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MAINTAINING MINIMUM INSTREAM FLOWS TO PROTECT FLUVIAL ARCTIC GRAYLING IN THE UPPER BIG HOLE RIVER DURING SEVERE DROUGHT IN 1994

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Abstract.— The Big Hole River sustains the only remaining strictly fluvial population of Arctic grayling in the 48 contiguous United States. During the 1980's, the population severely declined in abundance. One factor in the decline was critically low mid-summer stream flows due to severe drought and withdrawals of water for agriculture. In order to maintain a minimum "survival" flow of 20 cfs, we worked with water users to conserve water and secured a grant to provide stock water in exchange for ditch closures. In spite of our efforts, flows fell below 20 cfs on 55 days. The lowest flow recorded was 1.9 cfs in contrast to 1988 when the Big Hole River ceased to flow for 24 days. Diversion of river water for stock is extremely inefficient when compared to providing water in tanks through delivery or groundwater. Development of wells and other sources of stock water, along with cooperative efforts to conserve limited water is critical to the recovery of fluvial Arctic grayling in the Big Hole River.

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Fluvial, or river dwelling, Arctic grayling (Thymallus arcticus) were once widespread in the upper Missouri River drainage in southwest Montana. During the 20th century, however, the range of fluvial Arctic grayling in the lower 48 United States became solely restricted to the Big Hole River. The loss of range was attributed to habitat degradation, competition with non-native fishes, over-harvest, and climatic change (Vincent 1962).

The grayling population of the Big Hole River declined to low levels in the early 1980's. In response to the decline, an interagency committee convened in 1988 to develop strategies to protect, restore, and research the population. Since that time the Fluvial Arctic Grayling Workgroup has developed a restoration plan and instituted a coordinated recovery program (Fluvial Arctic Grayling Workgroup 1994). The grayling population of the Big Hole River was listed as a "Category 1" species under the Endangered Species Act. In 1991, a petition was submitted to upgrade the status of the grayling to "endangered" (Nordstrom 1993).

A primary objective of the restoration plan is to identify and mitigate limiting factors. Water quantity and quality have emerged as important factors impacting the abundance of grayling in the Big Hole River. Extreme flood flows during incubation and hatching periods of young grayling was hypothesized as a severe detriment to reproduction in the early 1980's (R. Oswald, Montana Fish, Wildlife, and Parks, personal communication). Clark (1994) found similar negative effects of high flows on grayling recruitment in Alaskan rivers. Extreme drought followed flood years and contributed further to declines in grayling numbers. Impacts of drought were exacerbated by withdrawals of stream flow for agriculture. In the upper Big Hole basin, irrigating hay meadows traditionally extended from May through early July, while diverting water for stock continued through October. In several recent drought years, withdrawals for agriculture led to extremely low flow conditions in critical grayling habitats. Low flow conditions also led to water temperatures exceeding thermal tolerances of grayling (Byorth 1994).

Drought conditions in 1994 necessitated intensive efforts to maintain minimum stream flows in the Big Hole River to protect the grayling population. This paper documents those efforts and proposes longer-term solutions for solving water shortages in dry years.

Study Area

The upper Big Hole basin is a wide intermontane valley in southwestern Montana. Much of the valley floor lies at elevations greater than 6,000 feet. The Big Hole River eminates from the Beaverhead Mountains of the Bitterroot Range and flows northerly approximately 65 miles before arching to the east into a narrow canyon. A 10 mile reach of the upper Big Hole River centered at Wisdom provides habitat for the highest density of Arctic grayling and a majority of their spawning habitat (Figure 1). Cattle ranching and hay production are the primary land uses of the valley floor. Much of the stream flow appropriated for agriculture is diverted upstream from the town of Wisdom and impacts primary grayling habitat.

Methods

Discharge was recorded hourly at a U. S. Geological Survey (USGS) gaging station at Wisdom (Figure 1). We also monitored the gage daily to track flows. Water temperatures were measured at the USGS gaging station and 4 thermograph stations. Temperature and discharge data were provided by USGS and were provisional during preparation of this report. Thermographs were Omnidata DP-212 units which recorded water temperature at 120 min intervals from April through October.

Nelson (1980) described two flow levels to protect salmonid habitat: an "absolute minimum" below which standing crops of fish decrease and a "most desirable minimum" which maximizes standing crops. In the upper Big Hole River, these flows were determined to be 60 cfs and 160 cfs, respectively (Mt. Dept. of Natural Resources and Conservation 1992). However, during 6 of 7 years between 1988 and 1994, flows near Wisdom have been under 60 cfs for the majority of days between June and September. During drought years a more pragmatic minimum flow was necessary. We estimated that 20 cfs would provide the minimum flow necessary to maintain a wetted channel and ensure survival of the grayling population during brief, critical periods.

To maintain a minimum flow of 20 cfs we elicited cooperation from water users in the upper Big Hole basin. As flows approached 20 cfs, we began to contact water users requesting that they conserve water by minimizing withdrawals. We also offered assistance in adjusting headgates, funded a water commissioner, and assisted in acquiring permits for maintenance on a diversion to allow water to pass downstream.

A second phase of efforts consisted of attempts to preserve stream flows by providing alternatives to watering stock through ditches. A grant was secured from the Environmental Contingency Grant Fund to purchase stock tanks, develop a well, and lease a tank truck and driver to deliver water to tanks. A total of 10 stock tanks were distributed over approximately 2,500 acres. An abandoned well was developed to pump water to two tanks installed at the site. The remaining tanks were filled by a 1,000 gallon tank truck which delivered water from established points of diversion on the Big Hole River from September 7 through October 1, 1994.

Results

The hydrograph during 1994 illustrates drought conditions (Figure 2). Instantaneous peak discharge was 976 cfs on April 23, 1994. A second brief peak in discharge of 818 cfs occurred on May 20. Each of the peaks were approximately 6 weeks earlier than those of years with a more typical hydrograph. The timing of these pulses may have impacted spawning success: the first peak coincided with spawning and the second occurred shortly after young grayling hatched. A similar pattern was observed in 1988, another severe drought year. The implications of early runoff were that below normal snowpack (71% of 25-year average on March 1: USGS Files) was depleted more than a month earlier than usual.

Flows declined steadily and fell below 20 cfs on 11 days during June. A combination of water user contacts, the end of irrigation season, and a substantial rain storm resulted in discharge increasing to 57 cfs by July 6 (Figure 3). Decreasing flows resulted in lethal water temperatures. Temperatures as high as 79.7°F were recorded at thermograph station 4 (Figure 1). Lethal temperatures resulted in a fish kill between July 24 and 27 that affected all resident fish species in all age classes. Mortalities were observed intermittently from the mouth of the North Fork of the Big Hole River to the mouth of Pintler Creek (Figure 1).

Due to critical conditions, water users were asked a second time to restrict their water withdrawals to a minimum. Among known contributions to augment stream flows, approximately 15 cfs was returned to the North Fork and an estimated 2 cfs was passed down Big Lake Creek. The Governor of the State of Montana convened a public meeting to discuss potential solutions to mitigate drought conditions. In order to protect grayling and other fishes from additional stress due to angling, the Montana Fish, Wildlife, and Parks Commission closed the fishing season July 30, 1994 from the mouth of the North Fork to Dickie Bridge.

The Big Hole River increased to 38 cfs due to conservation efforts, but declined to below 20 cfs again by August 10. By August 25, water users had been approached again, but flows continued to decline. The lowest discharge in 1994 was recorded on August 30, at 1.9 cfs. (Figure 3) In response to further requests for water conservation, 9 diversions were closed or reduced to augment instream flows.

The Spokane Ditch was also closed on September 7 in exchange for stock tanks and water delivery, provided by FWP through the Environmental Contingency Grant. Prior to its closing, approximately 5 cfs was diverted into the Spokane Ditch from the Big Hole Rver. As a result, flows increased to near 20 cfs by September 16 and continued to fluctuate between 15 and 20 cfs until early October when fall rains relieved drought conditions.

The success of delivering water to stock tanks as an alternative to providing water through ditches is illustrated in Table 1. We delivered water to stock tanks for 25 days. Had the Spokane ditch remained open at a rate of 5 cfs, approximately 81 million gallons of water would have been diverted from the Big Hole River. We delivered approximately 227,375 gallons of water over the 25 day period in addition to approximately 150,000 gallons provided by a well. The volume of water required via the alternative means was approximately 0.5% of that required by ditch delivery.

Discussion

During the last decade, drought has persisted in the Big Hole River basin. Of recent drought years, 1988 and 1994 were the most severe (Table 2). In both years poor snowpack, early runoff, and lack of mid-summer precipitation resulted in extremely low flows. However, efforts to conserve water and protect instream flows mitigated the severity of drought in 1994. For example, in 1988 flows diminished to 0 cfs for 24 days, while the lowest discharge recorded in 1994 was 1.9 cfs on 1 day.

Protecting instream flows in drought years is a function of awareness of the need for water conservation and cooperation from water users. In the Big Hole basin, irrigating hay crops generally coincides with runoff and generally does not dewater the Big Hole River. In dry years, stream flow is impacted only at the end of the irrigating season. Diversions for stock water, however, may severely impact stream flows from July through September. During drought years, transporting water through ditches over long distances is extremely inefficient. Only a small fraction of the volume of water that would have been diverted from the river was necessary to providing sufficient water to stock tanks. Future efforts should pursue development of groundwater resources to provide stock water and preserve instream flows.

Our efforts to maintain minimum instream flows were successful in protecting the Arctic grayling population of the Big Hole River during Summer 1994. While the Big Hole River flowed below the 20 cfs "survival flow" on 55 days, the Arctic grayling population appears to have endured the drought.~~well~~. Fall population surveys indicated that grayling densities in the Wisdom area are increasing. The age structure of the population is well balanced, with a full complement of age classes from age 0 to 5 (Byorth 1995). Preservation of minimum instream flows in the Big Hole River through improved water conservation and developing alternative means of watering stock will be critical to the continued survival of fluvial Arctic grayling.

Acknowledgements

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Table 2. Comparisons of Big Hole River discharge parameters measured at the U.S.G.S. gage at Wisdom, 1988 to 1994. Yield is the total volume of flow 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	1080	0	8/27-9/21	213
1989	0	4	978	12	8/20	3790
1990	1	0	667	18	5/23	5820
1991	0	16	4300	10	9/4	3690
1992	18	32	479	3.3	5/26	2760
1993	0	0	1700	55	10/5	17490
1994	11	55	976	1.9	8/30	1821

Table 1. Comparison of efficiency of providing stock water via ditch at 5.0 cfs versus delivering water by stock tanks and a well between September 7 and October 1, 1994.

Water Volume	Ditch	Tanks	Well	Tank + Well
Flow (cfs)	5.0	0.014	0.005	0.019
Gallons per Day	3,231,580	9,095	3,000	12,095
Total Gallons	8.1×10^7	227,000	150,000	377,000
% of Ditch Volume	100	0.34	0.19	0.53

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	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