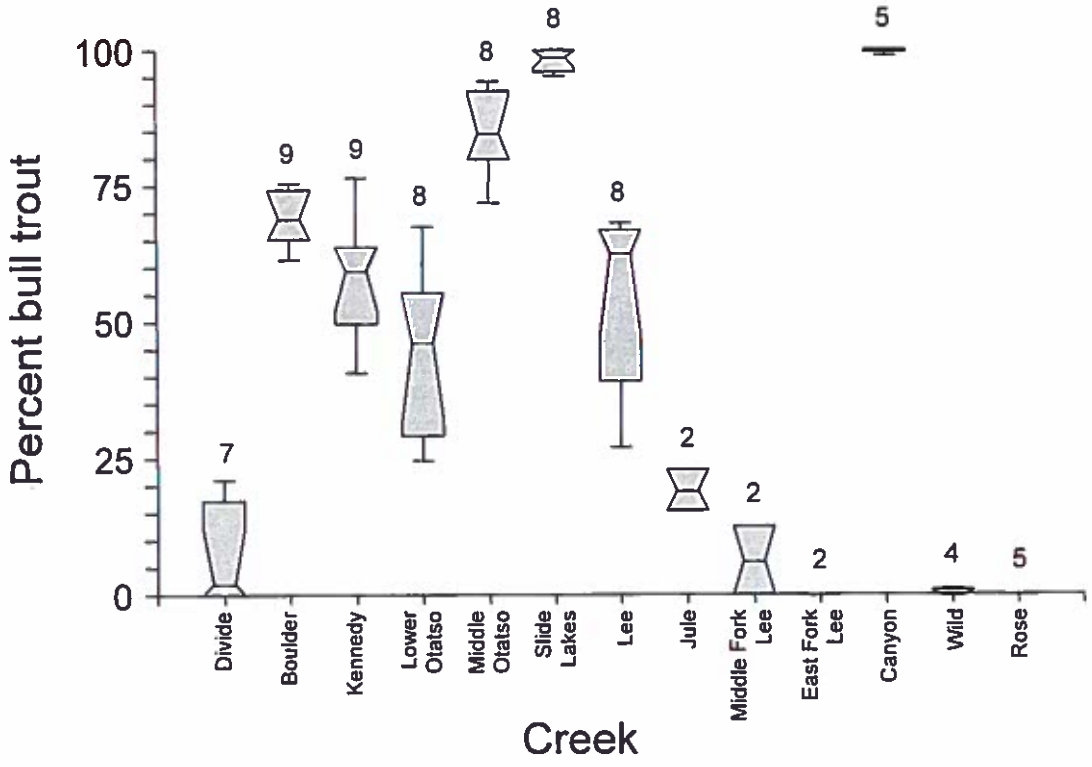

Figure 2. Box plots of percent bull trout in samples caught by electrofishing in creeks, 1998–2006. Box plots indicate the median value at the box notch, interquartile range by the box itself, and the range of values by horizontal lines at the end of vertical lines. Numbers indicate number of samples (years).

Summaries for individual creeks

The upper Divide Creek drainage was surveyed at several locations in the park, from its head to the park boundary, in 1998 (Table 1). No bull trout and only two cutthroat trout (80 and 220 mm TL) were caught, just inside the park. Lower Divide Creek was surveyed at several locations along the reach from its mouth to the park boundary in 1999 (Table 1). The few fish encountered were cutthroat × rainbow intergrades (69–186 mm TL) and mountain whitefish. Upper Divide Creek was resurveyed in August 2002–2005 (Table 1). In a 1.6- km reach beginning at the park boundary, 32 juvenile bull trout (156–190 mm TL; Figure 3), 120 cutthroat × rainbow intergrades (54–270 mm TL), and one mountain whitefish were captured in 2002, 28 juvenile bull trout (199–245 mm TL; Figure 3), one adult bull trout (547 mm TL: Figure 3) and 138 cutthroat × rainbow intergrades (61–494 mm TL) were captured in 2003, three juvenile bull trout (260–301 mm TL; Figure 3) and 136 cutthroat × rainbow intergrades (56–261 mm TL) were captured in 2004, and four sub-adult bull trout (312–347 mm TL; Figure 3) and 108 cutthroat × rainbow intergrades (52–246 mm TL) were captured in 2005. One of the three juveniles captured in 2004 and three of the four sub-adults captured in 2005 were recaptured fish. Another Divide Creek fish, originally tagged in 2003 (205 mm TL), was recaptured in Boulder Creek in 2005 (401 mm TL) and 2006 (491 mm TL) and appeared to be sexually mature both years. Although no obvious barrier to the upstream movement of fish was encountered in Divide Creek, high-gradient cascades probably prohibit fish movement into the creek's few small tributaries.

The Divide Creek survey was delayed until mid-October in 2006 due to a forest fire that started in late July and burned throughout August. The Red Eagle Fire burned more than 34,000 acres in Glacier National Park and on the Blackfeet Reservation, including the entire Red Eagle and Divide creek drainages. During the October 2006 survey, no bull trout and 86 cutthroat × rainbow intergrades (72–260 mm TL) were captured in Divide Creek.

Electrofishing in Boulder Creek revealed bull trout (43–763 mm TL; Figure 3), cutthroat × rainbow intergrades (34–482 mm TL), brook trout (87–256 mm TL), and mountain whitefish. Many large (> 400 mm TL) bull trout were caught just downstream from the reach of entirely subsurface flow. The region of subsurface flow is apparently only a seasonal barrier to fish movement because each species of fish found downstream in Boulder Creek was also caught above that region. Two first-order tributaries that enter upper Boulder Creek from the south were sampled in 2000; bull trout (< 200 mm TL) and westslope cutthroat trout (≥ 95% genetic purity) were found in lower reaches of both creeks. Remaining tributaries appeared too small or too high-gradient to support fish, and were not sampled.

In Kennedy Creek, no fish were found upstream from the waterfall at the outlet of Poia Lake, but bull trout (44–725 mm TL; Figure 3), cutthroat × rainbow trout intergrades (33–450 mm TL), brook trout (53–404 mm TL), and mountain whitefish were caught downstream. Many bull trout > 400 mm TL were caught from the 5-km reach of Kennedy Creek near the park boundary. About 3.5 km upstream from the park boundary, a

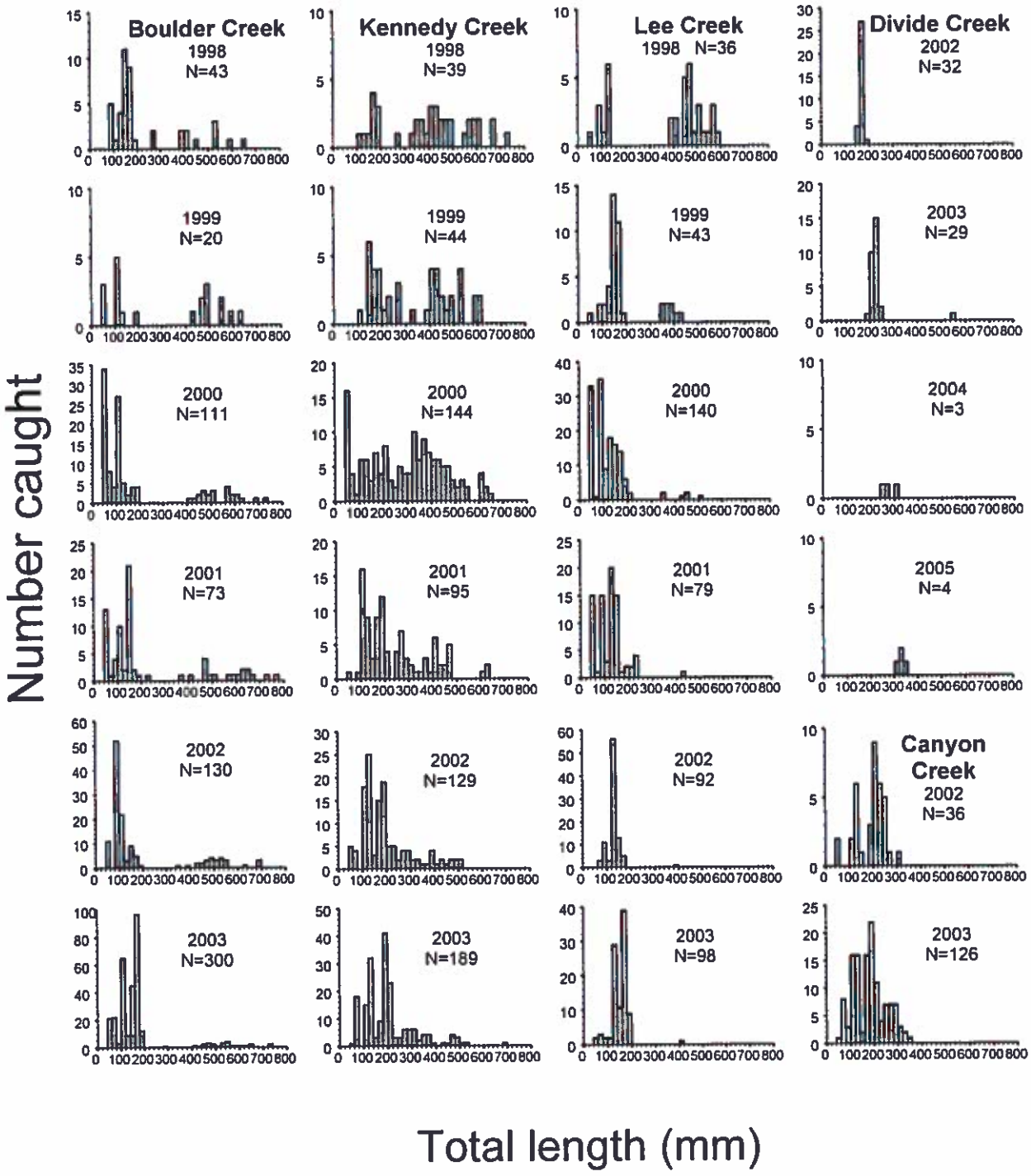

Figure 3. Length-frequency distributions for bull trout caught by electrofishing in Boulder, Kennedy, Lee, Divide and Canyon creeks, St. Mary River drainage, Montana, 1998–2006.

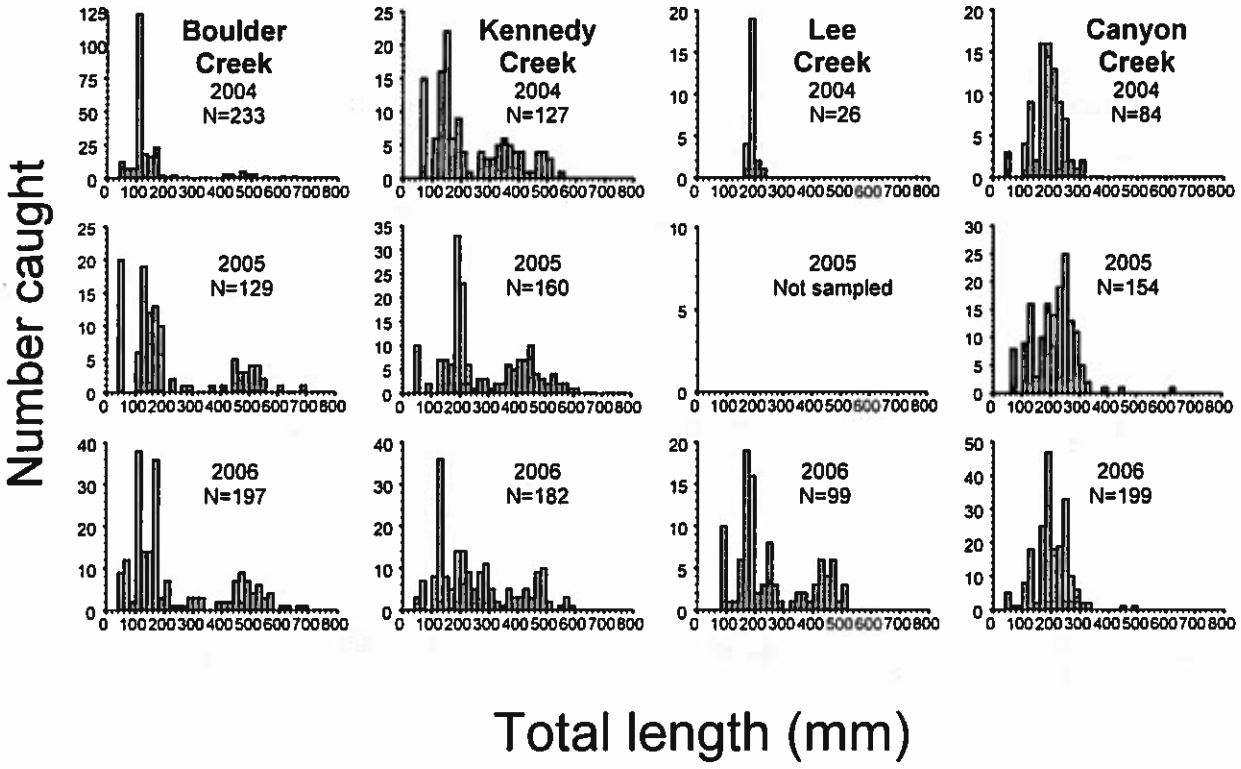

Figure 3 (cont.) Length-frequency distributions for bull trout caught by electrofishing in Boulder, Kennedy, Lee, Divide and Canyon creeks, St. Mary River drainage, Montana, 1998–2006.

second-order tributary that enters Kennedy Creek from the north appeared large enough to support fish but a large waterfall (30 m high) 400 m from the tributary's mouth prohibits fish passage upstream. In this lowermost 400 m stretch, 4 bull trout (151–208 mm TL), 12 cutthroat × rainbow trout intergrades (105–450 mm TL) and 1 brook trout (98 mm TL) were captured in 2006 (the only year sampled). Remaining Kennedy Creek tributaries appeared too small or too high-gradient to support fish, and were not sampled.

In Lower Otatso Creek, bull trout (105–662 mm TL; Figure 4), cutthroat × rainbow intergrades (42–357 mm TL), and mountain whitefish were caught. Most adult bull trout caught in this reach were just downstream (< 100 m) from the fall near the park boundary. In the middle Otatso Creek reach, many bull trout (53–589 mm TL; Figure 4) were found, as were a few cutthroat × rainbow intergrades (36–382 mm TL). The Slide Lakes reach also supports populations of bull trout and cutthroat × rainbow intergrades. Otatso Creek is fishless above the large fall, 1 km upstream from the lakes. Bull trout (59–593 mm TL; Figure 4) and cutthroat × rainbow intergrades (105–341 mm TL) were caught from the Slide Lakes reach.

In Lee Creek, bull trout (46–592 mm TL; Figure 3), cutthroat × rainbow intergrades (70–382 mm TL), and mountain whitefish were caught. The lower 4 km of Jule Creek, entirely within the park, provides summer habitat for juvenile bull trout (89–148 mm TL) and cutthroat × rainbow intergrades (63–195 mm TL). Streamside livestock grazing and extensive logging in the Middle Fork Lee Creek drainage result in large silt

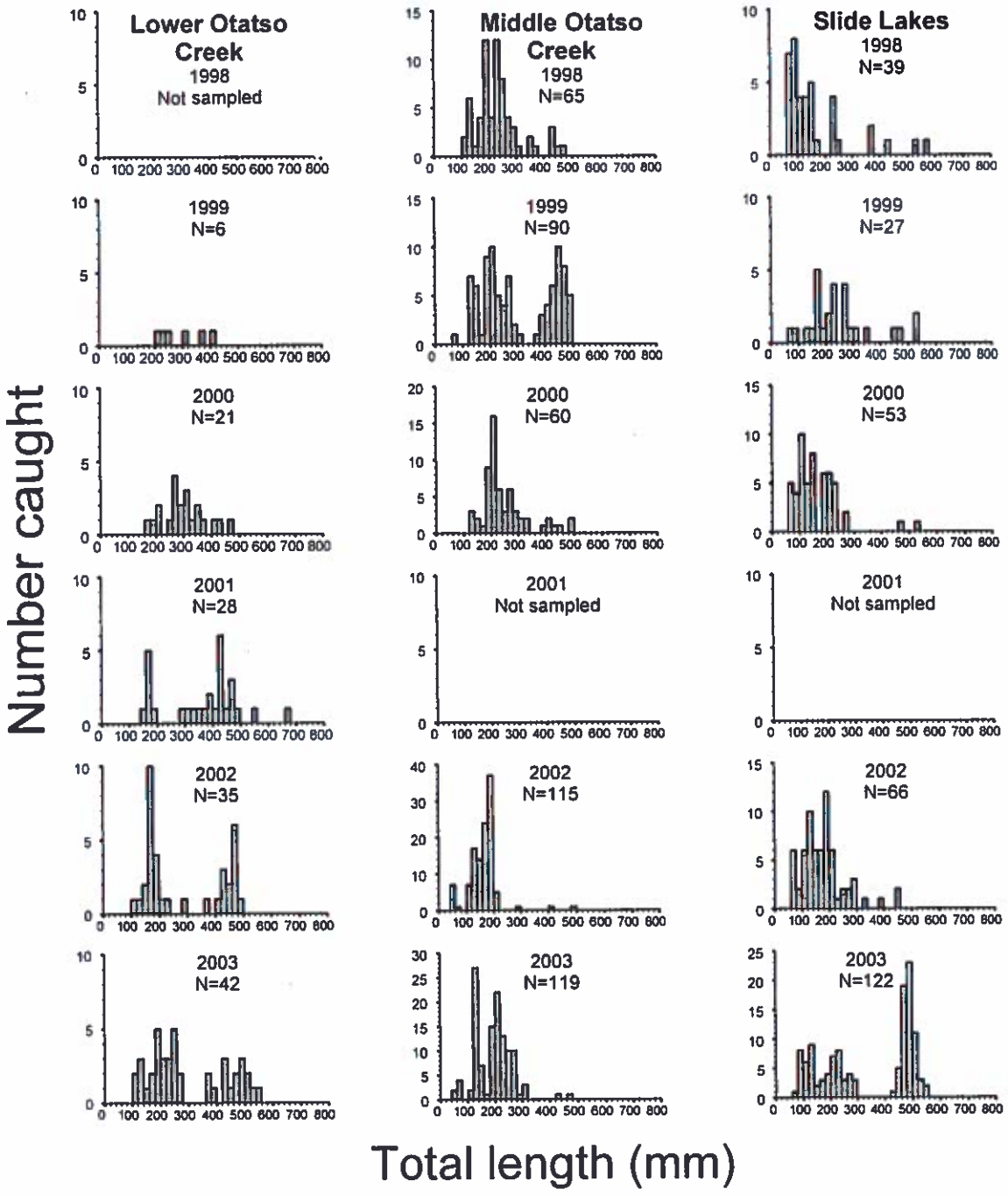

Figure 4. Length-frequency distributions for bull trout caught by electrofishing in the three reaches of Otatso Creek, St. Mary River drainage, Montana, 1998–2006.

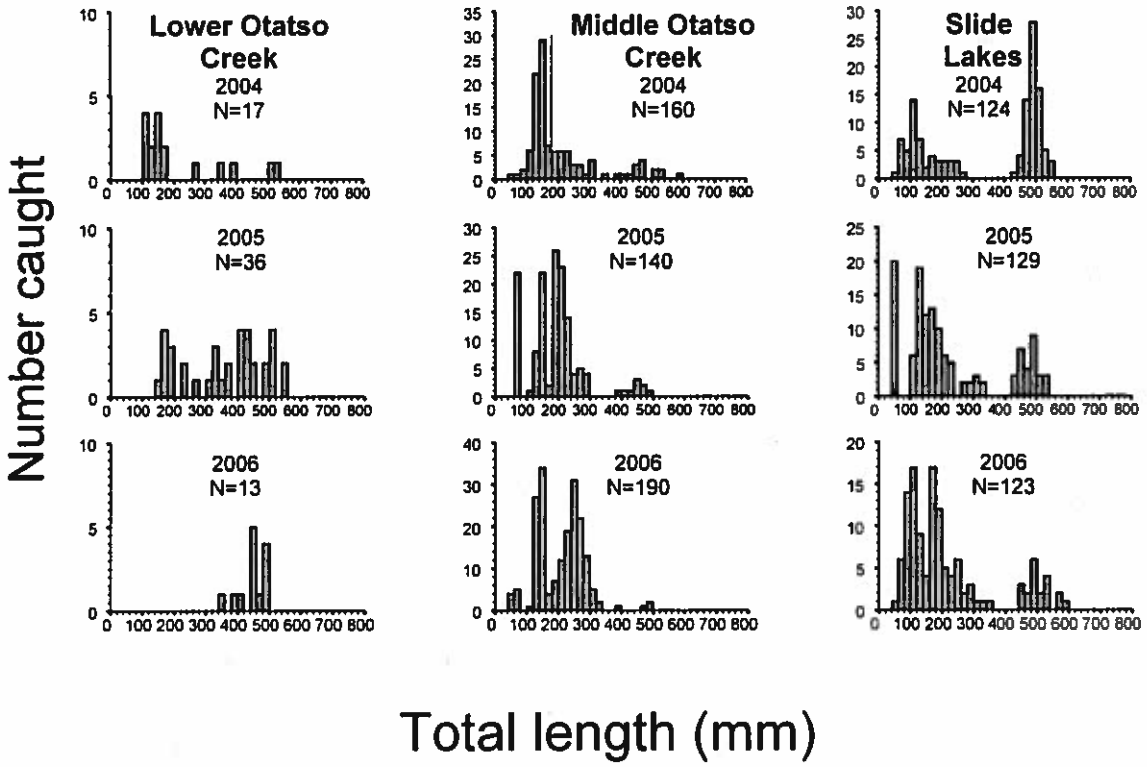

Figure 4 cont. Length-frequency distributions for bull trout caught by electrofishing in the three reaches of Otatso Creek, St. Mary River drainage, Montana, 1998–2006.

loads and substantial creek turbidity. No fish were caught from a 200-m reach upstream from an elevated highway culvert that is a barrier (2-m fall) to the upstream movement of fish, whereas two bull trout (175–235 mm TL) and several cutthroat × rainbow intergrades (115–234 mm TL) were caught from a 500-m reach downstream from the culvert. Although also affected by grazing and logging, East Fork Lee Creek supports a population of small westslope cutthroat trout (96–217 mm TL). A sample (N = 25) of these fish collected in 2002 was subsequently determined to genetically consist of 97.7% westslope cutthroat trout (2.3% rainbow trout genes).

Canyon Creek was surveyed in 2002 along the entire reach from near its mouth to the small fall 4.0 km upstream, and in 2003–2006 along the entire reach beginning 2 km below the fall and ending 1 km above the fall (Table 1). Although few fish were found in the lower 2 km of Canyon Creek, the creek supports a robust population of small bull trout (50–329 mm TL; Figure 3) in its middle and upper reaches (i.e., both below and above the fall). However, in 2005 three large (393–635 mm TL) bull trout (apparently migratory fish from Lake Sherburne, were also captured downstream from the fall. In 2006, two large (453 and 493 mm TL) bull trout were also captured from this stretch, one of which was originally tagged in 2005. Only one brook trout (250 mm TL) was captured in Canyon Creek (in 2004), approximately 2 km below the fall.

Wild Creek was surveyed at several locations along a 2-km reach near the park boundary (Table 1). The creek

appeared to be barren of fish upstream from the complex of small logjams, falls, and cascades 3 km upstream from its mouth. The middle reach of Wild Creek, immediately downstream from the apparent barrier complex, supports a population of small (29–250 mm TL) cutthroat trout. A sample (N = 13) of cutthroat trout collected from that reach in 1998 was subsequently determined to consist of genetically pure westslope cutthroat trout. In 2006, one bull trout (191 mm TL) was also captured from this reach. Farther downstream, near the creek's confluence with the St. Mary River, small cutthroat × rainbow intergrades and brook trout were found.

Rose Creek was surveyed at several locations between its mouth and 2 km upstream (Table 1). The creek appeared barren of fish in its upper reaches, upstream from the abandoned, 2-m-high dam 1 km upstream from its mouth. Although no fish were found above the dam, cutthroat × rainbow intergrades (25–263 mm TL), brook trout (128–253 mm TL), and mountain whitefish were found downstream.

Length Frequency of Electrofished Bull Trout

Length-frequency distributions for bull trout caught by electrofishing revealed multiple size-classes and suggested recent reproduction in each creek, except Divide and lower Otatso, as evidenced by fish < 100 mm TL (Figures 3 and 4). Many distributions for bull trout in Boulder and Kennedy creeks (Figure 3) showed modal size-classes centered around fish ~50 mm TL, ~100 mm TL, and ~180 mm TL that may have been age-0, age-1, and age-2 fish. However, similar size-classes were not readily apparent in the other creeks, except Canyon (Figure 3). The single bull trout size-class in Divide Creek was ~180 mm TL in 2002, ~220 mm TL in 2003 (when one 547 mm TL bull trout was also caught), ~278 mm in 2004, and ~329 mm in 2005 (Figure 3). The largest bull trout caught during the study (from Boulder Creek) was 763 mm TL.

Movements of Tagged Bull Trout

Either VI (N = 84) or PIT (N = 1,228) tags were placed in 1,312 bull trout (Table 2), 1,086 (83%) of which had been caught by electrofishing and 226 (17%) in traps (Figure 1). On the basis of captured fish that already had excised adipose fins, 224 (21%) of the tagged bull trout were recaptured in subsequent years (Tables 3 and 4) and tags were retained in 214 (96%) of those fish. Most (82%) recapture events occurred in the creek where the fish had been tagged, although there were 55 instances of bull trout movements between creeks (Table 4). Such movements occurred among all creeks, except Lee and Canyon. An adult bull trout tagged in 1998 in Kennedy Creek and recaptured in Boulder Creek in two subsequent years (2000 and 2002), was also recaptured in 2002 in a net deployed on a headgate of the St. Mary Canal, as part of a study to estimate the extent of fish entrainment in the canal (Table 4; Mogen and Kaeding 2002). That fish, released into the St. Mary River downstream from the diversion dam, was recaptured the following year (2003) in Boulder Creek.

Table 2. Total numbers of bull trout tagged in the St. Mary drainage, Montana, 1997–2006. PIT tags were used in all years except 1997 (VI tags).

Year	Method of Capture	Divide Creek	Boulder Creek	Kennedy Creek	Lower Otatso	Middle Otatso	Slide Lakes	Lee Creek	Canyon Creek	Swiftcurrent Creek	St. Mary River	TOTALS
1997	Trapping	2	34	32	16	—	—	—	—	—	—	**84**
1998	Electrofishing	0	11	22	—	39	0	25	—	—	—	**97**
	Trapping	0	53	28	17	—	—	—	—	—	—	**98**
1999	Electrofishing	0	2	17	5	41	0	8	—	—	—	**73**
	Trapping	—	6	4	4	—	—	10	—	—	—	**24**
2000	Electrofishing	—	10	61	13	17	3	5	—	—	—	**109**
	Trapping	—	11	3	4	—	—	2	—	—	—	**20**
2001	Electrofishing	—	7	36	11	—	—	7	—	—	—	**61**
2002	Electrofishing	0	14	27	9	4	13	1	22	—	—	**90**
2003	Electrofishing	29	11	36	21	53	47	1	0	6	—	**204**
2004	Electrofishing	2	20	45	2	39	48	3	38	—	—	**197**
2005	Electrofishing	1	21	66	18	55	42	—	52	—	6	**261**
2006	Electrofishing	0	49	88	8	93	30	45	80	—	4	**397**
TOTALS		**34**	**249**	**465**	**128**	**341**	**183**	**107**	**192**	**6**	**10**	**1715**

Table 3. Summary of annual bull trout tagging and recapture events, St. Mary River drainage, Montana, 1997–2006. Numbers in parentheses are percent maximum possible value, based on the number of tags at large, for that category.

Year	Number of fish tagged that year	Maximum tags at large at end of field season	Number of recapture events for fish tagged 1–6 years earlier						
			1 year	2 years	3 years	4 years	5 years	6 years	Total
1997	84	84	—	—	—	—	—	—	—
1998	195	279	24 (29)	—	—	—	—	—	24
1999	97	376	41 (21)	7 (8)	—	—	—	—	48
2000	129	505	9 (9)	34 (17)	5 (6)	—	—	—	48
2001	61	566	13 (10)	1(1)	12 (6)	1 (1)	—	—	27
2002	90	656	9 (15)	14 (11)	1 (1)	4 (2)	0 (0)	—	28
2003	204	860	15 (17)	7 (11)	9 (7)	3 (3)	4 (2)	0 (0)	38
2004	197	1057	21 (10)	8 (9)	1 (2)	3 (2)	1 (1)	0 (0)	34
2005	261	1318	38 (19)	13 (6)	7 (8)	3 (5)	1 (1)	1 (1)	63
2006	397	1715	52 (20)	18 (9)	5 (3)	3 (3)	1 (2)	0 (0)	79

Table 4. Summary of bull trout tagging and recapture events, 1997–2006 combined, by location of initial capture, St. Mary River drainage, Montana. Numbers in parentheses is percent for that tagging location, or of the total numbers of either fish tagged or recapture events.

Tagging Location	Number of Fish Tagged 1997-2005	Number of Fish Recaptured 1998-2006	Number of Recapture Events 1998-2006	Location of Recapture Events										
				Divide Creek	Boulder Creek	Kennedy Creek	Lower Otatso	Middle Otatso	Slide Lakes	Lee Creek	Canyon Creek	Swiftcurrent Creek	St.Mary River	St.Mary Canal
Divide Creek	34	5	6	4 (67)	2 (33)	0	0	0	0	0	0	0	0	0
Boulder Creek	200	71	115	0	108 (94)	2 (2)	3 (3)	0	0	0	0	2 (2)	0	0
Kennedy Creek	377	92	126	0	8 (6)	102 (81)	14 (11)	1 (1)	0	0	0	0	0	1 (1)
Lower Otatso	120	34	50	0	1 (2)	10 (20)	33 (66)	6 (12)	0	0	0	0	0	0
Middle Otatso	248	30	32	0	0	1 (3)	6 (19)	25 (78)	0	0	0	0	0	0
Slide Lakes	153	27	30	0	0	0	0	3 (10)	27 (90)	0	0	0	0	0
Lee Creek	62	7	8	0	0	0	0	0	0	8 (100)	0	0	0	0
Canyon Creek	112	22	24	0	0	0	0	0	0	0	24 (100)	0	0	0
Swiftcurrent Creek	6	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Mary River	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1318	224 (22%)	391	4 (1)	119 (30)	115 (29)	56 (14)	35 (9)	27 (7)	8 (2)	24 (6)	2 (.5)	0 (0)	1 (.5)

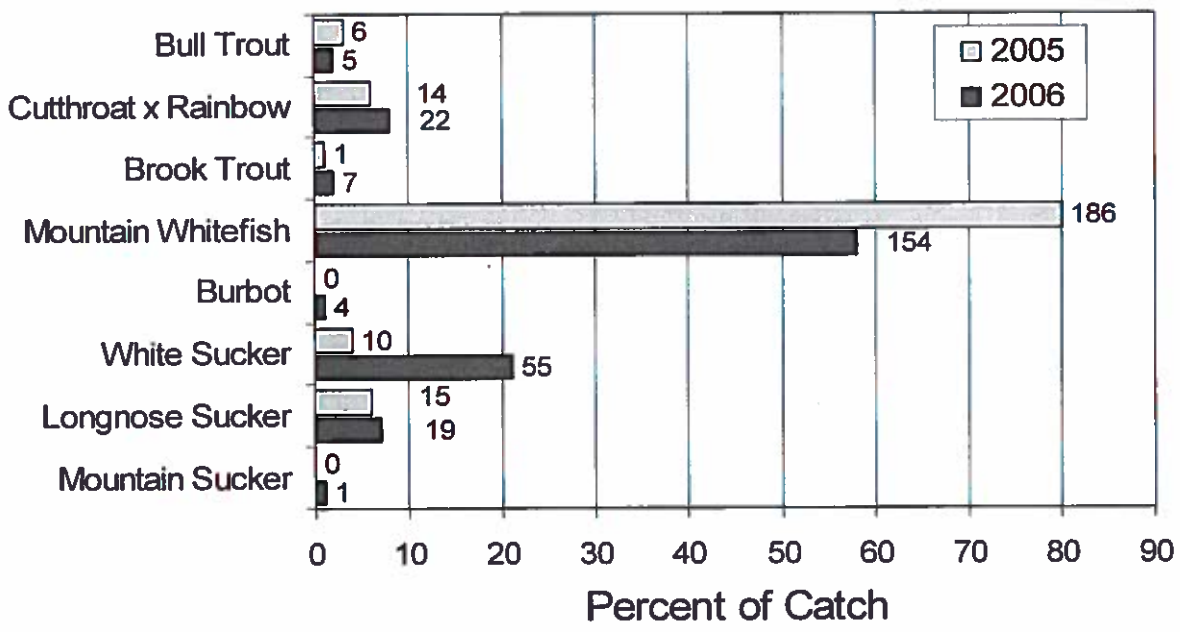

Figure 5. Percent composition of total catch during summer electrofishing surveys in the St. Mary River, downstream from the diversion dam, Montana, 2005-2006.

St. Mary River Surveys

The St. Mary River was surveyed in mid-summer 2005 and 2006 at several locations along its length between the diversion and the Bureau's Camp Nine facilities, approximately 14 km of stream (Table 1). Boat electrofishing revealed bull trout (233–374 mm TL), cutthroat × rainbow intergrades (165–391 mm TL), brook trout (136–373 mm TL), mountain whitefish, burbot, suckers, sculpins and dace (Figure 5). Bull trout accounted for less than 3 percent of the total catch in both years (Figure 5) and appeared most abundant near the mouth of Kennedy Creek. Mountain whitefish dominated the catch, followed by suckers, trout and char. The numerous small fish observed included sculpins, dace, and juveniles of the other species.

Lake Sherburne Surveys

Altogether, 112 fish were captured in gillnets deployed in Lake Sherburne in October 2006: 71 mountain whitefish (187–372 mm TL), 30 longnose suckers (177–574 mm TL), 10 northern pike (362–1070 mm TL) and 1 brook trout (229 mm TL). No bull trout were captured. Among the seven gillnet sets (5 evening, 2 morning), soak times ranged from 1 to 14 hours (mean, 8 hrs 43 min; total, 61 hrs, 10 min).

Redd Surveys

Principle bull trout spawning areas were found in Boulder and Kennedy creeks. In addition, during electrofishing in 2003 we observed several bull trout spawning in the Slides Lakes reach, just upstream from the lakes (Figure 1). In Boulder and Kennedy creeks, spawning areas were 3 km and 2 km long and occurred in areas of probable groundwater upwelling, just downstream from the regions of entirely subsurface flow. Redds were often associated with nearby undercut banks, root wads, debris jams, or beaver dams and were constructed in substrates that appeared to range from fine gravel (~10-mm diameter) to small cobble (< 150-mm diameter). Although seemingly comparable substrates occurred downstream from both Boulder and Kennedy Creek spawning areas, as well as at various locations in Divide Creek, no redds were found in those areas. Mean numbers of redds counted annually did not differ between the two creeks (ANOVA, $F_{1,16} = 4.04$, $P = 0.06$; overall mean, 24.8 redds), nor were they correlated between creeks ($P = 0.45$).

DISCUSSION

Bull trout were widely distributed and often locally abundant in tributaries of the St. Mary River. Although we did not examine Red Eagle or Swiftcurrent creeks, nor the St. Mary lakes or Cracker Lake as part of the study described here, bull trout are known to also occur in those waters (Fredenberg 1996, Michels 1996, Mogen and Kaeding 2003). Thus bull trout presently occur in all of the creeks and lakes that they historically inhabited in the St. Mary River drainage in Montana.

Bull trout in Boulder and Kennedy creeks spawned in areas of probable groundwater upwelling, as has been reported for this species elsewhere (e.g., Fraley and Shepard 1989, Boag and Hvenegaard 1997). However, those Boulder and Kennedy Creek locations were not the only areas where bull trout spawned. The occurrence of age-0 bull trout indicated recent spawning and reproduction in each creek in which bull trout were found, except Divide and lower Otatso. Furthermore, annual reproduction was indicated by the occurrence of multiple age-classes of young bull trout. In contrast, the single year-class of young bull trout in Divide Creek suggested only periodic reproduction there. Divide Creek's bull trout spawning stock was especially small, as indicated by the capture of only two adult fish in the trap and a single adult by electrofishing. Although we have no explanation for the scarcity of that spawning stock, small stock size, coupled with widely varying reproductive success among years, probably account for the single year-class of young bull trout that we found in the creek. In lower Otatso Creek, the mostly embedded gravels and cobbles (and associated absence of groundwater upwellings) may not be conducive to bull trout spawning. Instead, bull trout probably spawn in middle Otatso, where the large rubble and turbulent flows may make their redds difficult to observe. Bull trout also spawned in the Slide Lakes reach, but those spawners probably reside in the Slide Lakes themselves.

Our tag-recapture data revealed bull trout movements among all creeks, except Canyon and Lee. Both of those creeks are characterized by fewer tagged adult bull trout and distinct isolation from the other study creeks, both of which may explain our inability to detect between-creek movements of bull trout tagged in those creeks. Movements of bull trout were both upstream and downstream over the St. Mary Diversion dam and the waterfall near the park boundary on Otatso Creek, as well as downstream over the rockslide that formed the Slide Lakes. None of those movements had been anticipated prior to our study. Although the effects of those movements on the bull trout genomes of each creek are unknown, the movements suggest that the spawning stocks of those creeks are not reproductively isolated.

Westslope cutthroat trout were found in three creeks in the St. Mary River drainage, and one of those populations (Wild Creek) apparently consisted of genetically pure fish. Westslope cutthroat trout may have never been widespread or abundant in the St. Mary River drainage (Marnell 1988). Their populations that became established in the Glacier National Park part of the drainage may have occurred only in creeks where they were secure from the highly predacious, native lake trout that subsequently and naturally colonized the St. Mary lakes.

Although adult bull trout were captured from the St. Mary River, none was an adult fish. During our river surveys in late July–early August, most adult bull trout may have entered river tributaries in preparation for spawning (Mogen and Kaeding 2005b). Similarly most age-0 through about age-2 bull trout remain in their natal tributaries during that time (Mogen and Kaeding 2005a), and therefore do not inhabit the river. Instead, the 11 bull trout caught from the river during our electrofishing surveys were sub-adult fish, 233–374 mm long.

Although no bull trout were captured in gillnets deployed in Lake Sherburne, a small population of adfluvial bull trout must reside there. Large (> 390 mm TL) migratory adult bull trout have been captured during August electrofishing surveys in Canyon Creek, the only accessible spawning tributary of Lake Sherburne. Our gillnetting was conducted in early October, when the adults may have been spawning in Canyon Creek. However, gillnetting surveys conducted in June and September 1994 by Wagner and Fitzgerald (1995) revealed only northern pike, mountain whitefish, longnose suckers, kokanee and burbot. A late September 2000, electrofishing of Swiftcurrent Creek immediately upstream from Lake Sherburne to the base of Swiftcurrent Falls, a short stream reach typically inundated by the reservoir during full pool, revealed abundant brook trout (70–252 mm TL), a few mountain whitefish and one burbot (Mogen and Kaeding 2003). Despite marked annual fluctuations in reservoir level, Lake Sherburne sustains a diverse fish community.

Factors That May Limit Bull Trout

Milk River Project effects on bull trout

In reaching its decision to list the bull trout as a threatened species, the Service concluded (*Federal Register* 64: 58910), among other things, that bull trout in the St. Mary River drainage are negatively affected by operation of water-storage and delivery systems that are part of the Milk River Irrigation Project. Results of our study and concurrent investigations support several Service conclusions important to reaching that decision, including that bull trout are entrained in the St. Mary Canal (Mogen and Kaeding 2002). Because the canal headgates are barriers to the upstream movement of fish, bull trout entrained in the canal are unlikely to return to the river and therefore are lost from the reproducing population. In addition, our results from radio telemetry (Mogen and Kaeding 2005b) suggested the acute reductions in discharge from Sherburne Dam in the fall produced low-flow conditions downstream in Swiftcurrent Creek that contributed to the deaths of two radiotagged bull trout.

Although the Service also concluded (*Federal Register* 64: 58910) that the St. Mary Diversion is a substantial barrier to the movement of bull trout in the river, results of the present study and elsewhere (Mogen and Kaeding 2003, 2005a, 2005b) showed upstream and downstream movements of bull trout past the dam. Timing of those movements is not precisely known but may have been when the dam was open, usually between October and April. Our radiotelemetry work (Mogen and Kaeding 2005b), however, indicated the

dam is at least a seasonal barrier to the movement of bull trout in the river. Nevertheless, the present study revealed more extensive movements of bull trout among St. Mary River tributaries than had earlier been suspected (*Federal Register* 64: 58910).

Effects of nonnative fishes on bull trout

Brook trout constituted a small portion of the fish communities in St. Mary River tributaries. Although other studies have reported that bull trout rarely coexist with brook trout (e.g., Watson and Hillman 1997, Paul and Post 2001, Rich et al. 2003), we found no evidence that brook trout, which have persisted in the drainage for many decades, had displaced bull trout in tributaries. Similarly, although hybridization has been considered a common problem where bull trout are sympatric with brook trout (Cavender 1978, Leary et al. 1993, Kanda 2002) and the Service concluded (*Federal Register* 64: 58910) that such hybridization was a threat to bull trout in the St. Mary River drainage, we found only one probable brook trout × bull trout hybrid. Furthermore, laboratory analyses of tissues taken from numerous bull trout revealed no evidence of hybridization with brook trout (Paul Spruell, Wild Trout and Salmon Genetics Laboratory, personal communication). Thus hybridization with brook trout does not appear to be an emerging threat to the bull trout genome. Finally, the Service also concluded that brown trout posed a threat to bull trout in the drainage, but we found no brown trout in St. Mary River tributaries.

Management Recommendations

On the basis of information described in the present report and in preceding reports that described our radiotelemetry and entrainment investigations (Mogen and Kaeding 2002, 2003, 2004, 2005a, 2005b), we offer several recommendations for actions that would benefit bull trout in the St. Mary River drainage. (1) Year-round movement of adult bull trout over the St. Mary Diversion dam should be facilitated. This would likely require installation of a fish-passage structure (i.e., "ladder"), perhaps on either a greatly modified or completely reconstructed dam. (2) Water should be released from Sherburne Dam to provide adequate winter habitat for bull trout downstream in Swiftcurrent Creek. Among other things, this would apparently require modification of the existing Sherburne Dam outlet works. (3) Entrainment of bull trout and other fishes in the St. Mary Canal should be prevented. This may require installation of a fish screen or other barrier, perhaps as part of a modified or completely reconstructed dam. (4) An assessment of the effects of water diversion into the St. Mary Canal (i.e., removal of water from the drainage) on bull trout habitat in the St. Mary River downstream from the diversion should be performed. Our radiotelemetry study showed that many adult bull trout inhibit the St. Mary River downstream from the diversion, in both Montana and Alberta, during the non-spawning season (Mogen and Kaeding 2005b). It is important that that feeding and wintering habitat for bull trout be maintained and that adverse effects to that habitat that result from reductions in stream flow be identified and remediated, if possible.

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