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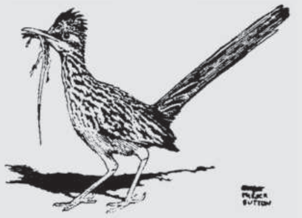

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ABSTRACT—We compared two populations of the bluehead sucker (*Catostomus discobolus*) during 2007–2009 in the Weber River, Davis, Summit, and Weber counties, Utah. We estimated 225 and 546 individuals in these populations. Based on recaptured, PIT-tagged fish, annual survival of adults (202–575 mm total length) was high (77%); however, our top model indicated mortality increased with size (i.e., senescence). We documented movements ≤15 km downstream and 5 km upstream and 88% of detections from a stationary antenna occurred at night. Despite high rates of survival of adults, recruitment appeared minimal in one of the populations because it was composed primarily of mature adults. Recruitment potentially was limited by interactions with a high density of brown trout (*Salmo trutta*) and combined effects of an altered hydrograph (magnitude, duration, and timing) and thermal regime. If conservation of these populations is a priority, recruitment must be increased immediately in one of the populations to avoid extinction.

RESUMEN—Se compararon dos poblaciones del matalote cabeza azul (*Catostomus discobolus*) durante 2007–2009 en el río Weber, en los condados de Davis, Summit, y Weber, Utah. Se estimaron 225 y 546 individuos en estas poblaciones. Basándose en los peces recapturados con transmisores PIT, la supervivencia anual de adultos (202–575 mm longitud total) fue alta (77%); sin embargo, nuestro mejor modelo indicó que la mortandad aumentó con el tamaño (por ejemplo, la senectud). Documentamos desplazamientos ≤15 km río abajo y 5 km río arriba y 88% de los registros de una antena fija ocurrieron en la noche. A pesar de las altas tasas de supervivencia de adultos, el reclutamiento fue mínimo en una de las poblaciones, ya que se compuso principalmente de adultos maduros. El reclutamiento fue limitado potencialmente por la interacción con una densidad alta de trucha marrón, (*Salmo trutta*) y los efectos combinados de un hidrógrafo alterado (magnitud, duración, y estacionalidad) y el régimen térmico. Si la conservación de estas poblaciones es una prioridad, el éxito del reclutamiento se debe aumentar inmediatamente en una de las poblaciones para evitar extinción.

Native fishes declined steadily in distribution and abundance across western North America in the 20th century (Williams et al., 1989; Moyle and Leidy, 1992). These declines have been especially pronounced in the Colorado River Basin and include seven large-bodied, warm-water species native to this arid region (Minckley et al., 2003). Of these fishes, four are listed federally as endangered under the Endangered Species Act and three, including the bluehead sucker (*Catostomus discobolus*) are now restricted to ca. 50% of their historical range (N. Bezzerides and K. R. Bestgen, in litt.). Little is known about structure of size classes of populations of the bluehead sucker or its basic vital rates in the few systems where it still persists, due in part to its cryptic nature, lack of sportfish status, and low perceived charisma. These critical gaps in knowledge limit our ability to prioritize management activities aimed at ensuring their persistence and recovery (Botcher, 2009).

The bluehead sucker historically occurred in the Upper Snake, Weber, and Bear river drainages (Sigler and Miller, 1963; Sublette et al., 1990). Bluehead suckers still persist in the Upper Snake River in Idaho (T. R. Maret and D. S. Ott, in litt.) and in the Bear and Snake rivers in Wyoming (Carlson, 2006), but status of populations is unknown and distribution appears to be spotty. In Utah, Andreasen (1973) reported that portions of the Bear, Ogden, and Weber river drainages in the Bonneville Basin were occupied by bluehead suckers. However, despite extensive sampling by personnel of the Utah Division of Wildlife Resources during 2004–2009, they were able to document persistence of bluehead suckers only in the Weber River in the Bonneville Basin (Thompson and McKay, 2010).

As with many imperiled riverine fishes, factors that threaten bluehead suckers include dams and diversions, degradation of habitat, and introduction of nonnative fishes. Dams change environmental conditions to which the bluehead sucker evolved through alterations to the natural hydrograph and water-temperature regime, homogenization of instream habitat, and prevention of movement to different and necessary environments (Vanicek et al., 1970; Martinez et al., 1994; K. R. Bestgen and L. W. Crist, in litt.). Small irrigation-diversion dams are numerous throughout many western drainages and not only remove water from rivers, but fragment populations and strand fish in canals and agricultural fields (McAda, 1977; Mueller and Marsh, 2002; Carlson, 2006). Barriers can block access to spawning environments in tributaries and preferred environments in other reaches and cause fragmentation (Martinez et al., 1994; Compton et al., 2008). Through time, fragmentation can lead to genetic bottlenecks, which further decrease fitness (Bessert and Orti, 2008).

Often working in combination with effects of dams and diversions, degradation of instream habitat represents a substantial threat to bluehead suckers. In the Colorado River Basin, larvae of bluehead suckers drift after emergence from the egg stage (Carter et al., 1986; Robinson et al., 1998) and inhabit backwaters and shallow riffles as juveniles (Vanicek, 1967). Adults appear to prefer more complex habitat with large substrate, faster water, and shallow water with riffles (Botcher, 2009). However, many of these preferred habitats have been eliminated due to construction and channelization of streams for irrigation in systems where bluehead suckers persist. This alteration of geomorphology and hydrology potentially contributes to factors limiting distribution and abundance of the bluehead sucker (Botcher, 2009).

In addition to combined effects of dams and diversions and instream degradation of habitat, introduced species of fish threaten bluehead suckers through predation, competition, and hybridization (N. Bezzerides and K. R. Bestgen, in litt.). Predation by nonnative predators on bluehead suckers is well documented and can limit abundance and distribution of populations (Brandenburg and Gido, 1999; L. Coggins et al., in litt.). Consequently, efforts to remove nonnative predators (e.g., northern pike *Esox lucius* and smallmouth bass *Micropterus dolomieu*) are currently a key focus of recovery efforts for endangered fish in the upper Colorado River Basin (United States Fish and Wildlife Service, 1987). Nonnative fish also have the potential to compete for the same food resources as bluehead suckers (J. A. Ptacek et al., http://www.fs.fed.us/r2/projects/scp/assessments/blueheadsucker.pdf). Hybridization of bluehead suckers with white (*Catostomus commersonii*), flannelmouth (*Catostomus latipinnis*), and mountain suckers (*Catostomus platyrhynchus*) has been documented in the Colorado River Basin (McAda, 1977; Bower, 2005; Compton, 2007; N. Bezzerides and K. R. Bestgen, in litt.), as well as with Utah suckers (*Catostomus ardens*) in the Weber River (M. R. Douglas et al., in litt.). Hybridization can rapidly reduce fitness in a population of fish (C. C. Muhlfeld et al., in litt.) and has led to extinction of many species and populations of plants and animals worldwide (Allendorf et al., 2001).

The bluehead sucker in the Weber River is a unique and understudied fish. Based on a study by M. R. Douglas et al. (in litt.) assessing mtDNA, the bluehead sucker in the Weber, Bear, and Upper Snake rivers were distinct from populations in the Colorado River Basin. This discovery prompted the Utah Division of Wildlife Resources to manage these populations as a distinct unit; future management actions will be directed toward long-term persistence of these populations, including maintenance of actively reproducing populations of sufficient size that exhibit a natural age structure. Achieving this goal, however, requires a basic understanding of structure, vital rates, and factors limiting persistence of populations of bluehead suckers; this information is not readily available.

Working toward the goal of providing necessary information to guide conservation and management of bluehead suckers in the Weber River and other systems, we completed an extensive study of two populations in the Weber River, northern Utah. These are two of the few known populations outside the Colorado River Basin with sufficient numbers for study. The Weber River is typical of many western rivers in that dams, diversions, and introduction of nonnative fishes potentially threaten native fishes, including the bluehead sucker. We chose these two populations because both structure of the population and the physical characteristics of the reaches where these two populations occurred vary dramatically, and as such, these differences might aide in identifying factors limiting abundance and distribution of bluehead suckers. Our objectives were to: 1) quantify size classes of populations, rates of survival, and movement patterns of bluehead suckers in two reaches of the Weber River, 2) use these vital rates to better understand which life stage or stages most limit viability and persistence, and 3) identify factors impeding viability and persistence.

MATERIALS AND METHODS—The Weber River (a tributary to the Great Salt Lake) occurs in a 6,413-km^2 watershed in north-central Utah (Fig. 1). It originates near Reids Peak (3,569 m above mean sea level) and flows 201 km northwest to the Great Salt Lake (1,280 m above mean sea level). The riparian community is typical of an interior stream in the western United States and is composed primarily of willows (*Salix*) and cottonwoods (*Populus angustifolia*, *P. fremontii*). Grazing is the primary use of land. The natural hydrograph is dominated by snowmelt runoff with highest annual discharge occurring

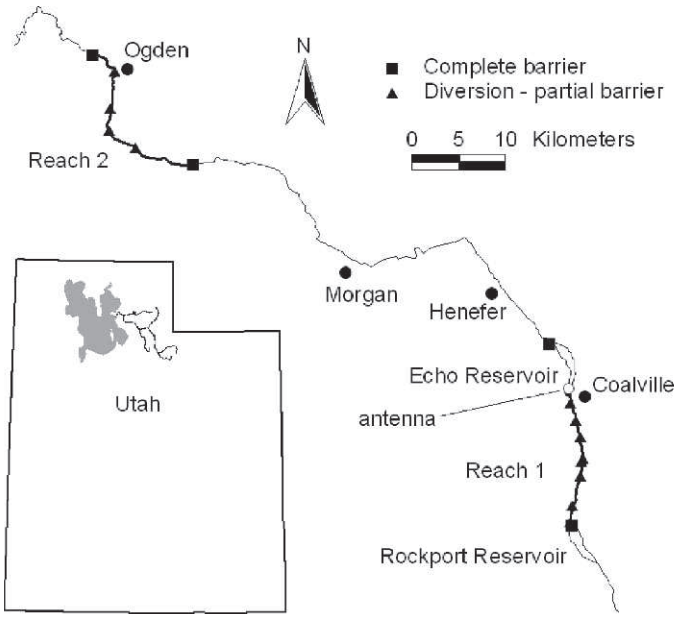

FIG. 1—The Weber River, Utah, with locations of four instream complete barriers (>1-m high) bounding the two reaches studied and location of instream partial barriers (<1-m high) within the reaches.

during early April–late June and periods of base flow during July–March. Water resources in the Weber River watershed are regulated with seven large irrigation or flood-control reservoirs (height of dam spillway ≥19.5 m); Echo and Rockport reservoirs are on the mainstem (Fig. 1). The seven reservoirs dictate base flow within segments of the mainstem Weber River; base flow can fluctuate greatly depending on location within the watershed and time of year.

The Weber River has been severely altered from historical conditions, including introduction of many nonnative fishes. Additionally, physical characteristics of the river have changed. A large portion of the slow-velocity and backwater environment within the section of the Weber River occupied by bluehead suckers was eliminated by construction of Interstate-84 in 1968, when many reaches were straightened and channelized (J. R. Barton and P. V. Winger, in litt.).

Other native fish in the Weber River include the mountain whitefish (*Prosopium williamsoni*), Bonneville cutthroat trout (*Oncorhynchus clarki utah*), Utah sucker, mountain sucker (*Catostomus platyrhynchus*), speckled dace (*Rhinichthys osculus*), longnose dace (*Rhinichthys cataractae*), mottled sculpin (*Cottus bairdii*), Paiute sculpin (*Cottus beldingi*), Utah chub (*Gila atraria*) and redside shiner (*Richardsonius balteatus*). In addition, many nonnative species were introduced into the Weber River including the common carp (*Cyprinus carpio*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*). The Utah Division of Wildlife Resources managed the Weber River primarily for rainbow trout until the mid-1980s. Densities of brown trout began increasing in the mid-1970s and by the mid-1980s, brown trout had become the most widely distributed large predator in the drainage (P. D. Thompson, pers. comm.). Brown trout are sympatric with bluehead suckers in the Weber River, which currently is managed as a wild brown trout and Bonneville cutthroat trout fishery.

The two reaches studied are separated by ca. 70 km; intermixing between the two populations is unlikely due to dams and diversions. Theoretically, fish from the upper reach could move through dams and diversions downstream to the lower reach, but during this study, no tagged fish from the upper reach was documented below the first large dam. In addition, the two reaches have different hydrologic regimes, water temperatures, instream habitats, and they contain different densities of nonnative predators (i.e., exotic brown trout).

Reach 1 (16.8 km in length) was between Echo Reservoir (construction completed in 1931) and Rockport Dam (construction completed in 1957; Fig. 1), Summit County, Utah. There are seven instream diversion structures within Reach 1 (Fig. 1) that likely limit movement of bluehead suckers during low-water periods, usually August–March. Elevation of Reach 1 was 1,692–1,795 m above mean sea level and mean wetted width during the base-flow period in summer was 15.9 m.

Reach 2 (20.2 km in length) was near the town of Ogden, Davis and Weber counties, Utah (Fig. 1) between two >1-m high instream irrigation-diversion structures. The downstream diversion was completed in 1957; the upstream diversion was completed in 1953. These and an additional four <1-m high instream irrigation-diversion structures (Fig. 1) likely limit movement of fish, especially during low-water periods (August–March). The elevation of Reach 2 was 1,297–1,390 m above mean sea level and mean wetted width during the base-flow period in summer was 19.7 m.

We used two-pass mark-recapture with a raft electrofisher to estimate abundance of bluehead suckers in July 2007 and 2008 (Reach 1) and July 2009 (Reach 2). For both reaches, we separated each electrofishing pass by 2–7 days. We calculated within-year estimates of abundance of subadults and adults (>150 mm total length) using the Petersen index with the small-population correction factor of Bailey (1951); we calculated 95% confidence intervals (*CI*s) based on Ricker (1975) due to small numbers of recaptures. To evaluate improvement in precision of added passes for future monitoring, we completed two additional electrofishing passes in Reach 2, one in March 2009 and the second in July 2009 (1 week following the two-pass estimate). Assuming a closed population, we estimated abundance in 2009 using a Schumacher and Eschmeyer model (Krebbs, 1989) using both three passes (July sampling only) and four passes (March and July sampling events), and expressed variance as 95% *CI*s of our estimates. We estimated density (number/m^2) using length of the entire reach and average width of each reach. We completed the two-pass estimate of abundance in 4 days for Reach 1 (2 days/electrofishing pass). In 2007, we sampled the entire 16.8 km of Reach 1 (2 days/electrofishing pass), but did not encounter bluehead suckers in the upper 6.2 km; consequently, we sampled only the lower 10.6 km (1 day/electrofishing pass) during 2008. We electrofished with a three-person team on the raft (two netters and an operator). A 2–4-person team followed the electrofishing raft in a canoe or raft to provide assistance with netting and primarily to assist with processing fish.

Prior to the two-pass mark-recapture electrofishing, we already had tagged 24 bluehead suckers captured during 2006 in Reach 1 and 132 bluehead suckers captured during 2007–2009 in Reach 2 as part of other sampling efforts. We used 12.5 mm, 134.2 kHz ISO passive-integrated-transponder (PIT) tags (Biomark, Boise, Idaho). We measured (total length in mm), weighed (g), and recorded location of all captured bluehead suckers. We scanned all bluehead suckers >150 mm total length for a PIT-tag using a hand-held detection wand, and recorded the PIT-tag number of recaptured fish. If we did not detect a tag, we tagged the fish and recorded the number. After handling, we released all fish ≤100 m of location of capture.

We characterized structure of size classes of the population for each reach we studied by categorizing the length at initial capture of each bluehead sucker sampled during 2006–2009 using 10-mm size bins. We compared frequency distributions of sizes between reaches using a Kolmorgorov-Smirnov goodness-of-fit test for discrete data with an a priori $\alpha = 0.05$ (Zar, 1984).

We measured movements of individuals by calculating distances moved from GPS coordinates of active and passive PIT-tag captures-detections in ArcGIS. We operated a single-passive-instream-flat-plate antenna (PIA) during September 2007–March 2008 and October 2008–March 2009. We used the PIA (30.5 by 66 cm) only in Reach 1 and installed it in a 1-m deep run in a location that had a high concentration of bluehead suckers. Because the PIA system only sampled ca. 0.05% of the width of the river and did not differentiate upstream or downstream directions of movement, the PIA was installed initially to obtain detections to determine distance moved by individual fish. We placed the PIA at the downstream end of Reach 1 (Fig. 1) because we suspected that bluehead suckers captured during electrofishing were upstream in summer while spawning and resided near the PIA during winter. Due to the number of detections on the PIA, these data also were used to assess timing of activity and in analyses of annual rates of survival. The PIA was connected to a Biomark FS2001F-ISO Reader (Biomark, Boise, Idaho) powered by a 12-V deep-cycle battery, which was housed in a metal box at streamside. We programmed the reader to record time and date of each detection and exclude the same fish from detection if identified twice within a 10-s period. We changed the battery powering the PIA twice a week and we passed a wooden stake with an attached PIT-tag over the PIA following a week-long period with no detection to ensure that the PIA was functioning properly. We used sunrise–sunset tables for Salt Lake City, Salt Lake County, Utah, to determine movements in day versus night, and we screened multiple detections to ensure that each fish was counted only once during each day–night period.

We calculated annual rates of survival of bluehead suckers in Reach 1 using a combination of active-recapture data during electrofishing surveys performed in 2006–2009 and passive detection from the PIA. The active sampling and recapture interval spanned July–August. During this time, we marked and recaptured fish up to three times. In addition to active sampling, the PIA passively collected continuous detections of fish marked during active sampling in September–March. As these efforts were continued each year for 3 years, we estimated annual survival during July–July for each year. In each year, we had two intervals, an active-recapture and a passive-resight interval as described above. We based our analysis on 181 marked fish representing one group with initial length (mm) at time of first capture as an individual covariate (range, 202–575 mm). We used the Barker model in Program MARK (White and Burnham, 1999) to estimate survival. This open mark-recapture model incorporates capture-recapture data from individual sampling occasions and recapture data between sampling occasions. Therefore, the Barker model improves precision of estimates of survival over models that only incorporate recaptures from sampling occasions (e.g., the Cormack-Jolly-Seber model; Barker, 1999). In addition to survival, the Barker model also estimates probability of recapture (p), probability of resighting a dead animal (r), probability of recapturing an animal between sampling intervals (R), probability of recapturing an animal before the animal dies between sampling intervals (R'), probability that an animal at risk of capture in time (t) is also at risk of capture in time t + 1 (F), and probability that an animal not at risk of capture in time (t) is at risk of capture in time t + 1 (F'). We modeled only one group and used length at time of capture as a covariate. We ran a series of models with and without effects of time for all combinations of parameters and ran a subset of models constraining R, and R' to 0, as there was insufficient data to estimate these parameters. We used Akaike's Information Criterion (AIC) as the criterion to determine the best-fitting model; AIC balances the increased precision of estimates of parameters through reduction in number of parameters against the reduced fit of the model to the data as the number of parameters are reduced (Burnham and Anderson, 1998).

We considered potential effects of three candidate-limiting factors for bluehead suckers in the Weber River and compared the relative contribution of these factors between the two reaches we studied: densities of brown trout changes with the hydrologic regime post-construction of the mainstem dam, and effects of an altered thermal regime. We estimated abundance of brown trout (>200 mm total length) for Reach 1 (2007) and Reach 2 (2009) using the same two-pass mark-recapture method used for bluehead suckers, except we marked brown trout during the first electrofishing pass with a hole punched in the caudal fin. We assessed changes in discharge of stream (cubic meters per second; m^3/s) within the two reaches based on average mean daily discharge for a 10-year pre-dam period (1947–1956 for Reach 1; 1920–1929 for Reach 2) and a recent (1999–2008) period using the closest data from United States Geological Survey stations 10130500 and 10136500 for Reach 1 and Reach 2, respectively. To compare mean daily temperature (°C) of stream in summer between the two reaches, we deployed a temperature data logger in each reach during 2 April–30 September 2009. We positioned each logger in the middle of the portion of the reach occupied by bluehead suckers and secured them >0.3 m below the surface. We programmed loggers to record temperature every 2 h.

RESULTS—Abundance of bluehead suckers >150 mm total length was greater in Reach 2 (546; 95% *CI* 423–772) than in Reach 1 (225; 95% *CI* 141–416), but densities were comparable between the two reaches (Table 1). The addition of a third and fourth electrofishing pass in Reach 2 resulted in higher estimates of abundance, density, and greater precision (Table 1). Estimates of abundance and density obtained during 2007 and 2008 in Reach 1 were similar (Table 1).

Overall structure of size classes differed substantially between the two reaches (Fig. 2). In Reach 2, we observed multiple size classes of bluehead suckers with 200–300 mm total length being dominate size classes. These smaller bluehead suckers were nearly absent from the sample in Reach 1 (Fig. 2). The population in Reach 1

Table 1—Estimates of abundance of bluehead suckers (*Catostomus discobolus*) that were >150 mm total length and brown trout (*Salmo trutta*) that were >200 mm total length in the Weber River, Utah. Two-pass estimates were calculated using the Bailey (1951) modification of the Peterson Index; 95% confidence intervals (*CI*s) for bluehead suckers were calculated using Ricker (1975: appendix 2). Multiple-pass estimates were calculated using the Schnabel, Schumacher, and Eschmeyer model (Krebbs, 1989); variance was expressed as 95% *CI*s of the estimates.

Species	Reach	Year	Number of electrofishing passes	Total number of fish captured	Total number of recaptures	Estimated size of population (95% *CI*)	Density of population (number/ m^2*1,000)
Bluehead sucker	1	2007	2	104	15	225 (141–416)	0.8 (0.5–1.6)
			2	115	24	197 (135–313)	0.7 (0.5–1.2)
	2	2008	2	99	7	357 (191–984)	0.9 (0.5–2.5)
			3 (July only)	145	18	498 (316–1177)	1.3 (0.8–3.0)
			4 (March and July)	192	34	546 (423–772)	1.4 (1.1–1.9)
Brown trout	1	2007	2	1,386	55	9,995 (8,201–11,789)	37.4 (30.7–44.1)
	2	2009	2	627	67	2,131 (1,655–2,607)	5.4 (4.2–6.6)

was comprised predominantly of larger fish that were 400–500 mm total length (Fig. 2). We considered fish >400 mm total length to represent adults, as the smallest sexually mature bluehead suckers in our sampling were a male 397 mm total length and a female 412 mm total length. Frequency distributions of lengths were significantly different between the two populations (Reach 1, $n = 197$, range 97–524 mm total length; Reach 2, $n = 262$, range 202–575 mm total length; $D = 0.70$; $P < 0.001$).

Bluehead suckers moved longer distances in Reach 2 than in Reach 1. We recaptured 25 bluehead suckers at least once in Reach 2 (fish were PIT-tagged starting in 2007); the longest movement was 15.0 km downstream. Of the 25 recaptures, 48% (12) moved <1 km, 36% (9) moved 1–5 km, and 16% (4) moved >5 km. Three bluehead suckers moved upstream >1 km; the longest of which was 5.0 km.

We actively recaptured or passively detected on the PIA 110 bluehead suckers in Reach 1 (fish were PIT-tagged starting in 2006); the longest movement was 2.6 km upstream. Of the 110 recaptures, 62% (68) moved <1 km and 38% (42) moved 1–2.6 km. At least once in Reach 1, 35 bluehead suckers moved upstream >1 km. We passively detected 46.4% (89 of 192) of PIT-tagged bluehead suckers in Reach 1. The PIA functioned properly 100% of the time while it was in operation during September 2007–March 2008 and October 2008–March 2009.

Bluehead suckers were more active during night than in day at the PIA in Reach 1. Of detections on the PIA, 88% occurred during night and frequency increased to 96% during November–February. We did not observe any detection in day during December 2007 or 2008 (Fig. 3).

Of 181 marked fish used in our estimate of survival, we recaptured 82 (45%) during active-capture and recapture-electrofishing surveys and 83 (46%) at the PIA. We detected 50 (28%) with both methods at least once, and 32 (18%) and 33 (18%) only with electrofishing or the PIA, respectively. Our top ranking (survival{t}) model based on ΔAIC included length at initial capture as an individual covariate and necessarily limited some intervals of R and R' = 0. Based on our top model, annual survival of bluehead suckers in Reach 1 was high with an annual mean of 77% (95% $CI = 39–95\%$) and a small decrease in

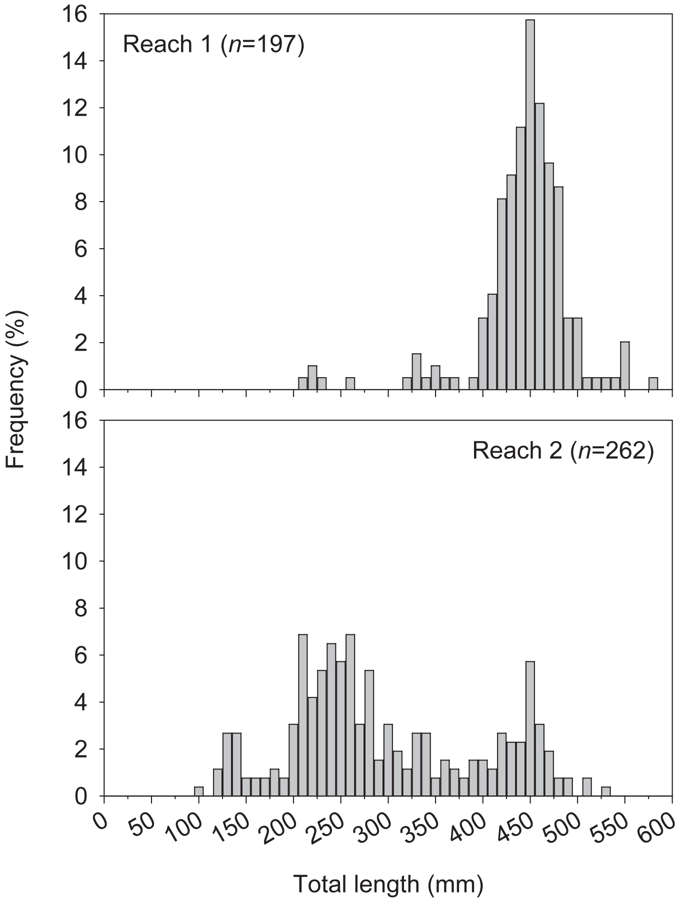

Fig. 2—Structure of size classes of populations of bluehead suckers (*Catostomus discobolus*) captured in Reaches 1 and 2 of the Weber River, Utah, 2006–2009. Only total length from initial capture was used.

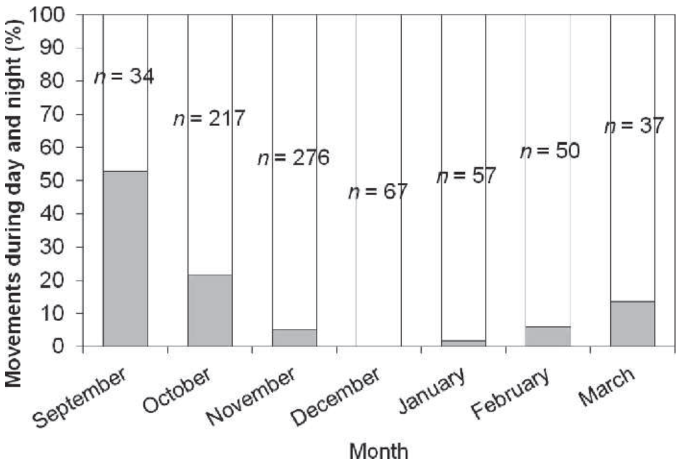

FIG. 3—Percentage of movements of bluehead suckers (*Catostomus discobolus*) during day (■) versus night (□) in Reach 1 of the Weber River, Utah, during September 2007–March 2008 and October 2008–March 2009.

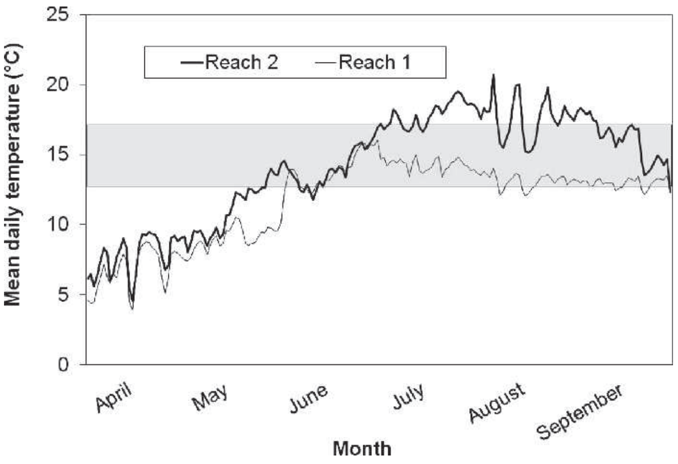

FIG. 5—Mean daily temperature (°C) for two reaches of the Weber River, Utah, during April–September 2009, with shaded area representing optimal temperature for brown trout (*Salmo trutta*; modified from Budy et al., 2008).

survival and increase in variability across years. For intervals for which it was not fixed a priori, probability of resighting averaged 49% (95% $CI = 31$–69%) for $R_{t2,3}$ and was 37% (95% $CI = 12$–72%) for $R_{t2'}$.

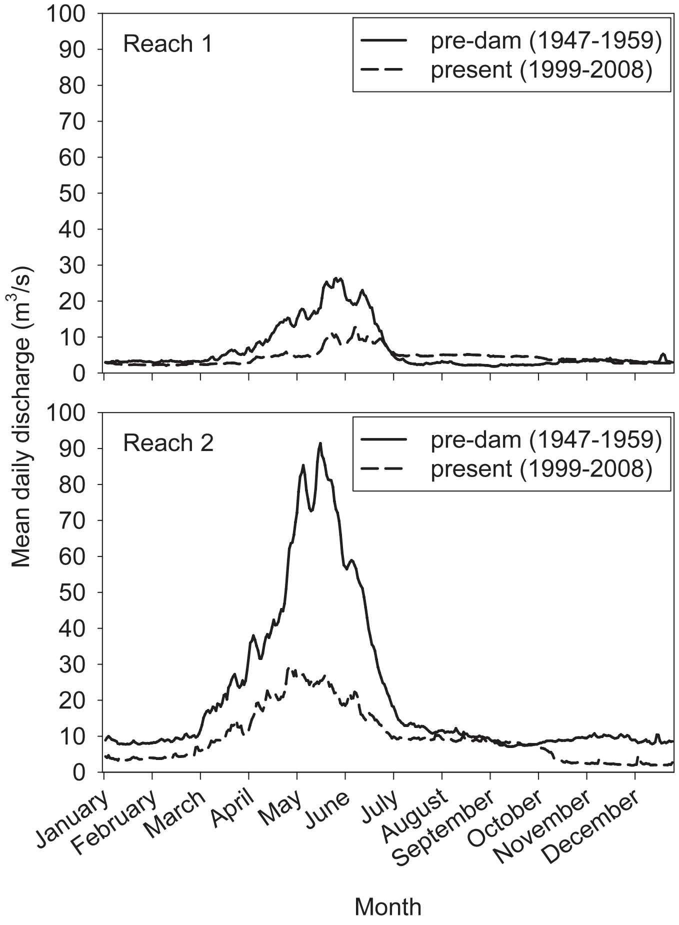

FIG. 4—Mean daily discharge (m^3/s) for two reaches of the Weber River, Utah, during pre-dam and more recent periods.

Abundance of brown trout (>200 mm total length) in Reach 1 was about five times greater than Reach 2. Abundance of brown trout was six times greater than abundance of bluehead suckers in Reach 2 as compared to 50 times greater in Reach 1 (Table 1).

Mean daily discharge during peak runoff was reduced in Reach 1 by one-half and in Reach 2 by two-thirds following construction of mainstem dams upstream. In addition, the ascending limb of runoff was shifted from early April to mid-May in Reach 1. Base flows currently are lower in Reach 2 and are similar to slightly higher in Reach 1, relative to pre-dam conditions (Fig. 4). In general, water temperature in Reach 2 was considerably warmer than Reach 1 during July–September 2009. The lower 2 km of Reach 1 were inundated by Echo Reservoir during late May–mid-June, which resulted in lower water temperatures (Fig. 5).

DISCUSSION—Reversing the rangewide decline of the bluehead sucker has been hampered by a general lack of information about this species. Within the Bonneville Basin in Utah, populations have been documented only in the Weber River in recent years. Our goal was to gather baseline data to further conservation of this species in the Weber River, as well as in other similar systems. Our results indicate that the two reaches we studied maintain small populations that differ substantially in structure of size classes, status of populations, and in likely effects from extrinsic factors.

Estimates of abundance in both reaches we studied were small, and both populations shared remarkably similar densities. Nevertheless, structure of size classes between the two reaches was notably different, suggesting that the relative role of extrinsic factors might vary between these populations. While Reach 2 contained multiple size classes including smaller fish (i.e., 200–300 mm total length being the dominant size class), Reach 1 was comprised almost entirely of larger, adult fish (i.e., >400 mm total length). Although the smallest size classes (i.e., <150 mm total length) likely were not sampled as effectively as larger size classes (Reynolds, 1989) with a raft electrofisher, we did successfully capture fish <150 mm total length in Reach 2; thus, demonstrating successful recruitment in Reach 2. In contrast, recruitment of bluehead suckers in Reach 1 was nearly absent. Juveniles possibly could use Echo Reservoir (Fig. 1); however, the Utah Division of Wildlife Resources conducts annual monitoring by gill netting and electrofishing there and has never encountered bluehead suckers (P. D. Thompson, pers. comm.). It is possible that juveniles in Reach 1 use Echo Reservoir and do not move into the river until they are larger adults, or more likely, Echo Reservoir acts as a sink for this age class. Modde and Muirhead (1994) and Andersen et al. (2007) reported that nonnative predators prey on drifting June suckers (*Chasmistes liorus*) as they reach the Provo River–Utah Lake interface. Echo Reservoir contains a large population of smallmouth bass, yellow perch (*Perca flavescens*), channel catfish (*Ictalurus punctatus*), and nonnative trout. Future research should include surveys specifically investigating early life stages of bluehead suckers in Reach 1.

In addition to failure of recruitment, restricted movement might contribute to declines in bluehead suckers. Although bluehead suckers can move long distances, they are restricted to isolated areas between barriers in Reaches 1 and 2. Several studies have documented relatively small movements of several kilometers (Sweet, 2007; D. W. Beyers et al., in litt.; P. B. Holden and L. W. Crist, in litt.) as we observed, but P. B. Holden and L. W. Crist (in litt.) reported longer movements of ≥19 km. We documented movement of a juvenile from the upstream barrier in Reach 2 downstream 15 km. Given the barriers, there are only 20 km available to move within this reach. This observation suggests that longer movements might be important in the life history of bluehead suckers. Instream barriers limit or prevent movements here and elsewhere (Compton, 2007).

In addition to the movements we documented, we also observed that bluehead suckers were more active during night versus day at the PIA during September–March. The majority of detections occurred at night (Fig. 3), indicating that bluehead suckers were either moving past the PIA during night (and possibly active in other areas during day) or displaying a behavior that can occur in an attempt to minimize risk of predation or in response to availability of food (Darnell and Meierotto, 1965; Homel and Budy, 2008). In the Weber River, the primary predator is brown trout, which also can be more active at night (Young, 2005). Because bluehead suckers are primarily algae scrapers (Sigler and Miller, 1963) and availability of algae is not dictated by time of day, availability of food is an unlikely explanation for this behavior. Nonetheless, nocturnal behavior is well documented for a diversity of fishes and could occur in response to either a contemporary or evolutionary threat.

We observed relatively high annual rates of survival of adult bluehead suckers (>77%) that also were stable across the 3 years of study in Reach 1. In addition, rates of survival decreased slightly as a function of size. These rates of survival are similar to those of the razorback sucker (*Xyrauchen texanus*), a similar large-bodied riverine sucker, which has rates of survival of adults of 71–76% (Modde et al., 1996; K. R. Bestgen et al., in litt.). High survival of adults makes sense intuitively when considered collectively with the structure of size classes of the population in Reach 1. The population is comprised almost entirely of adults >400 mm total length for which risk of predation likely is low. Thus, although recruitment appeared nearly absent and rates of survival for early life stages must have been low, rates of survival of adults were high.

Densities of brown trout (>200 mm total length) were greater than densities of bluehead suckers in both reaches we studied, with brown trout outnumbering bluehead suckers by ca. 50:1 and 6:1 in Reach 1 and Reach 2, respectively. In Reach 1, estimates of survival for adult bluehead suckers were high, but recruitment was nearly absent. Predation by brown trout on juvenile bluehead suckers might be substantial in Reach 1 given such high densities of brown trout. In contrast, densities of brown trout were lower in Reach 2 and we observed evidence of successful recruitment of bluehead suckers as indicated by the structure of size classes of that population. Olsen and Belk (2005) noted that juvenile and adult southern leatherside chubs (*Lepidomeda aliciae*) and juvenile mountain suckers were present in main-channel pools in streams where brown trout were absent; however, these species were almost exclusively in backwater environments where brown trout were abundant. Presence of brown trout appeared to restrict these smaller native fishes to less preferred environments. Thus, in addition to direct effects of exotic brown trout (e.g., competition, predation), altered or channelized streams like the Weber River, might not contain sufficient off-channel refuge environments to allow for coexistence of small or juvenile native fishes with introduced brown trout (Quist et al., 2004).

In addition to negative biotic interactions with brown trout, the altered hydrograph of the Weber River likely impacts bluehead suckers through changes to hydrology and temperature. Mean daily discharge in both reaches has been altered following construction of mainstem dams upstream. In Reach 2, peak runoff was reduced by about two-thirds and in Reach 1, peak runoff was reduced by one-half and the ascending limb of runoff has been shifted to later in the year by ca. 1 month (early April–mid-May). In addition, base flows in autumn through spring are lower by ca. 5.7 m^3/s in Reach 2 (Fig. 4). The spring hydrograph (peak flows) typically cues spawning for razorback suckers (Tyus and Karp, 1990), and change in the hydrograph has been suggested as a factor that might affect ability of fish to form spawning aggregations (Modde and Irving, 1998). In the Colorado River Basin, Maddux and Kepner (1988) reported that bluehead suckers have a protracted spawning season during February–September, while Holden (1973) documented spawning in June and July.

In the Weber River, Andreasen and Barnes (1975) reported ripe male bluehead suckers during May and June in a section downstream of Reach 1. We did not specifically attempt to document spawning periods in our study; however, we did observe ripe and expressing individuals, tuberculated males, and spawning aggregations. In Reach 2, we observed six ripe and tuberculated males (15% of total adults captured) in mid-March, but did not observe any evidence of spawning in mid-July. In Reach 1, we did not sample in March; however, while sampling in mid-July 2008, 51% (n = 45) of adult bluehead suckers captured were ripe, and we observed spawning aggregations in mid-July in 2007 and 2008. Later peak runoff in Reach 1 might delay spawning of bluehead suckers, which would shorten the remaining critical growing season for age-0 fish.

Similar to hydrology, temperature of water is an important factor that directly affects bluehead suckers in these two reaches in several ways. First, warmer water in summer might limit brown trout in Reach 2. Mean daily water temperatures in summer during 2009 were colder in Reach 1 than Reach 2 by ca. 3°C (Fig. 5). Water temperatures in Reach 1 were consistently within the optimal temperature for brown trout (12.8–16.9°C) during summer, whereas Reach 2 generally was warmer than optimal (Fig. 5; Budy et al., 2008). Second, cooler water temperatures in summer might contribute to delayed spawning by bluehead suckers in Reach 1. Hamel et al. (1997) demonstrated that lower water temperatures delayed spawning in white suckers. Third, cooler water will slow growth in native fishes (McAda and Wydoski, 1983; Robinson and Childs, 2001; Bestgen, 2008), which might lead to higher mortality due to predation (Bestgen et al., 2006). Last, hypolimnetic releases from Rockport Dam might explain why we observed bluehead suckers concentrated in the lower 3 km of Reach 1. Cold water released from Rockport Reservoir should warm during summer as it flows 14 river km to the lower 3-km-occupied reach. Vanicek et al. (1970) detected a similar pattern below Flaming Gorge Dam, where cooler temperatures and flow regime displaced bluehead suckers in the first 11 km directly downstream from the dam.

Our study demonstrated major differences in three extrinsic factors affecting populations in the two reaches. Reach 2 contained far less brown trout, warmer water temperatures in summer, and while peak runoff has been reduced, a more natural flow regime than Reach 1. We hypothesize that these three factors contribute to limit abundance and viability of populations of bluehead suckers differentially between the two populations, highlighting opportunities for recovery and conservation.

Although relatively small, the population in Reach 2 appears to be recruiting, as evidenced by presence of multiple size classes. While survival of adults is relatively high in Reach 1, this population is small, composed only of large adults, and recruitment is absent. If conservation of bluehead suckers in the Weber River is a priority, management and conservation efforts should be immediately directed at spawning and early life stages in Reach 1 to avoid extinction of this population.

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