Fish Distribution in the Green River under the Serial Discontinuity Concept

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I. Research question(s) and testable hypothesis

The serial discontinuity concept (Stanford and Ward 2001) puts dams into the context of the river continuum concept (Vannote et al. 1980), which attempts to explain changes in rivers as they move from their headwaters to the their ends. In the middle Green River, Flaming Gorge Dam creates a discontinuity, most notably by modifying the flow regime, reducing water temperatures, and eliminating sediment. These physical changes result in a cascade of ecological effects, including increased invertebrate abundance (Vinson 2001), that combine to create ideal habitat for a variety of salmonids (Börk 2006), but make much of the habitat unsuitable for eight native fish species once found in the middle Green River, including the speckled dace, roundtail chub, bluehead sucker, flannelmouth sucker, razorback sucker, bonytail chub, humpback chub, and Colorado pikeminnow (Wintzer 2006).

According to the serial discontinuity concept, these habitat impacts should be moderated with increasing distance downstream from the dam (Stanford and Ward 2001). Vinson (2001) presented data that supported these predictions on the Green River, showing that conditions farther from the dam became closer to pre-dam conditions. The influx of warm, sediment-laden water from the largely unregulated Yampa River also acts to move the Green River closer to natural conditions (Stanford and Ward 2001). Given this pattern of amelioration, one expects to see predictable changes in the distribution and abundances of salmonids and native fishes in the middle Green River. However, invasives have come to dominate the fish fauna in the warm-water reaches (Baker 2006), while the native fishes have decreased ranges and/or abundances (Wintzer 2006). This study will investigate whether the habitat discontinuity introduced by the dam controls native fish distribution in the Green River.

We hypothesize that, from the perspective of the native fishes, the return of the river to more natural conditions as a function of distance from the dam is overwhelmed by the concomitant increase in invasive warm-water species.

II. Experimental design and methodology

The presence of a set of “dam-enabled” species was used as a proxy for the artificial habitat conditions created by the dam, and the increase in the number of warm-water invasive and native fish species was evaluated as a function of distance from the dam. The dam-enabled set consisted of mottled sculpin, brown trout, rainbow trout, and mountain whitefish, selected because the presence of the dam created water conditions conducive to their survival.

Data on fish species diversity, abundance, and size distribution were collected at a series of sites on the Green River between the spillway boat ramp (RM 289.7) and Split Mountain (RM 199.5) from June 13-21, 2006. A variety of sampling techniques were utilized depending on habitat type, and target species and size classes. Many areas not conducive to seining were sampled by hook and line. This method targeted adult fishes, especially salmonids in the tailwaters and invasive fishes in the warmer sections. Hook and line sampling was continuous and extended over virtually the entire river reach covered in this project.

Selected shallow backwaters and near-shore areas were fished with a bag seine (30 X 4ft., 1/4 in. mesh, 4ft. bag) to capture fishes that prefer slow-waters. An alternate seine (10 X 4ft., 1/8 in. mesh) was used occasionally to sample areas very small individuals. Seining was conducted both during the day and during the night, varying by location. Areas with night seining are noted in the comments section of the site-specific fish data. All fishes were identified, measured for fork length, and released.

The line of investigation presented in Section I focuses on presence/absence data for a variety of fish species, which obviates several potential problems inherent in the use of various size- or species-selective sampling methods. By using both hook and line sampling, observation of fish in the water, and day/night seining, the study methods sought to gather the widest possible sample of fish species at all locations.

III. Results

Species presence, noted through visual observation, seining, and hook and line sampling, was used to create the distribution map in Figure 1.

The number of species present at each site in each of the three separate groupings was tallied at sites moving downstream from the dam, and the percentage of each group was charted against river mile to create Figure 2. The “warm-water natives” group consisted of all warm-water natives collected in the Green River on this trip: flannelmouth suckers, speckled dace, Colorado pikeminnow, and roundtail chub. The “warm-water invasives” group consisted of all warm-water species collected in the Green river on this trip: fathead minnow, common carp, channel catfish, smallmouth bass, white sucker, bluegill sunfish, green sunfish, red shiner, sand shiner, and redside shiner. Difficulty in consistently distinguishing red and sand shiners necessitated their combination into a single shiner group for size range and abundance purposes, although they were still counted as two species for diversity measures.

The distributions of fishes within the system varied by species (Fig.1). Only dam-enabled fishes were present between the tailwaters and RM 257.8, Lower Brown’s Park sandbar (Fig. 1). This group continued to maintain a strong presence in the percent species composition from RM 257.8 to the confluence with the Yampa River, while warm-water natives and invasives were generally less common in the same region (Fig. 2). Invasive fishes accounted for 100% of the species collected directly below the confluence, and remained dominant downstream to the end of our sampling area (Fig. 2). Native species continued to represent a low percentage of the overall ichthyofauna and dam-enabled fishes made up only 0-10% of the species (Fig. 2).

Post-larval fishes were found at several sites during the survey. Samples included mottled sculpin, mountain whitefish, and unidentifiable minnow and trout species. Young-of-the-year (YOY) mountain whitefish presented a particularly dramatic distribution pattern, located downstream of adults from RM 257.8 to RM 213.5, Big Island (Fig. 3). Most of these fish were collected while seining at night.

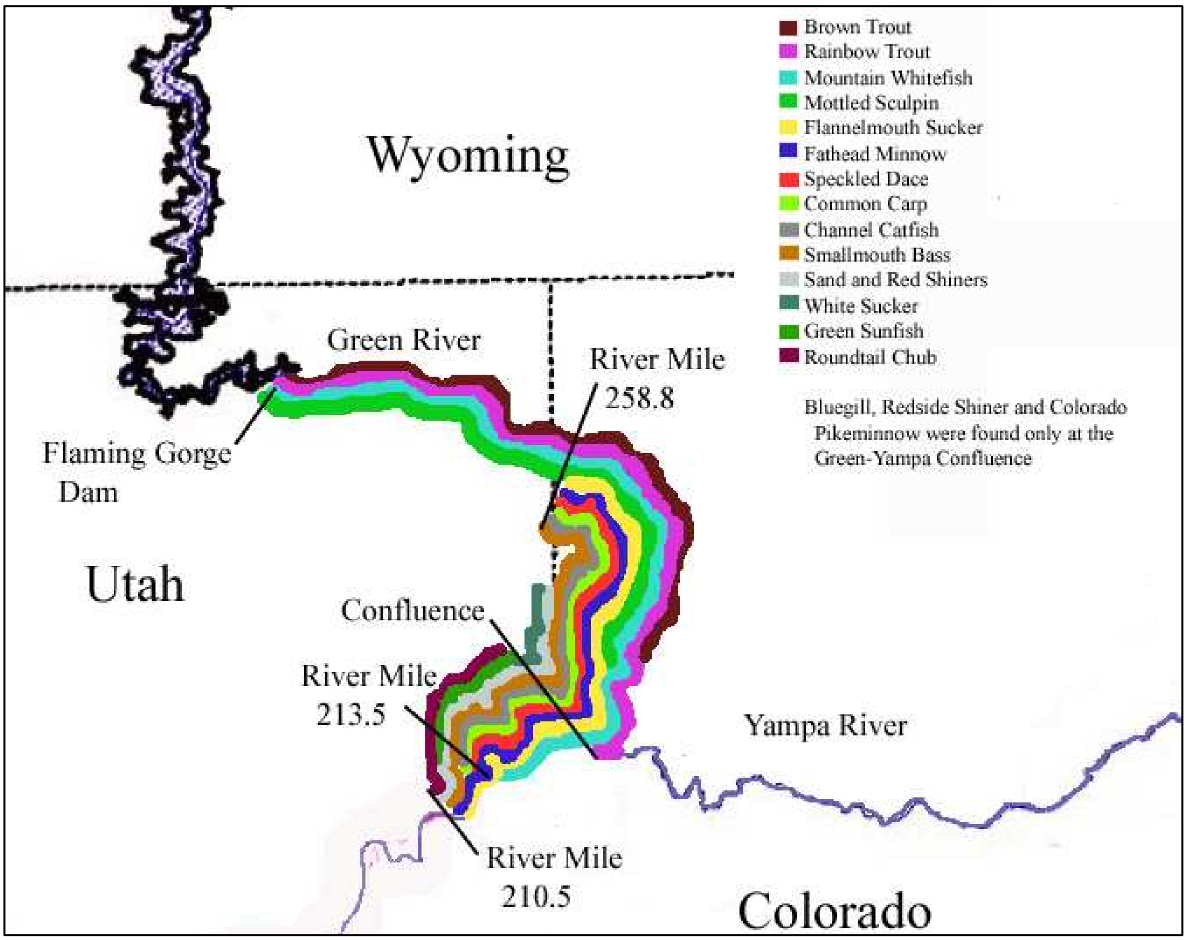

Figure 1. Species presence as documented by seining and angling. Note that the last sample site was at river mile 210.5. Thus, the ranges ending at river mile 210.5 likely extend farther downstream.

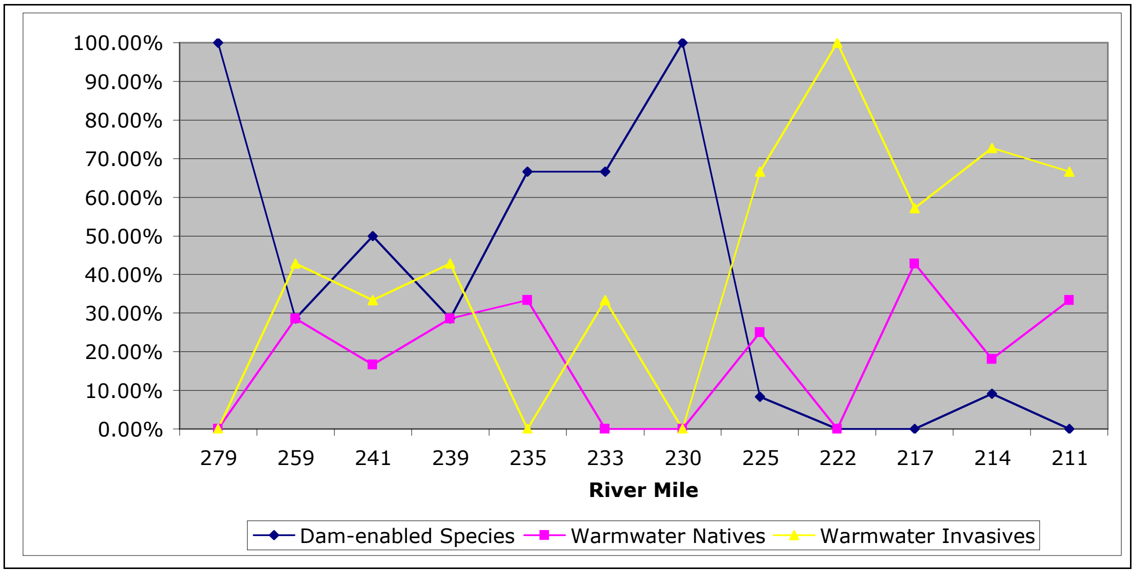

Figure 2. Percent species composition by river mile. Individual species included in dam-enabled species are listed in the *Methods* section, and the other groupings are listed under *Results*.

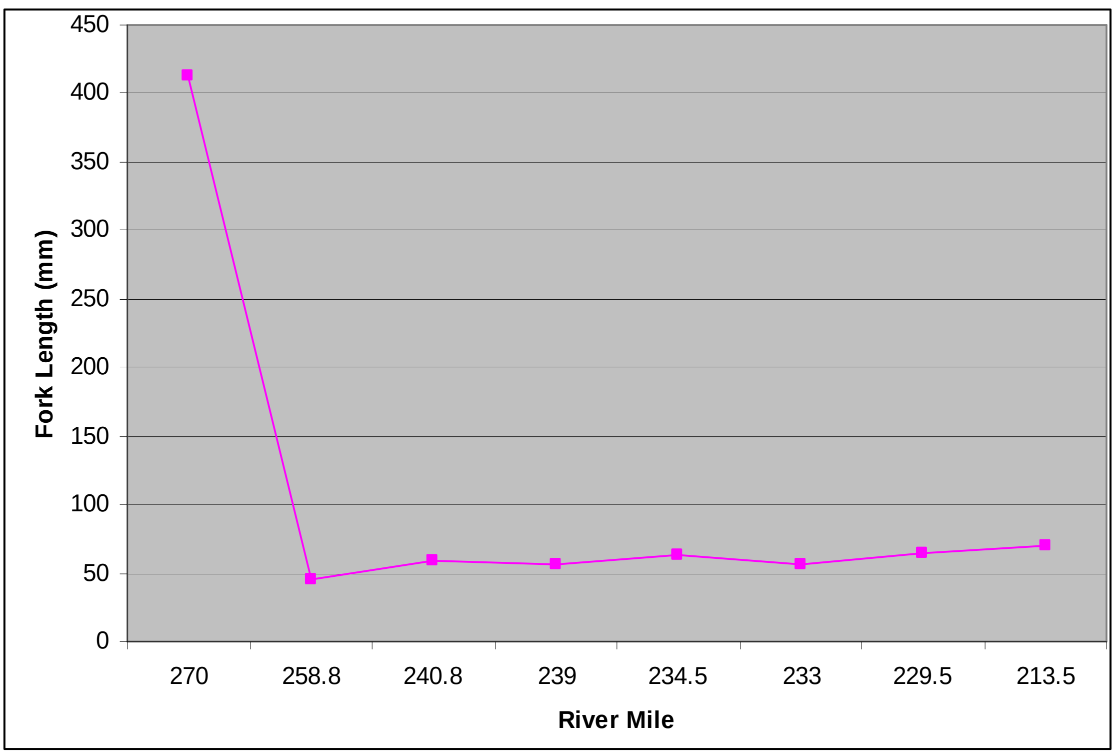

Figure 3. Average fork lengths of adult and YOY mountain whitefish collected by river mile.

IV. Discussion

The results from this study address the role of the dam-induced habitat discontinuity as a controlling factor in native fish distribution in this river. The results do not lend themselves to statistical analysis, but the picture they paint is generally consistent with our hypothesis. As predicted, the number of native fish species remained at low levels over the river reach covered in this investigation, while dam-enabled species diversity remained high until the confluence with the Yampa, where warm-water invasive species diversity increased dramatically, as they became the dominant group. This pattern parallels changes in the underlying water quality conditions in the Green River (Agnew et al. 2006, this volume). These findings indicate that habitat restoration alone is not sufficient for recovery of native species; the presence of the warm-water invasives is strongly correlated with low number of native fish species. This relationship suggests either that the conditions in the section of the river below the confluence are not accurately mimicking natural conditions, or that the invasive species are out-competing and/or preying upon the natives in spite of the natural conditions. The latter case suggests a need for additional control measures on invasive fishes.

The influence of the Yampa River was immediately apparent in the fish species diversity data. Adult salmonids were not found below the Yampa, although they were collected immediately upstream from the confluence. Adult warm-water invasives that represent higher trophic positions (e.g. smallmouth bass) were found upstream of the confluence in the Green River, while the juveniles of this group first appeared in the seine hauls in the backwaters at the confluence. The difference between Figure 1, based on both seine hauls and hook and line sampling, and Figure 2, based entirely on seine hauls, illustrates the difference in this adult and juvenile distribution. This pattern suggests that these higher trophic level adult invasives in the Green River may be spillover from the Yampa, with the Green River acting as a population sink. Based on the juvenile fish data, the Yampa does move the Green River back toward natural conditions, reflected in the elimination of adult salmonids and the staggering increase in juvenile warm-water invasive species. This finding comports with the serial discontinuity concept, which stresses the role of tributaries in the return of a river to natural conditions following a discontinuity.

The use of dam-enabled species as a proxy for the artificial habitat conditions created by the dam met several challenges. While the distribution of adult salmonids followed expected patterns of change with distance from the dam, the presence of post-larval salmonids, both in the Yampa River immediately above the confluence and in the Green River throughout the sampled reach, did not reflect expected changes in habitat conditions. There are several potential explanations for this deviation. First, YOY mountain whitefish have been known to migrate downstream during their first year, maturing in condition that are not favorable to their adult counterparts (Pettit et al. 1975). The other post-larval salmonids that were collected may be surviving outside of their ideal habitat, forced downstream by high spring flows. The adults may better able to select their preferred habitat, which would explain their adherence to the expected salmonid distribution. Second, the data gathered in this study only presents a snapshot of fish distributions and the same patterns may not be present throughout the year. For example, during sampling at the confluence, the Green River was warmer than the Yampa River (Agnew et al. 2006, this volume), which is not the case during most of the summer months (Muth et al. 2000). However, the Yampa was more than three times as turbid (Agnew et al. 2006, this volume), which may limit the survival of adult salmonids in the mainstem Green River post-confluence. A longer-term analysis would better document the full range of dam impacts on the aquatic conditions and might present a more accurate distribution for the salmonids.

V. References

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