ARCTIC GRAYLING RECOVERY PROGRAM
MONTANA ARCTIC GRAYLING MONITORING REPORT
2007

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Fluvial Arctic Grayling Workgroup
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Montana Arctic Grayling

Introduction

Montana Arctic grayling (*Thymallus arcticus)* are at the southern extent of Arctic grayling distribution and are discrete from other Arctic grayling populations within their circumpolar range. They are genetically and geographically distinct from populations residing in Canada and Alaska (Kaya 1990). Montana grayling populations can be divided into two life history groups, those exhibiting fluvial (stream dwelling) characteristics and those exhibiting adfluvial (lake dwelling) characteristics. Fluvial populations were historically found in the upper Missouri River drainage upstream from Great Falls (Figure 1). Native adfluvial populations originated in the Red Rock Drainage and in Big Hole drainage (Figure 1). Declines in both native fluvial and adfluvial grayling populations in Montana over the past 30 years have spurred numerous management, conservation, and research actions. Grayling conservation efforts that occurred in 2007 are summarized in this report.

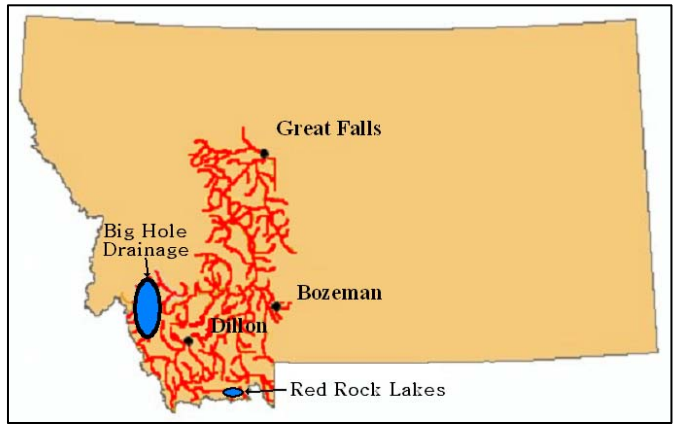


Figure 1. Historic range of Arctic grayling in Montana. Red lines represent fluvial populations and blue circles represent adfluvial populations.

Fluvial Arctic Grayling Status

The fluvial form of Arctic grayling historically occupied the Missouri River and its' major tributaries upstream of Great Falls, MT. Currently, fluvial Arctic grayling distribution is limited to the Big Hole River, representing 4% of their native, historic range. Fluvial Arctic grayling in Montana are designated as a "Species of Special Concern" by Montana Fish, Wildlife & Parks (FWP), the Endangered Species Committee of the American Fisheries Society, the Montana Chapter of the American Fisheries Society (MCAFS) and the Montana Natural Heritage Program (MNHP) (Holton 1980, MNHP 2004). The U.S. Forest Service (USFS) and the Bureau of Land Management (BLM) classify fluvial Arctic grayling as a sensitive species. In October 1991, the U.S. Fish and Wildlife Service (USFWS) received a petition to list fluvial grayling in Montana throughout its historic range for protection under the Endangered Species Act (ESA). In 1994, the USFWS finding classified fluvial grayling in Montana as a Category 1 species, which indicates that there is enough information on file to support a proposal to list the grayling as threatened or endangered (USFWS 1994). In March 2004, the USFWS elevated grayling listing priority for a Distinct Population Segment (DPS) from a level 9 to a level 3 (USFWS 2004). This is the highest priority level given to a DPS. The priority level was elevated because: 1) the current distribution of fluvial grayling represents 4% of the historic range, and 2) recent population surveys indicate a decline in the Big Hole River population. In May of 2004, the USFWS was petitioned to emergency list the fluvial grayling due to ongoing drought conditions and decreased population abundance. The USFWS announced their finding on the petition April 24, 2007, which stated that the upper Missouri River DPS of fluvial Arctic grayling does not constitute a species, subspecies or DPS and is therefore not warranted protection under the ESA.

Upper Missouri Arctic grayling were removed from the candidate species list (USFWS 2007). This ruling was challenged in November of 2007 and is currently under litigation.

Big Hole River Population

Introduction

Fluvial Arctic Grayling

The fluvial Arctic grayling of the Big Hole River represent the last strictly fluvial native grayling population in the contiguous United States. After the population declined during the mid-1980's, the Arctic Grayling Recovery Program (AGRP) was formed, which now includes representatives from FWP, the BLM, USFS, USFWS, MNHP, MCAFS, Montana State University (MSU), University of Montana (UM), Montana Trout Unlimited (TU), Pennsylvania Power and Light (PPL), and the National Park Service (NPS). The program's goals are to address ecological factors limiting the Big Hole grayling population, monitor and enhance essential habitats, monitor abundance and population demographics, restore additional grayling populations within their native range, develop relationships that promote conservation actions and inform the general public of grayling conservation efforts and status. Monitoring and research results have been reported annually since 1991 (Byorth 1991, 1993, 1994, 1995, 1997, Byorth and Magee 1996, Magee and Byorth 1998, Magee 1999 and 2002, Magee and Opitz 2000, Magee and Lamothe 2003 and 2004, Magee, Rens and Lamothe 2005, and Rens and Magee 2006).

Arctic grayling conservation objectives in the Big Hole River from January 1 through December 31, 2007 were to:

- Promote and initiate habitat improvement projects that include: riparian and channel function, fish passage, stream flow dynamics and minimizing entrainment into irrigation systems in the Big Hole River basin on private land through the Candidate Conservation Agreements with Assurances Program (CCAA).
- Develop and promote landowner relationships and continually educate public and interest groups of grayling conservation needs and status.
- Monitor water temperatures and discharge in the Big Hole River and its tributaries.
- Monitor abundance and distribution of grayling and sympatric native and sportfish species in the Upper Big Hole basin.

Methods

Conservation Efforts and Projects

Planting willow sprigs on a restoration reach in the upper Big Hole valley.

Conservation efforts and projects initiated in 2007 focused on the objectives outlined in the CCAA. The Big Hole River Fluvial Arctic Grayling CCAA is an agreement between the USFWS and a non-federal landowner that voluntarily agrees to manage their lands or waters to remove threats to grayling. Landowners receive assurances against additional regulatory requirements if grayling become listed under the ESA. The CCAA outlines specific restoration goals for derived reaches on the Big Hole River and its' tributaries.

The goal of the CCAA program is to secure and enhance the population of fluvial Arctic grayling within the upper reaches of the Big Hole River drainage (Figure 2). Under the CCAA, FWP holds an ESA Section 10(a) (1) (A) Enhancement of Survival Permit issued by the USFWS. As defined in the CCAA, FWP will issue Certificates of Inclusion to non-federal property owners within the project area who agree to comply with all stipulations of the CCAA and agree to develop and implement a site-specific conservation plan, approved by FWP and the USFWS. Site-specific plans will be developed with each landowner by an interdisciplinary technical team made up of individuals representing FWP, USFWS, NRCS, and the Department of Natural Resource and Conservation (DNRC). Conservation measures addressed in each plan will: 1) Improve streamflow, 2) Improve and protect the function of streams and riparian habitats, 3) Identify and reduce or eliminate entrainment threats to grayling, and 4) Remove barriers to grayling migration.

The Enhancement of Survival Permit delineates the upper Big Hole into five management reaches (Figure 2). Conservation measures described above will be implemented in each management reach. Flow, temperature, habitat, channel morphology, and population monitoring will be completed annually in each reach. Results of the 2007 CCAA efforts are reported separately and available online at http://fwp.mt.gov/wildthings/concern/grayling.html

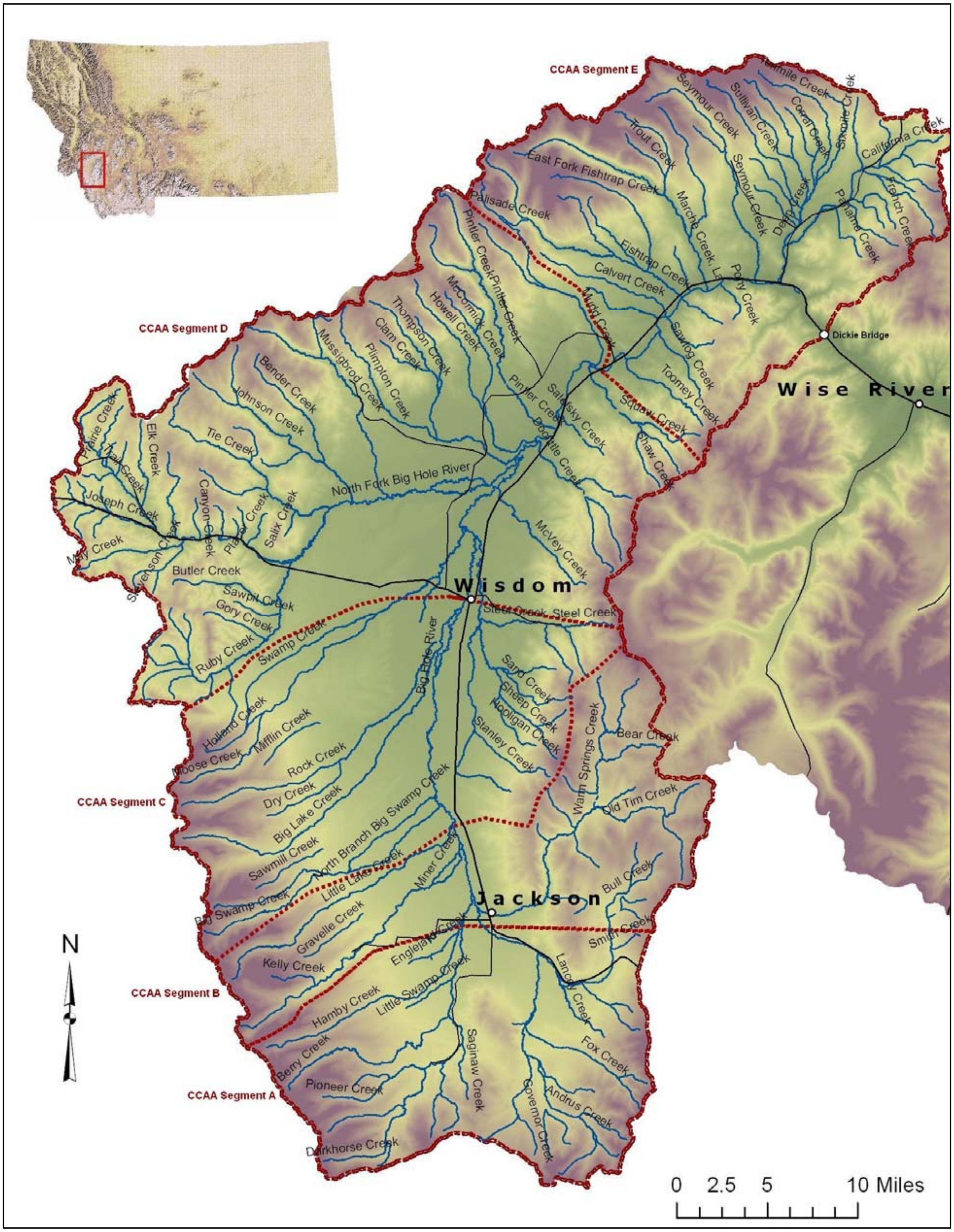


Figure 2. The upper Big Hole Valley including the Big Hole River and its' tributaries, towns, highways and CCAA segment boundaries (dotted red) from the headwaters to Dickie bridge.

Snow Pack, Stream Discharge, and Water Temperatures

Twenty-one snowpack monitoring sites were maintained by NRCS in the Big Hole Basin during 2007. Results for the sites are summarized monthly and reported as percent of average and percent of last year (http://www.wcc.nrcs.usda.gov). Stream discharge monitoring consisted of three real-time sites maintained by the U.S. Geological Survey (USGS). Two gauges located on the mainstem Big Hole River (BHR) at the Wisdom Bridge and at Mudd Creek Bridge are operated from April to October. The gauge located at the Melrose Station is operated year round [USGS 2007, http://waterdata.usgs.gov/nwis (Figure 3)]. Thirty-three continuous stage-recording instruments [either AquaRod© (13), Sequoia Version 4.0 2003, or TruTrack© (20) WT-HR 1000] were maintained by FWP and DNRC to spatially assess flow dynamics in the Upper Big Hole River (6), tributaries (17) and irrigation ditches (10); (Figure 4, Appendix A). Stage-discharge ratings were developed at each site and applied to data collected by the instrument. Eighteen of these sites were established in 2007. Three sites in the mainstem are used to monitor representative flows in CCAA Management Segments A, B, and E (BHR at Miner Lakes Rd, BHR at Little Lake Creek Rd, and BHR at Dickie Bridge). Management Segments C and D are monitored with USGS Wisdom and Mudd Creek real-time stations. Sites were also established in representative tributaries (Governor Creek, Miner Creek, Rock Creek, Steel Creek, and Deep Creek) for each CCAA Management Segment. Stream flow data collected were used to:

- Track baseline flows (pre-CCAA implementation)
- Provide daily flow status for on-the-ground flow management
- Monitor flow targets outlined in the CCAA
- Develop flow agreements within the CCAA site-specific plans
- Monitor pre- and post-project data
- Assess irrigation efficiency

Water temperature was monitored at the USGS Wisdom and Melrose gauging stations and at thirty-three thermograph stations located in the mainstem Big Hole or tributaries (Figure 3). FWP used Onset HOBO Water Temp Pro™ thermographs to record temperatures at 60-minute intervals. Data were downloaded into Microsoft Excel and analyzed to determine daily maximum, minimum, and mean temperatures. Temperature analysis was used to compare mainstem and tributary reaches, identify thermal refuge areas, and to assess relationships between fish abundance, riparian health, instream flows, and thermal regimes. Data was analyzed by using mean daily temperatures and by hours and days over 70ºF, (as an indication of thermal stress; Behkne 1991) and 77ºF (the upper incipient lethal temperature for grayling; Lohr et. al. 1996).

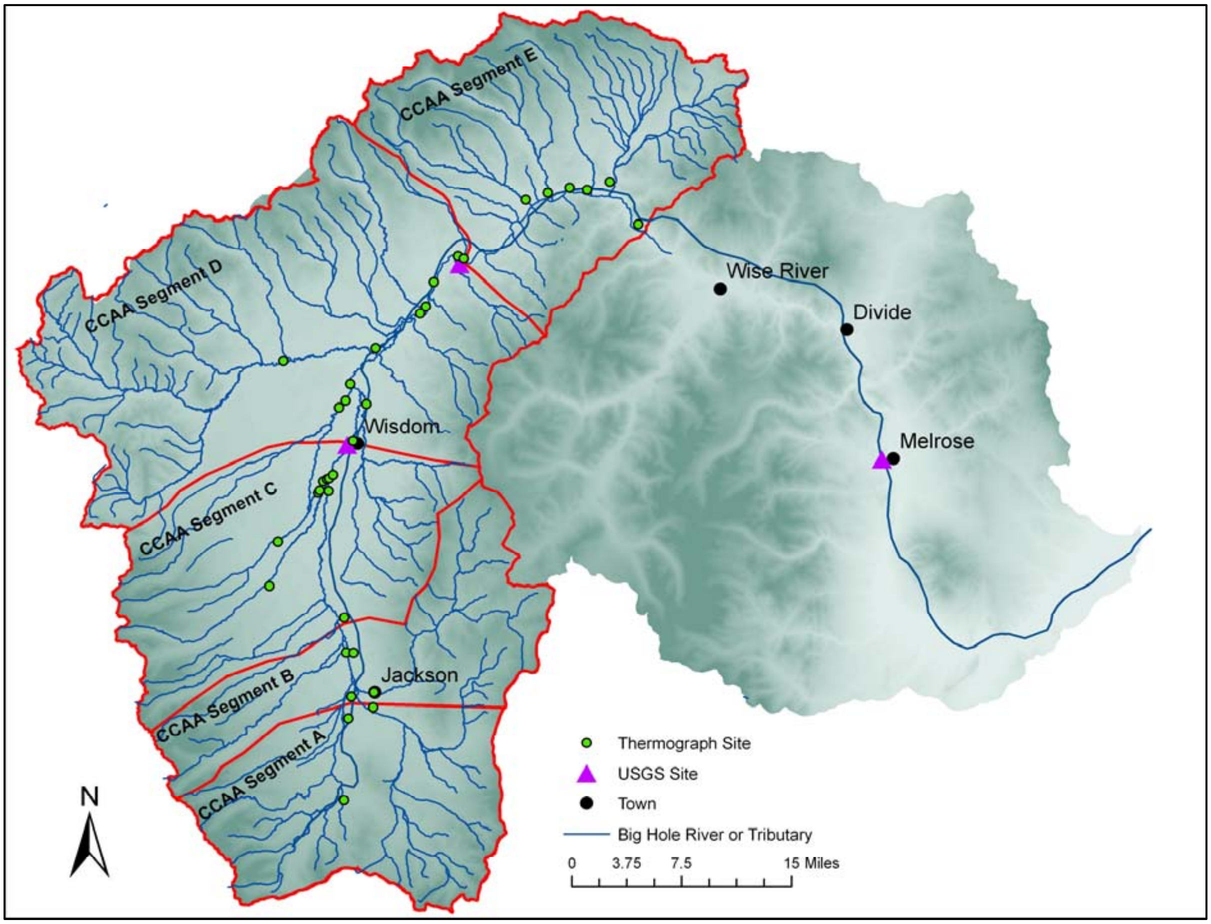


Figure 3. The Big Hole drainage with FWP thermograph sites (33 sites), USGS flow gauging stations (3 sites), and CCAA reaches (red lines).

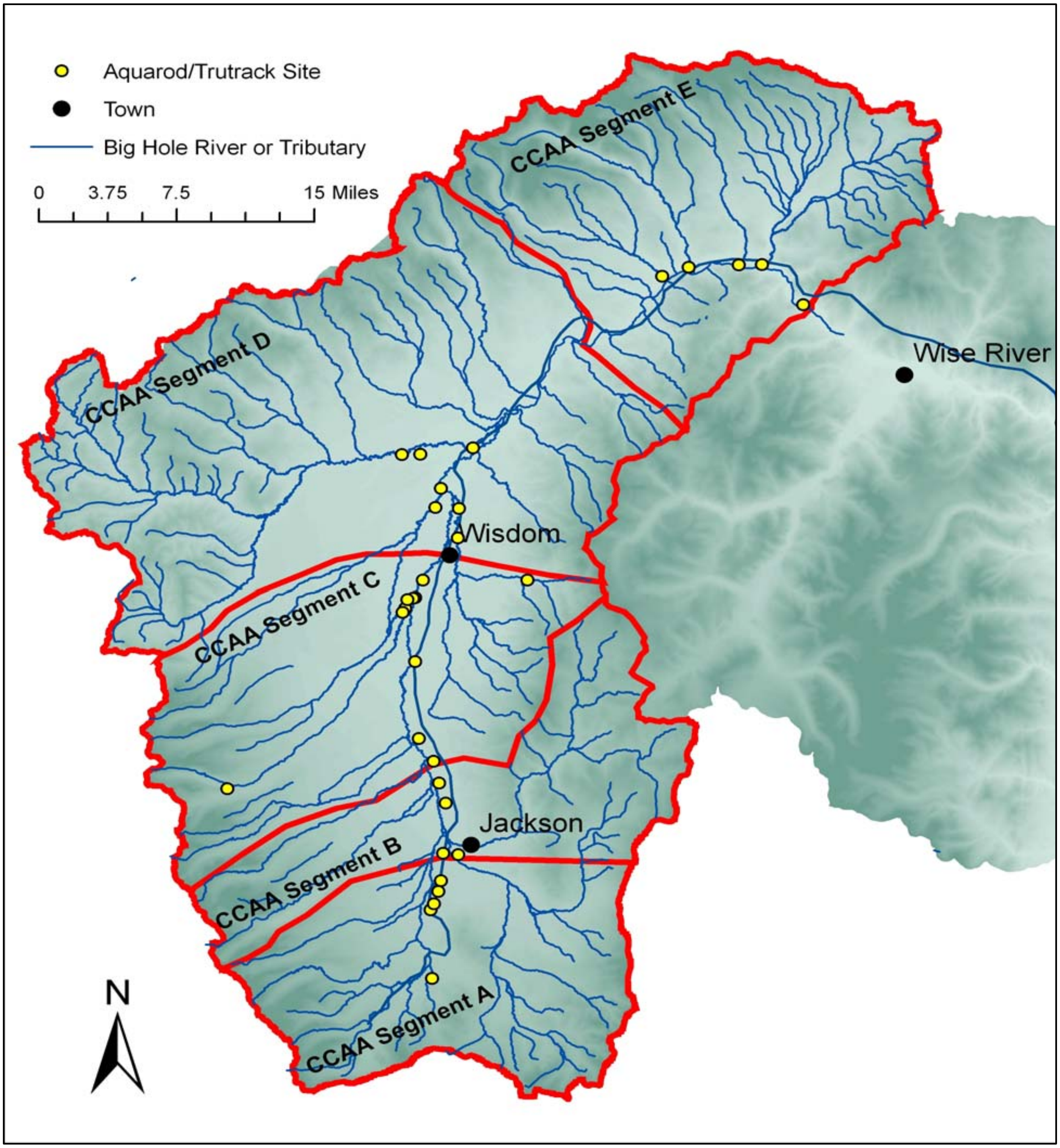


Figure 4. The upper Big Hole drainage continuous stage-recording instrument (either AquaRods or TruTracks) locations and CCAA management reaches. A total of 33 sites were managed in 2007.

Population Monitoring

FWP monitors the Big Hole River grayling population to assess population abundance, recruitment, age class strength, and distribution. Electrofishing surveys are conducted in the fall (September-October) when temperature and flow conditions are optimal for sampling efficiency and handling. Rainbow trout *Oncorhynchus mykiss*, brown trout *Salmo trutta*, brook trout *Salvelinus fontinalis* and burbot *Lota lota* greater than six inches are also sampled to determine densities and relative abundance. All sizes of grayling are sampled. Electrofishing sampling uses a mobile-anode DC system powered by 4,000-watt generator coupled with a Coffelt Mark XXII-M rectifying unit mounted on a drift boat or Pelican Intruder 12™ or Smith-Root **Model 12-B battery powered backpack electrofisher unit.**

Target species are captured and held in a live well. Fish are anesthetized using Tricaine Methanesulfonate-222 (MS-222), measured [total length (± 0.1 in.) and weighed (± 0.01 lb.)], fins are notched as a temporary mark and scales are collected for age determination. Grayling greater than six inches in length are tagged with a visible-implant (VI) tag in transparent adipose tissue immediately posterior to the left eye. Each VI tag is marked with a unique three-digit code to differentiate between individuals. Tissue samples for genetic analyses were taken from pelvic fin clips and preserved in non-denatured ethanol.

Big Hole Arctic Grayling with visible implant tag (VI tag)

In 2007, FWP conducted electrofishing surveys between September 6 and October 30. One-pass surveys were completed on a mainstem and a tributary reach in each of the 5 CCAA management reaches. These reaches will be referred to as CCAA (A), CCAA (B), CCAA (C), CCAA (D) and CCAA (E) on the mainstem River and include Governor Creek, Miner Creek, Rock Creek, Steel Creek and Deep Creek sections on the tributaries, respectively (Figure 5). Additional surveys were conducted on mainstem Big Hole River reaches including: Little Lake Creek road to Big Swamp Creek road, 40-Bar, the Airport Channel, Wisdom, Dickie Bridge to Mallons, and the "Pools" (Sawlog, Fishtrap, and Sportsman's pools). Electrofishing reaches on tributaries included Swamp Creek, the North Fork, Squaw Creek, Fishtrap Creek, LaMarche Creek, Seymour Creek, and Bryant Creek. If more than 10 age 1+ (>6.0 inches) grayling were captured in a sampling reach, a second pass was conducted in order to complete a mark-recapture population estimate. Catch per unit effort (number of fish per mile) estimates were completed on all other sampling reaches. Mark-recapture estimates were conducted on Fishtrap Creek, LaMarche Creek, and

FWP crew conducts electrofishing surveys .

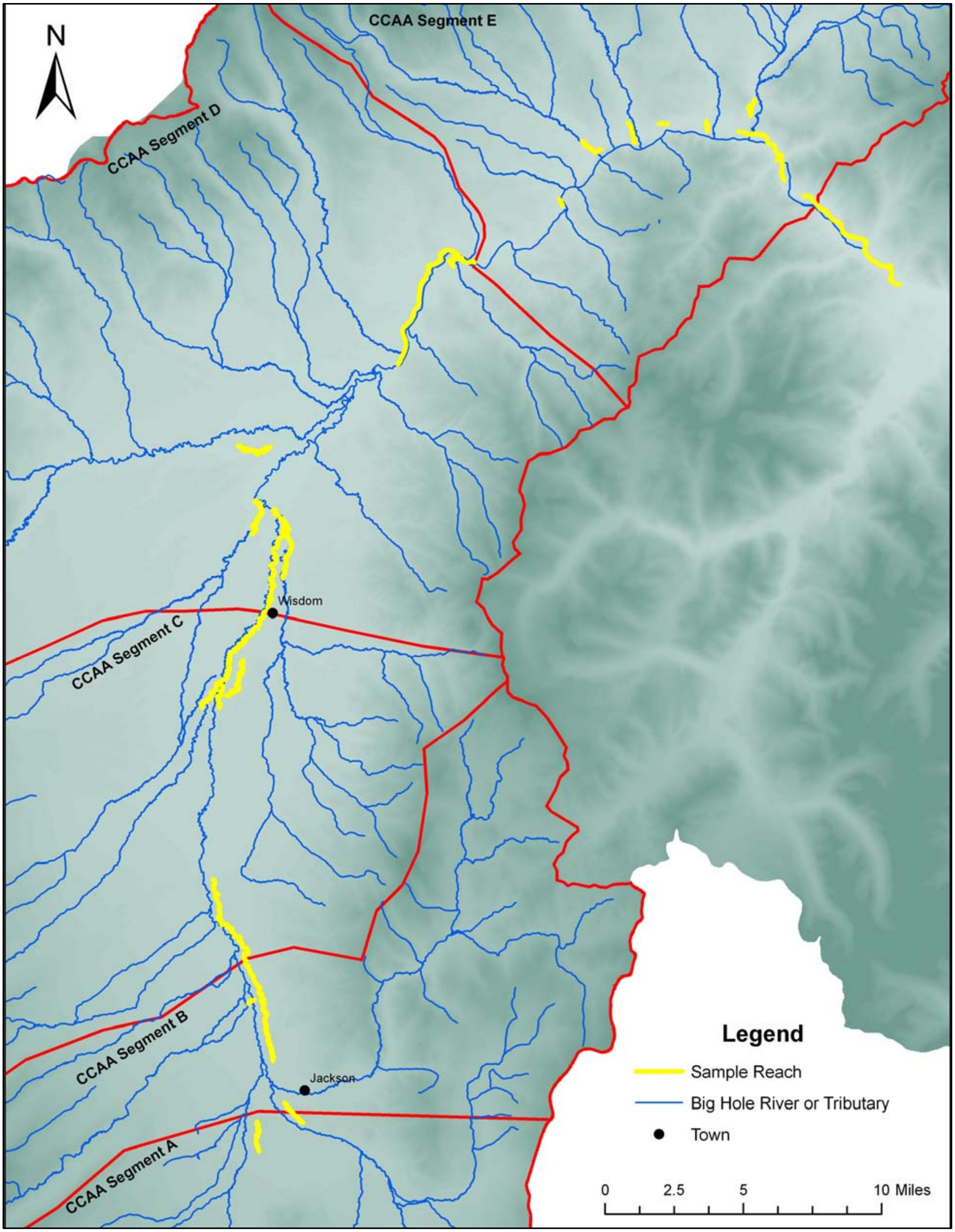


Figure 5. FWP electrofishing reaches in the upper Big Hole drainage (Approximately 60 miles) sampled during fall 2007 and the CCAA management segments (red lines).

Results

Conservation Efforts and Projects

As part of the CCAA conservation efforts enrolled landowners participated in conservation measures that would improve instream flows. In April, landowners individually reduced or delayed irrigation diversions to enhance instream that moved sediment, scoured streambeds, and improved habitat conditions for spawning grayling (Figure 6). Conservation efforts continued throughout the summer and focused on improving irrigation infrastructure and measuring devices that allow water users to measure and control diverted water. FWP collaborated with the NRCS and DNRC to install numerous headgates, diversion structures, measuring devices and stock water systems in 2007 (Figure 7). These improvements and voluntary irrigations reductions were critical to mitigate ongoing drought conditions throughout the summer.

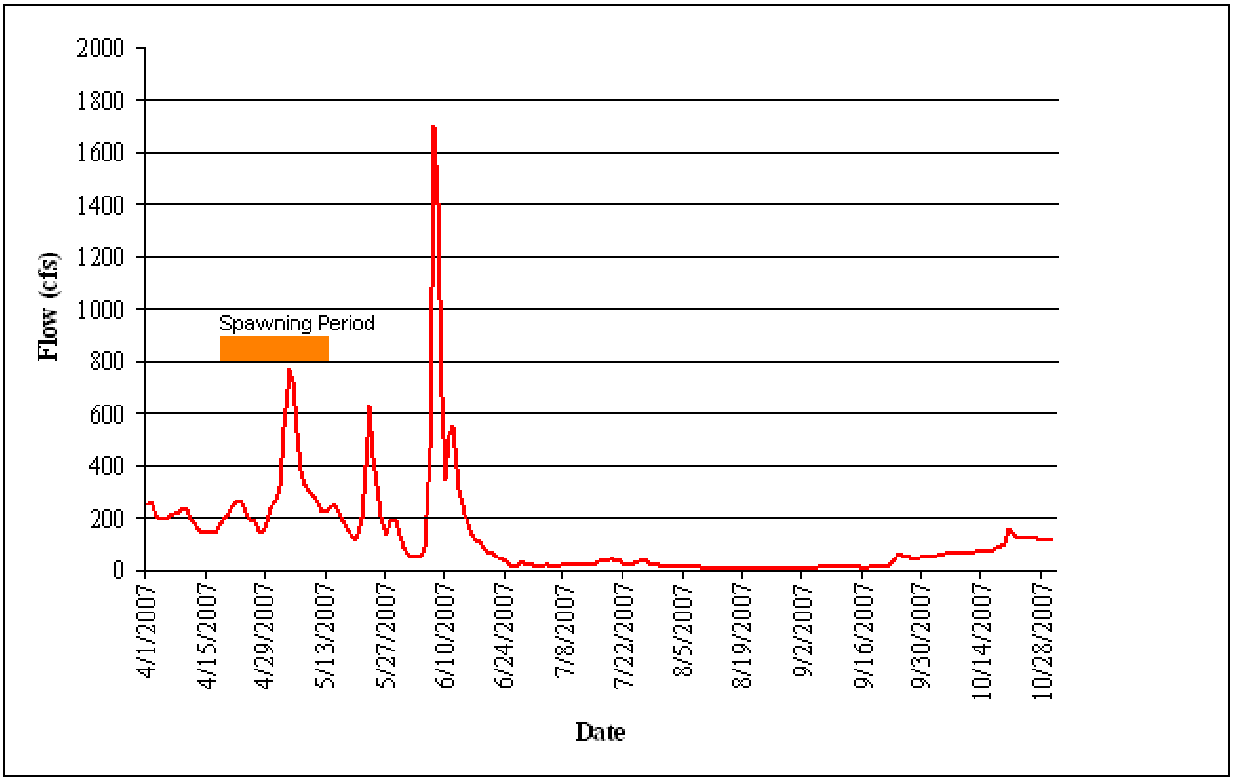


Figure 6. USGS Wisdom gauge hydrograph for 2007, and the approximate grayling spawning period.

The Big Hole Drought Management Plan (DMP) recommends angling closures to further reduce stress to fish during extreme low-flow periods. The DMP for the upper reach of the Big Hole (from Rock Creek Road to the Mouth of the North Fork) recommends maintaining an average daily flow (ADF) of 20 cfs to maintain a wetted channel that will allow fish to access important life-history habitats or other reaches and tributaries with improved conditions. When the ADF at the USGS Wisdom gauge declines below 20 cfs, FWP implements an angling closure to reduce

Planting of a mature willow during one of several restoration projects in the upper Big Hole in 2007.

additional potential stress (BHWC 2006). In 2007, an angling closure was implemented on the upper reach from July 5 – October 6.

Over the past ten years numerous additional conservation projects have been implemented in the upper Big Hole drainage to improve fish and wildlife habitats, fish passage, riparian health, bank stability, water quality, irrigation efficiency and instream flows. In 2007, these projects include stream restoration in the form of riparian vegetation improvements, channel and bank reconstruction and/or pool enhancements (Lamothe and Petersen 2006). Nearly three miles of stream restoration took place in 2007, with an additional 6.0 miles scheduled for 2008 (Figure 7). Riparian fence projects have been initiated or completed on approximately sixty-eight miles of stream or river to protect stream banks and re-establish riparian plant communities within riparian corridors (Figure 7). Riparian enhancement projects include development of grazing management plans as part as the CCAA landowner site-specific plans. Thirty-seven stock water systems have been developed including twelve in 2007 (Figure 7). Nine fish ladders have been installed into existing or newly constructed diversions to enable uninhibited fish movement (Figure 7). In October, one animal feeding operation area was relocated outside of the floodplain, and six similar projects are scheduled for 2008 (Figure 7). Projects were funded cooperatively by FWP, BHWC, USFWS Partners, NRCS, BLM, and individual landowners. More information on individual projects can be found on the FWP website: http://fwp.mt.gov/wildthings/concern/grayling.html

Snow Pack, Stream Discharge, and Water Temperatures

Snowpack in the Big Hole basin was 70% of the Period-of-Record (POR) and 67% of the 2006 snow pack on April 30, 2007. Big Hole River peak runoff generally occurs between June 1 and June 15, and flows typically decline thereafter through August. The highest mean daily flow at the USGS Wisdom gauge in 2007 was 1,700 cfs on June 7, and the lowest mean daily flow was 7.9 cfs on September 3 (Figure 8). Below average snowpack coupled with poor precipitation from June to August resulted in instream flows below the long-term average (nineteen years). Stream flows were 53%, 82%, and 62% of the POR for the Wisdom, Mudd Creek, and Melrose USGS gauges respectively (Figure 8). At the Mudd Creek station, flows were over 117% of the long-term average in May; however, flows dropped below the long-term average from June through September (Figure 8). Mainstem flows in CCAA segments D and E were maintained above minimum flow targets better than the upper reaches (Figure 9). Detailed summary of instream flows and conservation is reported separately by the DNRC and can be found on the FWP website: http://fwp.mt.gov/wildthings/concern/grayling.html

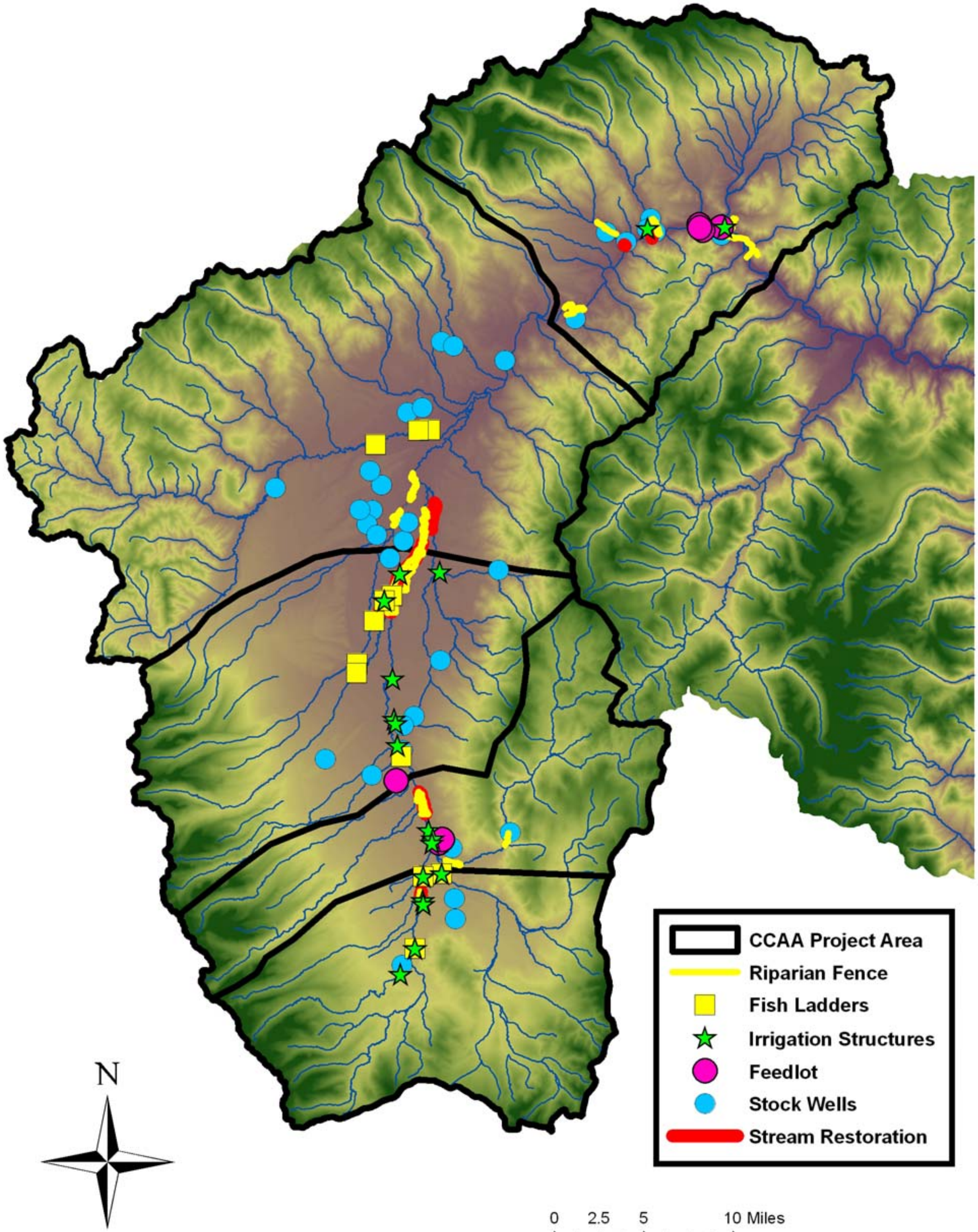


Figure 7. Upper Big Hole drainage stream restoration projects completed through 2007 or scheduled to be complete in 2008.

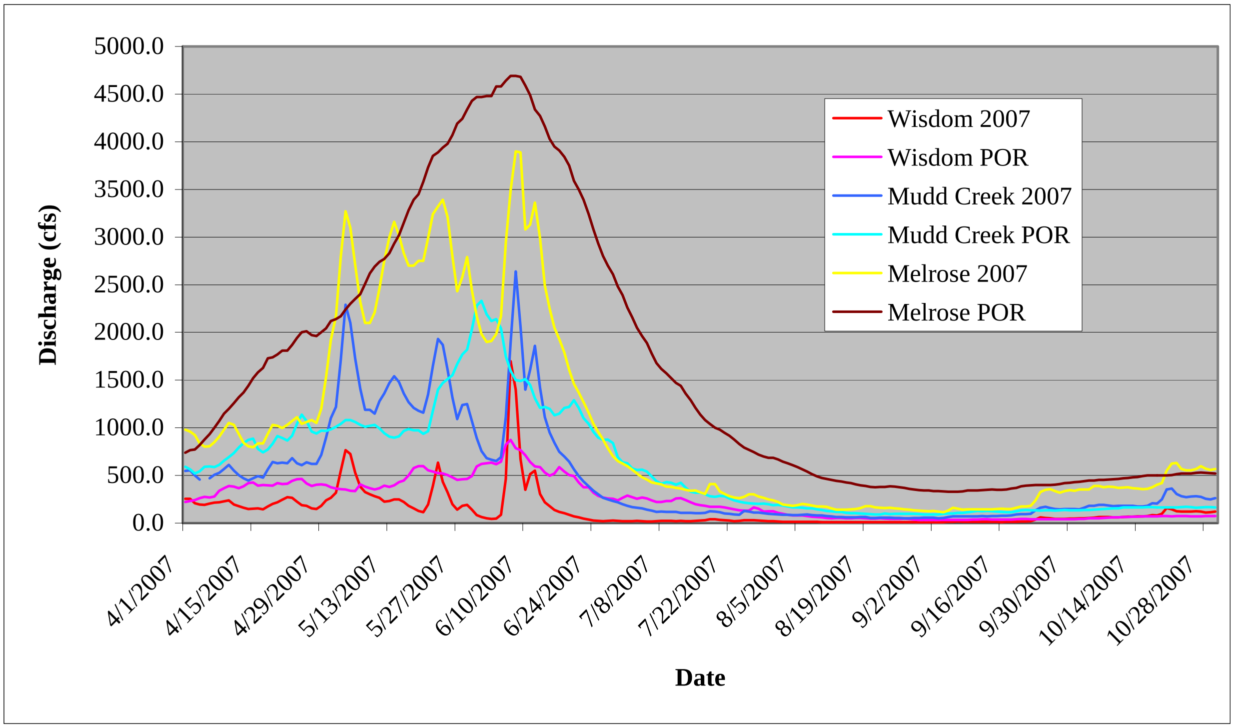


Figure 8. Mean daily flow in 2007 and for the period of record at the USGS Wisdom, Mudd Creek and Melrose gauging stations (data are provisional).

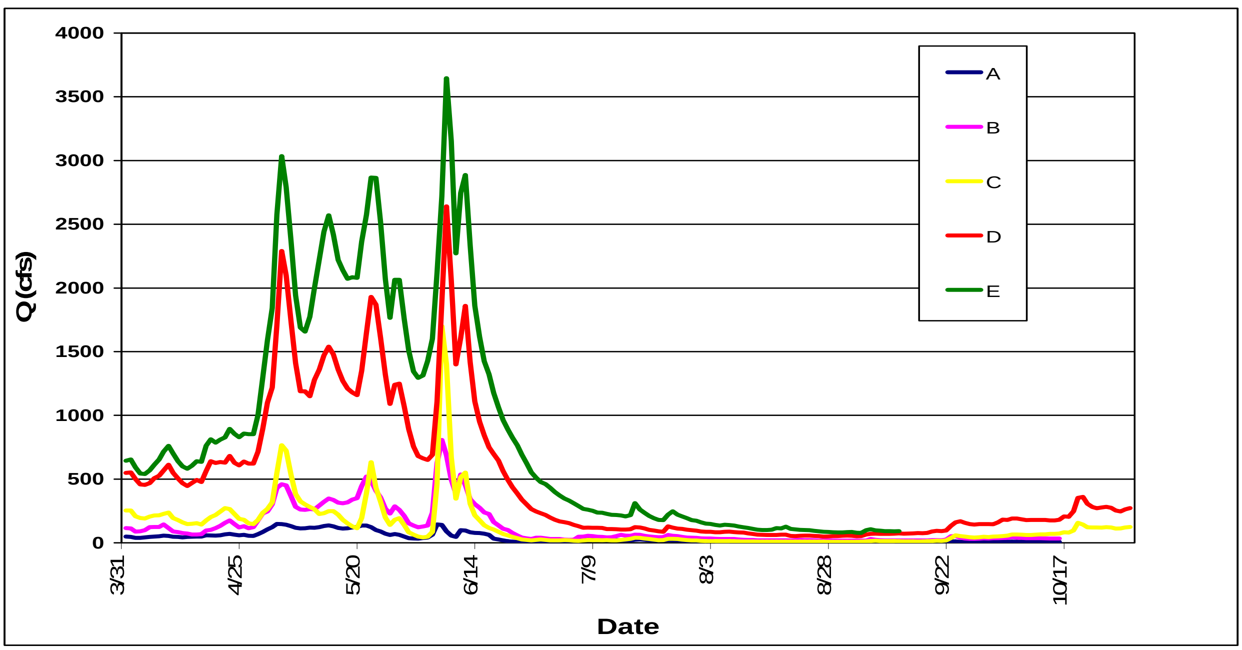


Figure 9. Mainstem Big Hole River discharge (cfs) recorded at the lower end of each CCAA segment by DNRC between April and October of 2007.

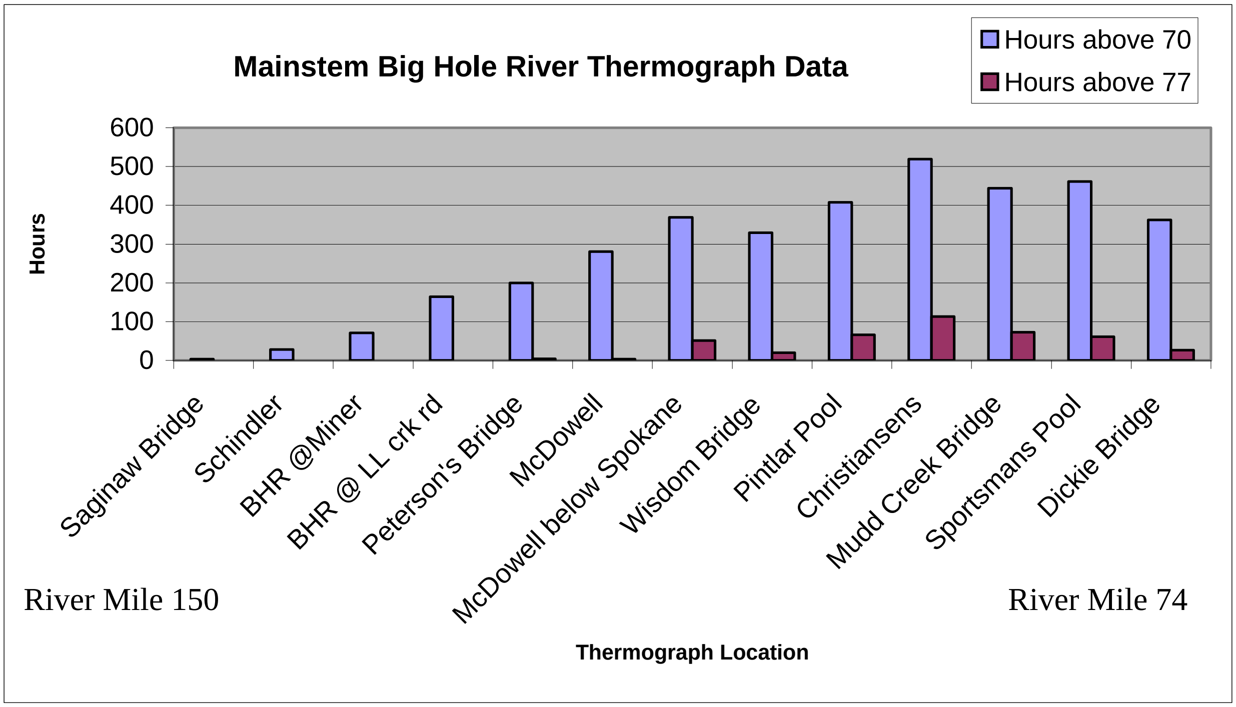


Figure 10. Total hours recorded exceeding 70º and 77º Fahrenheit for mainstem Big Hole River thermographs between April and November 2007.

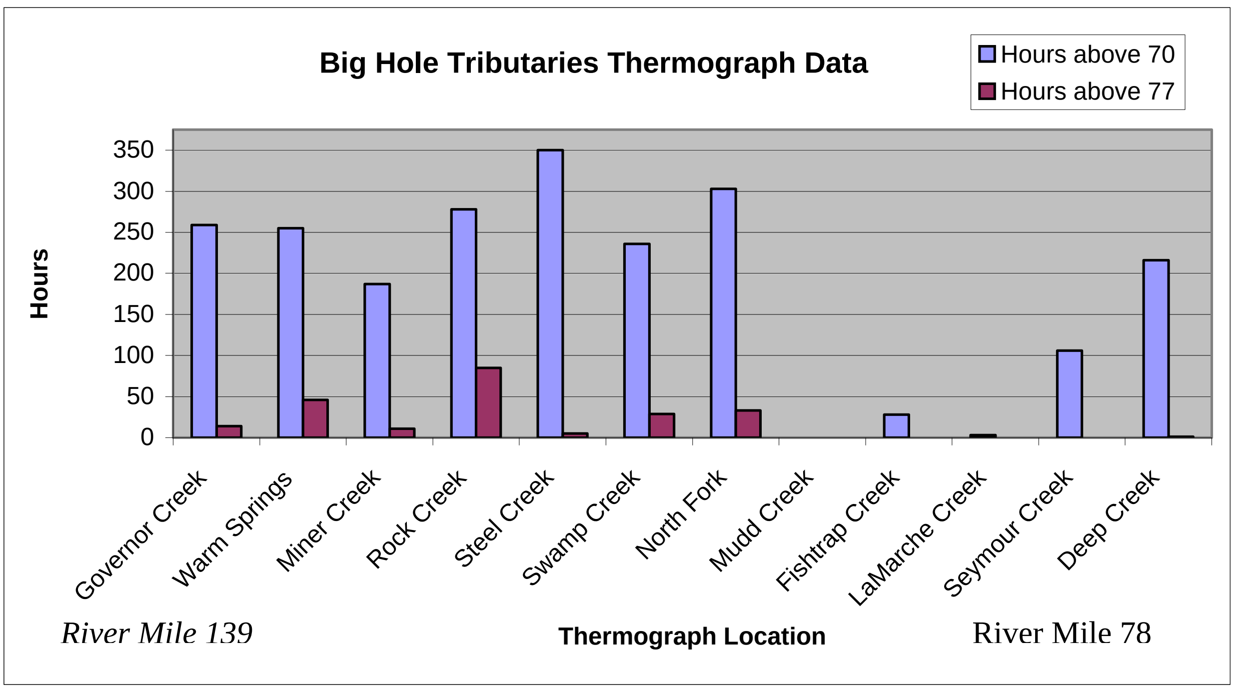


Figure 11. Total hours recorded exceeding 70º and 77º Fahrenheit at Big Hole River tributary thermograph sites between April and November 2007.

Instream water temperatures are a result of air temperature, day-length, riparian health, shading, channel morphology, streamflow, springs and thermal input from merging tributaries or returning irrigation water. Maximum instream temperatures in the upper Big Hole River typically peak in July and decrease in August as nighttime temperatures are cooler and day-length decreases. Maximum temperatures in 2007 occurred on July 5 and July 20 (Figure 10, 11). Big Hole River instream temperatures increased from the headwaters (Saginaw Bridge) downstream to the lower end of CCAA (D), and then decreased in CCAA (E). Mid-river tributaries (Mudd Creek, Fishtrap Creek, and LaMarche Creek) had the coolest temperatures and fewest hours over 70° F (Figure 10 & 11). All Mainstem sites from Peterson's bridge (Big Swamp Creek road) downstream exceeded upper incipient lethal temperatures (77°F) for Arctic grayling (Lohr et. al. 1996; Figure 16), and all mainstem and tributary thermograph sites, excluding Mudd Creek, exceeded 70ºF, (Figure 10 & 11).

Population Monitoring

A total of 222 grayling were captured in fall electrofishing surveys of which 71% were Young-of-the-Year (YOY), which are typically <6.0 inches in length, and 29% were age one and older (Age-1+), which are typically >6.0 inches in length (Figure 12). The age structure of the grayling population sampled in 2007 is similar to surveys from 2003-2006 with YOY the most abundant year class (Figure 12). Similar to 2006 results, grayling abundance was highest in the tributaries and YOY abundance was highest in Steel Creek. Age -1+ grayling were dispersed throughout the Big Hole and tributaries from Deep Creek upstream to Wisdom, MT (CCAA section C; Figure 13, Figure 14). Age-3 and older grayling remain at low abundance exemplified by lower CPUE in the "Pools" (Sportsman's, Fishtrap and Sawlog Pools), which historically had higher numbers of adult grayling (Figure 13).

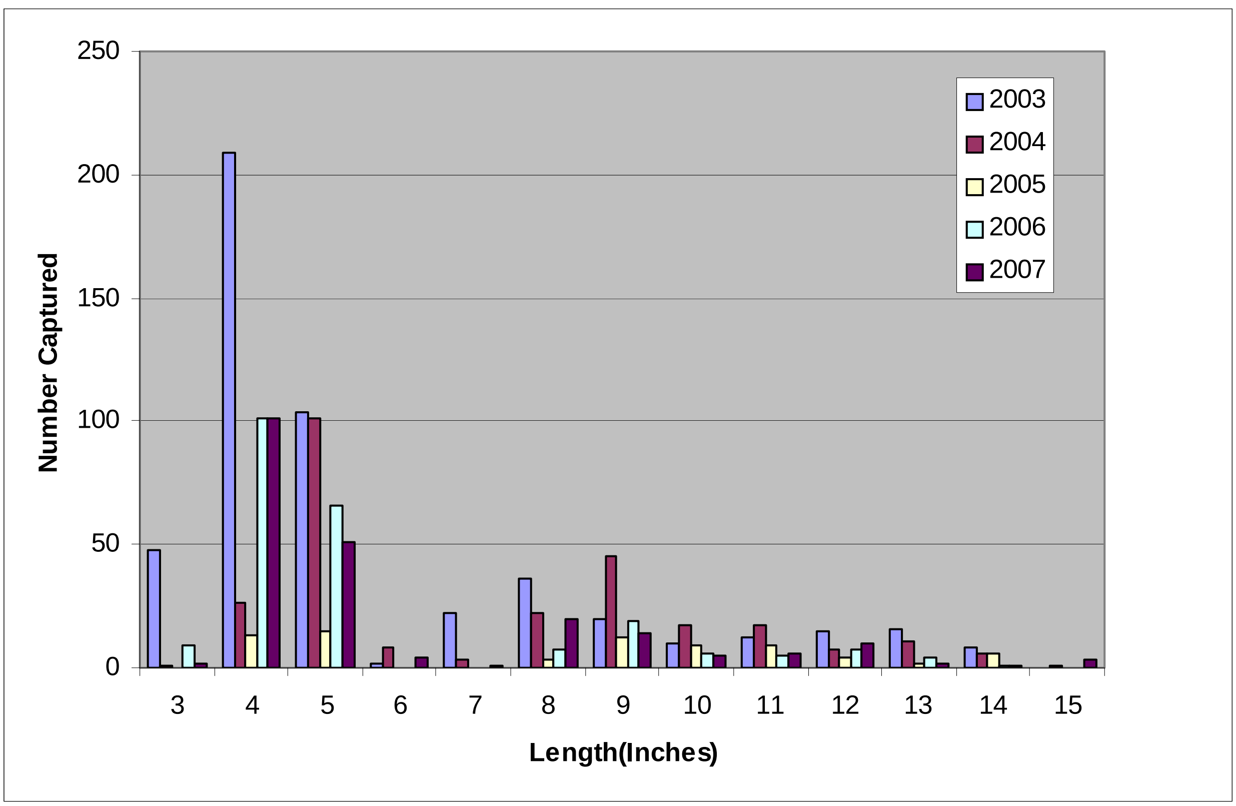


Figure 12. A length frequency histogram for Big Hole grayling captured during FWP Fall electrofishing surveys between 2003 and 2007.

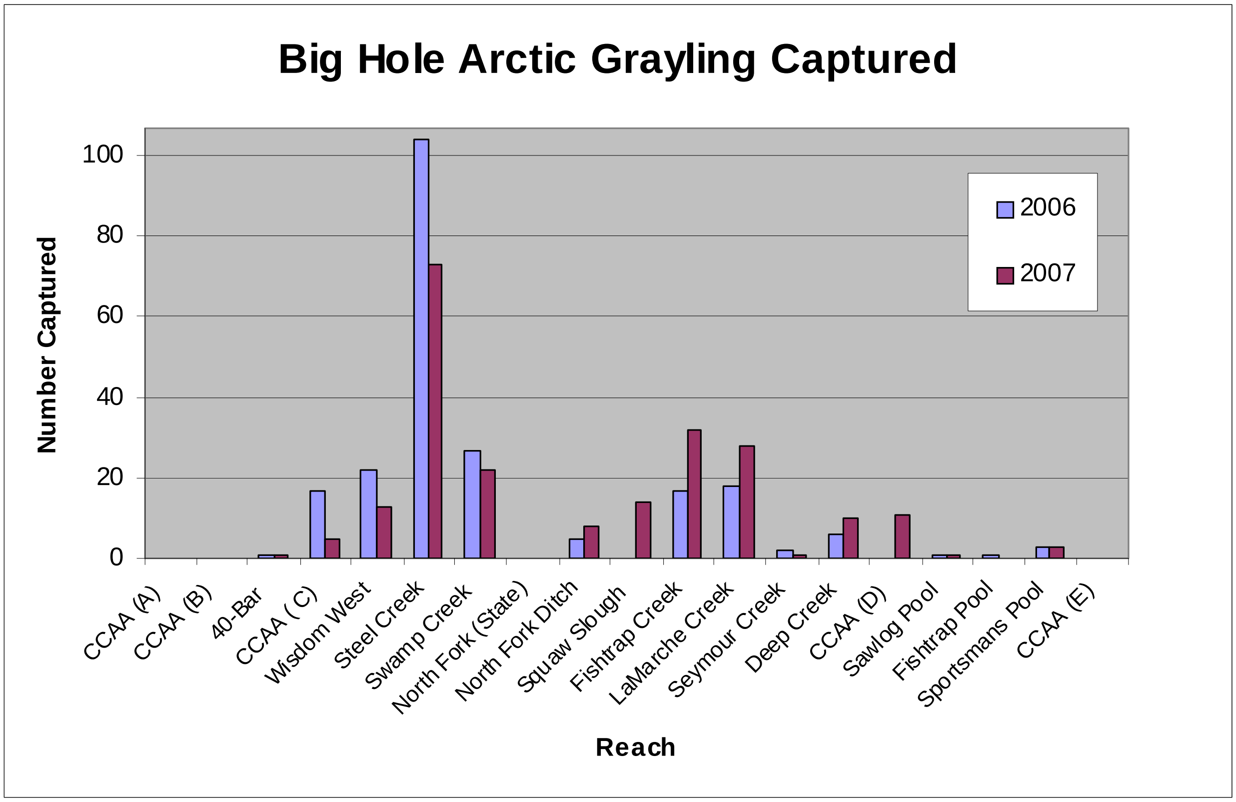


Figure 13. Catch per unit effort of Arctic grayling from fall 2006 and 2007 FWP electrofishing surveys.

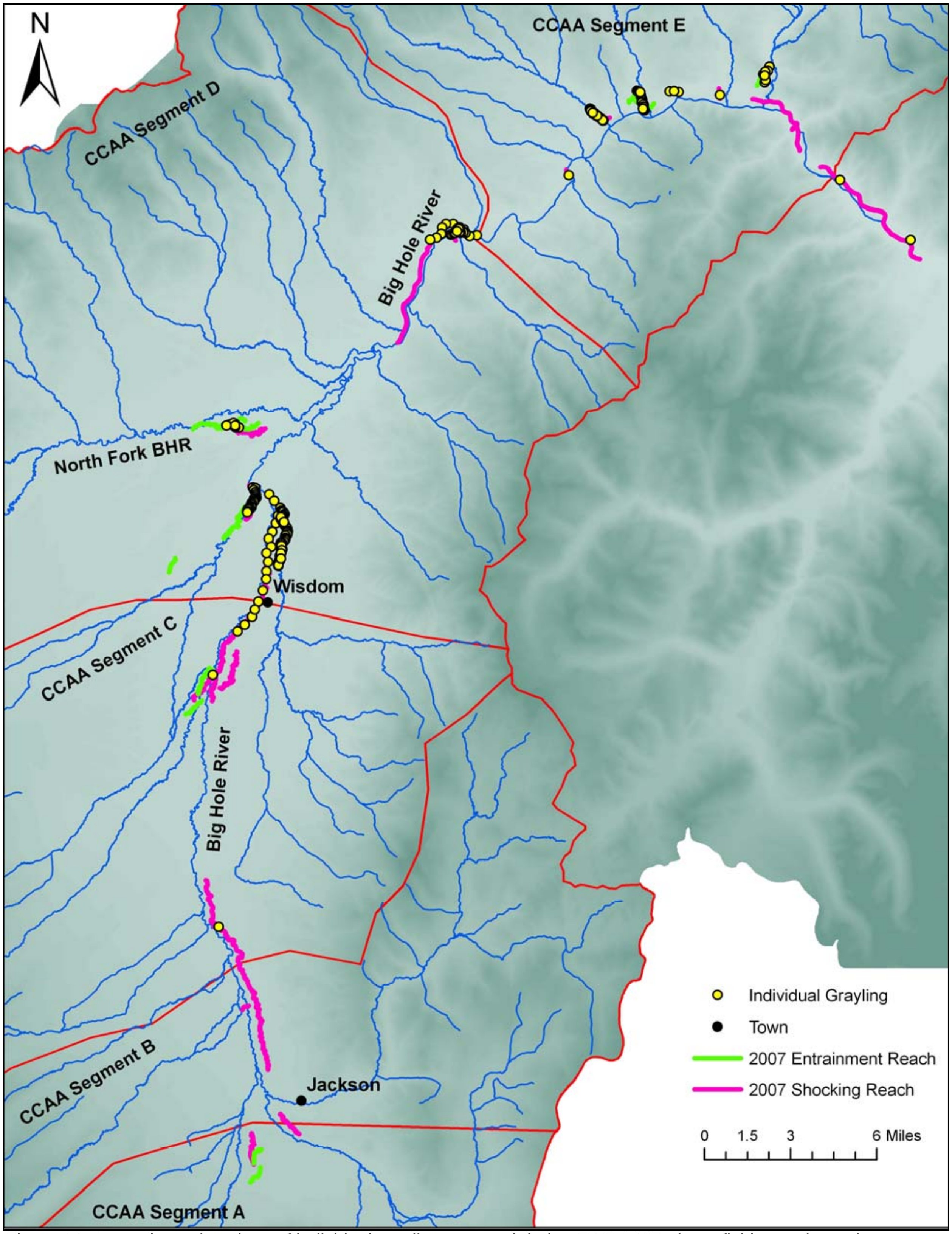


Figure 14. Approximate locations of individual grayling captured during FWP 2007 electrofishing and entrainment surveys.

Discussion

Conservation efforts continue to enhance grayling habitat in the Big Hole Drainage. Partnerships with landowners, agencies, non-government organizations, and special interest groups are instrumental to watershed restoration. The conservation projects developed through the CCCA and landowner site-specific plans are focused on improving stream function, riparian and channel health, instream flows, and fish passage, and reduce entrainment of grayling into irrigation systems. Cumulatively these actions will improve habitat and connectivity to benefit the Arctic grayling population. The Arctic grayling population abundance and age structure has been similar over the past few years with key reaches and tributaries providing habitat to sustain the grayling population and maintain recruitment. Progression of the conservation actions identified in the CCAA should improve habitat conditions that benefit the grayling population.

Reintroduction Efforts

Introduction

The long-term restoration goal for the Montana fluvial Arctic grayling is to establish additional populations within the species' historic drainages (Montana Fluvial Arctic Grayling Restoration Plan, 1995). The fluvial grayling brood program was developed to ensure that the genetic integrity of fluvial grayling was preserved, and to provide a source of grayling for restoration efforts. Three fluvial brood stock populations have been developed and are located at FWP Yellowstone River Trout Hatchery, Axolotl chain of lakes and Green Hollow II Reservoir. Reintroduction efforts were initiated in 1997 in the upper Ruby River and were expanded to the North and South forks of the Sun River in 1999, the lower Beaverhead River in 1999, and the Missouri River Headwaters in 2000. Due to drought conditions and limited resources, the Montana Arctic Grayling Workgroup in 2002 recommended focusing reintroduction efforts on the upper Ruby River, but to continuing other efforts as funding, workload and resources allow. In 2007, remote site incubators (RSIs) were used to release grayling into the North Fork of the Sun River and the upper Ruby River. FWP also continued to assess the limiting factors and survival of previous grayling RSI and stocking efforts. Specific objectives of the restoration efforts reported in this summary were to:

FWP personnel monitor RSI's setup in the upper Ruby drainage, MT.

- Monitor grayling brood stock populations at Axolotl Lake and Green Hollow II Reservoir, collect gametes and supplement the population with additional year classes as needed.
- Monitor abundance and distribution of planted grayling and potential competitors/predators at each of the restoration sites.
- Monitor to determine if natural reproduction of grayling has occurred at each of the restoration sites.

- Monitor physical factors such as stream flows and temperatures that may affect success of establishing grayling populations at each of the restoration sites.
- Continue to use RSIs in the Upper Ruby and North Fork of the Sun.
- Implement habitat enhancement projects in the Ruby drainage to address potential limiting habitat conditions.

Brood Program

The Arctic grayling brood reserves at the Axolotl chain of lakes and Green Hollow II Reservoir provide gametes that are developed to eyed-eggs, fingerlings, or yearlings for reintroduction efforts in streams or rivers in historically native drainages of fluvial Arctic grayling. These brood populations are sampled annually to estimate abundance, determine size structure, and conduct fish health testing and to collect gametes. Fyke nets, gill nets, and hook-and-line techniques are used to capture grayling. As per the FWP fish health protocol, grayling are tested for pathogens prior to being transported or planted into restoration streams. The Yellowstone River Trout Hatchery serves as an additional brood source and is also used to develop fertilized eggs collected from Green Hollow II and Axolotl Lakes.

Methods

Green Hollow II Reservoir Brood

The Arctic grayling brood reserve at Green Hollow II Reservoir was established in 1998 on Turner Enterprises' Flying D Ranch. This brood reserve has since been supplemented periodically with progeny of the fluvial grayling brood stock derived from Big Hole River grayling.

Pathogen testing ensures disease-free status of grayling broods

For fish health analysis on April 11, 2007, kidney samples were taken from forty-two grayling for pathogen testing. An additional eighteen grayling and four brook trout were tested for pathogens and ovarian fluids were taken from sixty grayling during gamete collection on May 9, 2007. Grayling captured for gamete collection were weighed, measured, and marked for population estimation. As grayling became ripe, they were sorted by sex and retained in separate live cars. Eggs were stripped from female grayling, pooled and fertilized with milt from multiple males. Spawned grayling were implanted with a VI tag so they may be identified in subsequent years and alternative individuals may be used to diversify the genetic pool. After fertilization, eggs were rinsed, packed in ice, and transported to FWP's

Yellowstone River Trout Hatchery. Stripped grayling were released back into the lake. Yellowstone River Trout Hatchery personnel assisted with gamete collection. To reduce the risk of Bacterial Kidney Disease (BKD), the FWP Fish Health Committee recommended that all captured eastern brook trout were removed from the lake during population surveys and gamete collection efforts.

Axolotl Lake Brood

The fluvial Arctic grayling brood reserve in Axolotl Chain of Lakes was established in 1989 and has been supplemented periodically with progeny of the fluvial grayling brood stock derived from Big Hole River grayling.

Montana Arctic grayling from Axolotl fluvial brood population.

For fish health analysis, kidney samples were taken from sixty grayling on April 17, 2007, and ovarian fluids were taken from sixty spawned grayling on May 16, 2007. Grayling captured for gamete collection were weighed, measured, and marked for population estimation. As grayling became ripe, they were sorted by sex and retained in separate live cars. Yellowstone River Trout Hatchery personnel assisted with the egg collection. Eggs were stripped from female grayling, pooled, and fertilized with milt from multiple males. Spawned grayling were implanted with a VI tag so they may be identified in subsequent years and alternative individuals may be used to diversify the genetic pool. After fertilization, eggs were rinsed, packed in ice, and transported to Yellowstone River Trout Hatchery. Stripped grayling were then released in to the lake.

Results

Green Hollow II Reservoir Brood

All grayling and trout samples submitted for disease analysis tested negative for pathogens. FWP captured 565 grayling for gamete collection and population abundance estimates. The mean length for captured grayling was 11.27 inches. Partial Log Likelihood (FWP FA+ 2008) analysis estimated abundance as N = 1,525 (±229). We spawned 121 females and collected approximately 165,000 eggs. Fecundity averaged 1,363 eggs per female. Gamete viability was exceptional for Green Hollow II Reservoir at 85% eye-up of fertilized eggs. On May 18, approximately 42,000 eyed-eggs were transported from Yellowstone River Trout Hatchery to the upper Ruby River to support RSI efforts. The remainder of the eggs collected during spawning were used to supplement the Yellowstone Trout Hatchery brood population. A total of four brook trout were removed from the lake during spawning activities. No hatchery-reared grayling were used to supplement the Green Hollow II Lake population in 2007.

Axolotl Lake Brood

All samples taken for disease analysis tested negative for pathogens. On May 15 and 16, FWP crews capture 515 Arctic grayling for gamete collection. Average length for all grayling captured was 11.97 inches. FWP spawned 103 females and collected approximately 166,000 eggs. Due to the increasing presence of larger, older fish, the average fecundity has increased dramatically over the past five years from 419 eggs per female in 2002 to 1,611 eggs per female in 2007. Fertilized eggs were taken to Yellowstone River Trout Hatchery for development to eye-up. Gamete collection probably occurred after the peak spawning period, and eggs were over-ripe resulting in poor eye-up (only 40%). On May 25, 44,800 eggs were transported to the upper Ruby River to support RSI efforts; however, poor viability resulted in very low numbers of emerging fry. The remainder of the eggs were sent to the North Fork Sun River to support RSI efforts. No hatchery-reared grayling were used to supplement the Axolotl Lake population in 2007.

Discussion

In 2007, gametes from the brood populations were used in reintroduction efforts in the Upper Ruby and North Fork of the Sun River. While Green Hollow II eye-up at 85% resulted in successful production of fry for the upper Ruby system, poor viability from the Axolotl brood limited the success in RSIs in the upper Ruby and of reintroduction efforts into the Sun River. As the grayling in both Green Hollow and Axolotl brood lakes have matured, the average fecundity has increased substantially, thereby increasing the number of eyed-eggs available for hatchery stocking and RSI efforts. Maintaining the disease-free status of our brood populations has allowed us the continued opportunity to utilize grayling from the brood populations for restoration efforts.

Upper Ruby River Reintroduction Efforts

Methods

Water Temperature and Stream Discharge

Stream flows are monitored annually at the USGS gauge station just upstream from Ruby Reservoir (Figure 15). Additionally, two continuous stage-recording instruments (AquaRods) were used to record pre- and post-projects flow data on Lazyman Creek (Figure 15). Water temperature was monitored at Sweetwater, Canyon, Warm Spring Creek, Vigilante, Three Forks, Middle Fork, East Fork, West Fork, Lazyman Creek, and Willow Creek (Figure 15). Onset Water Temp Pro v2 ™ thermographs were used to record temperatures at 60-minute intervals. Data were downloaded into Microsoft Excel and analyzed to determine daily maximum, minimum, and average temperatures.

Arctic grayling RSI and Stocking Efforts

Arctic grayling reintroduction efforts began in the upper Ruby River in 1997. The reintroduction reach includes the Ruby River and its tributaries upstream of Ruby Reservoir (Figure 15). Age-1 and 2 hatchery reared fluvial Arctic grayling were planted annually from 1997-2004. RSIs have been used to produce grayling fry that have been incubated under the natural selective mechanisms of the stream system since 2003. RSIs became the sole means of introducing grayling in to the system in 2005. This technique has proven successful at producing fry, and will potentially produce mature grayling that return to natal streams to spawn.

Population Monitoring

In order to assess distribution, abundance, and population demographics of stocked, RSI, and potentially naturally reproduced grayling, FWP completed electrofishing surveys in two reaches of the upper Ruby River in April 2007 and eight reaches in October and November 2007. Survey reaches were distributed from Ruby Reservoir upstream to Divide Creek. Spring surveys included the Culvert section and the Shovel Creek section (Figure 16). Ice conditions and spring runoff limited the number of surveys conducted in the spring. Fall surveys were completed on Upper Letterman, Canyon, Vigilante, Three Forks, Lazyman Creek, Willow Creek, Middle Fork-Pete's Creek section, Culvert section, and Corral Creek sections (Figure 16). The Willow Creek and Lazyman Creek sections were completed in part for pre- and post-habitat improvement project monitoring. Electrofishing data were entered and summarized with Fisheries Analysis + 1.2.7 (Montana Fish, Wildlife & Parks 2007). Density estimates are reported as number of fish per mile with the standard deviation in parentheses. Catch-per-unit-effort (CPUE) for all age classes is reported as number of fish captured per mile. CPUE was used to show trends of grayling population abundance and spatial distribution. Length–frequency histograms were used to summarize population age structure. Mark-recapture estimates were completed for the Vigilante, Canyon, and Three-Forks sections in fall 2007.

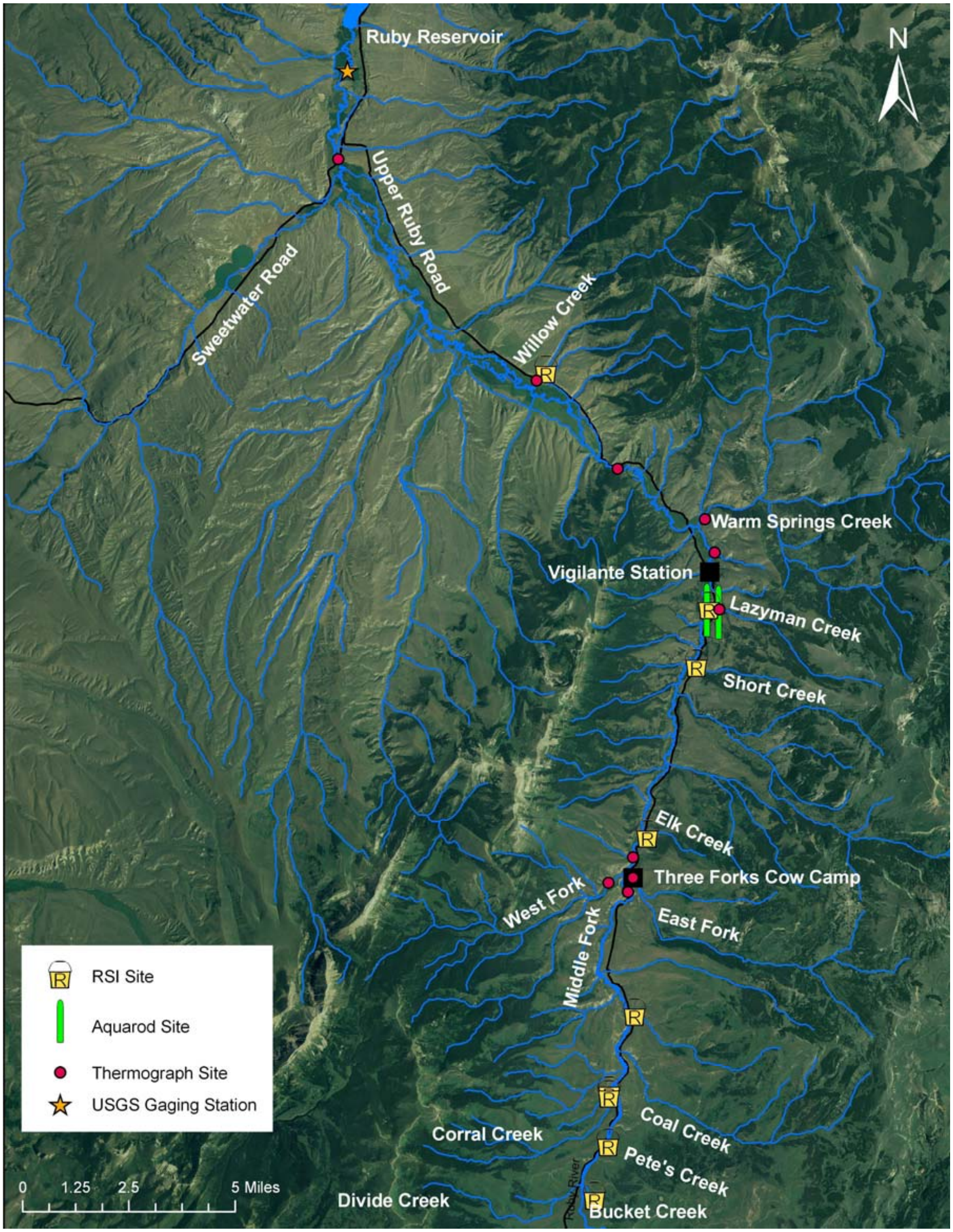


Figure 15. Upper Ruby River 2007 RSIs, Aqua Rod and thermograph locations and the USGS flow gauging station located upstream from the Ruby Reservoir.

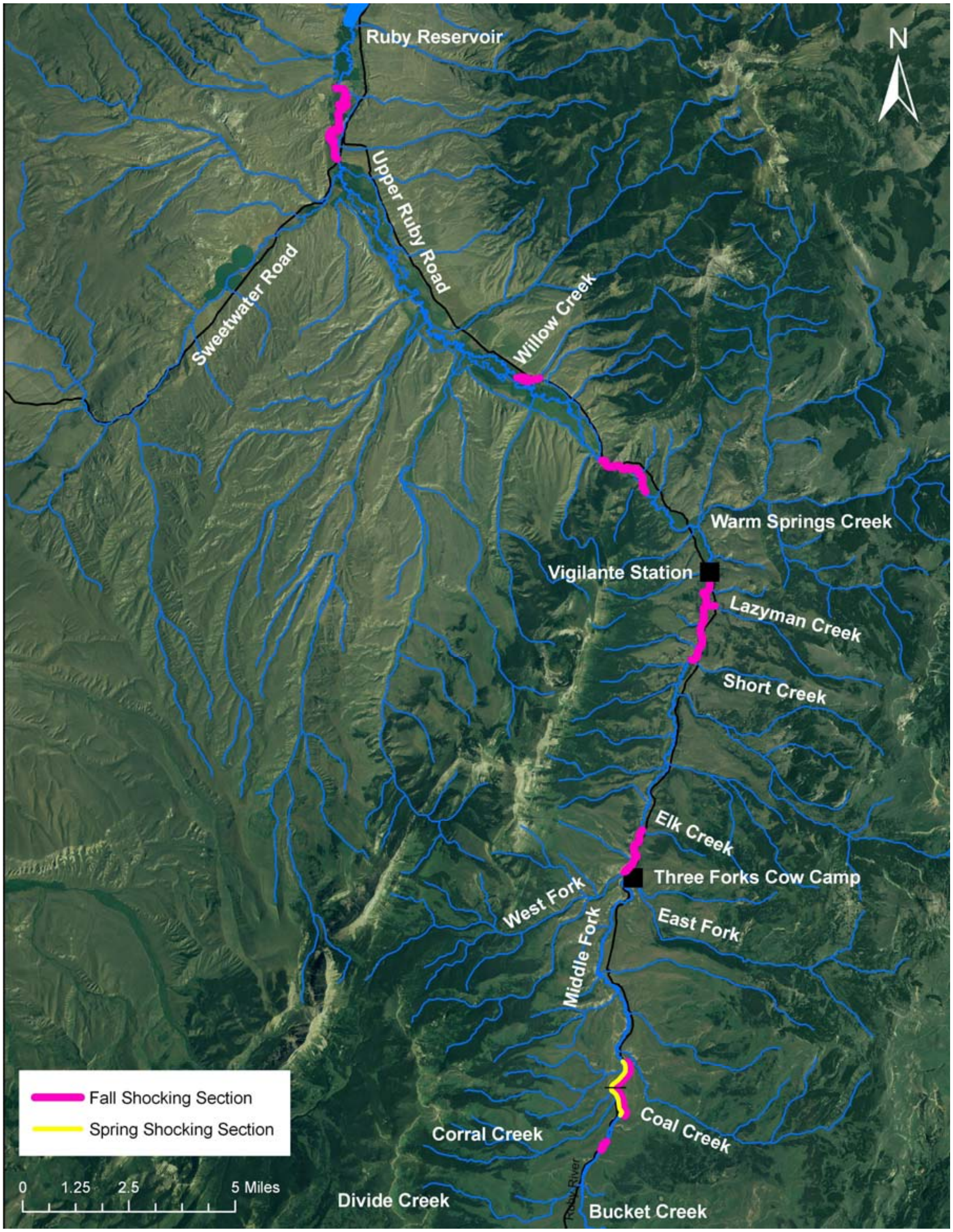


Figure 16. Upper Ruby River Arctic grayling reintroduction reach from Ruby Reservoir upstream to the headwaters and tributaries and FWP 2007 spring and fall electrofishing reaches.

Results

Water Temperatures and Stream Discharge

Maximum, minimum, and average daily temperatures were calculated for East Fork, West Fork, Middle Fork, Three Forks, Vigilante, Canyon, Willow Creek, and Lazyman Creek sites. Daily maximum temperatures were coolest in Willow Creek, a newly restored tributary to the Ruby River. Highest maximum instream temperatures were found at the Canyon site in part due to input from Warm Springs Creek (Figure 17). Warm Springs Creek enters the Ruby River just downstream of Vigilante Station and has an annual mean daily temperature of 68ºF. Daily maximum stream temperatures in the upper Ruby River typically peak in mid-July and August, and decrease in mid-August due to cooler air temperatures and decreasing day length. Maximum temperatures in 2007 occurred on July 22 for most thermograph sites (Figure 17). Temperatures exceeded the upper incipient lethal temperature (77°F; Lohr et al. 1996) for grayling at the Middle Fork (41 hours), Three Forks (56 hours) and Canyon sites (160 hours) (Figure 17). Early spring flows were near or above the long-term average but declined throughout the summer. March was 124%, April 102%, May 81%, June 38%, July 52% and August 67% of the long-term average (Figure 18). The lowest mean daily flow was 75 cfs on August 28, and the highest mean daily flow was 594 cfs on May13, 2007.

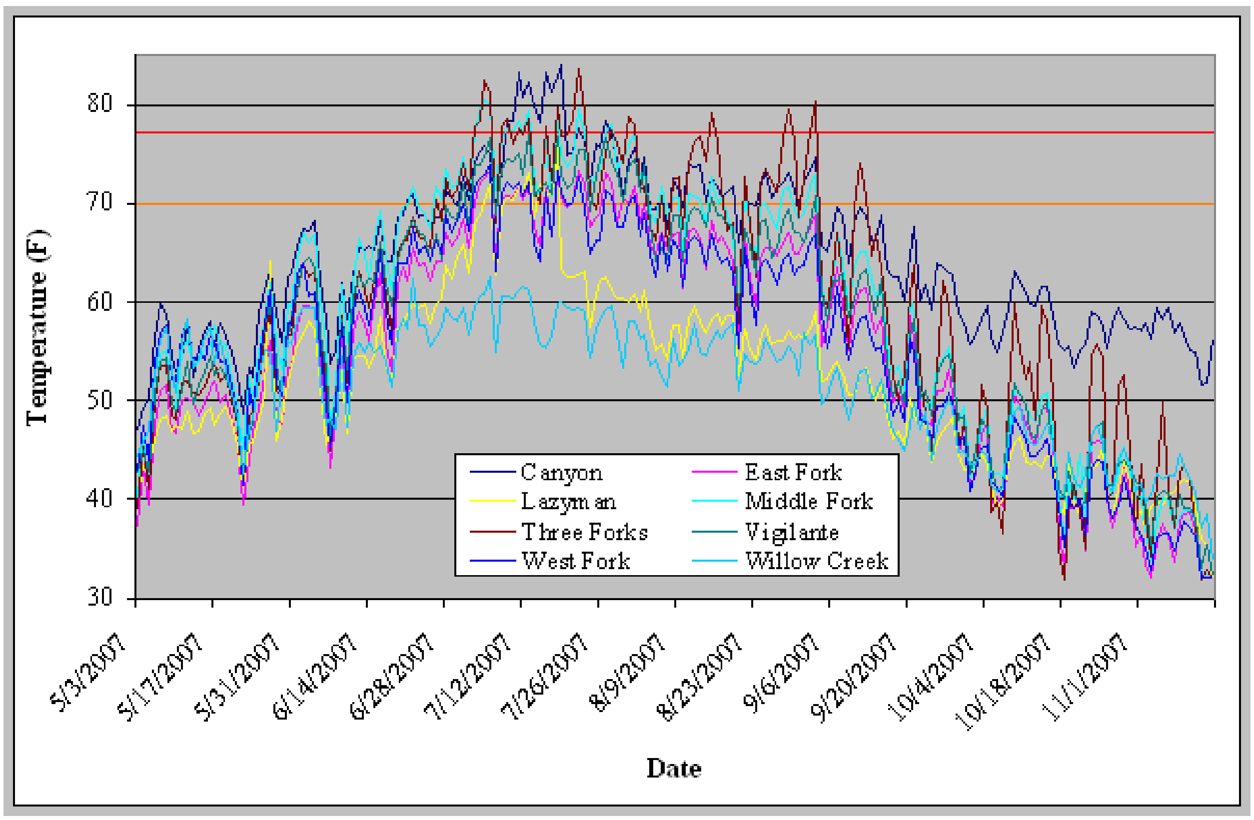


Figure 17. Maximum daily temperatures recorded for thermograph sites in the upper Ruby drainage. The orange line at 70ºF represents the thermal stress threshold for grayling, and the red line at 77ºF represents the upper incipient thermal threshold for grayling.

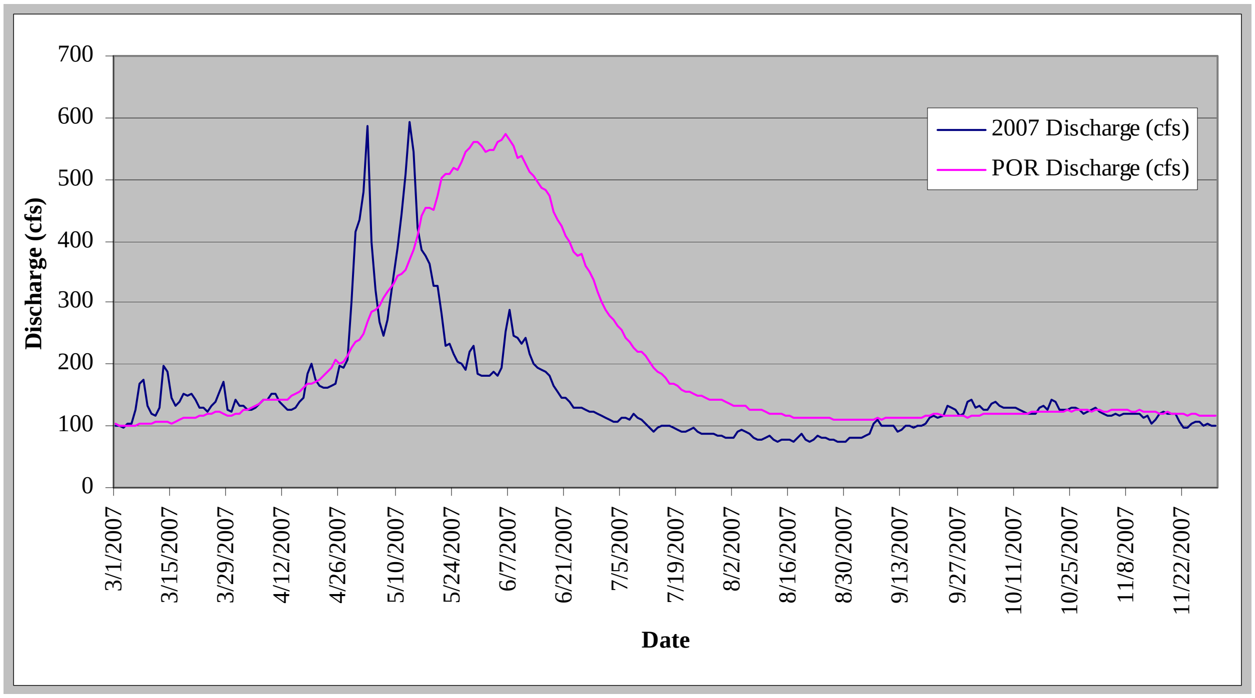


Figure 18. Mean daily flow discharge (cfs) for 2007 and the long-term average for the period of record at the USGS Alder gauge upstream from Ruby Reservoir (data are provisional).

Arctic grayling RSI and Stocking Efforts

On May 18, 2007, eyed-eggs from Green Hollow II brood population were distributed in thirty RSI's at nine locations in the upper Ruby River, with most fry emerging from each incubator by May 25. A second batch of eyed-eggs from Axolotl brood pond was distributed in seven RSI's at four locations on May 25, with all fry emerging at all sites by June 19 (Figure 15). Very few fry were produced from the second batch of RSI's due to poor egg viability. Each RSI received approximately 1,400 eggs. Grayling YOY produced from RSI and/or natural recruitment captured during fall 2007 surveys ranged from 3.1 – 6.0 inches (Figure 19). The majority of grayling inhabiting the Ruby River are from either RSI efforts or natural recruitment. Grayling present from stocking efforts are age-4 or older.

Population Monitoring

Electrofishing surveys were completed in two reaches in the spring and eight reaches in the fall to assess previous plant survival, RSI fry production, distribution, abundance, and population demographics. Spring surveys were limited because of the short time frame between ice-off and high spring flows. Highest densities of grayling for both spring and fall were found in the Culvert section of the Middle Fork. This reach had thirteen RSIs at four sites located in the general vicinity of this electrofishing survey (Figure 15 & 16). As result 86% of grayling captured in this reach in 2007 were young-of-the-year. Fall 2007 mark-recapture grayling estimates (reported as the number of grayling per mile with standard deviation in parentheses were 9 (±3.2) grayling per mile in the Canyon section, 50 (±6.7) grayling per mile in the Vigilante section, and 18 (±1.1) grayling per mile in the Three-Forks section.

Young-of-the-year grayling captured during fall population surveys in 2007 (n = 88) increased considerably from fall surveys in 2006 (n =12) with similar sampling efforts (Figure 19). These grayling may have been produced from RSIs or from natural recruitment. Both YOY and age 1+ grayling were primarily captured in the reaches upstream of Warm Springs Creek with the highest densities in the Culvert section (Figure 21). No grayling were found downstream of the Canyon Section. Brown trout were primarily found in the lower reaches (downstream of Warm Springs Creek) and no brown trout were captured upstream of the Vigilante section (Figure 20). Hybrid rainbow-cutthroat trout were most abundant between the Canyon and Three Forks sections and decreased up and downstream from these reaches (Figure 20).

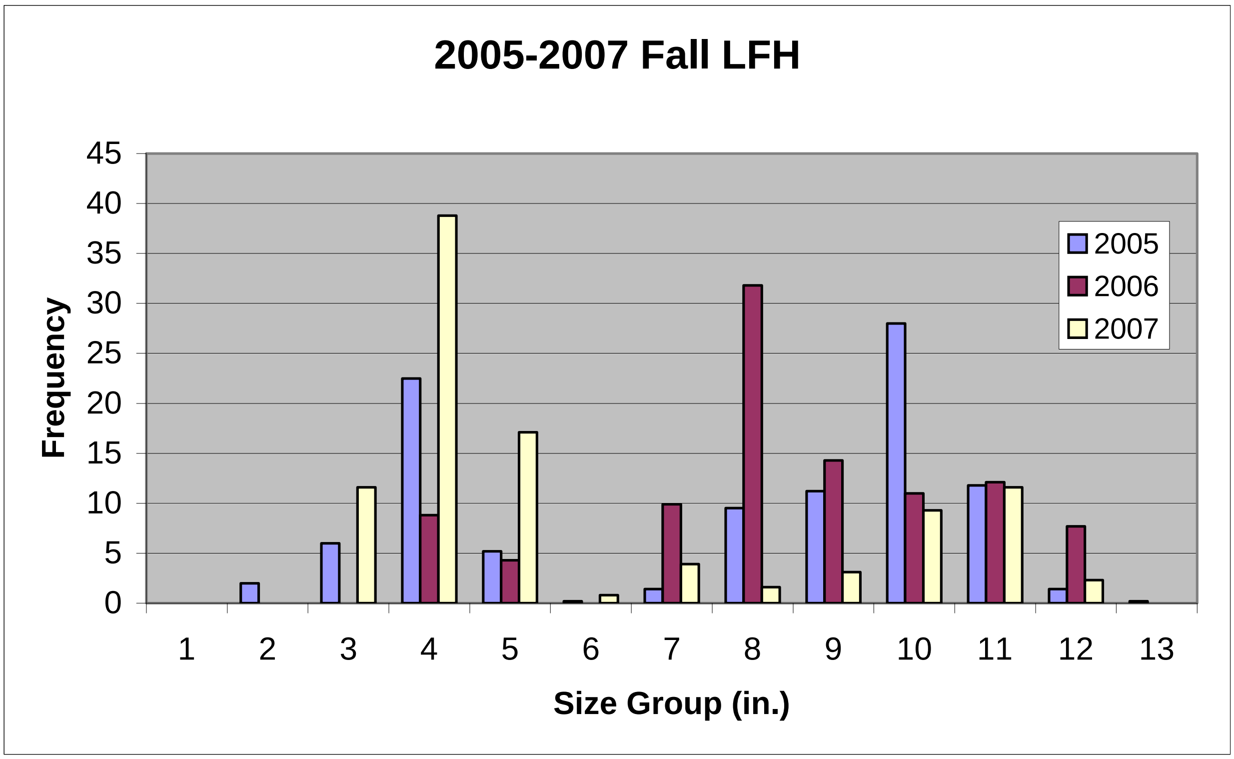


Figure 19. A length frequency histogram for grayling captured in the Ruby River in the fall of 2005-2007.

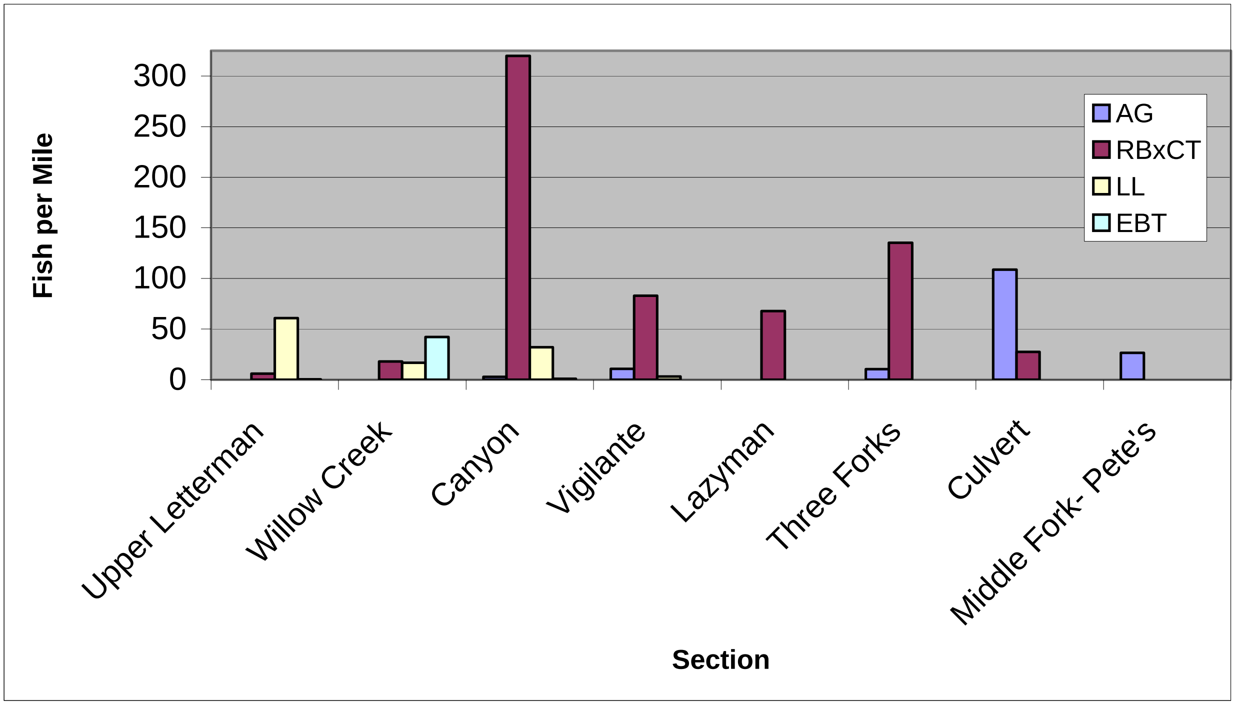


Figure 20. Species distribution and abundance in FWP electrofishing reaches surveyed during fall 2007 in the upper Ruby River.

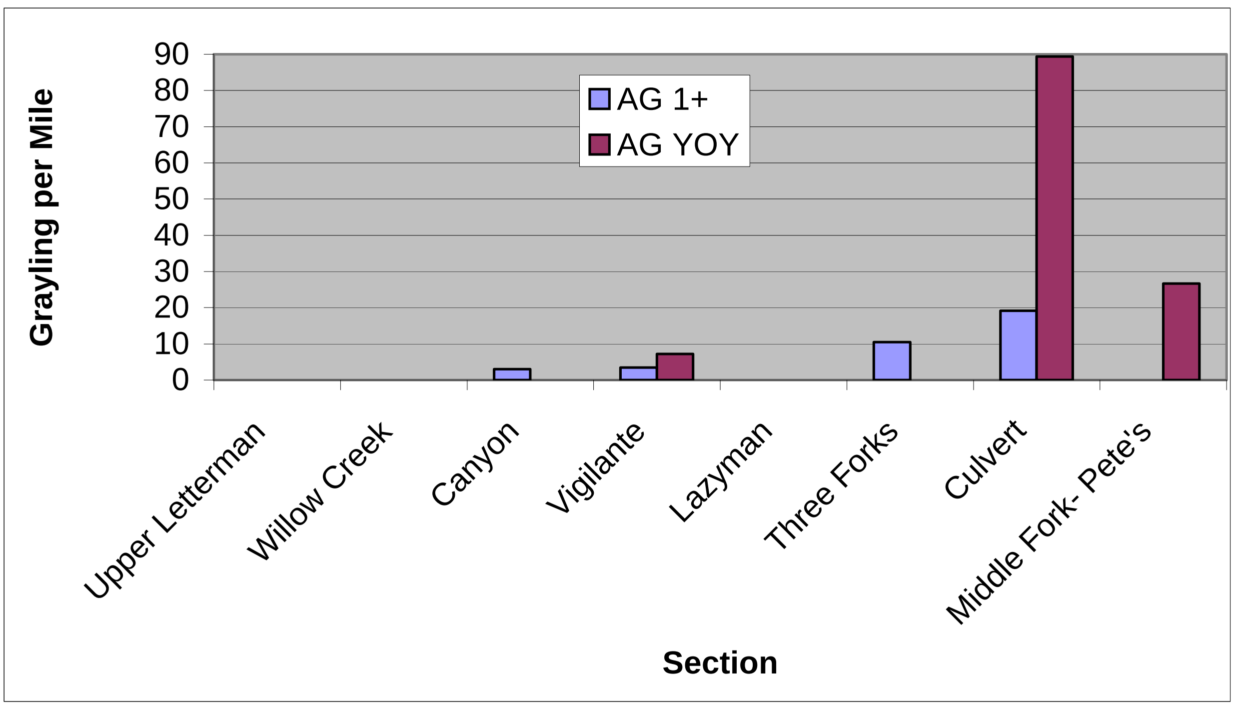


Figure 21. Distribution of age one and older (1+) and young-of-the-year (YOY) Arctic grayling (AG) grayling captured during FWP electrofishing surveys in fall of 2007 in the upper Ruby River.

Habitat Improvement Projects

Several habitat improvement projects on the upper Ruby River and tributaries have been completed since 2006 (Figure 22). The purpose of these projects was to address the potential limiting habitats for grayling including high quality pools and spawning and rearing habitats.

Willow Creek Restoration Project

In 2006, the Willow Creek Channel Restoration Project was completed. This project involved relocating Willow Creek back into its historical channel, which increased channel length three-fold and created quality fish habitat. The restored section of the creek was sampled in the fall of 2006 and 2007 with a backpack electrofishing unit to determine species composition, abundance, and project success. No grayling were captured in either year; however, native species include mottled sculpin and mountain whitefish, and non-native species including brown trout, rainbow hybrids, and brook trout were captured during surveys (Figure 23). Various sizes (ranging from 2.0 –12.8 inches) of each fish species were captured indicating spawning and juvenile rearing habitat conditions are favorable.

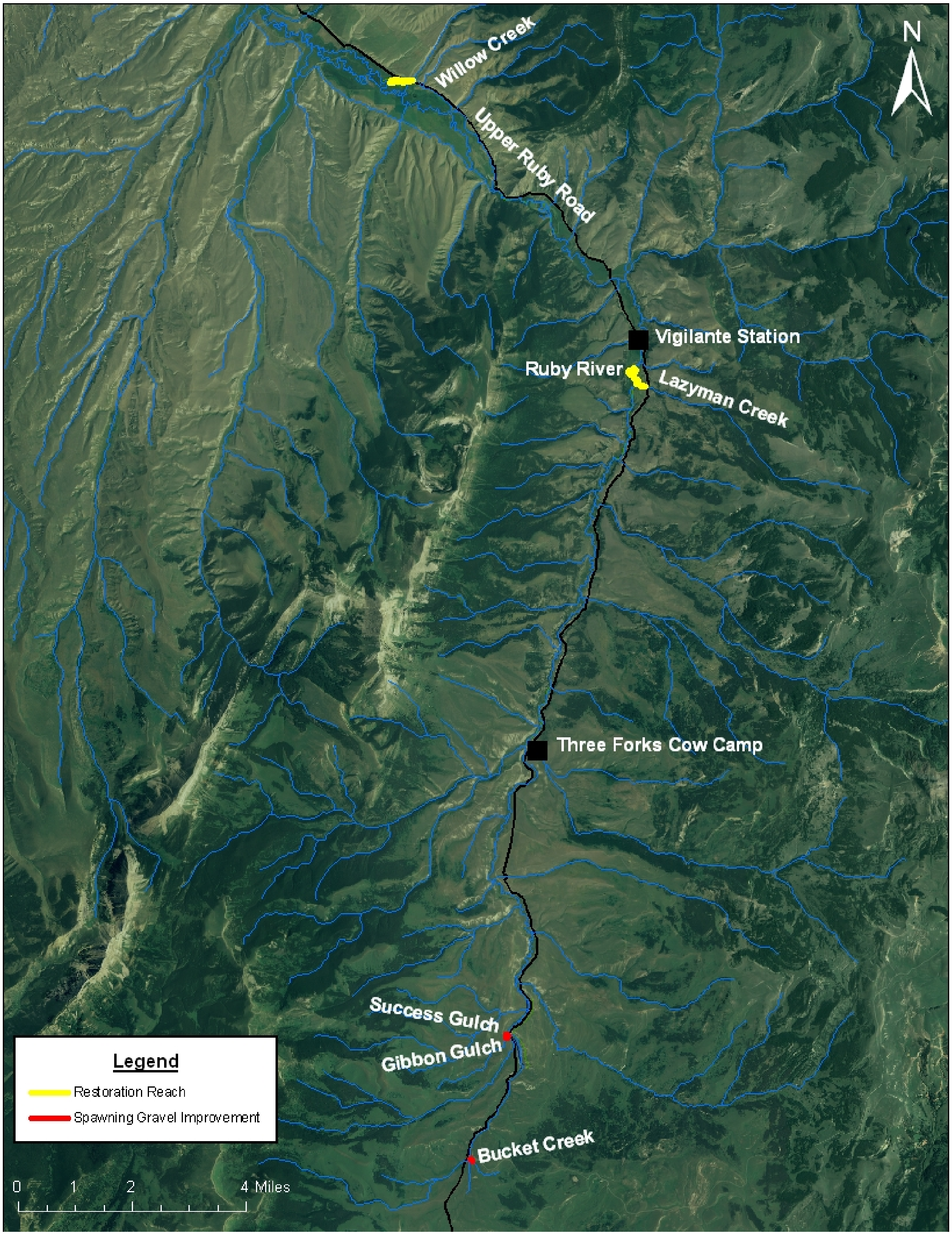


Figure 22. Location of restoration and spawning gravel improvement projects in the upper Ruby drainage in 2007.

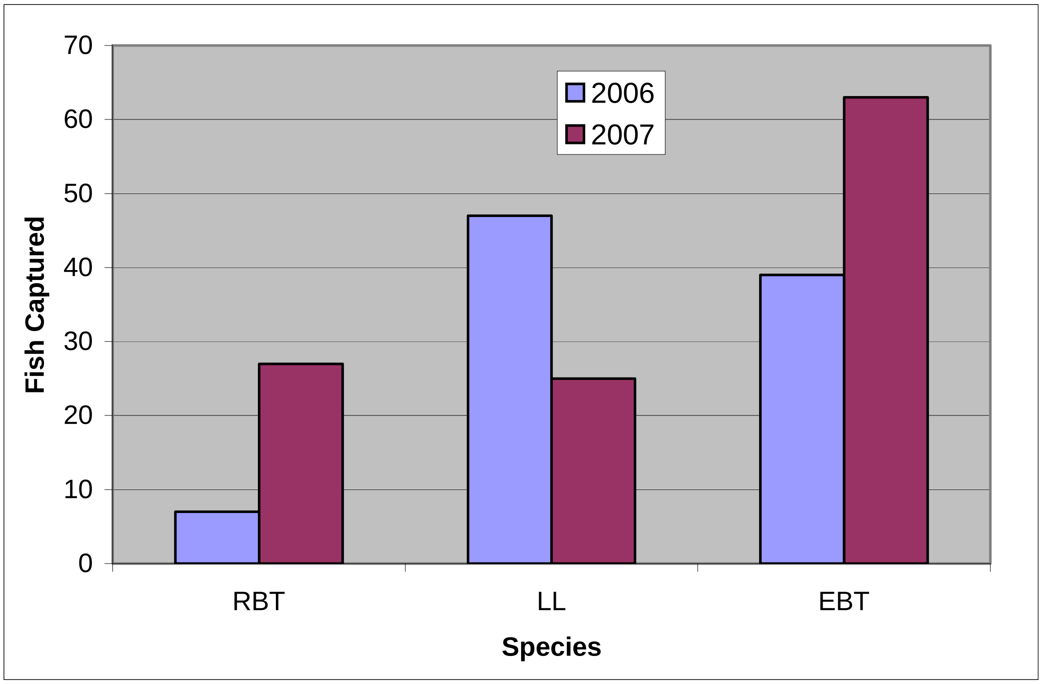


Figure 23. Numbers of rainbow trout, (RBT) brown trout (LL) and eastern brook trout (EBT) captured in 2006 and 2007 in the newly restored Willow Creek channel.

During fall 2007, a project was completed in three small tributaries in the upper Ruby River drainage to enhance spawning habitat (Figure 22). These tributaries have adequate stream flow, minimal sediment input and have been used to successfully incubate grayling eggs using RSI's; however, spawning gravels at these sites were either insufficient or absent. The expectation is that mature grayling will be able to spawn and imprint juveniles to these sites. Between 10-20 square feet of spawning size gravel was installed at each site. Gravel was stabilized using low-head log structures or rock weirs at the downstream end of the target reach. Sedge plugs were planted at one site to maintain channel function and allow fish passage during low flows.

Spawning site constructed in tributaries in the upper Ruby River.

In 2007, a project was completed on Lazyman Creek to create functional spawning and juvenile rearing habitat. The project also repaired an incised channel by re-sloping streambanks to allow flows access to the floodplain. Riparian vegetation and bank stabilization were improved by transferring sod mats, mature willows and mature Juniper trees, which were pinned horizontally on outside banks for increased stabilization. Base flows will be maintained through a water-right leasing agreement with the private landowner to ensure the projects success. RSIs were used in Lazyman Creek in 2006 and 2007 and will be used in 2008 to potentially imprint grayling to Lazyman Creek.

Re-sloping banks on Lazyman Creek allow flows to access the floodplain

Juvenile rearing habitat constructed on the Lazyman Creek project.

A project was also completed on the main stem of the Ruby River, downstream from its' confluence with Lazyman Creek (Figure 22). Nine pools of varying volume, instream complexity, and overhead cover were excavated to create adult pool habitat. This project includes stabilizing and revegetating eroding and trampled banks to reduce sediment inputs to the river. In 2008, pools will be sampled during spring and fall population monitoring to determine grayling use. Cross sections will be measured annually to assess changes in pool volume and channel shape. Project monitoring results and outcomes will be used to guide future river restoration efforts on the Ruby River.

Bank stabilization techniques were implemented on a reach of the upper Ruby River.

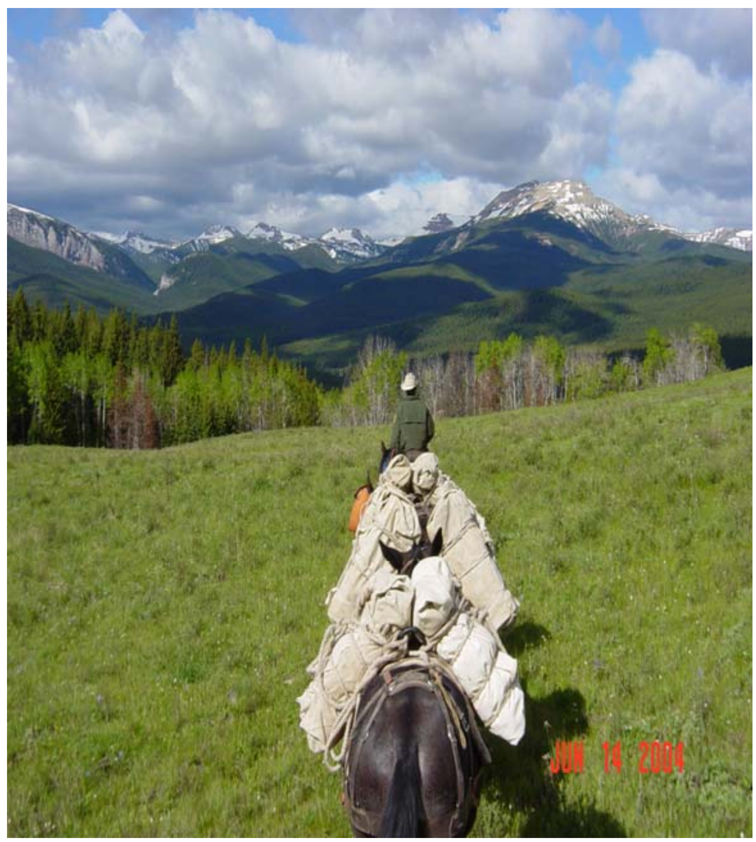
Discussion

Natural reproduction from stocked grayling captured in 2000 and 2002, indicate that at least some spawning habitat is available and that grayling can successfully spawn and survive in the upper Ruby River. Over the past five years RSI techniques and egg availability have improved, thereby increasing the annual numbers of grayling fry developed in the upper Ruby River. Population demographics have shifted since 2005 (when RSI's became the sole means for grayling introduction) from predominantly age 2+ grayling to a better distribution of age groups including increased numbers of YOY or age 1 grayling. The increase in numbers of YOY grayling captured can be attributed to RSI efforts but also may be from the spawning efforts of stocked grayling from 1997-2004 or grayling produced from RSIs since 2003. Young-of-the-year and age-1 grayling are distributed from Divide Creek to Vigilante Station (approximately 23 miles) indicating that rearing habitat is available at some level in this reach. However, the majority of the YOY grayling were captured upstream of Coal Creek where other native and non-native fish species are less abundant and the potential for inter-specific competition or predation is limited. Abundance of grayling in upper reaches may also be attributed to a healthy riparian corridor and numerous beaver ponds that provide quality winter habitat for both YOY and older grayling. In 2008, FWP will expand RSI efforts to encompass other areas in the upper Ruby River drainage, and hopefully increase densities in lower reaches. Ideally, dispersing RSIs in areas with potential spawning habitat will imprint developing fry to return to these reaches to spawn when they mature. The short -term goal is to establish a balanced age structure with multiple age classes and then determine if grayling can sustain a population without supplementation.

Sun River Reintroduction Efforts

Methods

Sun River reintroduction efforts in the North and South Forks began in 1999. A total of 34,500 age-1 grayling were stocked from 1999-2001. In 2004 and 2005, RSIs were used to hatch grayling fry in the North Fork of the Sun River (Figure 24). Due to poor egg viability in spring 2006, RSIs were not used. In 2007, RSI reintroduction efforts continued in the North Fork Sun River using eggs collected from the Axolotl Brood population. Twenty RSI's were used to incubate grayling eggs at two sites in the North Fork drainage.



Horses and mules are used to pack grayling eggs to RSIs in the North Fork of the Sun River.

A combination of electrofishing, angling, tagging and snorkeling methods were used to assess overall population demographics, distribution, survival and to determine if natural recruitment has occurred. In June 2007, electrofishing surveys were conducted on the North and South Fork of the Sun River immediately upstream of Gibson Reservoir, and on Big George Creek and Lange Creek, tributaries to Gibson Reservoir, to determine if grayling were moving from the reservoir into the tributaries to spawn

(Figure 24). Bi-annual population estimates were conducted on the North Fork near its' confluence with Circle Creek via angling, tagging and snorkeling. Hoop traps were also set at two locations in Gibson Reservoir.

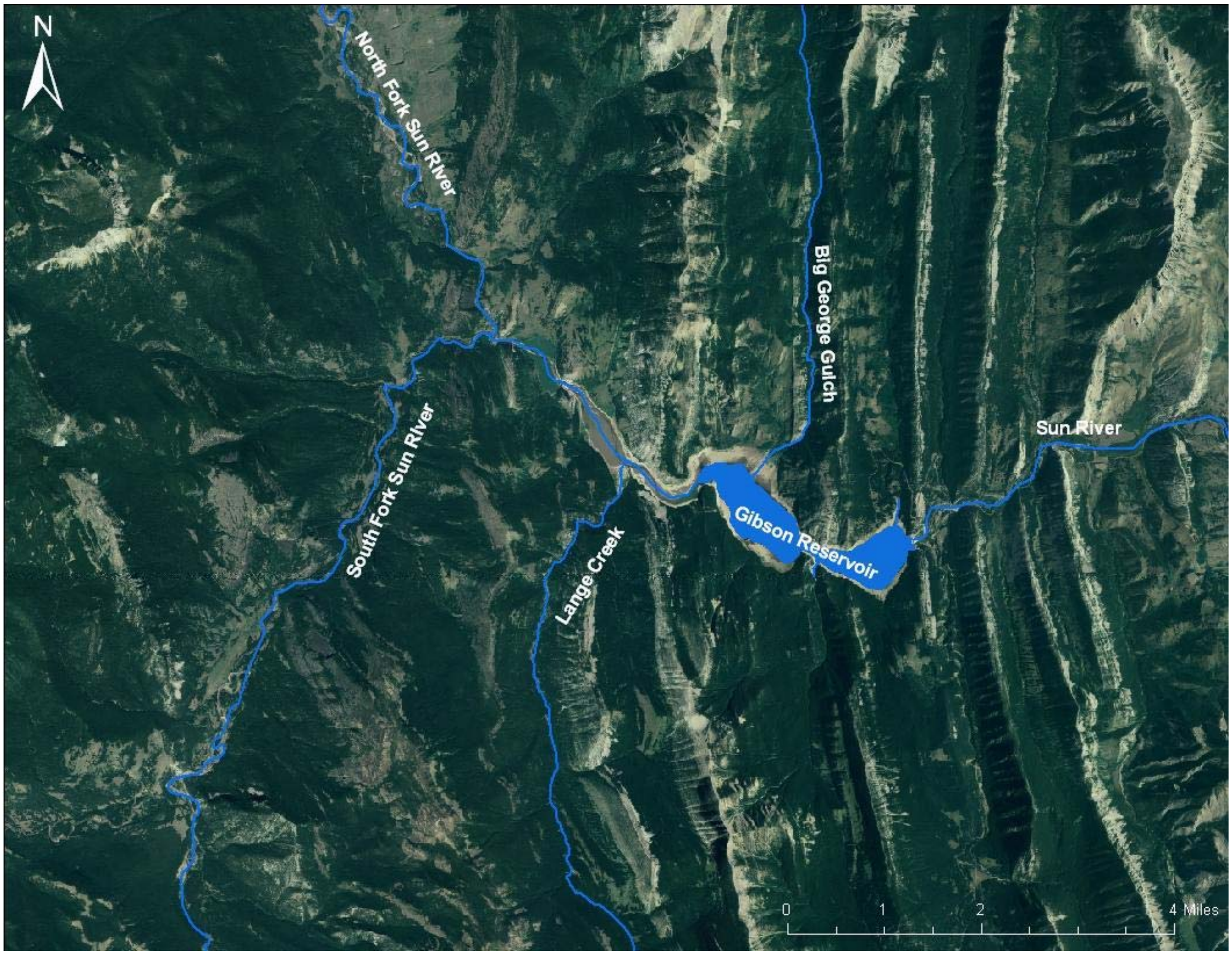


Figure 24. Gibson Reservoir and tributaries (North Fork, South Fork, Lange Creek and Big George Creek) that were sampled by FWP in the spring of 2007 by electrofishing, angling, trapping or snorkeling.

Results

On May 24, 2007 grayling eggs collected from the Axolotl Brood population were distributed into twenty RSI's at two sites in the North Fork of the Sun River. Viability of fertilized eggs was limited (40% eye-up at Yellowstone Trout Hatchery) and continued to decline throughout the RSI incubation period. RSI's were monitored until June 14; during this period no egg development or fry production was observed.

No grayling were captured during electro- fishing surveys in the North Fork, South Fork, Big George or Lang Creeks. One 9.2-inche grayling was captured in a hoop trap net set in Gibson Reservoir.

Discussion

RSI efforts in the North Fork of the Sun River were unsuccessful in 2007 due to poor egg viability. Twenty to twenty-five RSI's will be used in 2008 for continued grayling reintroduction efforts in the North Fork of the Sun River. Although no grayling were captured during electrofishing surveys in tributaries to Gibson Reservoir in 2007, age-1 and adult grayling were captured in the mouth of the South Fork of the Sun River in 2006, which indicates either natural reproduction is occurring, or RSI produced grayling are moving downstream. Future sampling will be necessary to identify additional natural recruitment and investigate life history behaviors. (fluvial\adfluvial)

Sunny Slope Canal

Introduction

The Sunny Slope Canal is the major water source for the Greenfield Irrigation District located in Teton and Cascade Counties, Montana. The canal originates at Pishkun Reservoir, which was stocked with 330,000 grayling from 1937- 1943 (Barndt 1996; Figure 18). Poor stocking records do not indicate the exact source of these grayling; however, they were likely derived from the Madison/Ennis grayling (Barndt 1996). Grayling were able to migrate into the Sunny Slope Canal through the reservoir outlet, and were first documented in the canal in the early 1940s (Barndt 1996). Arctic grayling have disappeared from Pishkun Reservoir; however, they have established a self-sustaining population in Sunny Slope Canal. To protect this population from potential predators moving into the Sunny Slope Canal, the reservoir outlet was fitted with a 2.5-cm mesh fish screen that inhibits fish movement from the reservoir to the canal. The grayling population exists in a five-mile section of the Sunny Slope Canal that has contrasting flow conditions. During irrigation from May through September maximum flows reach 1,680 cfs (Barndt 1996). From September through May, the canal is dewatered, and the only remaining water is in intermittent pools extending from the dam 3.5 miles downstream and in pools located at the base of concrete flumes found further downstream (Figure 18).

Male grayling captured in Upper Turnbull drop pool

Monitoring Efforts

The Sunny Slope Canal grayling population exists in a five-mile section of canal immediately downstream of the reservoir outlet. Telemetry studies indicate that many grayling move downstream during summer flows and are present in the pools below drop structures when flows cease (Barndt 1996). These drop structures are impassable to upstream movement by fish; therefore, grayling trapped in these pools are lost to the population. Starting in 1985, FWP has relocated grayling captured in drop pools to Tunnel Lake, located four miles from Pishkun Reservoir (Figure 25). In 2008, Tunnel Lake will undergo a rotenone treatment to remove an over-abundance of white suckers that may be inhibiting the success of other species. After detoxification, Tunnel Lake will be stocked with westslope cutthroat trout and will continue to harbor grayling rescued from the drop pools in the Sunny Slope Canal. In 2007, no sampling took place in the Sunny Slope Canal due to time constraints and plans for treating Tunnel Lake. Visual observations of the Turnbull drop pools were made during the first week of October finding no grayling.

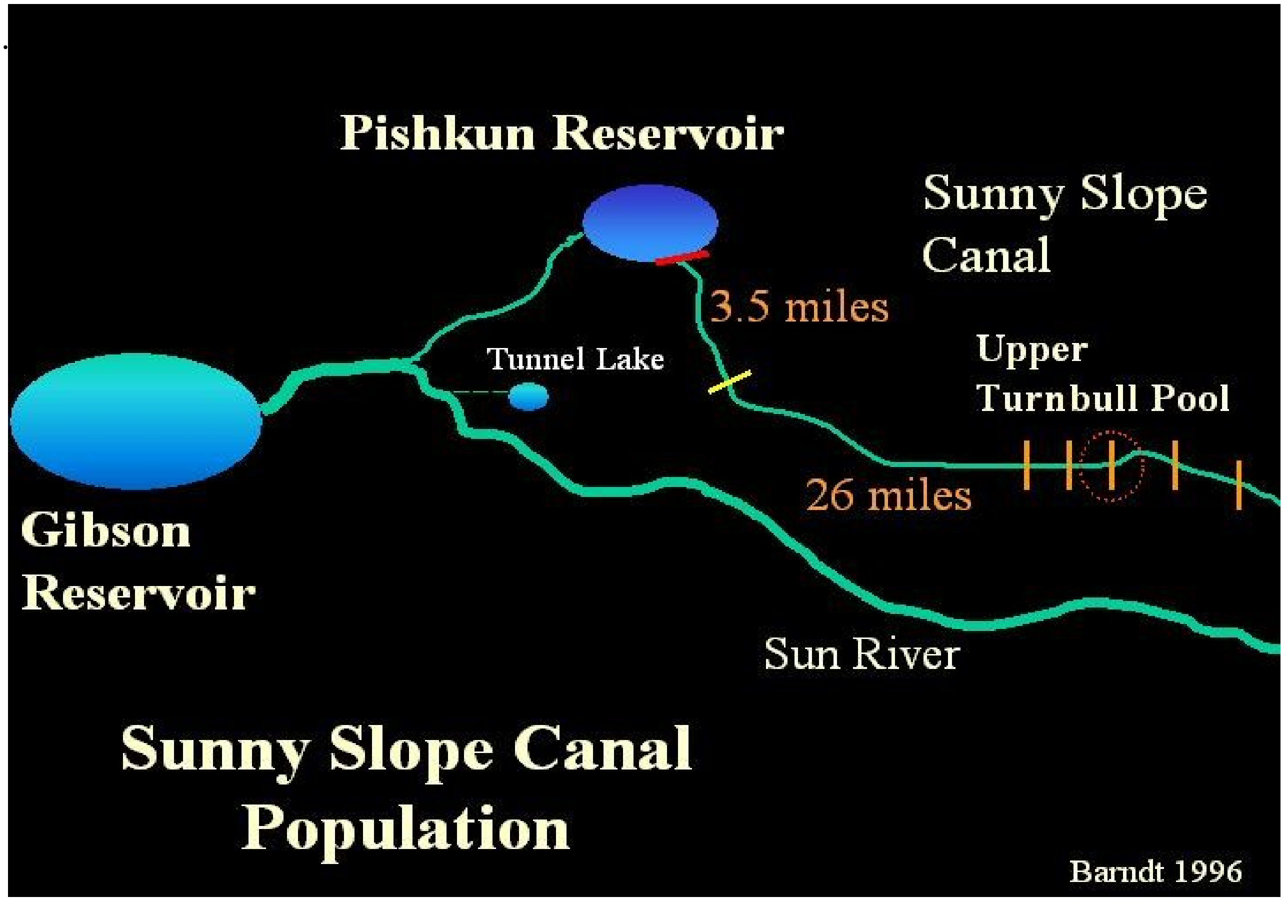


Figure 25. Gibson and Pishkun Reservoir systems with Sunny Slope canal and upper Turnbull pools.

Madison River / Ennis Lake

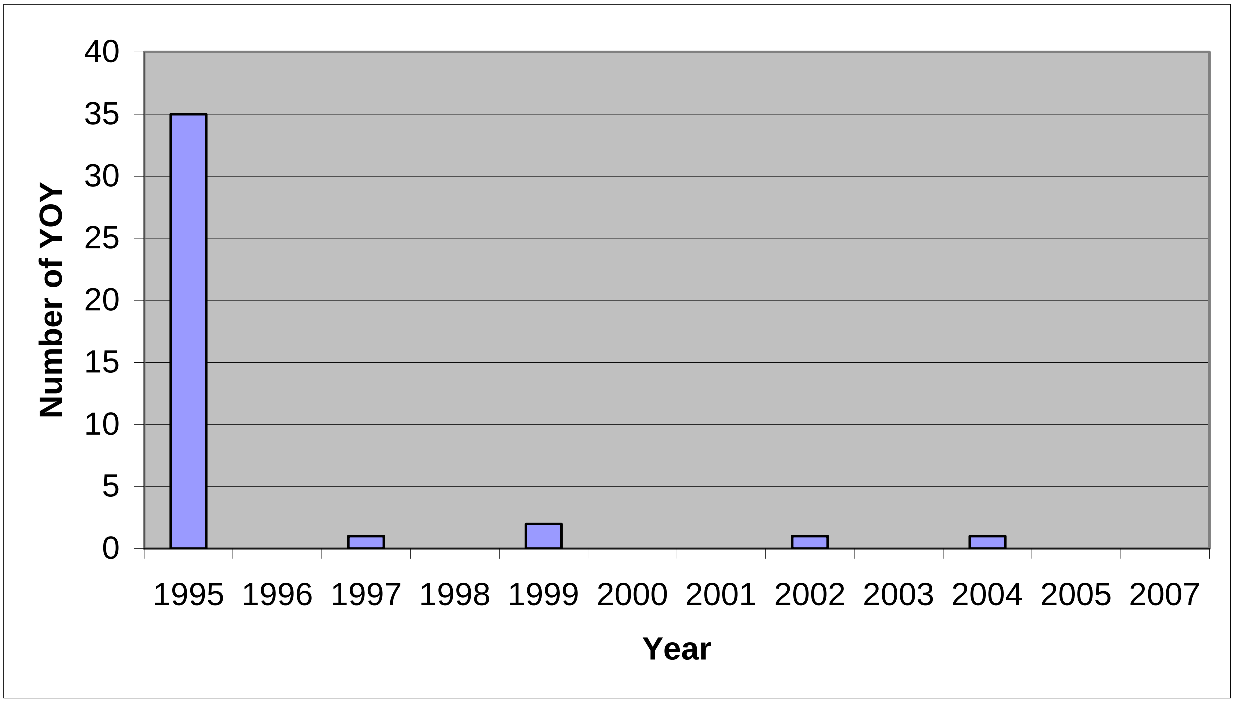
Introduction

The grayling population residing in the Madison River and Ennis Lake is hypothesized to be a remnant of the Madison River fluvial Arctic grayling population. Ennis Lake was formed in 1907 by the construction of the Madison Dam for power generation. This dam is a barrier to migrating fish. With the construction of the dam, grayling adopted adfluvial life history characteristics and now inhabit the lake but move into the Madison River to spawn. Spawning occurs in the mile and a half reach of the Madison River upstream of Ennis Lake. The grayling generally reside in the lake during the rest of the year. FWP began monitoring this population starting in the early 1990s.

Monitoring Efforts

Electrofishing surveys have taken place on the Madison River upstream from Ennis Lake since 1990. In 2007, no electrofishing surveys were conducted. In 2006, spring electrofishing sampling was conducted between April 17 and May 9. The Fletcher Channel of the Madison River was sampled three times with two shocking boats sampling different channels each day. Seven grayling were captured, all of which were males ranging in length from 14.5-15.5 inches (Figure 25). From 1994 to 2005, Ennis Lake littoral areas were seined for YOY grayling in June and July. In 2007, FWP resumed seining littoral areas for YOY grayling; however, no grayling were sampled (Figure 26). Both adult and YOY grayling numbers have continually declined in the Madison River system (Figure 25 & 26).

FWP personnel hold an Arctic grayling captured in the Madison River during population surveys



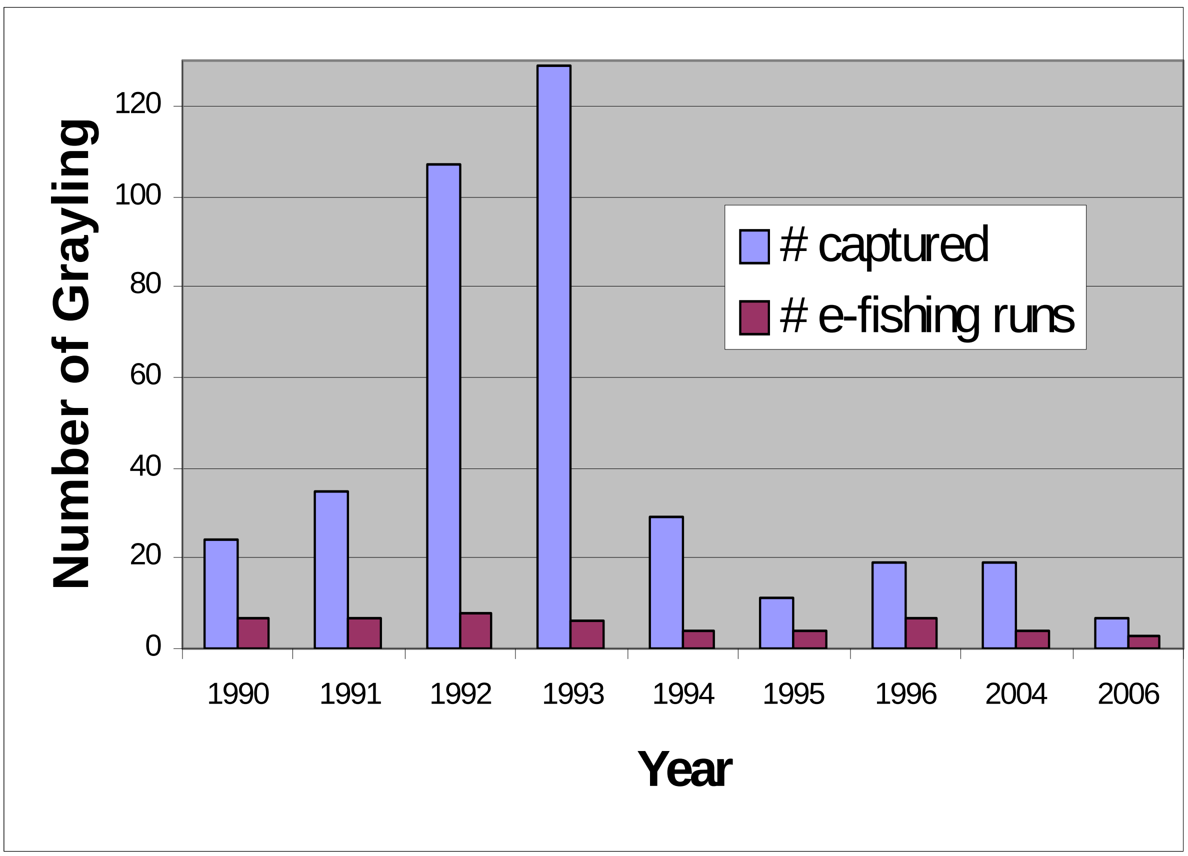


Figure 19. Number of grayling captured during spring electrofishing surveys and the number of surveys completed on the Madison River upstream from Ennis Lake between 1990 and 2006. No surveys were completed in 2007.

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