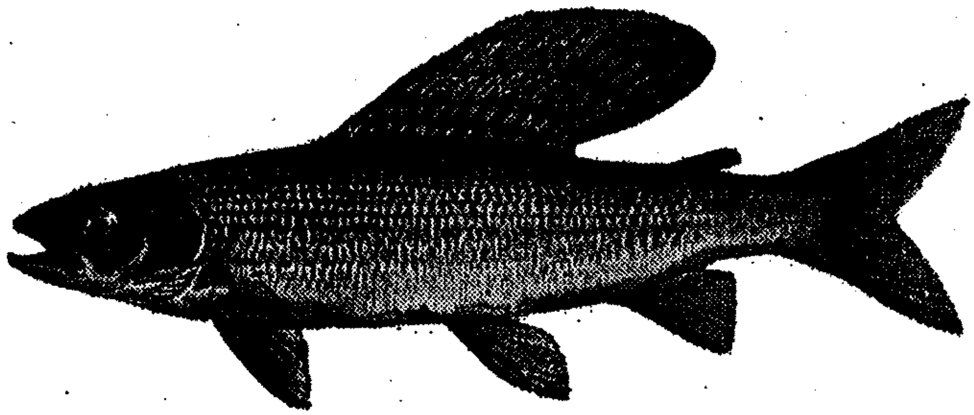

MONTANA FLUVIAL ARCTIC GRAYLING RECOVERY PROJECT:

ANNUAL MONITORING REPORT 1999

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Submitted To:

Fluvial Arctic Grayling Workgroup

and

Beaverhead National Forest
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ABSTRACT

We annually monitor the fluvial Arctic grayling population in the upper Big Hole River and other factors including discharge, water temperatures, and abundance of potential competitors. Discharge of the upper Big Hole River was moderate in spring and early summer due to near normal snowpack and below average spring temperatures. Despite below average precipitation during the spring and summer months, sufficient ground water recharge maintained flows through mid-August. All phases of the Big Hole Drought Management Plan were initiated when flows dropped below trigger points of 60, 40, and 20 cfs at Wisdom. Flows decreased to 16 cfs on August 25. To alleviate any further potential stress to the Arctic grayling population, an angling closure was enacted from the Twin Lakes Road to Dickie Bridge from August 28-September 21. From September 1-14, the Flow Enhancement Program utilized 10 stockwater wells, closing 5 diversion ditches, and provided water to up to 6,000 cattle. As a result flows more than doubled, and were maintained above survival levels (20 cfs). Water temperatures were cooler than 1998 and reached lethal levels at only one thermograph station, located in the "warmed reach". In the Wisdom Section, the estimated Arctic grayling density decreased from 76 age 1+ per mile in 1998 to 35 age 1+ per mile in 1999. The density estimate increased in the Sportsmans-Eastbank reach from 23 age 1+ per mile in 1998 to 46 age 1+ per mile in 1999. The spawning population was represented by a stable portion of mature year classes with 74% of the graying sampled being age 3 and older. Fall catch rates for young-of-the-year grayling continued to decrease and were the lowest since 1987. In the Wisdom area, brook trout density estimates decreased from 613 per mile in 1998 to 417 age 1+ per mile in 1999. Rainbow trout abundance remained low in the Wisdom section (7 age 1+ per mile)and decreased in the Sportsmans-Eastbank section (127 age 1+ per mile). The broodstock reserve at Axolotl Lakes was successfully spawned and 194,000 eggs were collected and transported to Big Springs State Hatchery for rearing. To establish an additional year class 1,740 yearling grayling raised at the Big Springs Sate Hatchery were planted in the Axolotl brood lake. Survival of the grayling planted in 1998 in Green Hollow II Lake was poor and may be attributed to poor water quality at the time of planting. The broodstock at the USFWS Bozeman Fish Technology Center tested disease free and 3,680 young-of-the-year were planted in Green Hollow II Lake in August.

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 since 1991 (Byorth 1991, 1993, 1994, 1995a, 1997, Magee and Byorth 1994, Magee and Byorth 1995, Byorth and Magee 1996, Magee and Byorth 1998, Magee 1999).

Objectives of the project from January 1 through December 31, 1999 were:

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

B. Maintain minimum flows by promoting water conservation among Big Hole basin water users.

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

D. Monitor the broodstock reserve of grayling at Axolotl Lakes and collect gametes.

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

F. Reintroduce grayling, and monitor abundance and distribution of grayling and potential competitors in the Upper Ruby River.

G. Initiate and monitor restoration efforts for the North and South Forks of the Sun River.

H. Complete Environmental Assessment, public review, and comment periods on restoration proposals for the lower Beaverhead, upper Madison and Missouri River Headwater River systems.

I. Complete the Reintroduction Plan as well as plant and monitor grayling in the lower Beaverhead River.

Results are reported for objectives A through E in this report. Progress on objectives F, G, H, and I will be reported separately.

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 and the USGS Mudd Creek Station (USGS 1999). Water temperature was also monitored at the Wisdom Gage and 10 thermograph stations (Figure 1). Four thermograph stations have been operated since 1992 and an additional six were established in 1995 (Byorth and Magee 1996). We used Onset Hobotemp and Stowaway thermographs at the ten stations recording at 36 to 144 minute intervals. Following removal, each thermograph was tested for accuracy and calibrated following procedures from Scholz (1998). Data were downloaded into Microsoft Excel and reduced to daily maximum, minimum, and average temperatures.

Flow Enhancement Project

As of September 1, 1999, fourteen wells and two springs involving ten landowners and nine diversion systems have been completed and were operable. In 1999, we worked closely with the U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program (PFWP), the Big Hole Watershed Committee (BHWC), and local landowners to fine tune the Drought Management and Flow Enhancement Programs.

Efforts focused on completing all wells for operation by September 1999. Two Future Fisheries Improvement Project (FFIP) grants were used to fund: 1) a power line to a previously completed stock-water well, and 2) development of two additional springs to supplement wells on the Spokane ranch. Construction of the power line was completed in July 1999 and development of the springs will began in summer 2000. An additional well and five stock-water tanks (funded by a BLM grant to the BHWC and PFWP) were strategically developed allowing the closure of the Huntley ditch during low flow periods. We worked closely with landowners and in conjunction with PFWP personnel in strategic planning, developing stock water wells, construction of fences around stock tanks, power systems, and overseeing and scheduling specific tasks.

A revised Drought Management Plan (DMP) was adopted by the BHWC in June. The plan outlines conservation measures to be triggered at three flow levels (60, 40, and 20 cfs) and temperatures exceeding 70° F for over eight hours per day for three consecutive days at the USGS Wisdom Gage. Each trigger level promotes public awareness of potential stress to the fishery and encourages water conservation measures. Twenty cfs is considered the survival flow (Byorth 1995b), below this level FWP will recommend an angling closure in specific affected reaches to the FWP Commission as recommended in the DMP. We met with landowners on June 21, 1999 to discuss synchronizing stock water well use to test the efficiency of the Flow Enhancement Program as well as the implications of the Drought Management Plan. Regardless of flow levels we had planned to sychronize the use of the wells from September 1-14, 1999. However, in August flows decreased below each of the three of the trigger levels and the DMP was implemented. Stock-water wells were used to increase instream flows and an angling closure was implemented to further protect the fishery.

Population Monitoring

We sample the Arctic grayling population of the Big Hole River each spring and fall to document population abundance, recruitment, age class strength, 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.

The spawning population of grayling was surveyed by electrofishing the McDowell, Wisdom East and West, North Fork, and Pintlar-Squaw sections of the Big Hole River. A single electrofishing pass was made through each section between April 20 and 28. We sampled Deep Creek April 19, 1999 to assess the contribution of this tributary to spawning and recruitment.

Fall population surveys of the McDowell-Wisdom sections have been conducted since 1983 to provide an index of grayling abundance and recruitment. Due to low capture rates over the past ten years, the McDowell Section was not surveyed and will be monitored on a two year rotation. We conducted dual marking runs in both the Wisdom East and West Sections to decrease bias and increase statistical validity of population estimates (Byorth 1997). Due to a mechanical breakdown the Wisdom West Section was marked two and one-half times. A second recapture run was also made in the Wisdom West Section because of limited recaptures on the first effort. We marked grayling, brook trout, rainbow trout, burbot, and brown trout in the Wisdom West Section on September 10, 14, 20 and conducted the recaptured run on September 29 and 30.

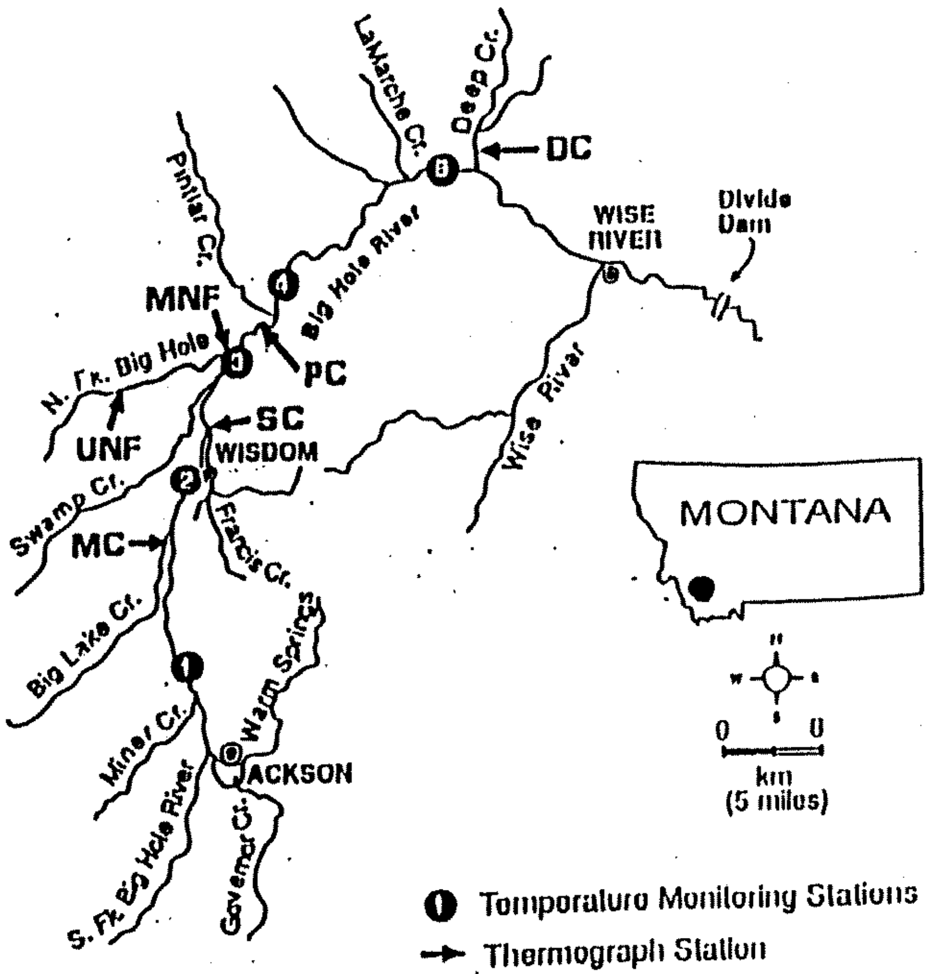

Figure 1. Map of the upper Big Hole River temperature monitoring stations. Stations are: 1 = Peterson Bridge, MC = McDowell Section, 2 = USGS gage at Wisdom, SC = Steel Creek, 3 = Buffalo Ranch, MNF = mouth of North Fork Big Hole River, UNF = Upper North Fork Big Hole River, PC = mouth of Pintlar Creek, 4 = Christianson Ranch, 5 = Sportsmans Park, and DC = Deep Creek.

Wisdom East was marked September 13 and 16 and recaptured on September 23, 1999. The Sportsmans-Eastbank section was established in 1995 to provide additional information on the segment of the grayling population residing in mid-river reaches, and to monitor rainbow trout populations. Sportsmans-Eastbank was marked October 4 and recaptured on October 12, 1999. To assess tributary contribution to the Big Hole population Deep Creek was marked on Septemebr 29 and recaptured on October 13. A Montana Fish, Wildlife & Parks crew monitoring trout populations in the lower river; also marked, tagged, and measured grayling in the Jerry Creek and Melrose sections.

To assess brook trout abundance and upstream grayling distribution, we conducted a mark and recapture experiment on the 40 Bar section near the town of Jackson. The 40 Bar section was marked on September 8 and recaptured on September 21. A one-pass electrofishing survey is conducted annually in the Fishtrap and Sawlog pools to analyze age structure of the adult population. Fishtrap and Sawlog pools were surveyed on October 20, 1999.

Electrofishing data were entered and analyzed with Mark/Recapture 4.0 (Montana Fish, Wildlife and Parks 1994). We calculated population estimates using Log-Likelihood or modified Peterson methods (Ricker, 1958). Catch-per-unit-effort (number per electrofishing pass) of YOY grayling was calculated as an index of recruitment. To compare with previous years, estimates for the Wisdom East and West sections were analyzed separately, and combined as the Wisdom section.

BROOD RESERVE

Axolotl Lake Brood

The Arctic grayling brood reserve at Axolotl Lakes, planted in 1989 and supplemented in 1992 and 1997, provides a source of fluvial grayling gametes to supplement the captive brood stock and provide young fish for reintroductions. We monitor the reserve population annually to determine abundance and collect gametes. Fyke nets and hook-and-line were employed to capture grayling. Most 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. Grayling were spawned with assistance from personnel from the U.S. Fish and Wildlife Service Ennis National Fish Hatchery and Washoe Park Trout Hatchery on May 24 and 28. Eggs were stripped from up to five female grayling, pooled, and fertilized with milt aspirated from two to five 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).

Green Hollow II Lake

The Arctic grayling brood reserve at Green Hollow II Lake on Turner Enterprises' Flying D Ranch was first planted with age one fluvial brood stock on October 14, 1998. The lake had been drawn down to increase removal efficiency of potentially competing cutthroat, rainbow trout, and brook trout, and was only partially filled at the time grayling were planted. A fish screen was constructed to prevent spawning grayling from moving into Green Hollow Creek, and to inhibit brook and rainbow trout from moving into the lake. Turner Enterprises personnel reported a fish kill three weeks after the plant with approxiametely 20-30 mortalities observed. Samples were collected for histological analysis and processed at the USFWS Fish Health Lab, Bozeman, Montana. The results indicated septic water conditions from the reservoir draw down had caused bacterial infections. The consensus was that conditions would improve with increased reservoir levels. Multiple attempts were made to assess survival and population health in May and June 1999. Fyke nets and hook-and-line methods were used to capture grayling. In order to establish multiple year classes, additional grayling, originating from the fluvial brood stock at the Bozeman Fish Technology Center, were planted on August 12, 1999.

RESULTS

Discharge and Water Temperatures

The 1999 spring run off was similar to 1998 and dramatically different than the previous three years. Runoffs in 1995, 1996, and 1997 were large and prolonged with record high flows in 1997. In 1999, runoff was of a considerably lower magnitude. Snowpack for the Jefferson Drainage was 109% of the long-term average as of June 1 (Natural Resources Conservation Service (NRCS)Snotel Surveys). Near average snowpack and below normal spring precipitation resulted in moderate run off conditions during the month of May. Instantaneous peak flow recorded at Wisdom occurred on May 31, at 1,750 cubic feet per second (cfs). Cooler than average June temperatures slowed snow melt and charged the aquifer, maintaining instream flows through July and mid-August (Figure 2). Monthly precipitation at Wisdom was below average for April (52%), May (72%), June (75%), July (5%), September (13%) and October (21%). Fortunately, thunderstorms in August (120% of the historic monthly average) provided some relief. Despite below average summer precipitation in April, May, June and July, flows remained above 60 cfs through mid-August due to the sufficient ground water storage. The minimum flow recorded at the Wisdom gauge was 16 cfs on August 25 and 26 (Table 1). August-September water yield in 1999 was 4,460 Acre-Feet, well below the 10,310 Acre-Feet in 1998, and depictive of the below average percipitaion in spring and summer 1999 (Table 1).

Mean daily water temperatures in 1999 were cooler than in 1998. Maximum instream temperatures peaked at most thermograph stations on July 13 or August 19, with the highest daily mean temperatures recorded on August 19 (Table 2).

The Hobo logger at the PC Station was removed by an angler shortly after installation and thus no data was recorded. The Hobo logger at station 4 (Christianson Ranch) was out of the

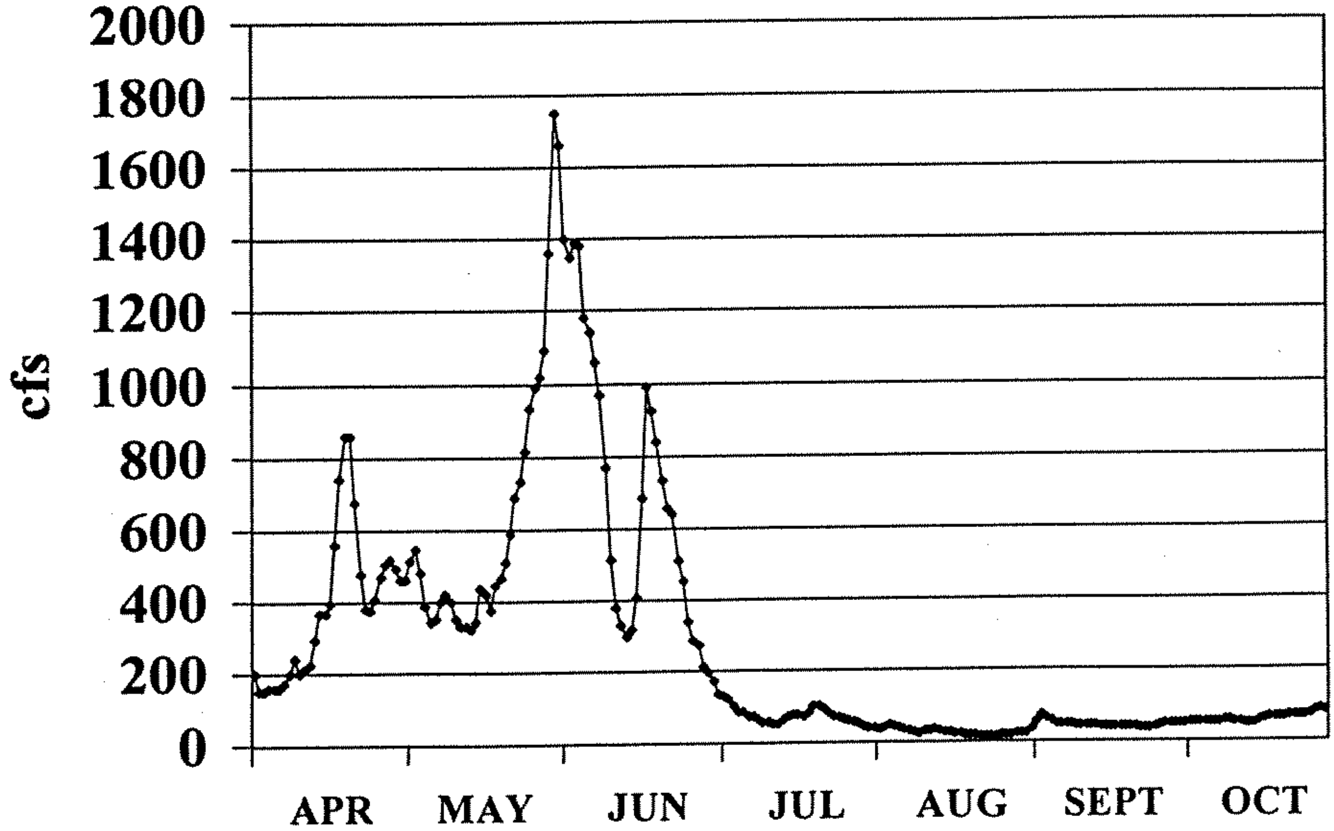

Figure 2. Hydrograph of the Big Hole River measured at the USGS gage at Wisdom, Montana, 1999.

Table 1. Comparisons of Big Hole River discharge parameters measured at the USGS gage at Wisdom, 1988 to 1999. 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

water between July 3-29 and at Station 5 (Sportsmans Park) between July 5-29. Thus, data from these two sites do not include most July temperatures. Station 4 recorded the highest maximum temperature of 80.6 °F and the highest mean daily maximum of 69.2°F on August 19. Lethal temperature levels of 77°F reported by Lohr et al.(1996) were recorded only at the Station 4, and surpassed lethal levels on 12 days for a total of 26.5 hours between July 30-August 29. Temperatures likely surpassed these levels on numerous days in July, however the inoperative logger prevented data collection. In the "warmed reach", where the highest temperatures normally occur,(Stations 3, PC, and Station 4) temperatures were greater than 70°F for more than 6 hours for 6 days at Station 3, and 16 days at station 4. No other station recorded temperatures above 70°F for this duration on any day.

Table 2. Maximum daily (T_{max}) and maximum mean daily water temperature at thermograph stations in the Big Hole River 1999. Stations are: 1 = Peterson Bridge, MC = McDowell, 2 = USGS gage at Wisdom, SC = Steel Creek, 3 = Buffalo Ranch, MNF = mouth of North Fork Big Hole River, UNF = Upper North Fork Big Hole River, PC = mouth of Pintlar Creek, 4 = Christianson Ranch, 5 = Sportsmans Park, DC = Deep Creek.

Station	T_{max} (°F)	Max T_{mean} (°F)	Days/Hrs >70°F	Days/Hrs >77°F
1	70.5	62.9	1/1	0/0
MC	72.9	65.9	14/36.5	0/0
2[1]	75.0	67	36/-	0/0
SC	74.3	66.2	29/57	0/0
3	74.3	67.2	33/135.5	0/0
MNF	73.8	65.1	25/43	0/0
UNF	70.1	64.4	1/1	0/0
PC[2]	NA			
4[3]	80.6	69.2	25/146.5	12/26.5
5[4]	73.1	62.7	11/15	0/0
DC	70.1	63	1/1	0/0

[1]Hourly temperatures Not Available

[2]Pintlar Hobo removed by angler

[3]Christianson Hobo not operating 7/3-7/29

[4]Sportsmans Hobo not operating 7/5-7/29

Flow Enhancement Program

Phase One of the Drought Management Plan (DMP) was initiated when flows decreased to 60 cfs at Wisdom on July 28. Landowners were contacted and asked to conserve water and utilize stock-water wells where possible. At this point, many of the stock water wells were not used, and in fact, pastures with wells were irrigated to increase feed for use later in the month. Phase Two was implemented on August 13 when flows dropped to 40 cfs. A Montana Standard news release advised anglers of low flow conditions and possible temperature induced stress, and encouraged anglers to fish only during morning hours. Water users were contacted again and encouraged to practice water conservation measures. Six wells were in use prior to September 1. Flows decreased to 19 cfs on August 22 and phase three of the DMP was initiated. In order to alleviate any further stress accompanying low flow levels, the FWP Commission approved an angling closure of the upper Big Hole River (between Dickie Bridge and the Twin Lakes Road) on August 29, 1999. On September 1, a major irrigation diversion was closed, and 4 additional wells were operated. As a result, instream flow levels increased to 38 cfs. An additional diversion was closed on September 3 and flows increased to 56 cfs. From Septmeber 1-14, 10 wells were utilized, closing 5 diversion ditches, and watering up to 6,000 cattle. As diversions were closed, instream flows increased from 16 cfs to 73 cfs (in conjunction with a precipitaion event on

September 5, 1999) and then stabilized in the low 40's (Figure 3). The angling closure ended on September 21 when flows had stabilized at more than 40 cfs for seven consecutive days as required by the DMP.

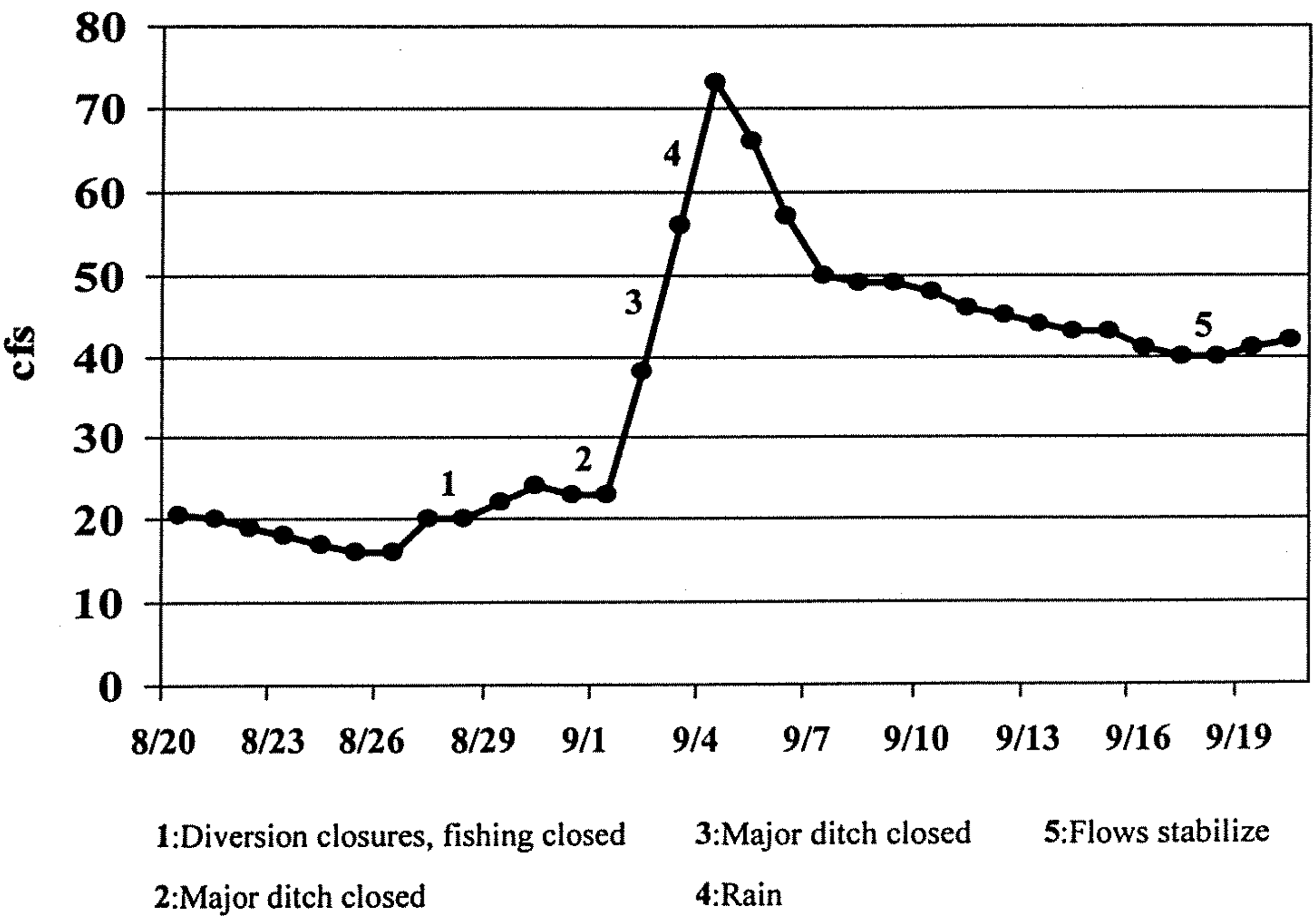

Figure 3. Big Hole River hydrograph at USGS Wisdom gage station during Drought Management Plan and Flow Enhancement Project implementation August 20 - September 22, 1999.

Population Monitoring

Spawning and Recruitment

In Big Hole River spawning surveys, we captured 87 grayling of which 3 were age 1 fish. Sampling occurred from April 19-28 and no ripe females captured. The overall sex ratio was skewed toward males at 1.4:1, which is indicative of pre-spawning ratios. Grayling normally spawn in the Big Hole River when daily maximum temperatures exceed 50°F. Temperatures first reached 50°F April 24-26. However, colder weather decreased temperatures below the 50°F threshold until May 6. While there was most likely some spawning from April 24-26, the majority of spawning probably did not occur until May 6-8, when daily mean temperatures ranged from 46 to 49 °F. The mean daily discharge ranged from 373 cfs to 470 cfs during these spawning periods. Predicted time of emergence of larval grayling for the early spawners (April 24-27) was May 14-16 when mean daily discharge was 323-434 cfs. The majority of grayling larva emerged between May 23-25 when mean daily flows ranged between 687-814 cfs at Wisdom (Figure 2).

The spring surveys indicated a balanced age distribution of the spawning population in 1999. Approximately 74% of spawning age grayling captured were Age 3 and older (Table 3). This proportion of mature grayling in the spawning population has been stable since 1992. With average over-winter survival the spawning population should be dominated by age 3 and 4 fish in 2000.

In Deep Creek, sampling apparently occurred prior to spawning movements as mean daily temperatures were in the low 40's and no grayling were captured.

Table 3. Percent composition by age class of Arctic grayling captured during spawning surveys in the upper Big Hole River, 1989 - 1999.

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

Catch rates of YOY grayling during fall electrofishing surveys provide an index of recruitment. Catch rates in 1999 continued to decline and were the lowest since 1987 in the Wisdom section (Table 4). As in 1998, we captured no YOY grayling in the Sportsmans-Eastbank section compared to a catch-per-unit-effort of 0.66 in 1997, 3.7 in 1996 and 0.33 in 1995. No YOY grayling were captured in the 40 Bar section in 1999 or 1998, whereas one was captured in 1997.

Table 4. Catch rates (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 - 1999. The McDowell Section was not sampled in 1999.

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

Fall Population Surveys

The 1999 estimates of age 1+ grayling abundance in the Wisdom Section decreased for the second consecutive year. We estimated grayling abundance in the Wisdom Section at 35 (SD ±8.4) age 1 + per mile decreasing from 76 (SD ±30) age 1+ per mile in 1998 and 96 (SD ± 66) age 1+ per mile in 1997(Table 5). In contrast, the estimate in the Sportsmans-Eastbank section increased to 46 (SD ± 33) age 1+ grayling per mile compared to 23 (SD ± 13) age 1+ grayling per mile in 1998, but below the historic high of 73 (SD ± 50) age 1+ grayling per mile in 1997 (Table 6). Although grayling continue to be rare in the 40 Bar section, we captured more (five) in 1999 than 1998 (One). The catch-per-unit effort for the pool surveys was 31 grayling per pool, up from 21 grayling per pool in 1998. The average catch in the three pools from 1992-1996 is 14 grayling per pool. These pools (Sportsmans Park, Fishtrap, and Sawlog) are important summer and over-winter habitats. Variability in catch rates may be attributed to timing of the grayling moving into over-winter habitats as well as overall grayling numbers.

The length-frequency distribution and scale analysis of the fall grayling sample indicates poor recruitment of the 1998 age 1 year class and few YOY indicates either poor survival of age 0 fish or limited spawning success (Figure 4). Contrary to high water years of 1995-1997 when survival of age 0 grayling was good, in 1999 we have observed a decreased abundance of age 1 and 2 grayling. In 1997, age 1-2 grayling comprised 68% of the sampled grayling in fall surveys, compared to 77% in 1998, and 37% in 1999. In 1999 the age structure has been shifted to older age 3+ grayling. In 1997 age 3+ grayling comprised 32% of the fall sample compared to 22% in 1998 and 62% in 1999.

Table 5. Estimated number per mile of Arctic grayling, brook trout, and rainbow trout from 1978 to 1999 in the upper Big Hole River, Montana, from Montana Fish, Wildlife and Parks electrofishing surveys. McWisdom Section is the McDowell and Wisdom sections combined. Standard deviations shown in parenthesis.

SECTION	YEAR	ARCTIC GRAYLING > 6 INCHES	BROOK TROUT > 6 INCHES	RAINBOW TROUT ALL
McDowell	1978	69	109	0
Wisdom	1983	111 (50)	234	14
Wisdom	1984	68 (29)	274	11
McWisdom	1985	44 (29)	208	26
Wisdom	1986	33	331	5
McWisdom	1987	51	211	27
McWisdom	1988	30	82	3
McWisdom	1989	22	65 (14)	3
McWisdom	1990	34	68 (10)	6
McWisdom	1991	34 (24)	111 (24)	7
Wisdom	1992	31 (16)	112 (14)	2
Wisdom	1993	32 (22)	260 (86)	2
Wisdom	1994	65 (50)	256 (47)	6
Wisdom	1995	70 (62)	198 (34)	4
Wisdom	1996	64 (27)	183 (15)	6
Wisdom	1997	96 (66)	529 (54)	6
Wisdom	1998	76 (30)	613 (43)	17 (9)
Wisdom	1999	35 (8)	417 (20))	7 (3)

Table 6. Mark/Recapture abundance estimates (Standard Deviations)for age 1 + Arctic Grayling and Rainbow trout in the Sportsmans to Eastbank Section on the Big Hole River, Montana 1995-1999, from Montana Fish, Wildlife and Parks electrofishing surveys.

Year	Arctic Grayling	Rainbow Trout
1995	37 (33)	226 (92)
1996	47 (35)	222 (64)
1997	73 (50)	257 (140)
1998	23 (13)	232 (96)
1999	46 (33)	127 (66)

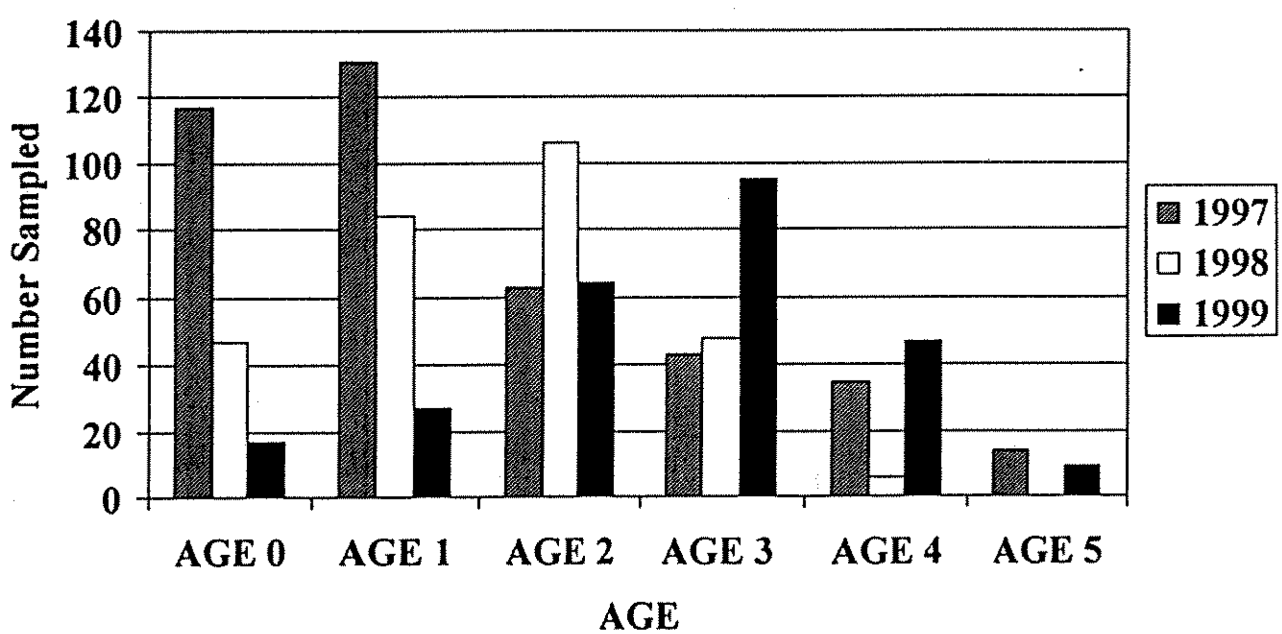

Figure 4. Arctic grayling age class histogram from Montana Fish, Wildlife, and Parks fall population surveys in the Big Hole River for 1997, 1998, and 1999.

Brook trout numbers in the upper Big Hole River declined dramatically in the mid 80's to a low of 62 (greater than 6 inches) fish per mile in 1989 in the McWisdom section (Table 5). Thereafter, populations began to increase but were set back by drought in 1994. With four consecutive years of ample flows (1995-1998) brook trout abundance has increased. In the 40 Bar section we estimated 706 (SD ± 134) brook trout greater than 8 inches. This increase from the 1998 estimate of 408 (SD ± 189) and 1997 of 260 (SD ± 168) is consistent with the trends in the McDowell and Wisdom sections in 1996-1998. In the Wisdom section, the brook trout population (≥ 6.0 inches) has increased dramatically from 1996 to 1998 from 183 (SD ± 15) per mile in 1996, 529 (SD ± 54) in 1997, and 613 (SD ± 43) in 1998. The 1998 abundance represents the highest estimate since monitoring began in 1978. However, in 1999 the abundance of brook trout decreased and was estimated at 417 (SD ±20). Although spawning movements may have biased estimates upward, high efficiency rates have resulted in fairly robust estimates and provide a good index of population demographics.

The Sportsmans-Eastbank section is a transitional reach from brook trout to rainbow trout predominance. Unbiased estimates are difficult to obtain due to low capture and recapture rates attributed to spawning movements and lower densities. We captured 19 brook trout but were unable to make a valid estimate.

Rainbow trout densities remain low in the upper Big Hole River. Only 3 rainbow trout were captured in the 40 Bar section.

In the Wisdom Section we estimated 7(SD ± 3) rainbow trout per mile (Table 5). In the Sportsmans-Eastbank section, 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 (Table 6).

Brood Reserve

<u>Axolotl Lakes Brood</u>

We monitored the Axolotl Lakes brood and gathered gametes for reintroduction efforts. The 1988 year class has dwindled from 2,800 planted in 1989 to 44 (SD ± 9.5) in 1999. We spawned 11 males and 9 females of the age 11 fish. Mean length increased slightly from 14.2 inches to 14.4 inches.

The 1992 cohort decreased to 217 (SD ±49) from 249 (SD ± 25) in 1998 and 420 (SD ± 110) fish in 1997 of the 3,000 planted. The age 7, 1992 cohort of grayling which had grown at a consistent rate of approximately 1.0 inch per year since 1994 through 1998, and averaged, 12.7 inches in 1998. Growth rates decreased in 1999, and average length was 13.1 inches. For comparison, the mean length of the 1988 cohort was 13.5 inches at age 7. We estimate the number of mature grayling (1988 and 1992 year classes) in Axolotl Lake to be 261 (SD ± 45) prior to disease sampling that sacrificed some older fish. Predation is most likely one of the major causes of mortality. We witnessed osprey capturing grayling on several occasions and also observed great blue herons and bald eagles in the vicinity.

The 1,760 YOY grayling planted in September 1997 were age 2 in May 1999 and averaged 9.64 inches in length. The survival rate for this year class has been very good and we estimated 1,728 (SD ± 236) of the 1997 year class. To establish multiple year classes and avoid bottle necks of mature adults for egg-take operations, 1,740 yearling grayling (average length 8 inches) spawned from the Axolotl Lake brood in 1998 and reared at Big Springs State Hatchery were planted into Axolotl lake on August 3.

We collected an estimated 194,374 eggs from 80 females (18 age 2, 46 age 7, and 9 age 11) and spawned them with 147 males (94 age 2, 42 age 7, and 11 Age 11) on May 24 and 28. Fecundity averaged 2,430 eggs per female. All of the eggs went to Big Springs State Trout Hatchery for eye up and rearing.

Grayling spawning behavior was consistent with observations in the past (Byorth 1997). Ice off occurred in the end of April or the first few days in May. Males were ripe by May 10, when grayling began to congregate into schools and feed voraciously. This behavior ceased May 15. Catch rates declined dramatically when grayling schooled in shallow areas and ceased feeding. Historically, females have become ripe three to four days following the cessation of feeding. In 1999, cold temperatures delayed egg development. We spawned 15 females on May 24, however, the majority of the females were still green. Between May 25 and May 27 temperatures increased, grayling were observed cruising shallow waters and were easily captured with Fyke nets.

By the second egg take on May 28, we had captured many more of the mature adults (age 7 and 11), and the majority of fish were ripe.

Green Hollow II Brood Reserve

Survival of the 1998 grayling plant was poor. In multiple attempts, only 3 grayling were captured in May and June 1999. The average length increased from 9.8 inches in October 1998, to 10.5 inches, in June 1999. A number of brook trout, one rainbow trout, and no cutthroat trout were captured. Although we removed the majority of resident fish prior to stocking graying, some of the resident fish were not captured or reinvaded through the barrier at the inlet.

The USFWS Fish Technology brood stock grayling were treated as per the disease plan and 57 fish were spawned in May. The progeny were tested and found to be negative by FAT testing at USFWS Fish Health Lab. On August 12, 3,680 young of the year, 1.7 gram fingerlings were stocked in Green Hollow II Lake. Monitoring will began in summer 2000 to assess survival. Additional plants should be made in 2000 or 2001 to establish multiple year classes.

DISCUSSION

Following three consecutive years of high and prolonged spring runoff in 1995-1997, moderate runoff conditions occurred the past two years. Despite dry spring and summer conditions near average snowpack and cool June temperatures slowed snow melt and maintained instream flows into mid-August. Flows dropped substantially in mid-August and the Drought Management Plan was initiated at each of the three trigger points. As instream flows decreased below the 20 cfs survival flows, an angling closure was placed on the reach from Twin Lakes Road to Dickie Bridge to avoid any additional stress to the Arctic grayling population by anglers. In 1999, the Flow Enhancement Program worked efficiently, more than doubling instream flows, maintained levels above the 20 cfs survival flow, and provided sufficient water for livestock. However, it is apparent this system cannot be the sole conservation program. During severe drought years like 1988 and 1994, when flows are depleted in July, stock water well use may be limited due to limited available feed in the stock water well pastures. A necessity of the Drought Management Plan is informing the landowners of low flow forecasts, snow pack, and precipitation data so they can plan pasture rotations accordingly. Water leasing or providing feed may be an alternative to investigate during severe drought years. 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, recreationist, and municipal interests, while fine tuning the Drought Management Plan as needed.

Water temperatures were cooler in 1999 than recent years. Temperatures exceeded lethal levels at only one of the 11 thermograph stations. Temperatures regularly exceed the thermal tolerance of 77°F for Arctic grayling in the "warmed reach" as was the case in 1999. Fortunately, at this time suitable flows during the warmest period of the summer (mid July-mid August) and adjacent reaches with well developed pools and riparian areas provided thermal refugia. 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 be investigated to alleviate temperature problems.

Arctic grayling population estimates with low variance are difficult to calculate. Sampling efficiencies are affected by low species densities and seasonal migrations. Arctic grayling abundance estimates are best used as indicators of population trends and in conjunction with age class data. These data indicate a shift in age class dominance to age 3+ fish as a result of limited spawning success or poor recruitment in 1999.

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-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 is slightly above the density parameters, the percentage of age 1 and age 2 grayling (37.6%) is below the 50-80% criteria.

In the Sportsman to Eastbank Section we estimated 46 (±33) age 1+ grayling per mile, compared to 23 (±13) age 1+ per mile in 1998. This section typically supports more older (age 3+) grayling than the rearing areas in the Wisdom Section. Based on the age class strength of age 3+ grayling (62% of total sampled) the majority of spawners in spring 2000 should be dominated by mature age 3+ fish with potential for excellent fecundity and reproductive success.

Since restoration efforts began, we have learned a great deal about the timing and characteristics of spawning Arctic grayling. Arctic grayling have a finite window of opportunity to spawn based on photoperiod, temperatures, and flow, and require specific spawning substrates. Without optimum conditions, spawning success is limited or inhibited. High and prolonged spring runoffs in 1995, 1996, and 1997 were theoretically unfavorable to newly emerged larval grayling. Moderate flows in 1998 and 1999 should have been favorable to newly emerging larva. However, colder temperatures in 1999 (only 6 days over 50°F from April 20-May 20, 1999) may have delayed or inhibited spawning.

Catch rates of YOY were lowest since 1987. Young-of-the-year catch rate efficiency may be affected by numerous factors (flows, crew experience, temperatures) and has not proven to be a dependable index to assess recruitment. Yearling estimates have proven a better index of recruitment. Fall 1999 surveys indicate low abundance of the age 1 year class grayling recruiting into the population. Low catch-per-effort of YOY in 1999 further indicates a poor spawning year or limited survival of YOY. As the 1999 age 0 and age 1 year classes are recruited as mature adults (2001 and 2002), the spawning potential may be limited. Hence, the abundance of grayling will most likely remain lower in the next two years than the previous 4-5 years, and in fact if recruitment is poor, it could decrease. Thus depending on the survival of the progeny from the spring 2000 spawning population, we can not expect abundance of Arctic grayling to increase dramatically at least until 2003, if environmental factors are favorable.

One potential concern is the increased numbers of brook trout in the upper Big Hole River over the past three years. While adult grayling and brook trout co-exist by utilizing different micro-habitats (Byorth and Magee 1998), predation could affect recruitment of juvenile grayling. Past studies found little evidence of predation of juvenile grayling by brook trout (McMichael 1990, Streu 1990). However, the number of brook trout has never been as high as current levels. The prey base for piscivorous species is plentiful in the upper Big Hole [longnose dace (Rhinichthys cataractae), suckers (Catostomus ssp.), Mountain whitefish, brook trout, burbot, Mottled sculpins (Cottus bairdi) and grayling]. The effect of record high numbers of brook trout in conjunction with low abundance of juvenile grayling is unknown.

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 2000, four restoration efforts will proceed, 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 2000) will be 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. Arctic grayling abundance in the Big Hole River has declined, and many challenges still remain to conserve the Big Hole population.

Efforts will continue to work with community-based groups like the Big Hole Watershed Committee, local landowners, recreationists, and other interest groups to maintain instream flows, facilitate habitat restoration, educate, and promote public awareness of this unique Montana native.

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