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UNITED STATES GOVERNMENT

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Memorandum

Denver, Colorado

DATE: February 9, 1990

TO : Head, Remote Sensing Section

FROM : Michael J. Pucherelli, Environmental Biologist
Richard C. Clark, Advanced Sciences Inc.

SUBJECT: Green River Backwater Habitat Mapping; Fluctuating Flow Test, Utilizing Airborne Videography Techniques. (Endangered Fish)

Applied Sciences Referral Memorandum No. 90-4-4

Principal Investigator: Michael J. Pucherelli

Background

Following the construction of Flaming Gorge Dam in 1962, the abundance of endemic fish species in the Green River has decreased. These species include the endangered Colorado squawfish (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*), and the rare but unlisted razorback sucker (*Xyrauchen texanus*). The dam has altered the natural state of the Green River by reducing flood events and their severity, increasing late fall and winter fluctuations and in general altering natural flows throughout the year (Tyus et al., 1987). Studies conducted by the U.S. Fish and Wildlife Service (FWS) have concluded that backwaters in the Green River serve as important nursery habitat for young-of-the-year Colorado squawfish (Tyus et al., 1987, Tyus and McAda, 1984). The Remote Sensing Section of the U.S. Bureau of Reclamation (Reclamation) has been studying the utility of remote sensing techniques and the effects of Flaming Gorge Dam releases on downstream fish habitat in the Green River since summer, 1986 (Pucherelli et al., 1988, 1989, Pucherelli and Clark, 1989).

A pilot study was developed in 1986 using color infrared photography and Geographic Information Systems (GIS) techniques to examine backwater availability in response to different Green River flows. The pilot study was considered successful, and in 1987 an expanded study was initiated which examined the relationships between seven different flows, and backwater area and number, at five sites on the Green River in Utah. During 1988, a study was designed to test the effect of fluctuating flows on backwater habitat in the Green River. However, extremely low-flow conditions produced by drought did not allow the study to be conducted. Alternatively, the stable low-flows of 1988 presented a unique situation to establish a relative baseline condition for riverine habitat during flows approximating a "normal" summer hydrograph for the Green River from about Island Park to the confluence with the Colorado River. Therefore, it was decided to conduct a fluctuating flow study on the Green River during 1989.

Although aerial photography is currently thought to be the optimum method for mapping and determining various riverine habitat, the cost of this method is prohibitive for extensive studies. Consequently, a more

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cost-effective alternative for mapping backwater availability using videography was investigated during 1988 (Pucherelli et al., 1989). The study found that the quality of videography was sufficient to replace aerial photography for use in river monitoring studies.

The objective of the study presented here was to determine the effects of fluctuating flows on backwater habitat at three sites in the Green River using airborne video.

Methods

Three study sites were selected by FWS and Reclamation in areas known to contain important backwater habitat for young-of-the-year Colorado squawfish: the Island Park site, just above Split Mountain in Dinosaur National Monument--river-mile (r-m) 328.5 to 334.5 (about 6 miles); the Jensen site, just below Split Mountain, located from r-m 303.0 to 310.0 (7 miles); and the Ouray site, located in Ouray National Wildlife Refuge, from r-m 250.5 to 261.5 (11.0 miles). River-mile designations were from Evan's and Belknap's Dinosaur River Guide. Video was acquired at each site on four dates: August 2 (flow = 1,515 ft^3/s), August 16 (flow = 1,500 ft^3/s), September 28 (flow = 1,420 ft^3/s), and October 11, 1989 (flow = 1,900 ft^3/s).

Two fluctuating flow events were analyzed: (1) Stable flows at Jensen were maintained for most of July to allow backwaters to form under a "normal" summer hydrograph, and video was acquired on August 2. Following this sequence, releases from Flaming Gorge Dam produced fluctuating flows at the Jensen gauge, beginning on August 7, ranging daily from approximately 1,600 to 2,900 ft^3/s until August 14. Flows were reduced to about 1,500 ft^3/s on August 15 and 16 and remained stable, and a video of each site was acquired on August 16. (2) Stable daily flows were maintained at the Jensen gauge from August 16 to September 28, with little variation in daily or weekly flows. Flows were generally about 1,000 ft^3/s or less from August 23 to September 27. On September 28, flows were increased to about 1,420 ft^3/s and video was acquired. Following this stable flow sequence, flows were again fluctuated beginning October 4 through October 11. Daily flows at the Jensen gauge ranged from about 1,600 to 3,700 ft^3/s. Video was acquired on October 11 for each of the sites as described above. The flow at the Jensen gauge was expected to be between 1,400 and 1,500 ft^3/s on October 11 (see enclosed letter dated July 27, 1989, from Reclamation to WAPA); however, when the video was acquired, the flow was about 1,900 ft^3/s. Thus, backwater area at the three sites cannot be successfully compared between September 28 and October 11 because the flows on these dates (1,420 and 1,900 ft^3/s were substantially different and would produce different amounts of backwater habitat regardless of antecedent flows.

The above flow scenarios allow the following comparisons at Island Park, Jensen, and Ouray sites, Green River: (1) The effects of fluctuating flows of 1,600 to 2,900 ft^3/s on backwaters formed under stable flow conditions, (2) the effects of stable flows, for about 6 weeks, on backwaters between

October 16 and September 28. In addition, the backwater data from this study can be compared with backwater data from previous studies at similar flows.

The airborne video was acquired at each site with an Ikigami video camera which was attached to the front of a helicopter on a Tyler mount. The camera was connected to a monitor viewed by a flight scientist in the helicopter. This allowed the flight scientist and helicopter pilot to maintain the river in the center of the video image. The flight scientist also annotated the video tape with audio information about backwaters, side channels, general water turbidity, and weather conditions as they appeared visually from the helicopter. This function served as a "ground truthing" effort which assisted the video interpreter in identifying river features on the video monitor in the laboratory.

The video images were analyzed on a 386-microcomputer system which included a video capture board, and a color monitor. Analysis was performed with Map and Image Processing System (MIPS) software. Video images were viewed on the color monitor and captured when backwater habitat was identified. The video image was viewed repeatedly until the MIPS operator was confident if backwaters were present and what their boundaries were. The audio portion of the tape was listened to at this time to facilitate the process. Scale was calculated with ground panels, constructed at specified distances 200 feet apart, from white, plastic paper which was visible on the video image. Ground panels were placed at each site.

Backwaters outlines were traced on the video monitor using a cursor controlled by a mouse and creating short line segments on the image. Backwater area and number were calculated by MIPS software and recorded for each flow for each site.

Results

Island Park

Data summarizations of backwater habitat for 1989 are presented in tables 1-3. Total backwater area at the Island Park site on August 2 (flow = 1,515 ft^3/s) was 15,682 m^2 or 2,614 m^2/mile (table 1). There was a total of 26 backwaters. Following fluctuation of flows between 1,600 and 2,900 ft^3/s, backwater area decreased 30 percent to 10,993 m^2, and backwater numbers decreased by about 15 percent, to 22 on August 16. Stabilized flows at about 1,000 ft^3/s for 6 weeks had little effect on backwater habitat. There were 25 backwaters with a total area of 10,946 m^2 on September 28 (flow = 1,420 ft^3/s).

The higher flows on October 11 (approximately 1,900 ft^3/s) produced the fewest backwaters (20) and least backwater area (8,614 m^2). It is not known if the decrease in backwater habitat was related to the antecedent fluctuating flows, or the substantially higher flows on this date.

Jensen

There were 26 backwaters at the Jensen site on August 2 (table 2) with a total of 10,870 m^2 (flow = 1,515 ft^3/s). Subsequent to fluctuating flows, backwater number increased to 34, but, backwater area remained stable (10,941 m^2) on August 16. Stabilized flows for 6 weeks increased backwater area by 36 percent to 14,930 m^2 on September 28, although backwater number decreased to 30.

Backwater area decreased by about 50 percent to 7,593 m^2 on October 11, and backwater numbers decreased similarly. The same concerns discussed above for this date and flow apply here.

Ouray

There were 37 backwaters at the Ouray site on August 2, with a total area of 35,098 m^2 (flow = 1,500 - 1,700 ft^3/s). Following the fluctuation of flows, the number of backwaters remained similar (33) while backwater area decreased about 13 percent to 30,482 m^2 on August 16. Subsequent to stable flows for 6 weeks, backwater number increased by approximately 70 percent, to 56, and backwater area also increased by 70 percent, to 51,824 m^2 on September 28 (flow = 1,420 ft^3/s).

The October 11 backwater number decreased substantially, to 29, as did backwater area, to 37,898 m^2 (flow = about 2,500 ft^3/s). The flow on this date was significantly higher than on the previous dates that video was collected, which probably had an impact on backwater habitat.

Discussion

It is apparent that the flows on October 11 were higher than anticipated and that they had a significant, negative impact on backwater habitat. At each site studied, this flow produced the fewest backwaters and the least backwater area. Although these data cannot be used in the fluctuating flow study, it is notable that the flow on this date (about 1,900 ft^3/s) is outside the range recommended by the 1987 study for optimum backwater availability (Pucherelli et al., 1988), of 1,100 to 1,800 ft^3/s at the Jensen gauge on the Green River.

There are two comparisons that may be made with the remaining three video events, (1) video results between August 2 and August 16, which reflect the effect of daily flow fluctuations between 1,600 and 2,900 ft^3/s, and (2) video results between August 16 and September 28, which reflect the effect of very stable daily flows.

Fluctuating flows of 1,600 to 2,900 ft^3/s produced a substantial decrease in backwater area only at the Island Park site. A smaller decrease was recorded at Ouray, while backwater habitat at Jensen remained relatively unchanged following this event. The decrease in backwater habitat at

Island Park is primarily attributable to the loss or reduction in size of large backwaters following fluctuating flows (table 1).

Stable daily flows for 6 weeks produced substantial increases in backwater area at Jensen and Ouray, and had little or no effect on backwater habitat at Island Park. We realize the limited nature of these data; however, the combination of reduction of backwater habitat at two sites following fluctuating flows and the increase in backwater habitat at two sites following stable flows may indicate that stable flows are more beneficial than fluctuating flows to backwater habitat formation/stability at the sites studied.

Tables 4, 5, and 6 present the backwater data at various flows during the 1987 study (Pucherelli et al., 1988) for Island Park, Jensen, and Ouray, respectively. The data from the 1,381-ft^3/s flow from these tables are the most comparable between the 1987 and 1989 study because it was formed under relatively stable conditions. At Island Park, there were considerably more backwaters and backwater area at the 1,381-ft^3/s during 1987 than during any flow event in 1989. The average backwater size was almost always larger during 1989 than 1987 (table 4) at Island Park.

During 1987, at Jensen, the 1,381-ft^3/s produced more backwaters and backwater area than any flow events of 1989 (table 5). It should be noted that the backwater habitat produced at the 1,381 flow of 1987 was allowed to form at relatively stable flows as were the September 28, 1989 backwaters. During 1987, at Ouray, the 1,381 flow produced about 40-percent less backwater area than the September 28, 1989 flow (table 6). The August 2 and August 16 flows of 1989 produced backwater area similar to the 1987 1,381-ft^3/s flow. During both studies, Ouray produced the largest backwaters, and these were substantially larger during the 1989 study.

It should be noted that earlier studies have indicated that yearly variation in backwater area can be significant between years (Pucherelli and Clark, 1989). Backwater habitat formation may be affected by the degree of spring runoff and other events including large iceflows during winter months. In addition, it should be noted that the 1989 data were collected with video, while the previous years' studies utilized aerial photography. This could produce differences among different years because 9 by 9 in. aerial photography is superior in resolution to videography.

Conclusions and Recommendations

Although the 1989 study data are limited in part because of the erroneous flow of October 11, it appears that fluctuating flows are deleterious to backwater habitat formation/stability. Furthermore, it appears that stable flows may be beneficial to backwater habitat formation/stability after backwaters are formed. However, the magnitude of change between the various flows studied during 1989 was not surprisingly large. The authors are not attempting to be ambiguous. The above statements are true; however, they are based on little data. Therefore, we recommend additional study to more adequately determine the magnitude of change fluctuating flows may have on backwater formation/stability. Further study should also determine what levels of fluctuation may be acceptable, relative to backwater formation.

References

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Michael J Pucherelli
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Enclosure

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Table 1. Summary of backwater data for fluctuating flow study at Island Park site, Green River, 1989.

Date	08/02/89	08/16/89	09/28/89	10/11/89
Flow (CFS)	1,515	1,500	1,420	~1,900
Total Backwaters	26	22	25	20
Backwaters/mile	4.3	3.7	4.2	3.3
Total Area (m^2)	15,682	10,993	10,946	8,614
Area/mile (m^2)	2,614	1,832	1,824	1,436
Mean Backwater Size (m^2)	603	500	438	431
Standard Deviation	1,095	723	730	656
Backwaters $< 50 m^2$	5	5	3	4
50-200 m^2	10	6	9	7
200-500 m^2	4	5	5	3
500-1000 m^2	2	3	7	4
1000-5000 m^2	5	3	1	2
$>5000 m^2$	-	-	-	-

Table 2. Summary of backwater data for fluctuation flow study at Jensen site, Green River, 1989.

Date	08/02/89	08/16/89	09/28/89	10/11/89
Flow (CFS)	1,515	1,500	1,420	~1,900
Total Backwaters	26	34	30	16
Backwaters/mile	3.7	4.9	4.3	2.3
Total Area (m^2)	10,870	10,941	14,930	7,593
Area/mile (m^2)	1,553	1,563	2,133	1,085
Mean Backwater Size	418	322	498	475
Standard Deviation	960	756	1,129	1,016
Backwaters < 50m^2	6	11	6	-
50-200 m^2	14	17	15	10
200-500 m^2	3	2	3	4
500-1000 m^2	1	1	3	1
1000-5000 m^2	2	3	3	1
>5000 m^2	-	-	-	-

Table 3. Summary of backwater data for fluctuation flow study at Ouray site, Green River, 1989.

Date	08/02/89	08/16/89	09/28/89	10/11/89
Flow (CFS)	1,500-1,700	1,550	1,420	>2,500
Total Backwaters	37	33	56	29
Backwaters/mile	3.4	3.0	5.1	2.6
Total Area (m^2)	35,098	30,482	51,824	37,898
Area/mile	3,191	2,771	4,711	3,445
Mean Backwater Size	949	924	925	1,307
Standard Deviation	2,173	2,242	1,828	2,612
Backwaters < $50m^2$	4	2	2	-
50-200 m^2	15	13	17	9
200-500 m^2	6	7	14	6
500-1000 m^2	7	3	11	4
1000-5000 m^2	3	7	10	8
>5000 m^2	2	1	2	2

Table 4. Green River backwater number, area, and average size under seven flows at Island Park, 1987.

Backwater descriptors	Flow CFS 5,260	2,423	1,773	1,687	1,430	1,381	1,101
Size class (m^2)							
<20	6	0	8	4	5	9	11
>20<200	22	22	26	22	26	32	29
>200<500	6	5	7	6	6	6	3
>500<1000	6	4	2	4	1	3	4
>1000	0	1	2	2	2	6	5
Total Backwaters	40	32	45	38	41	56	52
Backwaters/mile	7	6	8	7	7	10	9
Total Area	7,859	8,575	11,160	12,131	13,349	20,070	22,153
Area/mile	1,379	1,504	1,958	2,128	2,342	3,521	3,886
Average Size	196	268	248	319	326	358	426

Table 5. Green River backwater number, area, and average size at even different flows at Jensen, 1987.

Backwater descriptors	Flow CFS 5,260	2,423	1,773	1,687	1,430	1,381	1,101
Size Class							
<20	4	3	7	11	3	6	1
>20<200	20	27	27	29	22	23	27
>200<500	5	6	8	12	10	5	18
>500<1000	1	3	3	1	4	4	10
>1000	2	1	3	5	3	8	4
Total backwaters	32	40	48	58	42	46	54
Backwaters/mile	5	6	7	8	6	7	8
Total area	7,716	7,328	10,944	12,747	15,014	20,569	19,039
Area/mile	1,118	1,062	1,586	1,847	2,176	2,981	2,759
Average size	241	183	228	220	357	447	353

Table 6. Green River backwater numbers, area, and average size, under seven flows at Ouray, 1987.

Backwater descriptors	Flow CFS						
	5,260	2,423	1,773	1,687	1,430	1,381	1,101
Size class (m^2)							
<20	3	0	4	8	3	10	2
>20<200	24	36	27	32	32	23	24
>200<500	7	8	11	10	13	17	12
>500<1000	5	7	9	8	5	4	5
>1000	5	9	9	12	13	10	14
Total Backwaters	44	60	60	70	66	74	57
Backwaters/mile	4	5	5	6	6	7	5
Total Area	18,789	41,722	49,852	52,608	39,944	30,849	41,177
Area/mile	1,678	3,725	4,451	4,697	3,566	2,754	3,677
Average Size	427	695	831	741	605	417	722