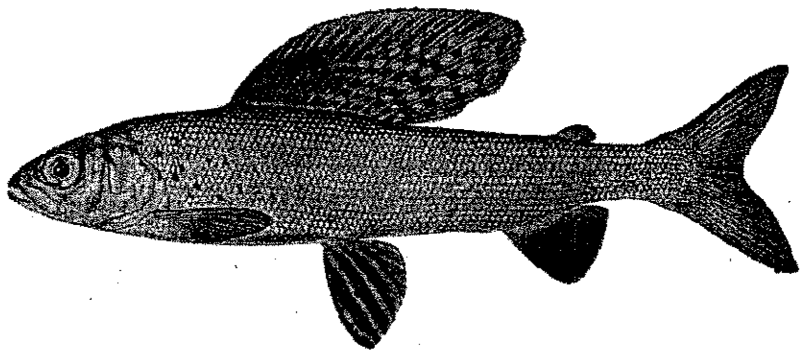
MONTANA FLUVIAL ARCTIC GRAYLING RECOVERY PROJECT: MONITORING REPORT 2000-2001



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Submitted To:

Fluvial Arctic Grayling Workgroup

And

Beaverhead National Forest
Bureau of Land Management
Montana Chapter, American Fisheries Society
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ABSTRACT

We annually monitor the fluvial Arctic grayling (Thymallus arcticus) population, discharge, water temperatures, and abundance of potential competitors in the upper Big Hole River. Peak spring runoff in the upper Big Hole River was low and runoff duration's short due to below average snowpack in both 2000 and 2001. Drought conditions that began in 1999 continued and low critical survival flows were reached by the end of June in both years. All phases of the Big Hole Drought Management Plan ((DMP), Appendix A) were initiated when flows dropped below trigger points of 60, 40, and 20 cubic feet per second (cfs) at Wisdom. To alleviate any further stress to the Arctic grayling population, an angling closure was enacted in the upper Big Hole drought reach from July 1 - October 10, 2000 and June 26 - October 22, 2001. Angling closures were also enacted in the middle reach for 75 days in 2000 and 51 days in 2001 and in the lower reach for 47 days in 2000. Low flows at Wisdom of 7 and 6 cfs occurred in late August and early September in 2000 and 2001, respectively. The Flow Enhancement Program utilized 16 stockwater wells and 2 spring developments to provide water to over 12,000 cattle in fall 2000 and 2001. Despite drought conditions similar to 1988 when the streambed went completely dry, a minimal flow through the core Arctic grayling rearing area was maintained. Water temperatures reached stressful levels (>70°F) throughout the river and reached lethal levels (>77°F) in the warmed reach in both years. Arctic grayling were located in tributaries and deep pools where temperatures were substantially cooler. Due to low flows and warm temperatures, traditional population surveys were not completed in fall of 2000 or 2001. Age frequency histograms from spring spawning surveys and limited fall surveys in 2000 indicate very low proportions of juvenile grayling (age 1 and 2) in the population. Age 3 and older grayling comprising 90% of total grayling sampled. The 2001 surveys indicate an improved age structure with age 3 and older grayling comprising 60% of the total sample. The numbers of age 1 grayling were encouraging and comprised 33% of the total sample in 2001. The broodstock reserve at Axolotl Lakes was successfully spawned and 218,000 and 359,000 eggs were collected in 2000 and 2001, respectively, and transported to Big Springs State Hatchery for rearing. To establish an additional year class from the genetically complete brood 2,452 YOY grayling from the BFTC were planted in fall 2000. Survival of the grayling planted in 1999 in Green Hollow II Lake was excellent. To establish an additional year class, 2,847 YOY from the completed brood were planted in fall 2000 in Green Hollow II brood lake.

INTRODUCTION

The fluvial Arctic grayling (Thymallus arcticus) of the Big Hole River represent the last, strictly fluvial native grayling population in the continental United States. After the population severely declined in abundance during the mid-1980's, the Arctic Grayling Recovery Program was initiated to determine ecological factors limiting the population, monitor their abundance, and inform the general public of their plight. Results of monitoring and research have been reported annually or in special reports since 1991 (Byorth 1991, 1993, 1994, 1995a, 1995b, 1997, Byorth and Magee 1996, Byorth and Magee 1998, Magee and Byorth 1994, 1995 and 1998, Magee 1999, Magee and Opitz 2000).

Recovery goals for the Fluvial Arctic Grayling Recovery Program were established by a Memorandum of Agreement (MOA) between the USFWS and FWP in 1996. The long-term restoration goal is to establish at least five stable, viable populations, distributed among three of the major river drainages, within historic range of Montana fluvial grayling by 2020. Short-term goals were to have four fluvial grayling reintroductions in progress by December 31, 2000. Goals specific to the Big Hole River population were to maintain abundance, and age class composition parameters, that characterize stability of the Big Hole River Arctic grayling population (MOA 1996). Specific project objectives, which will facilitate progress toward reaching recovery goals from January 1, 2000 through December 31, 2001, were to:

A. Monitor abundance and distribution of grayling and potential competitors in the upper Big Hole Basin.

B. Monitor water temperatures and discharge in the Big Hole River and tributaries.

C. Promote water conservation among Big Hole Basin water users, and act as a technical advisor for the Big Hole Watershed Committee.

D. Monitor the fluvial grayling broodstock at Axolotl Lakes and collect gametes as needed.

E. Monitor the fluvial grayling broodstock in Green Hollow II Lake.

F. Initiate a telemetry study in the upper Big Hole River to investigate fish movement and behavior under severe drought conditions.

G. Proceed with reintroduction planting efforts, monitor previous plants of fluvial grayling and potential competitors on the upper Ruby, North and South Forks of the Sun, lower Beaverhead Rivers and Missouri River Headwaters restoration sites.

Results are reported for objectives A through E in this report. Results of objective F will be reported separately. Progress on objective G is summarized in Appendix A in the 2001 Summary Report. A detailed analysis and summary report on all reintroduction efforts will be drafted in the near future.

METHODS

Discharge and Water Temperatures

Discharge of the Big Hole River was monitored by the U.S. Geological Survey (USGS) from April through October at the Wisdom Gage Station, the USGS Mudd Creek Station, and the USGS Melrose Station (USGS 2000 and 2001) (Figure 2). Water temperature was also monitored at the Wisdom gage, Melrose gage, and 13 thermograph stations (Figure 1). Four thermograph stations have been operated since 1992 and six more were established in 1995 (Byorth and Magee 1996). Thermal regimes of the "warmed reach" (between the mouth of McVey creek and the mouth of Squaw Creek, were assessed at the Buffalo, Pintlar and Christiansens sites (Figure 2). Due to a wide-shallow riverbed with little riparian cover, this reach regularly exceeds thermally tolerance levels of 77°F for Arctic grayling (Lohr et al. 1996). To assess thermal regimes of the lower river we established three new thermograph stations at Notch Bottom, Pennington Bridge, and High Road. We used Onset Hobotemp and Stowaway thermographs and recorded temperatures at 36 to 144 minute intervals. Data were downloaded into Microsoft Excel and reduced to daily maximum, minimum, and average temperatures.

Flow Enhancement Project

In 2000 and 2001, we worked closely with the USFWS Partners for Fish and Wildlife Program (PFWP), the Big Hole Watershed Committee (BHWC), and local landowners to fine tune the DMP (Appendix B) and FEP. As of January 1, 2002 nineteen wells, two springs and two pipelines involving fifteen landowners effecting nine diversion have been completed (Appendix C, Table C1).

Conservation projects thus far have focused on the mainstem Big Hole River. In 2000 and 2001, we investigated and expanded efforts to important tributaries. Two Future Fisheries Improvement Project (FFIP) grants were received and used in conjunction with PFWP funds to construct stock water well systems in the upper North Fork and Pintlar Creek drainages. These systems were designed to decrease withdrawals from tributaries by providing an alternative stockwater source and to decrease livestock use in the riparian corridor. At the North Fork site, a-single stock water well was developed, while the Pintlar Creek Project consisted of three stock water wells. In August 2001, we assisted the Big Hole Grazing Association with an emergency stock water system, which prevented diverting flows from Steel Creek and kept livestock out of the riparian corridor. An additional FFIP grant and PFWP funds were used to develop a pipeline from an existing well to provide stockwater to upland pastures on the Spokane Ranch. USFWS also received funds and installed a fish ladder at the Spokane Diversion near Wisdom.

However, the majority of the efforts during the drought conditions of 2000 and 2001 were spent contacting water users, measuring instream flows and temperatures, evaluating conservation efforts and implementing the DMP and FEP.

A revised DMP (Appendix B) was adopted by the BHWC in June 2000. The amended plan integrated an additional "middle reach" from the Mouth of the North Fork to Dickie Bridge (Figure 1). This reach has different flow and temperature regimes than the upper and lower reaches and gives the DMP additional flexibility. Each reach has specific low flow triggers that initiate conservation strategies to reduce stress to the fishery and promote public awareness. The lowest flow trigger in each reach implements angling closures to further protect the fishery.

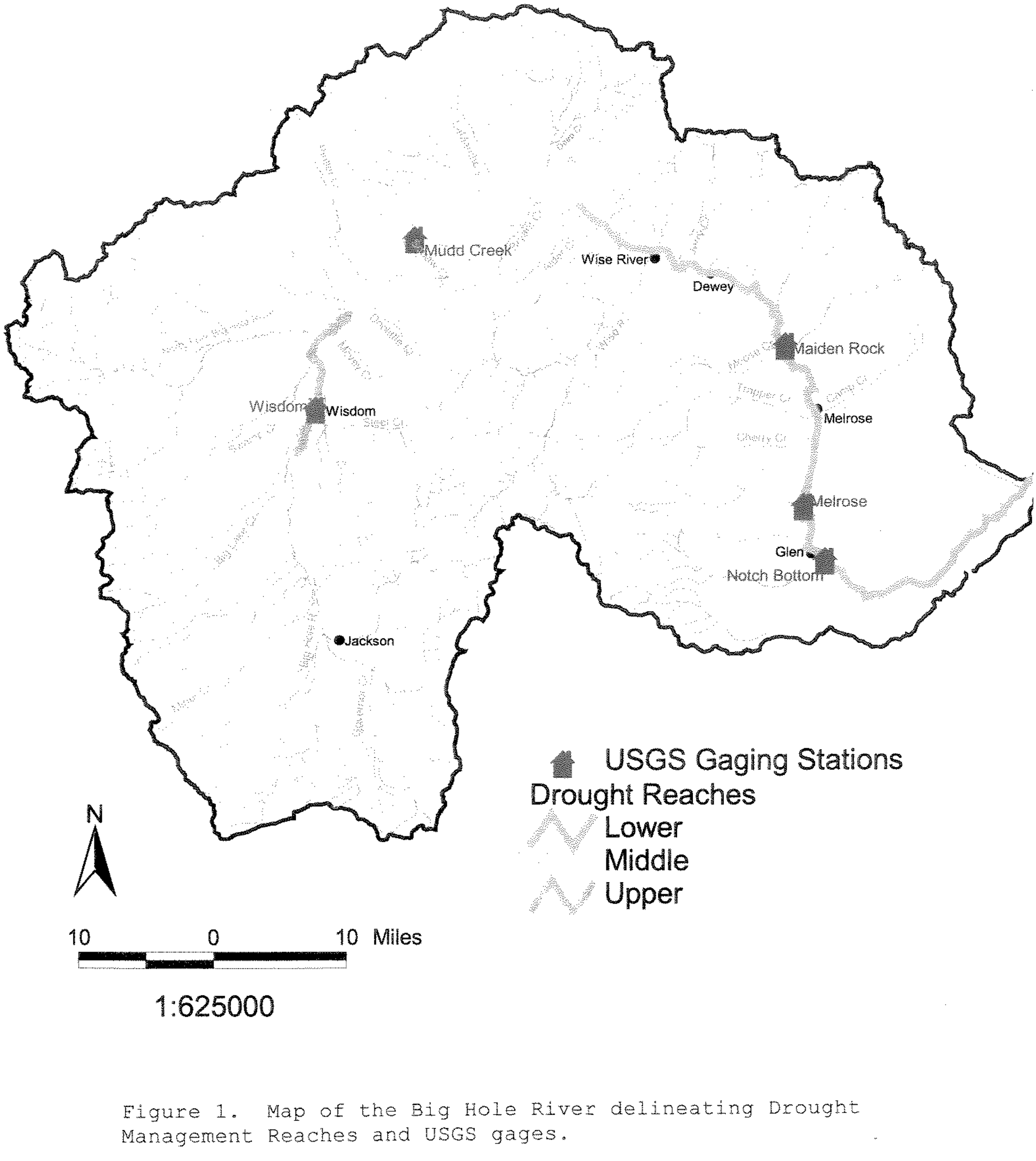

Figure 1. Map of the Big Hole River delineating Drought Management Reaches and USGS gages.

Population Monitoring

We sample the Arctic grayling population of the Big Hole River each spring and fall to document abundance, recruitment, age class strength, condition factor, and distribution. Rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), brook trout (*Salvelinus fontinalis*), and burbot (*Lota lota*) are also sampled to document densities and relative abundances. We electrofished with 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 Coleman Crawdad. Target species were captured and held in a live well. We anesthetized fish for processing in a Tricaine Methanesulfonate (MS-222) bath, measured total length (to 0.1 inches) and weight (to 0.01 lbs), notched a fin as a temporary mark, and collected scales. We tagged grayling with a visible-implant (VI) tag in transparent adipose tissue immediately posterior to an eye.

In 2000, the spawning population of grayling was surveyed by electrofishing the McDowell, Wisdom East, Wisdom West, upper and lower North Fork, and Pintlar-Squaw sections of the Big Hole River. A single electrofishing pass was made through each section between April 13 and 25, 2000. To assess the contribution of tributaries to spawning and recruitment, we sampled a section on the North Fork of the Big Hole River on April 24, 2000 and on Fishtrap and LaMarche Creeks on April 26, 2000.

Single pass electrofishing surveys were conducted in the Wisdom East, upper and lower North Fork Sections from April 12 - 26, 2001. Two passes were conducted in the McDowell and Wisdom West Sections to collect additional grayling for the telemetry research project.

Fall population surveys of the McDowell-Wisdom sections (Figure 2) have been conducted since 1983 to provide an index of grayling abundance and recruitment. The MOA between the USFWS and FWP requires population monitoring by FWP on an annual basis in the core grayling reaches near Wisdom. The FGW met on August 25, 2000 and recommended limited sampling efforts to alleviate any further stress on the grayling population until drought conditions improved. A letter was written to the USFWS explaining the recommendation and the limited sampling efforts in fall 2000. All sampling was delayed until flows improved and temperatures were reduced to minimize any potential stress. In order to assess recruitment and sample the juvenile portion of the population, we conducted one pass electrofishing surveys on Wisdom West and East on October 12 and 14, 2000 respectively. To analyze age structure of the mature-aged grayling, we surveyed the Sportsman, Sawlog, and Fishtrap pools on October 20, 2000.

In 2001, drought conditions continued and an additional letter was written to the USFWS explaining recommendations of limited sampling. Sampling was again delayed to allow condition to improve. To investigate tributary use as refugia to low instream flow and high thermal regimes, a snorkeling survey was conducted in LaMarche Creek on September 17, 2001 and a mark recapture survey was completed on Deep Creek. On Deep Creek we marked fish on September 19 and recaptured on October 2, 2001. To analyze age structure of the mature-aged grayling we electrofished the Sportsman, Sawlog, and Fishtrap pools on October 23, 2001.

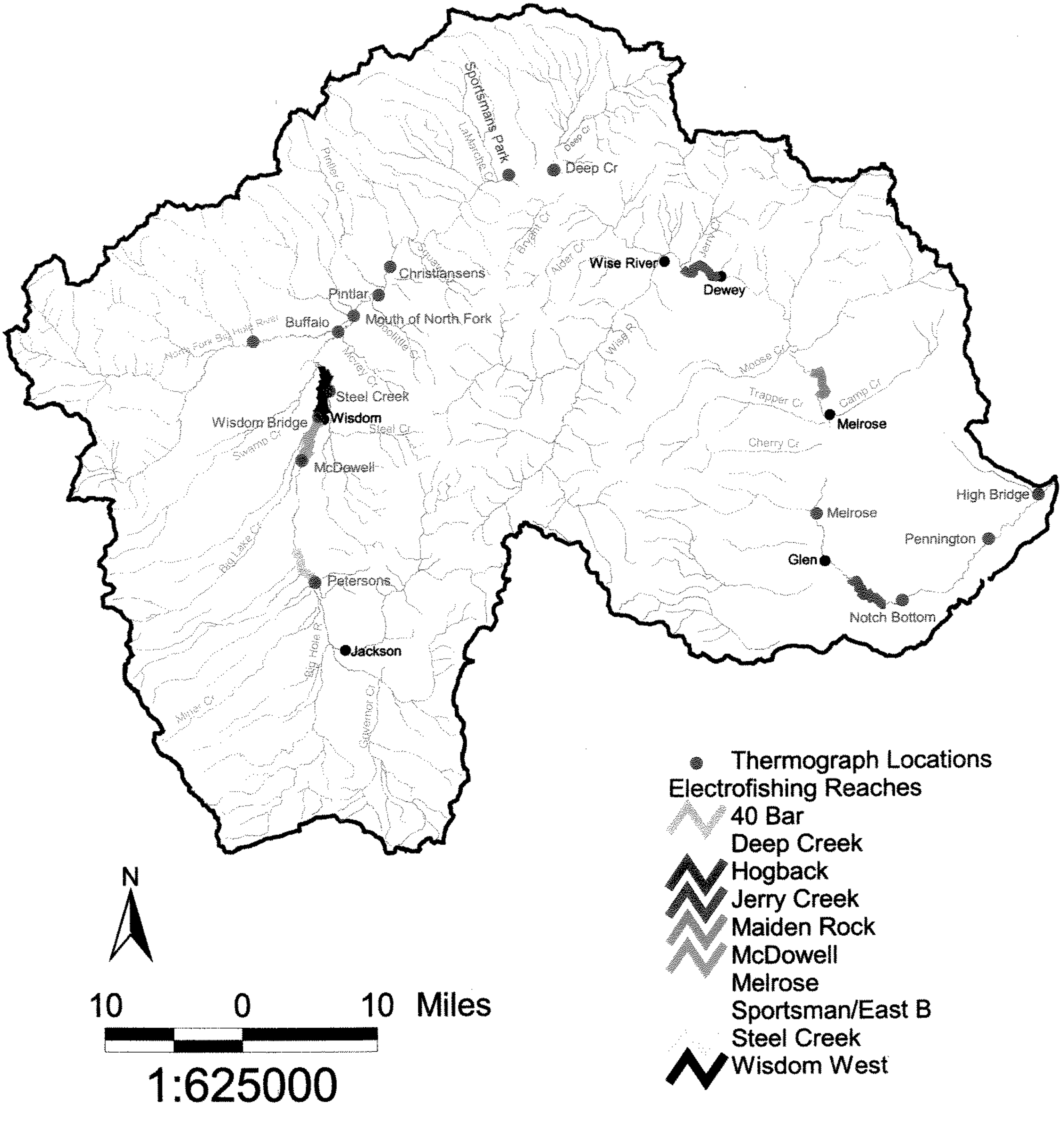

Figure 2. Map of the Big Hole River showing 15 thermograph locations and traditional Montana Fish, Wildlife, and Parks electrofishing reaches.

At the request of the National Park Service, we also conducted a one-pass electrofishing survey through the Big Hole National Battlefield on October 19, 2001 to assess whether Arctic grayling were utilizing the area within park boundaries.

A FWP crew that annually monitors trout populations in the lower river did not survey in fall 2000 due to low flow regimes. Improved flows in the lower river in 2001 allowed the crew to complete a mark recapture survey in September 2001 in the Jerry Creek Section (Figure 2).

Electrofishing data were entered and summarized with Mark/Recapture 4.0 (MFWP 1994). Catch-per-unit-effort (number per electrofishing pass) of young-of-the-year (YOY) grayling was calculated as an index of recruitment.

BROOD RESERVE

Bozeman Fish Technology Center

The BFTC maintains the completed fluvial Arctic grayling broodstock. Development of the broodstock required specific numbers of founding parents and diallele crosses in order to represent the genetic diversity of the wild fluvial Big Hole River Arctic grayling (Dwyer and Leary 1988, Leary 1988). The Axolotl lake and Green Hollow II brood reserves were developed as alternative sites, in the event the broodstock at the BFTC could not be used.

Some of the year classes stocked in these lakes did not have the recommended diallele crosses necessary to represent the genetic diversity of the Big Hole population. In order to utilize the complete brood for restoration efforts, Axolotl and Green Hollow II lakes were planted with YOY grayling from the BFTC beginning in 1999. Present management is to supplement the brood lake populations, as needed, with the complete brood. As these fish become mature gametes will be collected for future restoration efforts.

Axolotl Lake Brood

The Arctic grayling brood reserve at Axolotl Lakes, first planted with fluvial Arctic grayling in 1989 and supplemented in 1992, 1997, 1998, and 2000 provide a source of fluvial grayling gametes to supplement the captive brood stock and juvenile fish for reintroductions. We monitor the brood reserve population annually to determine abundance and collect gametes. Fyke nets and hook-and-line were employed to capture grayling. Captured grayling were processed as described above, marked for population estimates, and released. As grayling became gravid, they were sorted by sex and retained in separate live cars. In 2000, we collected gametes on May 16. Due to poor eye-up we spawned a second group of grayling on June 1. In 2001, grayling were initially spawned on April 17. In order to improve eye-up, a second egg take was completed on April 22, 2001 using improved egg and milt collection techniques as recommended by Big Springs State Hatchery personnel.

Eggs were stripped from female grayling, pooled, and fertilized with milt aspirated from males. After fertilization, eggs were rinsed, packed in ice, and transported to Big Springs Trout Hatchery. Personnel from the FWP Fish Health Laboratory sampled ovarian fluid, fecal matter, and various tissues for disease screening. We released the remaining grayling after processing. Grayling abundance in the lake was estimated with the modified Peterson model (Ricker 1958). To establish an additional year class and initiate use of the completed brood stock 2,452 YOY from the BFTC were planted on September 6, 2000. These grayling were given an adipose clip to identify year class prior to planting.

Green Hollow II Lake Brood

The Arctic grayling brood reserve at Green Hollow II Lake on Turner Enterprises Flying D Ranch was first planted with age one fluvial Axolotl brood stock in 1998. An additional 3,680 YOY of the genetically complete brood from the BFTC were planted in August 1999. In order to assess survival, growth, condition factor, and test the efficiency of sampling techniques we captured grayling, eastern brook, rainbow, and cutthroat trout on June 13 - 15, 2000. In 2001, with the assistance of Turner Enterprises personnel we were able to conduct a mark recapture estimate. Fish were marked from May 23 - June 6 and recaptured on June 7. Hook and line and Fyke traps were used to capture fish. A fish screen was maintained to prevent spawning grayling from moving into Green Hollow Creek, and to inhibit brook, cutthroat, or rainbow trout from moving into the lake. These species were removed from the lake if captured. In order to establish multiple year classes, YOY grayling, originating from the genetically complete fluvial brood stock at the BFTC, were planted on September 6, 2000. These grayling were adipose clipped on August 24, to identify year class prior to planting.

RESULTS

Discharge and Water Temperatures

The 2000 spring runoff was characteristic of below average snow pack with low magnitude duration and peaks. Snowpack for the Jefferson drainage was 79% of the long-term average as of May 1, 2000 (NRCS Snotel Surveys). Instantaneous peak flow of 649 cfs was recorded at the Wisdom gage on April 14, 2000, well below the 13-year mean of 1,884 cfs. Below average precipitation continued in June, and in conjunction with increased agricultural demand, resulted in critical low flows by late June (Figure 3a). Conditions worsened throughout the summer into

September (Figure 3b). Monthly precipitation at Wisdom was below average in April (71%), May (93%), June (36%), July (13%), August (2%) and September (86%), and finally improved in October (228%). Critical low flow levels (less than 20 cfs) that began in June improved temporarily in July due to decreased irrigation diversion and water conservation efforts. The minimum flow recorded at the Wisdom gage was 7.30 cfs on August 29 and 31 (Table 1). The August-September water yield in 2000 of 1,721 acre-feet was down from the 1999 yield of 4,460 acre-feet, and well below the yield of 10,310 acre-feet in 1998 (Table 1).

The drought continued in 2001 with below average snow pack, low peak flows and runoff duration. Snow pack for the Jefferson drainage was 70% of average as of May 1. Peak flow occurred on June 14, 2001 at 563 cfs, again, well below the long-term average. Two large precipitation events in June improved flows temporarily; however, critical low flow levels less than 20 cfs were reached by June 20. Flows continued to drop and were 7.5 cfs by June 25 (Figure 3a). While above average precipitation in June (136%) and July (129%) helped partially mitigate conditions from the low snow pack, August was dry with only 51% of normal precipitation and ground water storage was depleted. The minimum flow recorded at the Wisdom gage was 6.0 cfs on September 4, 2001 (Figure 3b), Table 1). The number of days with flows less than 20 cfs were similar to 1994, and second only to 1988, when the streambed was dry at Wisdom for 24 days in August-September. The August-September water yield in 2001 of 1,737 acre-feet was similar to 2000 (1,721 acre-feet) but dropped substantially from 1999 yield of 4,460 acre-feet (Table 1).

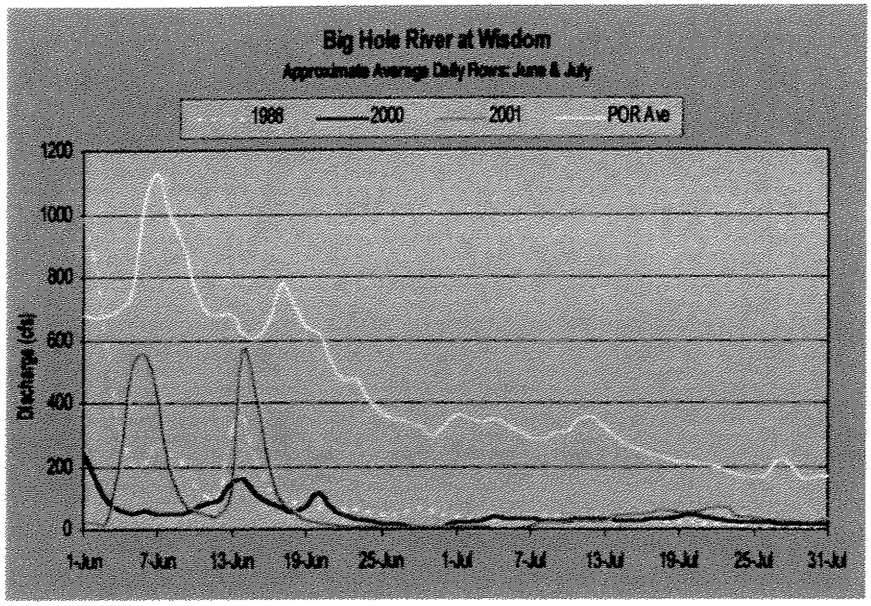

Figure 3a. Hydrograph of the Big Hole River measured at the USGS gage at Wisdom, Montana, for June 1-July 31 in 1988, 2000 and 2001.

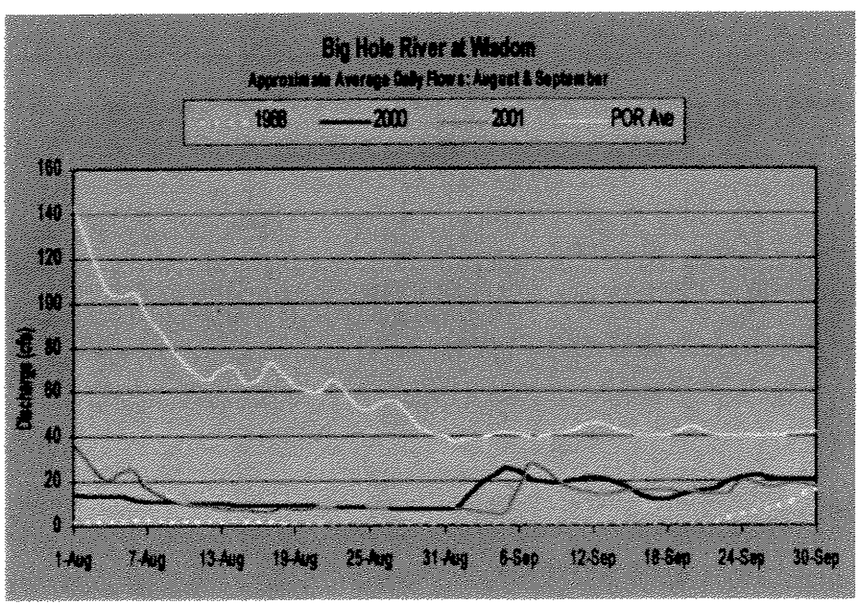

Figure 3b. Hydrograph of the Big Hole River measured at the USGS gage at Wisdom, Montana, for August 1-september 30 in 1988, 2000 and 2001.

Table 1. Comparisons of Big Hole River discharge parameters measured at the USGS gage at Wisdom, 1988 to 2001. Yield is the total volume of water passing the Wisdom gage during August and September.

Year	# Days less than 20 cfs		Max Flow (cfs)	Min Flow (cfs)	Dates At Min	Yield Aug-Sept (ac-ft)
	Apr-June	July-Sept				
1988	0	78	1,080	0	8/27-9/21	213
1989	0	4	978	12	8/20	3,790
1990	1	0	667	18	5/23	5,820
1991	0	16	3,830	10	9/4	3,690
1992	18	32	479	3.3	5/26	2,760
1993	0	0	1,700	55	10/5	17,490
1994	11	55	976	1.9	8/30	1,821
1995	0	0	4,200	31	9/3	11,150
1996	0	0	2,960	39	8/29, 9/14	8,600
1997	0	0	4,170	70	8/29	18,910
1998	0	0	1,550	45	9/5	10,310
1999	0	5	1,750	16	8/25,8/26	4,460
2000	6	49	649	7.3	8/29,8/31	1,721
2001	10	55	563	6.0	9/4	1,737

2001: 5 days in October, data is preliminary,

Table 2 summarizes temperatures at thermograph stations representing the lower, middle, and upper reaches of the Big Hole River for 2000 and 2001. Some of the data has not been included due to problems with the loggers, dewatering, or vandalism. Temperatures throughout the mainstem river reached stressful levels (greater than 70°F) for salmonid species (McCauley 1991) in 2000 and 2001.

In 2000, maximum instream temperatures peaked at most thermograph stations on July 29-August 2, with the highest daily mean temperatures recorded on August 19 (Table 2). The Christiansens Thermograph Site (Figure 1) located in the "warmed reach" recorded the highest maximum temperature of 80.1°F and the highest mean daily maximum of 69.6°F. Lethal temperatures for Arctic grayling of 77°F determined by Lohr et al. (1996) were recorded on four days at this location, and temperatures exceeding 70°F occurred on 46 days.

In 2001, temperatures were even warmer with longer durations over 70°F and higher maximums. Most stations recorded maximum temperatures on July 3 or August 8. Highest daily means were recorded on July 5 or August 8. Christiansens again recorded the highest temperature (80.8°F), measured 63 days over 70°F, and 10 days surpassing lethal levels of 77°F. In both years we observed some thermally caused mortality of mountain whitefish and catostomid species at Pintlar Pool in the "warmed reach". However, no specific fish kill events were observed and no grayling mortalities were documented.

Peterson's Station in the upper river (Figure 1), which typically has few or no days over 70°F, had 31 days exceeding these stressful temperature levels in 2001. Tributaries may act as refugia during stressful thermal regimes. Temperatures in the upper North Fork remained relatively cooler with only 3 days exceeding 70°F in 2001. In LaMarche Creek we visually observed 62 grayling in a one mile reach in which temperatures were 8°F cooler than the mainstem Big Hole River.

Table 2. Date of maximum temperature, maximum daily ($T_{max°F}$) and maximum mean daily (Tmax °F Mean) water temperatures, number of days over 70°F, and number of days over 77°F at thermograph stations in the Big Hole River 2000 and 2001.

Station	Date Tmax	Tmax °F	Tmax Mean°F	Days >70° F	Days >77°F
Upper North Fork	*A 8/08/01	*A 71.4	*A 59.8	*A 3	*A 0
Petersons	7/29/00 7/03/01	73.0 75.2	56.7 58.0	11 31	0 0
McDowell	7/30/00 7/03/01	75.0 78.7	66.5 61.5	24 42	0 3
Wisdom	7/30/00 7/08/01	76.3 76.1	66.9 68.2	45 41	0 0
Pintlar	7/30/00 7/03/01	79.4 80.1	69.1 65.6	32 61	3(*B) 6
Christiansens	7/30/00 7/03/01	80.1 80.8	69.6 64.2	46 63	4 10
Sportsmans	7/29/00 7/03/01	76.6 79.4	68.4 65.6	9 56	0 4
Melrose	7/29/00 7/03/01	73.2 73.8	67.8 68.5	13 20	0 0
Pennington	7/30/00 7/03/01	75.9 75.2	71.1 66.3	21 51	0 0
High Road	8/05/00 7/03/01	76.0 77.4	*C 69.0	*C	*C

*A Upper North Fork Bridge: not functional in 2000
*B Sportsmans Park: Four additional days over 77°F are suspect and not included in total.
*C High Road Bridge: Partially dewatered in 2000 and 2001

Flow Enhancement and Drought Management Programs

Due to below average snow packs, warm and dry spring months, and forecasted low instream flows, efforts to promote water conservation were ongoing throughout the year. With the initiation of irrigation in mid-May, flow dropped substantially in both years. In 2000, at Wisdom, flows dropped from 345 cfs on May 5 to 40 cfs on May 21. In 2001, flows decreased from 445 cfs on May 1 to 34 cfs by May 31. By the third week in June in both years, flows had decreased to the extent that all phases of the DMP (Appendix B) were initiated. In order to alleviate any further stress accompanying low flow levels, the FWP Commission approved angling closures on the upper Big Hole River drought reach (Figure 1) from July 1 - September 24, 2000 and from June 26 - October 22, 2001. These closures remained in affect until flows improved to 40 cfs for seven consecutive days. The middle reach was closed to angling from July 26 - October 10, 2000 and from August 28 - October 17, 2001. The lower reach was closed from August 12 - September 27, 2000, but did not close in 2001. The middle and lower reaches did not open until flows increased to 80 cfs and 200 cfs for seven consecutive days, respectively (DMP, Appendix B).

Throughout both summers, landowners were contacted and asked to conserve water and utilize stock-water wells where possible. In June and July, many of the stock water wells were not used, and in fact, pastures with wells were irrigated to increase feed for grazing later in August or September. Numerous news releases during both drought years advised anglers of angling closures, low flow conditions, possible temperature induced stress, and encouraged anglers to fish only during morning hours or in other locations.

The Flow Enhancement Program offered landowners an alternative stock water source other than diverting flows from the Big Hole River. In 2000, 11 wells and 2 springs were used to water up to 3,450 cattle between July and October. In 2001, with continued drought, stock water well use was higher with 16 wells and 2 springs used to water up to 8,990 cattle from July through October. This resulted in the maintenance of instream flows at low levels in the core spawning and rearing area near Wisdom. This is an improvement over the last severe drought in 1988 when the streambed at Wisdom was completely dry for 24 days in August and September. Improved flows can be further illustrated by the total water yield in acre-feet for August and September at the Wisdom gage. The 1988 yield was 236 acre-feet compared to 1,721 and 1,737 acre-feet in 2000 and 2001, respectively.

Population Monitoring

Spawning and Recruitment

In the 2000 Big Hole River spawning surveys, we captured 111 grayling, of which five were age 1 fish. Sampling occurred from April 13-25 and no ripe females were captured. The overall sex ratio was slightly skewed toward males at 1.3:1. Sampling was suspended following the April 25 survey that captured two spent and one ripe female and a sex ratio that was skewed towards females (4.7:1) indicative of near peak or post-peak spawning conditions.

Grayling typically spawn in the Big Hole River when daily maximum temperatures reach and exceed 50°F. Maximum temperatures first reached 50°F April 19, with peak spawning occurring between April 19-28, 2000, when daily mean temperatures ranged from 43 to 50°F. The mean daily discharge ranged from 297 cfs to 456 cfs during these spawning periods. Predicted time of emergence of larval grayling was May 5-12 when mean daily discharge was 224-340 cfs at Wisdom. Flows decreased dramatically between May 12 (239 cfs) through May 22 (38 cfs) at Wisdom, which may have affected survival of newly emerging fry.

Age distribution from spring surveys was skewed towards older fish. Approximately 90% of the grayling captured were Age 3 and older (Table 3, Figure 4a). The small percentage of the age 2-year class is the lowest in the past 12 years.

LaMarche and Fishtrap Creeks have been documented as juvenile grayling habitats (Byorth 1995a), however no grayling were captured in spring 2000 surveys.

In the 2001 spring surveys, we captured 97 grayling, of which 26 were age 1. Sampling occurred from April 13-25 and no ripe females were captured. The overall sex ratio was balanced with 40 males and 36 females sampled. Sampling was suspended following the April 25 survey as females became gravid and sex ratios were beginning to become skewed towards females, indicative of near peak spawning conditions. Maximum temperatures first reached 50°F April 24, with peak spawning occurring between April 24-29, 2001, when daily mean temperatures ranged from 47 to 51°F. The mean daily discharge ranged from 289 cfs to 514 cfs during these spawning periods. Predicted time of emergence of larval grayling was May 11-16 when mean daily discharge ranged from 72-215 cfs. The majority of the spawners were age 3 and older with only 3% of the sample composed of age 2 fish. This represents the lowest proportion of age 2 grayling during spawning surveys since 1989. The spawning population was dominated by age 4 grayling (58%) which have excellent reproductive viability (Table 3, Figure 4b). An encouraging sign was the large percentage (27%) of age 1 grayling. Although sampling was limited in fall 2000, we sampled few YOY; which were sampled in encouraging numbers as yearlings in spring 2001 (Figure 4a and 4b).

Table 3. Percent composition by age class of Arctic grayling captured during spawning surveys in the upper Big Hole River, 1989 - 2001.

Year	N	% by Age Class				
		2	3	4	5	6
1989	143	25	63	6	6	1
1990	150	46	20	32	1	1
1991	144	44	35	13	8	0
1992	120	19	53	28	0	0
1993	122	12	39	42	6	0
1994	80	30	26	26	16	1
1995	145	15	39	27	15	2
1996	81	24	24	41	10	0
1997	61	18	23	41	16	2
1998	147	43	23	19	10	5
1999	84	26	38	20	10	6
2000	102	10	22	43	24	1
2001	71	3	22	58	15	1

Fall Population Surveys

Catch rates of YOY grayling during fall electrofishing surveys provide an index of recruitment. Catch rates in 1999 were the lowest since 1987 in the Wisdom section (Table 4). Although sampling was limited in 2000, catch rates of YOY grayling continued to be low. In 2001, we did not sample the Wisdom or McDowell sections and thus catch rates cannot be calculated.

Table 4. Catch-per-unit-effort (CPE) of young-of-the-year (YOY) grayling captured in the McDowell and Wisdom sections of the Big Hole River, 1983 - 2000. The McDowell Section was not sampled in 1999 or 2000. The McDowell and Wisdom Sections were not sampled in 2001.

Year	McDowell Section			Wisdom Section		
	# YOY	# Runs	CPE	#YOY	# Runs	CPE
1983	---	---	---	2	6	0.33
1984	---	---	---	5	7	0.71
1985	0	3	0	0	3	0
1986	145	4	38.2	---	---	---
1987	3	1	3.0	0	1	0
1988	---	---	---	---	---	---
1989	178	2	89.0	90	2	45.0
1990	58	2	29.0	98	4	24.5
1991	10	2	5.0	41	2	20.5
1992	42	2	21.0	83	4	20.75
1993	2	2	1.0	31	4	7.75
1994	---	---	---	39	2	17.5
1995	12	3	4.0	97	6	16.2
1996	6	3	2.0	97	6	16.2
1997	8	3	2.7	80	6	13.3
1998	6	3	2.0	41	7	5.9
1999	---	---	---	17	7.5	2.3
2000	---	---	---	4	2	2.0
2001	---	---	---	---	---	---

In 1999, the number of age 1+ grayling in the Wisdom Section was estimated at 35 (SD ±8.4) per mile decreasing from 76 (SD ±30) age 1+ per mile in 1998 and 96 (SD ± 66) age 1+ per mile in 1997 (Appendix D, Table D1). In 2000, we completed only one pass surveys through the Wisdom West and Wisdom East Sections. We captured 12 grayling of which 4 were YOY. Age 1+ grayling typically migrate out of the Wisdom area by late September (Shepard and Oswald 1989, Byorth 1995a) and previous surveys are completed prior to these movements. Low numbers of grayling captured in 2000 may be partially attributed to emigration from the Wisdom area. However, population age structure, based on fall 2000 sampling, indicates low proportions of juveniles: YOY, yearlings, and age 2 grayling (Figure 4a).

The age-frequency distribution in 2000 indicated poor recruitment of the 1999 (age 1) and 1998 (age 2) year classes (Figure 4a). Contrary to high water years of 1995-1997 when survival of age 0 grayling was good, in 1999 and 2000 we have observed a decreased abundance of age 1 and 2 grayling. In 1997 and 1998, age 1 and 2 grayling comprised 68% and 77% of the sampled grayling in fall surveys. In contrast, in 1999 and 2000 age 1 and 2 grayling comprised only 35% and 10% of the sample, respectively. Thus, we have seen a shift in the population to age 3 and older grayling. In 1997, age 3+ grayling comprised 32% of the fall sample, compared to 22% in 1998, 65% in 1999, and 90 % in 2000.

Similar to spring 2001 surveys, fall surveys captured few age 2 grayling from the 1999 spawn (only 7% of the fall sample), however, the proportion of yearlings increased substantially from 2000 surveys. Yearlings made up 33% of the fall sample. The age structure improved with age 3 and older grayling comprising 60% of the total grayling sampled compared to 90% in 2000 (Figure 4a and 4b).

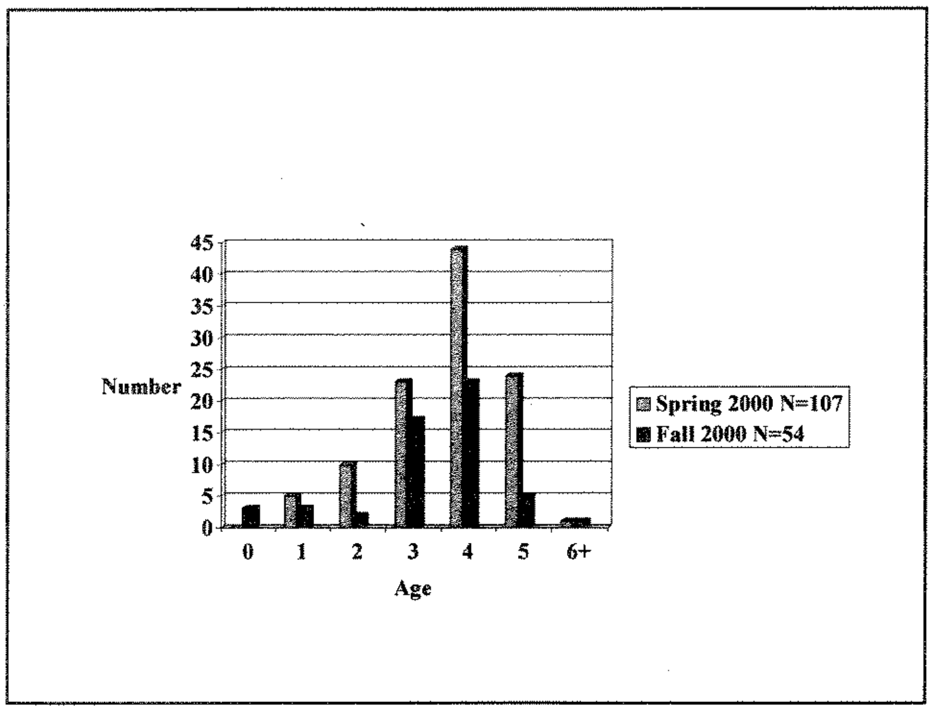

Figure 4a. Arctic grayling age class histogram from Montana Fish, Wildlife, and Parks spring and fall surveys in the Big Hole River for 2000.

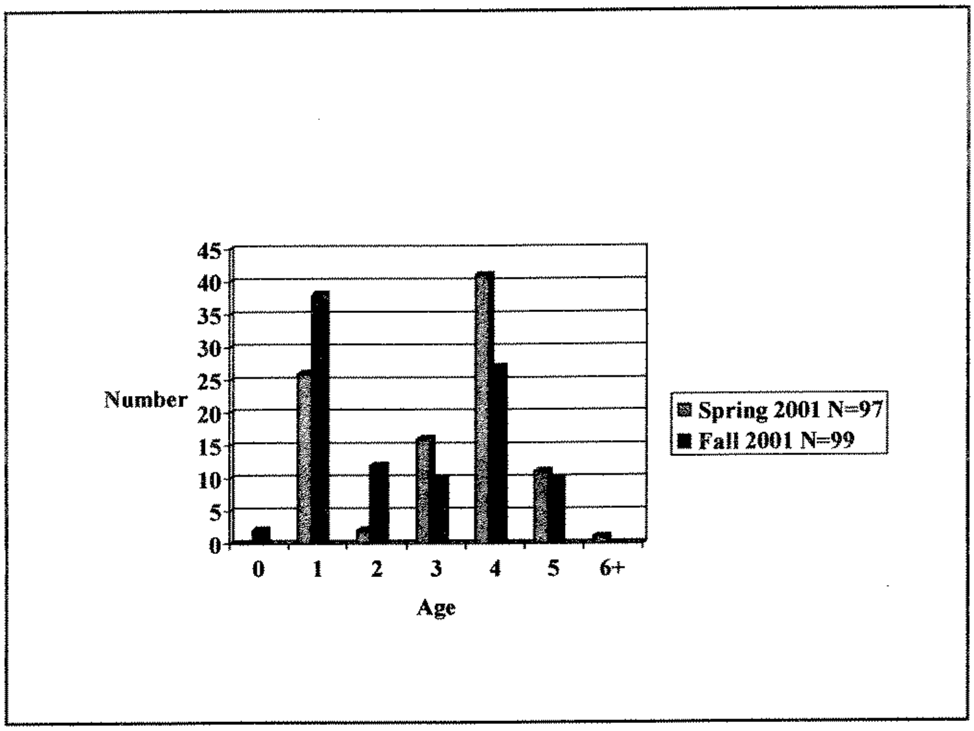

Figure 4b. Arctic grayling age class histogram from Montana Fish, Wildlife, and Parks spring and fall surveys in the Big Hole River for 2001.

Brook trout abundance in the upper Big Hole River declined dramatically with drought in the mid-1980s to a low of 62 (> 6 inches) fish per mile in 1989 in the McWisdom section (Appendix D, Table D1). The population slowly increased in the early 1990s. With four consecutive years of ample flows (1995-1998), brook trout abundance increased dramatically. In the Wisdom section, the brook trout population (> 6.0 inches) increased from 183 (SD ± 15) per mile in 1996, to 613 (SD ± 43) in 1998. The 1998 abundance represents the highest estimate since monitoring began in 1978. In 1999, the abundance of brook trout decreased and was estimated at 417 (SD ±20). Similar to what was seen after drought in the late 1980's and early 1990's brook trout numbers are most likely reduced in 2000 and 2001. However, no abundance estimates were completed in 2000 or 2001.

Rainbow trout presence has remained low in the upper Big Hole River. In the Wisdom Section in 1999 we estimated 7(SD ± 3) rainbow trout per mile (Appendix D, Table D1). In the Sportsmans-Eastbank section (Figure 2), the rainbow trout have remained stable from 1995 to 1998 ranging from 222-257 age 1+ rainbow per mile. In 1999, the estimated abundance decreased to 127 (SD ±66) age 1+ per mile. No estimates were completed in 2000 and 2001.

Brood Reserve

Axolotl Lakes Brood 2000

In May 2000, we captured 1,331 grayling for gamete collection and population estimates. The majority of these were age 2 and 3 (94.6%), with the age 8 and age 13 grayling composing the remaining 5.4% of the grayling captured. We estimated 2,614 (±105) age 2 and age 3, 148 (±27) Age 8 and 31 (±8) age 12 grayling. On May 16, 2000 we collected 218,000 eggs. Age 2 and 3 grayling produced 208,400 eggs from 394 females, averaging 529 eggs per female. Age 8 grayling produced 9,600 eggs from 7 females, averaging 1,371 eggs per female (Table 5). Age 13 grayling produced no viable eggs. The eye-up for the age 2-3 grayling eggs was only 29% resulting in approximately

60,000 eggs. In contrast, eye-up for the age 8 grayling was 98%, resulting in 9,400 eggs. Due to the poor eye-up of the younger grayling eggs, we attempted to capture and spawn additional grayling on June 1. These attempts were futile with over-ripe eggs and unviable gametes, resulting in virtually zero percent eye-up. Eggs were transported and reared at Big Springs State Fish Hatchery. Disease testing was negative for all pathogens tested (N=60). Approximately 50% of fry survive to yearlings after eye-up; thus, there were 30,000 - 35,000 yearling grayling available for summer 2001 restoration efforts. To facilitate future use of the genetically complete brood, 2,452 YOY grayling from the BFTC were planted on September 6, 2000 in the Axolotl Brood Lake. These grayling were adipose fin clipped to identify year class.

Table 5. Number of females spawned, percentage of female spawners by age, number of eggs collected, number of eggs per female, average length in inches by age, and density estimate for Axolotl Lake fluvial Arctic grayling brood reserve from 1996-2001, in southwest Montana.

Year	Number Females	Age	# Eggs Collected	Eggs/ Female	Average Length Inches	Density Estimate
1996	54	Age 8 :11% Age 4: 89%	95,900	1,776	Age 8: 13.8 Age 4: 10.6	1104
1997	151	Age 9: 7% Age 5:93%	390,000	2,500	Age 9: 13.9 Age 5: 11.7	499
1998	58	Age 10: 10% Age 6: 90%	132,000	2,276	Age 10: 14.3 Age 6: 12.7	343
1999	74	Age 11: 12% Age 7: 62% Age 2: 24%	194,374	2,627	Age11:14.4 Age 7: 13.1 Age 2: 9.7	2008
2000	401	Age 8: 2% Age 2-3: 98%	218,000	529♣	Age8: 13.3 Age 2-3:9.5	2762
2001	525	Age 9 and 13: 2% Age 3-4: 98%	359,400	684	Age13: 14.1 Age 9: 13.1 Age 3-4: 9.8	1864

♣ Note: Age 2-3 fecundity was 529 eggs/female. Age 8 grayling which composed only 2% of females spawned had 1,371 eggs/female.

Axolotl Lakes Brood: 2001

In 2001, we estimated 1,864 (±58) grayling in the Axolotl Brood Lake (Table 5). The majority of these fish (88 %) were age 3 and 4, with age 1 grayling comprising 8.5% and age 9 and 13 grayling comprising the remaining 3.5% of the fish captured. A total of 1,342 grayling were captured for gamete collection and population estimates. On May 17, we collected 280,000 eggs from 446 females (628 eggs/female), with 65% eye-up resulting in 100,000 fry. To assess techniques to improve percent eye-up, Big Spring

Hatchery personnel supervised a second egg-take on May 21, 2001. We collected 79,400 additional eggs from 79 females (1005 eggs/female), with a 93% eye-up resulting in 66,000 fry. Approximately 50% of fry survive to yearlings after eye-up; thus, there are approximately 79,000 yearling grayling available for summer 2002 restoration efforts. After hatching, eggs were divided, with 34,000 going to Bluewater State Hatchery, 40,000 to Big Springs State Hatchery, and 5,000 to Sekokani Springs State Hatchery. Disease testing was negative for all pathogens tested (N=60). The 1988 and 1992 (age 9 and 14) year classes are present in very low numbers. The 1997 and 1998 (age 3 and 4) year classes are numerous and approaching peak reproductive productivity. The 2000-year class will be age 2 in the spring of 2002 and viability of gametes will be limited. This year class represents the first year class in the Axolotl Brood Lake from the genetically complete brood stock.

Fecundity of females and percent eye-up decreased substantially since 1998 (Table 5). Decreased fecundity may be may be attributed to total number of grayling in the brood lake, age of spawning grayling, and the average length of females (Table 5). For example, in 1998 we estimated 343 (SD=32) grayling in the lake and collected 2,276 eggs per female. These age 10 and age 6 grayling averaged 14.3 and 12.7 inches respectively. In 2001, we estimated 1,864 (SD=58) grayling in the lake and collected

684 eggs per female. Age 3 and 4 grayling comprised 98% of the females and averaged 9.8 inches in length.

To improve eye-up, Big Springs State Hatchery personnel recommended experimenting with some different gamete collection techniques. These techniques helped increase eye-up from 65% to 93% between the two spawns. Techniques included: 1) use collected sperm as soon as possible, 2) aspirate one half of the sperm and strip the other half of the sperm, 3) only use fully sedated fish to reduce slime in collection vats, 4) decrease number of fish in lake to increase size and fecundity, 5) spawn fish on two occasions with approximately 100-150 females per spawn.

Property surrounding the Axolotl brood lake is privately owned and has recently been at risk of being sold for home-site development. In order to secure access and management of the fluvial brood stock at Axolotl Lakes, a land exchange and purchase of the property was initiated by FWP and the BLM. This process should be finalized by the end of March 2002. The purchase will secure 40 acres around the brood lake to state ownership and 400 additional acres of unique and pristine landscape to BLM ownership. A cooperative management plan will be drafted in the near future.

Green Hollow Brood Reserve Pond 2000:

On June 13-15, 2000, we sampled the brood reserve with assistance of Turner Enterprises personnel. Survival of the 1999 year class was encouraging (Table 6). Only one fish from the 1998 plant was captured, further indicating poor survival of that plant. The 1999 plant is the first year class from the genetically complete brood that may be available for restoration efforts. In order to establish an additional year class, 2,847 YOY from the BFTC were planted on September 6, 2000. These grayling were adipose fin clipped to identify year class.

Table 6. Species, number captured, average length, and length range (inches) for June 13-June 15, 2000 and May 23-June 7, 2001 sampling in Green Hollow 2 Arctic Grayling Brood Lake, Montana.

Species	Number 2000	Average Length 2000	Range 2000	Number 2001	Average Length 2001	Range 2001
Arctic grayling	222	6.7	5.3-12.4	267	8.8	4.4-13.3
Eastern Brook Trout	90	7.2	4.2-13.1	159	8.0	4.5-13.0
Yellowstone Cutthroat Trout	15	15	7.1-16.9	37	11.5	8.2-14.5
Rainbow Trout	5	9.0	6.1-14.1	12	11.5	8.3-13.1

Green Hollow II Brood Reserve Lake: 2001

With assistance from Turner Enterprises personnel, in 2001 we conducted a mark recapture survey to assess survival and growth of the three previous plants, and densities of sympatric trout species (YCT, EBT, and RBT). We estimated 1,279 (±302) grayling inhabited the lake. Ninety-eight percent of the captured grayling were age 2, 1.5% age 1, and 0.5% age 4. The percentage of age 1 grayling in the sample is not indicative of their survival. The age 1 grayling averaged 4.6 inches and were difficult to capture. We observed large groups of yearling grayling throughout the lake and it appeared survival was very good. Numbers captured by species, average length, and range are summarized in Table 6.

Efforts to reduce numbers of potentially competing trout initially may have been beneficial. However, these species have rebounded and are affecting grayling densities and survival (two YOY grayling were found in YCT stomachs). We will continue to monitor all species. The 1999-year class represents the first year class from the completed brood stock that will be available for restoration efforts. Some gametes may be collected in spring 2002.

DISCUSSION

Following four consecutive years (1995-1998) of adequate instream flows, drought conditions have persisted since 1999. Snow packs have been below long term averages (79% and 70% as of May 1, 2000 and 2001, respectively) resulting in runoffs of low magnitude and short duration. With poor ground water reserves and increased agricultural demand, instream flows suffered throughout the summers of 2000 and 2001. The Big Hole River Drought Management Plan has been key to promoting conservation efforts and protecting fisheries the past three years. Flows of less than 20 cfs (considered the critical minimal survival flow for the Wisdom reach, (Byorth 1995b)) have resulted in prolonged angling closures to further protect the Arctic grayling population. Despite drought conditions similar to 1988, a minimal flow has been maintained in key juvenile rearing areas near Wisdom in 2000 and 2001. In 2000, flows dropped to 7 cfs and in 2001 to 6 cfs in late August and early September. While these flows are far from ideal, they are a vast improvement from the completely dewatered channel experienced in 1988. The stock water well program utilized 16 wells and 2 springs and watered over 12,000 cattle in summer-fall 2000-2001. However, it is apparent this system cannot be the sole conservation program. Consensus among landowners is that most of the logistical and efficient locations for stock water systems have been identified and developed.

The effects of drought conditions on fisheries populations in the upper Big Hole are well-documented (FGW 1995, Byorth 1995b). Although a minimal flow was maintained in 2000 and 2001, minimal survival flows dropped to less than 20 cfs for 55 days in 2000, and 65 days in 2001, between June and September. Until flows stabilize at higher levels, abundance of fish populations in the upper Big Hole River will be limited. While recent conservation efforts have improved instream flows, long-term solutions that maintain survival flows and enhance riparian health are needed. A key to the success of this program and long-term health of the watershed is a community-based program involving not only water users, but anglers, recreationists, and municipal interests, while fine tuning the Drought Management Plan as needed.

Water temperatures exceeded stressful levels of 70°F for almost all stations in 2000 and 2001. Temperatures regularly exceed the thermal tolerance of 77°F for Arctic grayling in the "warmed reach", as was the case in 2000 and 2001. Although we did not see any specific fish kill events, numerous thermally caused mortalities of mountain whitefish and catostomid species were observed in July and August. Arctic grayling and sympatric species seek out thermal refugia as we observed in LaMarche Creek. Future surveys and temperature monitoring will investigate additional thermal refugia in the upper Big Hole. Depleted instream flows in conjunction with high water temperatures is a continued concern, specifically in the "warmed reach". As efforts continue to develop methods to maintain instream flows, projects stimulating riparian health should also be investigated to alleviate temperature problems.

Arctic grayling abundance estimates are best used as indicators of population trends and in conjunction with age-class data. While density estimates could not be completed during 2000 and 2001, age histograms indicate a shift in age class dominance to age 3+ fish as a result of limited spawning success or poor recruitment in 1999 and 2000. The restoration parameters for the Big Hole River Arctic grayling population outlined in the Memorandum of Agreement between FWP and the USFWS (1996) are: 1) based on fall census of the McDowell and Wisdom Sections the estimated density of age 1+ grayling must equal or exceed 30 grayling per mile and, 2) based on the annual surveys the proportion of age 1 and 2 grayling in the Big Hole River must constitute between 50-80% of the total population. If the population falls below these criteria for two consecutive years, FWP and the Montana Fluvial Arctic Grayling Workgroup will conduct an assessment of limiting factors and initiate corrective actions. The USFWS will initiate a formal status review if the parameters are not met for three consecutive years. While the estimated density of 35 (± 8) age 1+ Arctic grayling per mile was slightly above the density parameters in 1999, the percentage of age 1 and age 2 grayling in 1999 was 35%, 10% in 2000, and improved in 2001 to 40%. However, this is based on limited fall surveys in the Wisdom reach, which is within the core juvenile rearing area. Montana Fish, Wildlife and Parks will work with the USFWS to add alternative language to the MOA regarding sampling during drought conditions. Annual density surveys will be completed as soon as conditions permit that will not further stress the grayling population.

The 1999 - 2001 population age structure has been skewed toward age 3+ grayling, with poor recruitment of YOY and yearlings. Although sampling was limited, results of the 2001 surveys indicate an improved age structure with a higher percent of age 1 grayling in the population.

The key to conserving Montana fluvial Arctic grayling is to protect and maintain a stable population in the Big Hole River, and to increase distribution into historic waters. In summer 2002, four restoration efforts will be monitored or planted, including the upper Ruby River, the North and South forks of the Sun River, the lower Beaverhead River, and the Missouri River Headwaters near Three Forks. Establishing additional fluvial Arctic grayling populations is vital to the long-term conservation of the species in Montana. Recovery efforts have progressed and the short-term goals established by the USFWS and FWP (four restorations in progress by December

31, 2000, (MOA 1996)) have been achieved. Well planned restoration efforts will provide insight to fluvial Arctic grayling habitat requirements and subsequent fine-tuning of restoration plans to maximize the probability of success. However, the plight of fluvial Arctic grayling remains uncertain. The Arctic grayling in the Big Hole River have experienced extreme low flows and high temperatures since 1999, and many challenges still remain to conserve the Big Hole population. Efforts to work with community-based groups like the Big Hole Watershed Committee, local landowners, recreationists, and other interest groups will continue to maintain instream flows, facilitate habitat restoration, educate, and promote public awareness of this unique Montana native.

APPENDIX A

Arctic Grayling Recovery Program
2001 Summary

Reintroduction Summary

REINTRODUCTIONS:

Fluvial Arctic grayling restoration efforts continued in 2001 in the Upper Ruby, Lower Beaverhead, and the North and South Forks of the Sun River, and the Missouri River Headwaters. The planting program summary for fluvial Arctic grayling is summarized in Table A1.

Table A1. Planting location, date, number, and average length at planting time, and source (Big Springs State Hatchery (BSSH)), for fluvial Arctic grayling restoration efforts in summer 2001.

Site	Date	Number	Avg. Length	Source
Beaverhead	6/19	12,468	7.0	BSSH.
Missouri Headwaters	9/20	28,966	2-3	BSSH
N FK. Sun	7/11-18	7,200	7.2	BSSH
S Fk. Sun	7/21	4,500	7.2	BSSH
Ruby	9/20	1,177	8.8	BSSH
TOTAL		54,911		

A. Ruby River:

Grayling plants were not scheduled in the Ruby River in 2001. However, 1,177 yearling grayling remained at the Big Spring State Hatchery after all other plants had been completed. Severe drought conditions at other restoration sites made the upper Ruby the most logical site to obtain the highest survival rates. An extension to the original Environmental Assessment (EA) was drafted and reviewed. Proposed actions were found to have no further impact than the original project actions. The EA extension was approved and signed by FWP Region 3 Supervisor Pat Flowers.

We planted 1,177 yearling grayling on September 20, 2001. These grayling were given an adipose clip to identify year class. To investigate utilization of lower gradient/velocities and deeper pools in the Snowcrest Ranch Area, grayling were planted at Ledford Bridge. The bridge is approximately 10 miles downstream from Vigilante

Section. Most of the previous plant locations have been from Vigilante upstream.

In April one pass electrofishing surveys were conducted in four sections to assess survival, distribution, movements, spawning potential, and condition factor of the 1997-2000 plants. We captured 27 grayling of which 15 (55%) were age 3 and 12 (45%) were age 2 for the 1999 and 2000 plants respectively. No age 4 grayling from the 1998 plant were captured. Comparatively, in 2000 we captured 140 grayling of which 130 (93%) were age 2, and 10 (7%) were age 3, from the 1999 and 1998 plants, respectively. All grayling were individually tagged with Visible Implant tags. Some of the males were ripe and all the females were gravid indicating pre-spawning conditions.

Electrofishing mark recapture censuses were conducted on five traditional FWP sections in September and October. We captured 86 grayling of which approximately 85% were age 2 (2000 plant) and 15% were age 3 (1999 plant). By comparison in 2000 we captured 786 grayling in the fall surveys of which 120 (15.3%) were age 2+ grayling. The number of grayling captured, and mark recapture estimates for grayling in 2000 and 2001 are provided in Table A2. On average estimates were 92 % lower than in 2000. We captured no YOY in fall surveys indicating that if grayling did reproduce naturally the progeny are either in different reaches or survival was very poor. Most of the planted grayling have remained between Three Forks and Warm Springs. One grayling was reported captured by angler ice fishing on the Ruby reservoir. Volunteer creel survey continued and results were reflective of reduced densities with a lower average catch per unit effort than 2000.

Table A2. Number of captured grayling and density estimates per mile for five electrofishing sections in the upper Ruby River, Montana in fall 2000 and 2001.

#Section	# Sample 2000	Estimate 2000	#Sample 2001	Estimate 2001
Green Hollow	11	NE	2	NE
Section 1	4	NE	2	NE
Vigilante	501	542(±52)	47	27 (± 5)
Bear Creek	179	424(±174)	27	20 (± 3)
Three Forks	91	101(±9.5)	8	7 (± 0)

Whirling Disease has progressed upstream from Ruby Reservoir since 1995. In Section-One we first started to see deformities in 2000. In 2001, not only did we see a larger percentage of rainbow/cutthroat hybrids with physical deformities, but also a dramatic decline in the numbers of juvenile fishes (Table A3).

Table A3. Number of rainbow/cutthroat hybrids sampled less than 8 inches, population estimates (standard deviation), and percent deformities for Section One on the upper Ruby River.

Year	# < 8 inches	Estimate (SD)	Percent Deformities
1996	170	1606 (137)	0%
1997	414	3253 (471)	0%
1998	370	4586 (364)	0%
1999	321	2216 (81)	0%
2000	200	2169 (218)	24%
2001	37	1004 (61)	38%

B. Sun River:

In 2000, 4,500 and 7,200 yearling grayling were planted in the South and North Forks of the Sun River, respectively. This was the third of a four-year planting program. Grayling were transported by pack-stock in the Bob Marshall and Scapegoat Wilderness Areas. Short-term planting mortality was low and estimated at less than 10%. Angling reports, snorkel surveys and sampling in Gibson Reservoir indicates the general trend of downstream movement. In May 2001, we sampled Gibson Reservoir with gill nets and hoop traps, and electrofished the confluence of the North and South Forks. The results are summarized in Table A4.

Table A4. Number captured and percentage of total catch for FWP surveys at Gibson Reservoir and the confluence of the North and South Forks of the Sun River, in May 2001.

Species/Age	Number Captured	Percent of Total
Rainbow Trout	222	41.5%
White Suckers	190	36.5%
Grayling Age 2	61	11.5%
Grayling Age 3	61	11.5%
Total	534	100%

In 2000, we implanted coded-wire tags in the grayling planted in the South Fork to assess whether grayling captured in Gibson Reservoir were planted in the South Fork (higher gradient) or the North Fork. We found 49% of all the age 2 grayling were planted in the South Fork, indicating grayling are moving into Gibson Reservoir from both tributaries.

In June, a crew snorkeled from Ray Creek to the Wilderness Boundary approximately 15 miles. We observed no grayling. This stretch represents some of the best habitat in the North Fork and numerous grayling plants were located in this reach in 1999 and 2000. We observed no grayling. Annual population surveys did observe at least one grayling from the 2000 plant. Creel data indicates grayling are being caught into fall months. However, it appears the majority are moving into Gibson reservoir.

C. Beaverhead River

In summer 1999, 18,548 yearling grayling (Approximately 9 inches) were planted at three different sites (Anderson Lane, Beaverhead Rock, and Silverbow Lane) on the lower Beaverhead River. In 2000,15,012 grayling were planted at the same locations averaging 7 inches. In 2001, we planted 12,500 grayling averaging 7 inches. Initially surveys were encouraging indicating fairly good survival, and in spring 2000 grayling were located on gravel shears attempting to spawn. Grayling were actively dispersing and moving throughout the Beaverhead River and into the Ruby and Upper Jefferson River. Growth rates have been very good with age 2 grayling averaging about 12 inches compared to 10 inches in the Big Hole River.

However, with drought conditions since fall 1999 survival rate has decreased. Table A5 shows numbers of fish captured for each electrofishing section since fall

1999. One potential cause of increased mortality in conjunction with effects of drought is the smaller grayling (average 2 inches smaller) planted in 2000 and 2001. These smaller fish are more susceptible to predation and increased mortality rates. Recent data from two lower Beaverhead River electrofishing sections indicates lower native catostomid densities in areas of higher brown trout densities. In 2002, larger grayling from Bluewater State Fish Hatchery will be planted to decrease susceptibility to predation and ultimately increase survival to spawning age.

Table A5. Number of grayling captured in fall 1999, spring and fall 2000 and 2001 in MFWP electrofishing surveys in the lower Beaverhead River, Montana.

Section	Fall 1999	Spring 2000	Fall 2000	Spring 2001	Fall 2001
Anderson Lane	308	44	69	10	5
Mule Shoe	137	35	60	5	7
Silver bow	NA	NA	24	3	27
Total	445	79	153	18	39

D. Missouri River Headwater

In June 2000, grayling plants were initiated with 21,160 yearlings planted in the lower Gallatin, lower Madison, lower Jefferson, and the mainstem Missouri at Headwaters State Park. Due to poor eye-up the numbers of yearling grayling were limited in 2001 and the Missouri River Headwaters did not receive yearling grayling. However, 28,966 excess YOY grayling from the Axolotl spawn in May 2001 were planted in the lower Madison and lower Jefferson on September 20,2001.

We conducted one pass CPUE surveys on a four-mile reach downstream from the Fairweather FAS on the Missouri River, and a ½ mile reach from the mouth upstream on the Gallatin River on May 21 and November 1. Spring surveys captured two grayling in the lower Gallatin and no grayling in the Missouri. Fall surveys captured no grayling. Comparatively, in the fall of 2000 we had captured six grayling in the Missouri and 12 grayling in the lower Gallatin.

F. Madison River

An Environmental Assessment, public scoping and comment period, and a Decision Notice were completed in 1999. The Decision was to proceed with reintroduction efforts on the lower Beaverhead and Missouri River Headwaters and defer the decision on the Madison River until on-going research on whirling disease and life history aspects of rainbow and brown trout can be analyzed and management recommendations evaluated. Madison grayling restoration efforts in 2001 were on hold.

APPENDIX B

Big Hole River Drought Management Plan

Big Hole River Drought Management Plan
The Big Hole Watershed Committee
Adopted May 2000

Purpose

The purpose of the of the drought management plan is to mitigate the effects of low stream flows and lethal water temperatures for fisheries (particularly fluvial Arctic grayling) through a voluntary effort among agriculture, municipalities, business, conservation groups, anglers, and affected government agencies.

Overview

The Big Hole Watershed Committee has agreed on this dry year plan to help mitigate damage to the fishery during dry years as indicated by flows and temperature. This plan has been designed to take into full account the interests of all affected parties including ranching, municipalities, anglers, and conservation groups.

The Big Hole Watershed Committee agrees that if this plan is to be successful in a dry year, it will need broad-based support and understanding. Big Hole Committee members are committed to helping secure the support of their constituencies for the successful implementation of this plan.

This initial plan is intended as a starting point from which modifications can be made based on the lessons learned from research projects, such as the Big Hole Watershed Committee's return flow study, increased information from new river gages, and from the experiences gained by implementing this plan. The plan will be reviewed by the Big Hole Watershed Committee every January for modifications.

Roles and Responsibilities

Big Hole Watershed Committee roles:

- educate interested and affected parties;
- develop, adopt, and modify annually the dry year plan;
- receive, monitor, and act on information regarding stream conditions and snow pack levels throughout the year;

- notify interested and affected parties of implementation and secure support; and
- evaluate the environmental, social, and economic impact of the plan.

Montana Fish, Wildlife and Parks (FWP), Montana Department of Natural Resources and Conservation (DNRC), and the United States Natural Resource Conservation Service (NRCS) roles:

- provide accurate and timely information regarding stream conditions and snow pack levels throughout the year;
- provide technical assistance in reviewing the plan and monitoring its implementation; and
- ensure coordination of effort among all affected government agencies.
- Contacts and informs media of dry year plan implementation and stream flow and temperature status.

Definition of Dry Year Conditions and Recommended Actions

The Big Hole Watershed Committee will monitor snowpack levels and forecasted low stream level information provided by the USGS and NRCS throughout the year to prepare for potential water conservation measures. Stream flow information gathered from the USGS Wisdom and USGS Melrose gauging stations will be used to initiate specific voluntary actions to conserve water and mitigate the effects of dry year conditions on fisheries from May 1 through October 31.

The following flow targets take into consideration preparation time necessary to implement this voluntary plan. The annual evaluation of the effectiveness of the dry year plan will provide information to more intensively analyze the minimum instream flows necessary to sustain adequate habitat quality and buffer water temperatures[1].

I Upper River - Rock Creek Road to Mouth of the North Fork

Flows — Monitored at the USGS Wisdom Gauge

60 cfs — DNRC and FWP officials will meet with the Big Hole Watershed Committee to present data; formulate options including voluntary reduction of irrigation, stock water diversions, municipal water use, angling, and encourage the use of stock watering wells; and prepare to take action. A phone tree is initiated to advise water users, outfitters, and anglers of low water conditions and encourage conservation measures.

40 cfs — Notice to outfitters and anglers requesting fishing be voluntarily limited to morning hours. Well use will be encouraged for stock watering. A phone tree will advise water users and outfitters of low water conditions and encourage conservation measures. The media will be contacted and news articles released to inform publics of low flow conditions.

20 cfs — FWP will close the upper river to fishing, and will limit electrofishing sampling to core sections near Wisdom. Voluntary reduction of irrigation and public municipal water use is initiated, and continued well use for stock watering encouraged. The phone tree is again initiated to contact water users advising of extreme low water conditions and encourage conservation measures. The media is contacted and informed of fishing closures and encourages public conservation efforts. The river remains closed until flows exceed 40 cfs for seven consecutive days.

Temperature[2] July 15-September 1:

Step 1 — When temperatures exceed 70°F for over 8 hours per day for three consecutive days at the USGS Wisdom gage and flows are above 30 cfs, a phone tree is used to contact outfitting businesses and a news release is issued advising publics and anglers of potential stressful conditions to the fishery and encouraging anglers to seek other destinations (mountain lakes and streams, spring creeks).

Step 2 When flows are 25-30 cfs at the USGS Wisdom gage and temperatures exceed 70°F for more than 8 hours per day for three consecutive days, and evidence of thermally induced stress to the fishery occurs, FWP will close the upper river to fishing. News releases will be issued and a phone tree will again contact local outfitting businesses. The upper river will be closed until temperatures do not exceed 70°F for more than 8 hours per day for three consecutive days and flows are greater than 30 cfs for seven consecutive days.

Step 3 When flows are 25 cfs or less at the USGS Wisdom gage and temperatures exceed 70°F for more than 8 hours per day, for three consecutive days, FWP will close the upper river to fishing. News releases will be issued and a phone tree will again contact local outfitting businesses. The upper river will be closed until temperatures do not exceed 70°F for more than 8 hours per day for three consecutive days and flows are greater than 30 cfs for seven consecutive days.

[1] The wetted stream perimeter (flow below which standing crops of fish decrease (DNRC 1992)) for the upper Big Hole river is 60 cfs. While this flow may be reasonable to maintain in ample moisture years and should be the goal for flow preservation efforts, in most years it is not a realistic quantity. Data from the USGS Wisdom gage from 1988-1999 recorded flows below 60 cfs in each of the twelve years. Population and flow data indicate 40 cfs is feasible to maintain while still sufficient to protect the Arctic grayling population. A minimum survival flow of 20 cfs will provide flows necessary to maintain a wetted channel and ensure survival of the grayling population during brief, critical periods.

[2] Temperatures above 70°F are generally considered stressful to salmonids. Warm water temperatures typically occur between July 15 - September 1 in the Big Hole River. Although temperatures above 70°F can occur before and after this period, cooler night temperatures alleviate long periods of warm daytime temperatures. The upper incipient

lethal temperature (e.g. that temperature that is survivable indefinitely for periods longer than one week by 50% of the population) for Arctic grayling is 77°F (Lohr et. al. 1997). Critical thermal maximum temperature is 85° F resulting in instantaneous death.

II. Middle River: Mouth of the North Fork to Dickie Bridge

Flows: Monitored at USGS Mudd Creek Gage
Temperatures: Monitored at the Sportsmans Park Thermograph Site

100 cfs When flows decrease to 100 cfs or temperatures exceed 70°F for over 8 hours per day for three consecutive days. DNRC and FWP officials will meet with the Big Hole Watershed Committee to present data; formulate options including voluntary reduction of irrigation, stock water diversions, municipal water use, angling, and encourage the use of stock watering wells; and prepare to take action. A phone tree is initiated to advise water users, outfitters, and anglers of low water conditions and encourage conservation measures.

80 cfs When flows decrease to 80 cfs or temperatures exceed 70°F for over 8 hours per day for three consecutive days. Notice to outfitters and anglers requesting fishing be voluntarily limited to morning hours. Well use will be encouraged for stock watering. A phone tree will advise water users and outfitters of low water conditions and encourage conservation measures. The media will be contacted and news articles released to inform publics of low flow conditions.

60 cfs When flows decrease to 60 cfs or temperatures exceed 70°F for over 8 hours per day for three consecutive days. FWP will close the river to fishing and not conduct electrofishing surveys. Voluntary reduction of irrigation and water use is initiated. A phone tree and media releases inform waters users, outfitters, anglers, and publics of the continued decline of instream flows and encourages water conservation. The

river remains closed until flows exceed 80 cfs for seven consecutive days and temperatures do not exceed 70°F for more than 8 hours per day for three consecutive days.

Note: In years with clear cut drought conditions under which triggers in both the upper and middle reach are met, or about to be met, these two reaches could be treated as one unit Rock Creek Road to Dickie Bridge).

The Mudd Creek gage has limited data (1998-1999). Continued data on various flow scenarios will allow better analysis of wetted perimeter and instream flow regimes. This plan should be fine tuned or modified as needed, as additional data becomes available.

II Lower River - Dickie Bridge to confluence with the Jefferson

Monitored at USGS Melrose Gage

250 cfs — DNRC and FWP officials meet with Big Hole Watershed Committee to present data; formulate options including the voluntary reduction of irrigation, municipal water use, and angling; and prepare to take action. A phone tree is initiated to advise irrigators and outfitters of stream flow conditions.

200 cfs — Notice to outfitters and anglers requesting fishing be voluntarily limited to morning hours. The phone tree will inform local water users, anglers and outfitters of stream flow conditions. The media will be contacted and news articles released to inform publics of low flow conditions.

150 cfs — FWP will close the river to fishing and not conduct electrofishing surveys. Voluntary reduction of irrigation and water use is initiated. A phone tree and media releases inform waters users, outfitters, anglers, and publics of the continued decline of instream flows and encourages water conservation. The river will remain closed until flows exceed 200 cfs for seven consecutive days.

Temperatures triggers are the same as the middle reach.

Notification and Monitoring Process

Montana Fish, Wildlife, and Parks, Montana Department of Natural Resources and Conservation, and the United States Natural Resource Conservation Service will keep the Big Hole Watershed Committee fully informed throughout the year regarding stream flows, water temperature, and snow pack data. This will allow for timely information to help in encouraging appropriate courses of action.

Stream conditions, water temperature, and snow pack levels will be a standing agenda item at each Big Hole Watershed Committee meeting. Based on the yearlong monitoring of weather conditions that may influence flow, the Big Hole Watershed Committee will publish a notification of impending dry year conditions. Notifications will be sent to the press, ranchers, municipalities, outfitters, conservation and sportsmen groups, and posted on the "world wide web".

While most attention is on late summer conditions, it is crucial to certain species, including Fluvial Arctic grayling that springs flows are closely monitored.

The Montana Fish, Wildlife, and Parks will offer assistance to irrigators who are willing to cut back on water diversions. The Big Hole Watershed Committee will hold an open public meeting to present the information and conduct discussions with all parties concerning proposed actions.

Each caucus within the Big Hole Watershed Committee will communicate with their respective groups concerning implementation of the plan and secure support.

Public Education

The Big Hole Watershed Committee will develop and distribute educational material with agency assistance, describing the need for a drought management plan, its provisions, and anticipated benefits.

Information will be provided on the possible actions people can take to mitigate damage from dry years including but not limited to:

- voluntary reduction of irrigation and diversion stock watering during critical times;
- increase flood irrigation during spring runoff to augment return flows;
- water conservation policies by municipalities and industries during sensitive times;
- emergency water reduction policies by municipalities and industries during critical times;
- reduced recreation uses during sensitive times; and
- elimination of all recreation uses at critical times.

APPENDIX C

Flow Enhancement Projects

Table C1. Stockwater wells, year completed, ditch affected, landowner, major funder, and other conservation projects for Big Hole River Flow Enhancement Program, Montana, as of January 1, 2002.

Well	**Year Completed**	**Ditch**	**Landowner**	**Major Funders**
W1	1998	Spokane	Erb	PFWP, BBN, FFIP, SANDIA LABS
W2	1998	Spokane	Erb	PFWP, BBN, FFIP
W3	1998	Spokane	Erb	PFWP, BBN, FFIP
W4	1998	Spokane	Erb	PFWP, BBN, FFIP
W5	1998	Spokane	Erb	PFWP, BBN, FFIP
W6	1998	Nelson	J.Nelson	PFWP, BBN, FFIP
W7	1998	Huntley	Huntley	PFWP, BBN, FFIP
W8	1998	Huntley	Huntley	PFWP, BBN, FFIP
W9	1998	Hirschy	F.Hirschy	BCD,PFWP,FFIP
W10	1998	Burton	Lapham	BCD
W11	1998	Woody	Swenson	BCD
W12	1998	Woody	Schindler	BCD
W13	1999	RP	R.Peterson	BCD
W14	1999	Huntley	Huntley	PFWP,BLM
W15	2000	Up N.Fork	Kircher	PFWP,FFIP
W16	2001	Pintlar	Arrow Ranch	PFWP,FFIP
W17	2001	Pintlar	K.Bacon	PFWP,FFIP
W18	2001	Pintlar	T.Christiansen	PFWP,FFIP
W19	2001	Steel Cr.	BHGA	PFWP, BHGA
Springs				
S1	1998/99	SwampCr.	H.Peterson	BCD
S2	1998/99	Big Lake Cr.	J.Hirschy	BCD
Pipelines				
P1	1999	Spokane	Erb	PFWP
P2	2000	Spokane	Erb	PFWP, FFIP
OTHER				
Chnl Stb	1998	Deep Cr.	Ralston	FFIP,PFWP,BLM
Riparian	1996	Steel Cr.	F.Hirschy	FFIP, BBN
Fish Ladder	2001	BHR	Erb	PFWP

report 1997. Submitted to: Fluvial Arctic Grayling Workgroup. Montana Fish, Wildlife and Parks, Bozeman.

Magee, J. P. and S. T. Opitz. 2000. Big Hole River Arctic grayling recovery project: Annual monitoring report 1999. Submitted to: Fluvial Arctic Grayling Workgroup. Montana Fish, Wildlife and Parks, Bozeman.

McCauley, R. 1991. Trout, The Wildlife Series. Stackhole Books. Stolz J. and J. Schnell Edt. 6 pp.

Montana Department of Fish, Wildlife and Parks. 1994. Mark/Recapture version 4.0 a software package for fishery population estimates. Information Services, Montana Department of Fish, Wildlife and Parks, Bozeman.

Montana Department of Fish, Wildlife and Parks, and the U.S. Fish and Wildlife Service. 1996. Memorandum of Agreement, Implementation of the Fluvial Arctic Grayling Restoration Plan. Helena, Montana.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin 119. 300 p.

Shepard, B. B. and R. A. Oswald. 1989. Timing, location and population characteristics of spawning Montana Arctic grayling (Thymallus arcticus montanus (Milner)) in the Big Hole River drainage, 1988. Report to: Montana Department of Fish, Wildlife and Parks; Montana Natural Heritage Program - Nature Conservancy; U.S. Forest Service, Northern Region.

U. S. Geological Survey. 1988-2001. Water Resource Data, Montana, Water Year 2001. Montana Water Data Report MT-01-1. Helena, Montana.