Habitat Features Affect Bluehead Sucker, Flannelmouth Sucker, and Roundtail Chub across a Headwater Tributary System in the Colorado River Basin

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ABSTRACT

We assessed the distributions of three species of conservation concern, bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and roundtail chub (*Gila robusta*), relative to habitat features across a headwater tributary system of the Colorado River basin in Wyoming. We studied the upper Muddy Creek watershed, Carbon County, portions of which experience intermittent flows during late summer and early fall. Fish and habitat were sampled from 57 randomly-selected, 200-m reaches and 416 habitat units (i.e., pools, glides, or runs) during the summer and fall of 2003 and 2004. Among reaches, the occurrences of adults and juveniles of all three species were positively related to mean wetted width and the surface area of pool habitat, and the occurrences of adult bluehead sucker and roundtail chub were also positively related to the abundance of rock substrate. Only juvenile bluehead sucker appeared to be negatively influenced by the proportion of a reach that was dry at the time of sampling. Within individual pools, glides, and runs, the occurrences of adults and juveniles of all three species were positively related to surface area and maximum depth, and occurrences of bluehead sucker and flannelmouth sucker juveniles were more probable in pools than in glides or runs.

INTRODUCTION

Native fishes of the Colorado River basin (CRB) have declined in their distributions with many local extirpations (Minckley and Deacon 1968, Rinne and Minckley 1991). Of the large-bodied warmwater species native to the CRB, four species are listed as endangered under the U.S. Endangered Species Act and three species [i.e., bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and roundtail chub (*Gila robusta*)] now occur in about half of their historic ranges (Bezzerides and Bestgen 2002). Within the CRB of Wyoming, bluehead sucker, flannelmouth sucker, and roundtail chub are native to the Green River and Little Snake River drainages where they are classified as sensitive, declining, or vulnerable to extinction by the U.S. Bureau of Land Management, Wyoming Game and Fish Department, or Wyoming Natural Diversity Database.

Reasons cited for the declines of bluehead sucker, flannelmouth sucker, or roundtail chub include habitat degradation, the detrimental effects of dams, introduced competitors and predators, and hybridization (Bestgen and Probst 1989, Martinez et al. 1994, Bestgen and Crist 2000). However, relatively little is known as to how habitat features govern the distributions or abundances of these three species, particularly in small headwater tributary systems (Bezzerides and Bestgen 2002). Small tributary systems may be of high conservation value for all three species by sustaining isolated populations in areas where habitat and invasive non-native fishes are manageable (Bezzerides and Bestgen 2002).

Stream fishes often require unique habitats for spawning, feeding, rearing, and refuge. The spatial heterogeneity and connectivity of a stream system can necessitate the movements of

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fishes among habitats in order to complete their life cycles (Schlosser 1995). Within small tributary systems, the occurrences and abundances of bluehead sucker, flannelmouth sucker, and roundtail chub may be affected by numerous features including the amount of wetted habitat providing refuge during low-flow periods (Lake 2003, Magoulick and Kobza 2003); abundance of rock substrate (Holden and Stalnaker 1975); abundance of submersed aquatic vegetation (Bestgen and Probst 1989, Gido and Probst 1999); or availability of various habitat types such as pools, glides, runs, or riffles (Barrett and Maughan 1995, Gido and Probst 1999).

Our purpose was to obtain insight into the habitat features affecting occurrence patterns of juvenile and adult bluehead sucker, flannelmouth sucker, and roundtail chub in small tributary systems of the CRB. Recent research has identified the need to consider spatial scales when assessing habitat features that may affect stream-dwelling fishes (Schlosser 1995, Rabeni and Sowa 1996, Sowe et al. 2006), so we utilized reach and channel-unit (i.e., individual pools, glides, or runs) scales in this study. We tested hypotheses that the proportion of the reach length that was dry at the time of sampling, mean wetted width, abundance of rock substrate, or abundance of pool, glide, run, or riffle habitat types are related to the probability of occurrence of juveniles or adults of the three species. Additionally, we hypothesized that water surface area, maximum depth, amount of submersed aquatic vegetation, or habitat unit type (i.e., pool, glide, run) are related to the probability of occurrence of juveniles or adults of the three species among habitat units.

METHODS AND MATERIALS

Muddy Creek is a tributary to the Little Snake River that originates in the foothills of the Sierra Madre, Carbon County, southern Wyoming. The upstream portion of the Muddy Creek watershed is one of only two known stream systems in Wyoming where sympatric populations of bluehead sucker, flannelmouth sucker, and roundtail chub remain. However, the white sucker (*Catostomus commersoni*) has been introduced to the system (Quist et al. 2006), and there is evidence of its hybridization with the two native catostomid species (Bower 2005, Compton 2007)

Muddy Creek has wide seasonal fluctuations in streamflow and sediment transport (Goertler 1992) that maintain relatively natural habitat features in most of the system. The hydrograph is dominated by runoff originating from snowmelt in the spring followed by periods of low flow during summer. Thunderstorms during summer and fall occasionally result in short periods of high flows. During most years, segments of Muddy Creek and its tributaries become intermittent during summer.

The study area included 63 km of Muddy Creek, 16 km of McKinney Creek, and 2 km of Littlefield Creek (Fig. 1) and was segmented based on occurrence of anthropogenic barriers to upstream movements by fishes. Segment 1 began at the downstream boundary of the study area at a headcut stabilization structure and continued 43 km upstream on Muddy Creek to an irrigation diversion structure. This structure was found to be navigable by some fishes moving upstream during both high and low discharge (Compton 2007), but probably limited upstream movements by most fishes. Segment 2 consisted of Muddy Creek from the irrigation diversion structure upstream to a rock-gabion fish barrier on Muddy Creek immediately upstream of the confluence of McKinney Creek and included McKinney Creek upstream to where warmwater fishes were no longer found. Segment 3 consisted of Muddy Creek from the fish barrier upstream to the road culvert and Littlefield Creek upstream to another rock-gabion fish barrier. Each of the three study segments was divided into 200-m reaches, and 30 reaches in Segment 1, 20 reaches in Segment 2, and 7 reaches in Segment 3 were randomly selected for sampling. The number of reaches selected in each segment was proportional to the length of the segment relative to the total length of streams in the study area. We assumed that sampling a 200-m reach would enable all species that were present to be captured (Patton et al. 2000). Within each segment, equal proportions of reaches were randomly assigned to one of two sampling periods in 2003 (i.e., June 1–July 31 or August 1–October 8, 2003). Within each time strata, the chronological order in which reaches were sampled was randomly generated. In 2004, no time strata were used because all sampling took place in June and July.

The lengths of sampled reaches were adjusted (175-225 m) so that upstream and downstream boundaries terminated at riffles when possible. The proportion of the length of each reach with no observable surface flow at the time of sampling was measured. Channel units within reaches were classified as pool, glide-run, or riffle following Flossi and Reynolds (1994). Glides and runs were combined as one habitat type (i.e., glide-run) because classification of habitat units as glides or runs was uncertain and together they represented habitat types that are on a gradient between riffles and pools. Length and mean wetted width of each channel unit were used to calculate water surface area. The total water surface areas of pool, glide-run, and riffle habitat units were summed and divided by reach length to provide an estimate of mean wetted width over the length of the reach. The proportions of the water surface areas of all pool and glide-run habitat units having gravel, cobble, boulder, and bedrock substrates were visually estimated following the modified Wentworth classification (Cummins 1962). The proportion of the water surface area of each pool and glide-run with submersed aquatic vegetation covering the streambed was also visually estimated. From these estimates, the proportions of the water surface area of pools and glide-runs composed of rock substrate and submersed vegetation were computed. Maximum water depth was measured with a graduated staff in each pool and glide-run.

Each pool and glide-run habitat unit in a reach was sampled by electrofishing and seining during daylight. Preliminary sampling indicated that the three target species were rarely found in the shallow riffles common to the upper Muddy Creek study area, so riffles were not sampled throughout the study. Block nets were placed at the upstream and downstream boundaries of a channel unit. A single electrofishing pass with a pulsed DC backpack unit was made and all fish greater than 40 mm total length (TL) were collected, identified, and measured (TL). These fish were retained in a mesh cage until fish sampling was completed. The channel unit was then seined over its length with a 4.8-mm mesh bag sewn. All fish collected by seining were identified and measured. Bluehead suckers and roundtail chubs greater than 150 mm TL and flannelmouth suckers greater than 200 mm TL were classified as adults. Observations of tuberculation, expression of gametes, and spawning coloration among sampled fishes in Muddy Creek were used to develop these thresholds (Bower 2005). From these data, the occurrences of juvenile and adult stages of the three target species in each sampled reach and habitat unit were estimated. White sucker, hybrids of white sucker and the two native catostomids, and creek chub were captured but not included in our analysis.

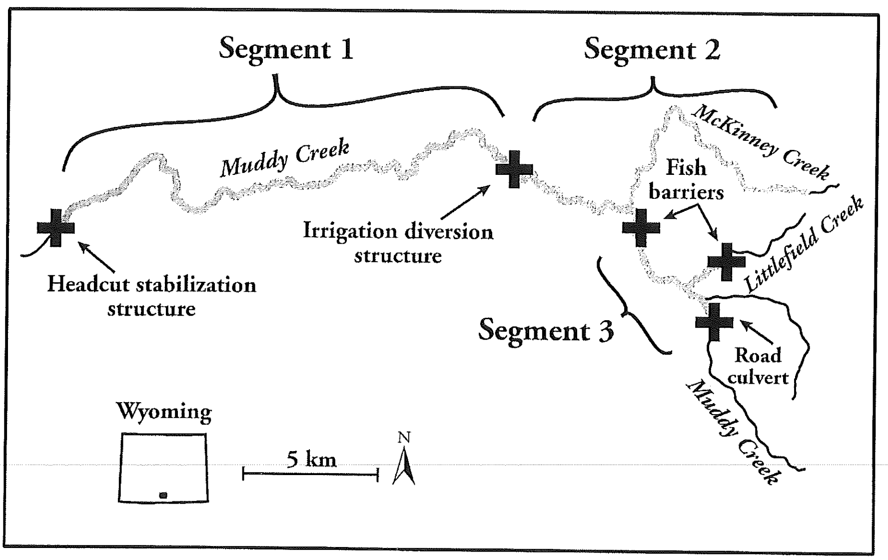

Figure 1. Study area and locations of anthropogenic barriers to upstream movements of fishes within the upper Muddy Creek watershed of southern Carbon County, Wyoming. Three study segments were established based on the locations of the barriers to upstream movements.

Analyses were conducted for reach-scale and channel-unit-scale variables. At the reach-scale, six variables describing physical habitat over the length of each reach were used in the analyses--mean wetted width, water surface areas of pools, water surface area of glide-runs, water surface area of riffles, proportion of the water surface area of pools and glide-runs with rock substrate (i.e., gravel, cobble, boulder, or bedrock), and proportion of the thalweg length with no surface flow. At the habitat-unit scale, four dependent variables describing the habitat were used in the analyses--water surface area, maximum depth, proportion of the water surface area with the bottom covered by submersed aquatic vegetation, and habitat type (0 = glide-run, 1 = pool).

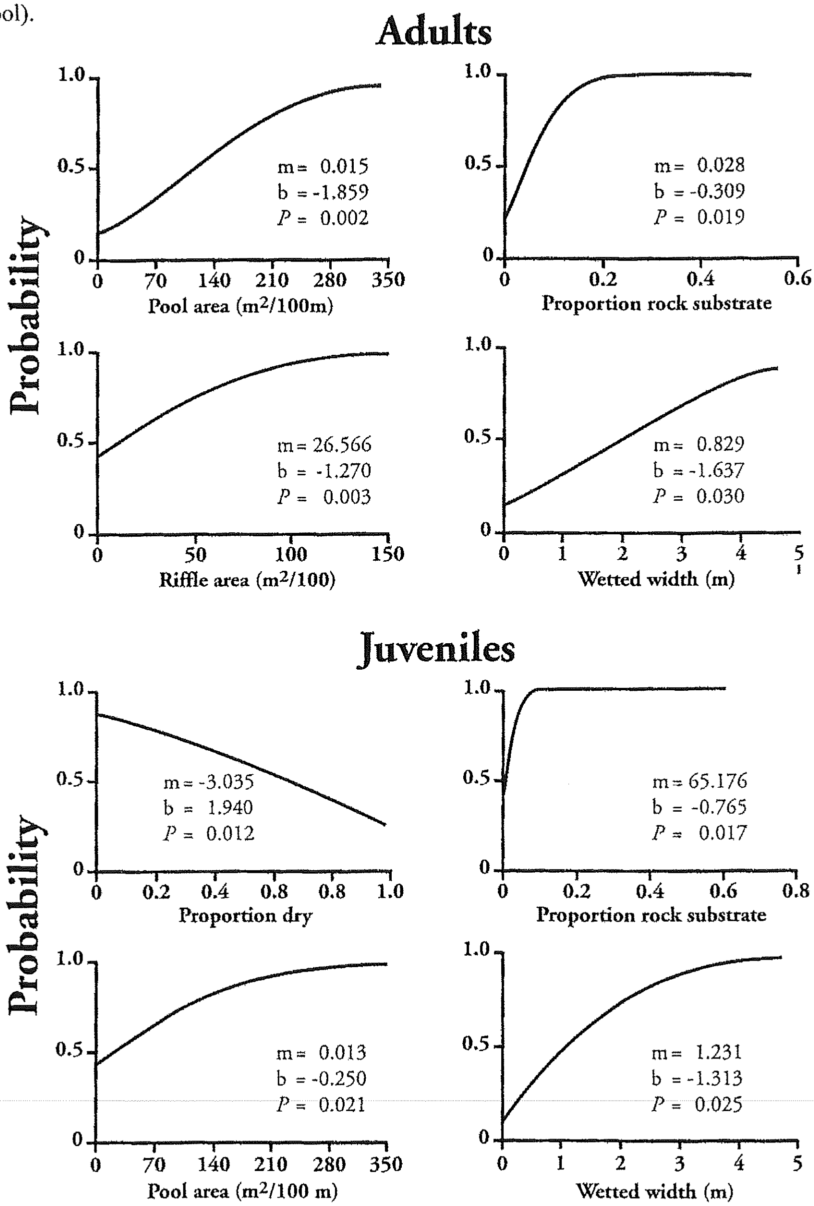

Figure 2. Probability plots for statistically significant ($P < 0.05$) logistic regression models accounting for the presence or absence of adult or juvenile bluehead sucker in samples among 51 reaches in the upper Muddy Creek study area. Included are the coefficient (m), constant (b), and probability (P) for the logistic regression model.

Simple logistic-regression models were computed at both the reach and habitat-unit scales with the presence (1) or absence (0) of individual species and life stages as dependent variables (Ramsey and Schafer 2002). Multiple logistic regression models were not computed because of correlations among independent variables. Models were considered significant when the probabilities were less than or equal to 0.05, recognizing that computed probabilities may be biased by spatial autocorrelation among reaches or habitat units but constant among models because the same sample of reaches and habitat units were included in all models. Probability plots were developed from these models to illustrate the effects of the predictor variables on the presence or absence of fish. We computed probabilities of fish occurrence (P) as $(P) = e^{logit}/(1 + e^{logit})$ where the logit is the linear regression model ($logit = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p$ where β_p = the regression constant, and X_p = independent variables) (Manly et al. 2002). Pearson correlation coefficients were computed to identify relationships among variables. All computations were made using Statistix7 (Analytical Software 2000).

RESULTS

Among the 57 reaches that were selected for sampling, three reaches in Segment 1 were entirely dry. The three most upstream reaches in Segment 2 had none of the three target species present and were likely upstream of their elevation limits. These six reaches were omitted from the logistic-regression analyses. There was substantial variation in the six measures of habitat among the 51 reaches and Pearson correlation coefficients suggested several relationships among the measures of habitat. The highest correlation ($r = 0.69$) occurred between mean wetted width and the surface area of pools.

Occurrence of adult bluehead sucker was accounted for by each of four of the reach features--surface area of pools, proportion of rock substrate in pool and glide-run habitats, surface area of riffles, and (4) mean wetted width. As each of these dependent variables increased, the probability of occurrence of adult bluehead sucker increased (Fig. 2). The

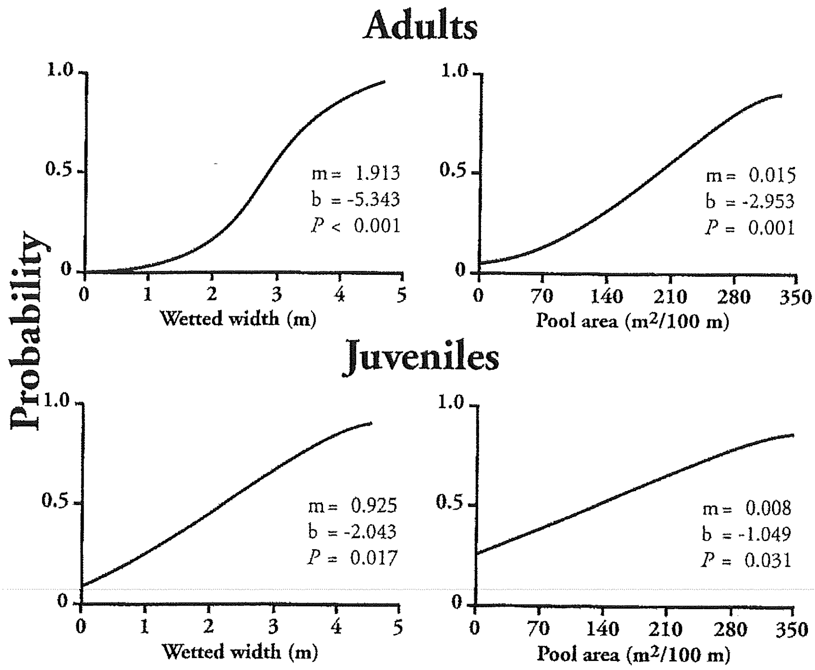

Figure 3. Probability plots for statistically significant ($P < 0.05$) logistic regression models accounting for the presence or absence of adult or juvenile flannelmouth sucker in samples among 51 reaches in the upper Muddy Creek study area. Included are the coefficient (m), constant (b), and probability (P) for the logistic regression model.

occurrence of juvenile bluehead sucker declined as the proportion of the reach length that was dry at the time of sampling increased, but its occurrence increased as the proportion of rock substrate, pool area, and wetted width increased. Occurrence of both juvenile and adult flannelmouth suckers was accounted for by two habitat features--wetted width and pool area (Fig. 3). Similarly, the occurrence of both juvenile and adult roundtail chub was accounted for by wetted width and pool area, but the occurrence of adults was also accounted for by the proportion of rock substrate (Fig. 4).

All total, 416 habitat units were sampled among the 51 reaches. There was substantial variation in surface area, maximum depth, and the proportion of submersed aquatic vegetation, with 254 habitat units classified as pools and 162 habitat units classified as glide-runs. The only significant Pearson correlation between measured habitat features was between surface area and maximum depth ($P < 0.0001$, r = 0.69).

The occurrences of adults of all three species in habitat units were related to both water surface area and maximum depth of habitat units with the probability of occurrence increasing as area or depth increased (Fig. 5-7). Similarly, occurrences of juveniles of all three species were

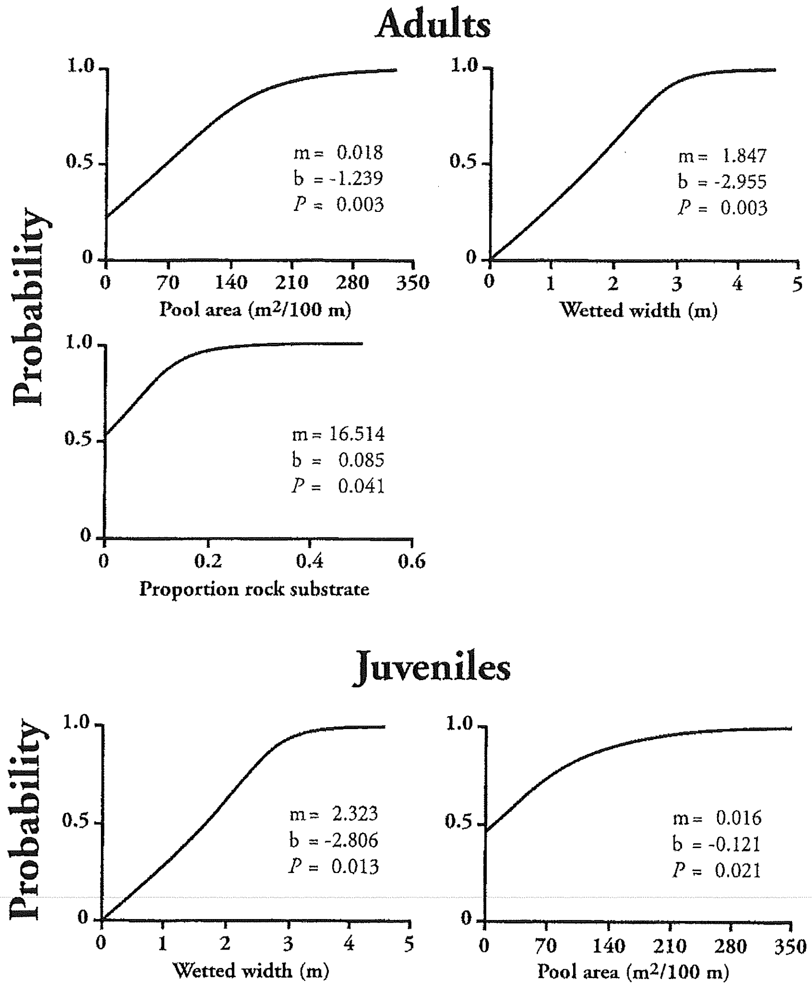

Figure 4. Probability plots for statistically significant ($P < 0.05$) logistic regression models accounting for the presence or absence of adult or juvenile roundtail chub in samples among 51 reaches in the upper Muddy Creek study area. Included are the coefficient (m), constant (b), and probability (P) for the logistic regression model.

related to both water surface area and maximum depth of habitat units, with increasing probability of occurrence with increasing area or depth. However, occurrences of bluehead sucker and flannelmouth sucker juveniles were also related to habitat type, with higher probabilities of occurrence in pools than in glide-runs.

DISCUSSION

The occurrences of both adult and juvenile bluehead sucker, flannelmouth sucker, and roundtail chub in sampled reaches of Muddy Creek were influenced by the abundance of large, deep pools during summer low-flow conditions. Adults and juveniles of all three species were found not only in reaches where surface flows occurred throughout the summer but also in reaches with no observable surface flow provided that deep pools were present. However, juveniles of bluehead sucker were less likely to occur in reaches that were partially dry. Reaches with ephemeral flows occurred in a headwater portion of the watershed (i.e., McKinney Creek) and in the most downstream portion of the study area (i.e., downstream portion of Segment 1 on Muddy Creek). Refuge habitat consisting of large, deep pools in reaches with surface flows, as well as in reaches having no observable surface flow, appeared to be an important for all three species. The ability of fishes to access such refuge habitats during periods of very low or no surface flow and to re-colonize adjacent reaches following resumption of flows have been shown to be major factors influencing fish communities in streams experiencing extensive drying (Lake 2003, Magoulick and Kobza 2003, Scheurer et al. 2003).

As the maximum depth of pools, glides, and runs increased, the probability of occurrence of all three species tended to increase. However, maximum depth and surface area of pool habitat were highly correlated, suggesting that maximum depth may be a surrogate for large pools. Nonetheless, Beyers et al. (2001) observed bluehead sucker and flannelmouth sucker use

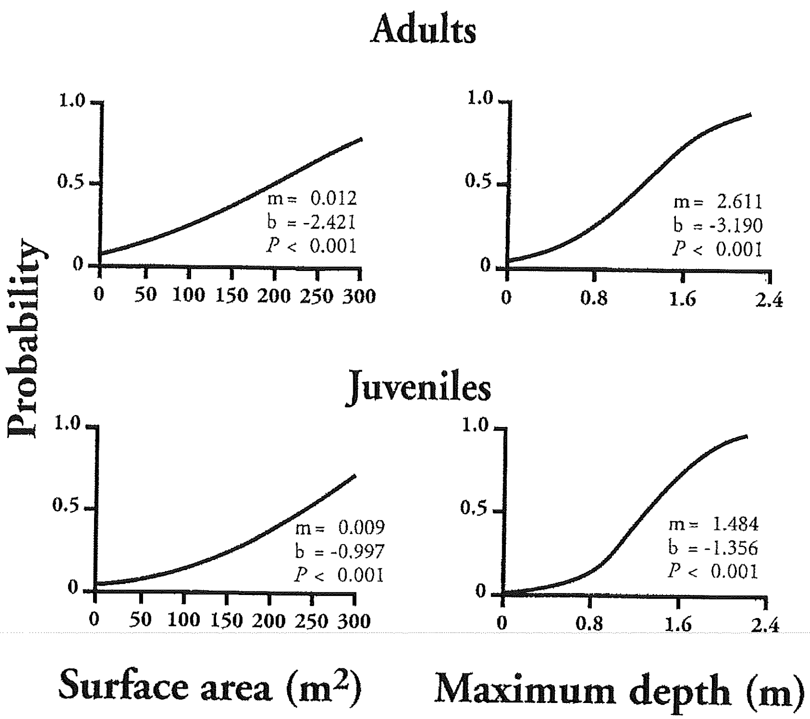

Figure 5. Probability plots for statistically significant ($P < 0.05$) logistic regression models accounting for the presence or absence of adult or juvenile bluehead sucker in samples among 416 habitat units (i.e., pools and glide-runs) in the upper Muddy Creek study area. Included are the coefficient (m), constant (b), and probability (P) for the logistic regression model.

of deep pools in the Colorado River, suggesting some selection for deep water. Deep water probably provides protection from avian predators and a higher probability of persistence of isolated pools during periods with no surface flow.

There was evidence that rock substrate in pools, glides, and runs influenced the occurrence of bluehead sucker, but not flannelmouth sucker as suggested by previous studies (Holden and Stalnaker 1975a). It is likely that rock substrate provides food resources needed by bluehead sucker, as its diet consists almost entirely of periphyton scraped from rocks by means of a cartilaginous ridge on the jaw (Baxter and Simon 1970). Occurrence of adults of roundtail chub was also related to rock substrate, and this species has been described to feed on insects and algae (Baxter and Simon 1970). A mechanism leading to the relationship with roundtail chub is less evident, but it is possible that rock substrates provide sources of both invertebrate and algal foods (Quist et al. 2006).

Occurrences of bluehead sucker and flannelmouth sucker juveniles appeared to be influenced by habitat type, tending to be higher in pools than glide-runs. Similarly, flannelmouth sucker juveniles have been observed to use habitats with low current velocities and fine substrates in the San Juan River, New Mexico (Gido and Probst 1999).

The abundance of submersed aquatic vegetation did not appear to influence the occurrence of any of the target species. Juveniles of all three species have been associated with backwaters having aquatic vegetation in larger streams (Gido and Probst 1999). Additionally, adult roundtail chubs have been associated with submersed vegetation in other systems (Bestgen and Probst 1989). However, submersed aquatic macrophytes were widespread over the Muddy Creek sampling area and, consequently, may not have been a limiting habitat feature.

In general, all three species were most common in reaches with perennial flows and deep pools having rock substrates. Such habitat was most prevalent in a relatively short portion of

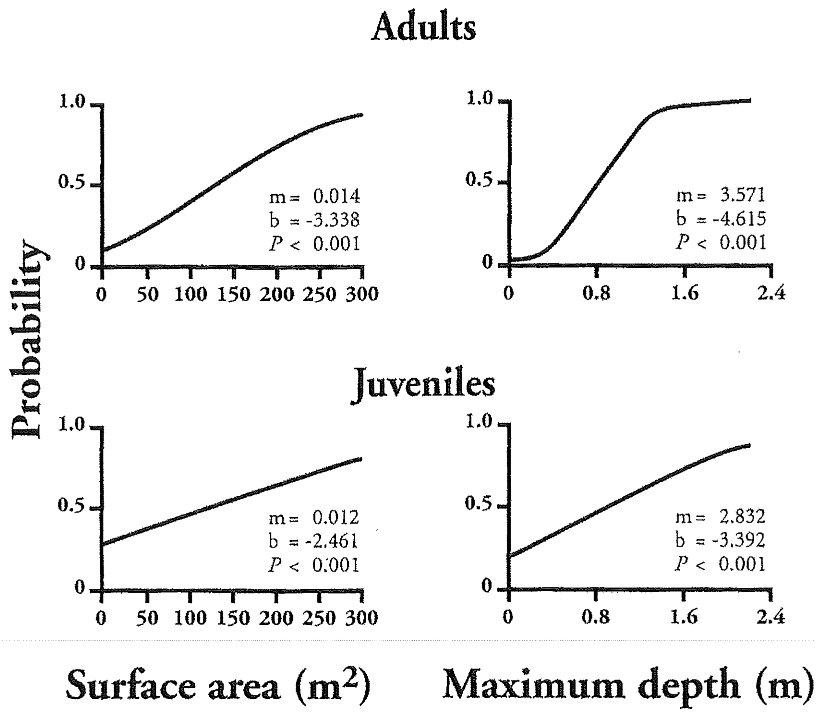

Figure 6. Probability plots for statistically significant ($P < 0.05$) logistic regression models accounting for the presence or absence of adult or juvenile flannelmouth sucker in samples among 416 habitat units (i.e., pools and glide-runs) in the upper Muddy Creek study area. Included are the coefficient (m), constant (b), and probability (P) for the logistic regression model.

Muddy Creek occurring from roughly 5 km downstream from the irrigation diversion upstream to the fish barrier forming the downstream boundary of Segment 3 of the study area. Preservation of the natural flow regime and deep pools within this segment may be critical to the preservation of bluehead sucker, flannelmouth sucker, and roundtail chub populations in Muddy Creek and similar headwater tributary systems of the CRB.

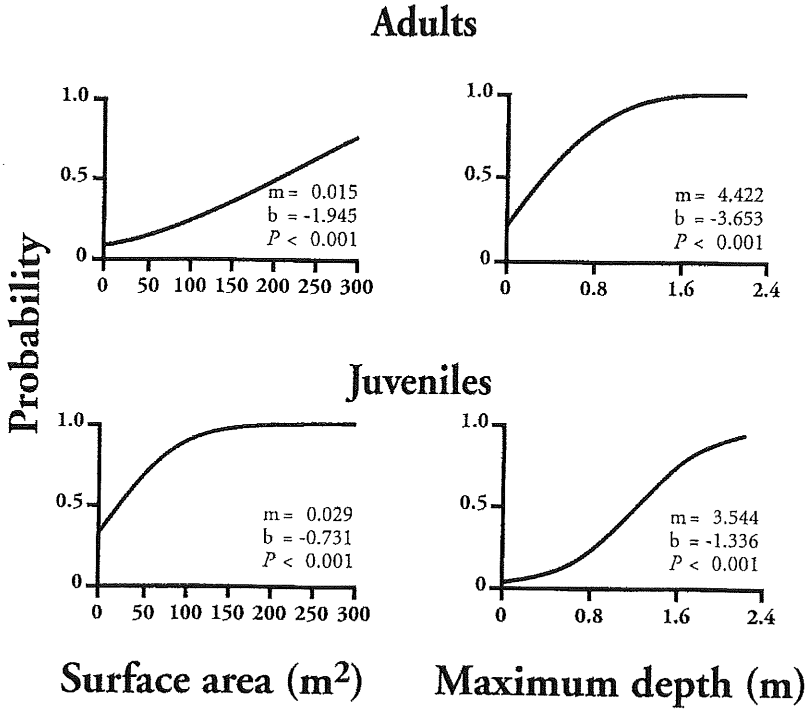

Figure 7. Probability plots for statistically significant ($P < 0.05$) logistic regression models accounting for the presence or absence of adult or juvenile roundtail chub in samples among 416 habitat units (i.e., pools and glide-runs) in the upper Muddy Creek study area. Included are the coefficient (m), constant (b), and probability (P) for the logistic regression model.

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