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# Occurrence of native Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in the Escalante River drainage, Utah

Dale K. Hepworth
*Utah Division of Wildlife Resources, Cedar City, Utah*

Michael J. Ottenbacher
*Utah Division of Wildlife Resources, Cedar City*

Charles B. Chamberlain
*Utah Division of Wildlife Resources, Cedar City*

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# OCCURRENCE OF NATIVE COLORADO RIVER CUTTHROAT TROUT (*ONCORHYNCHUS CLARKI PLEURITICUS*) IN THE ESCALANTE RIVER DRAINAGE, UTAH

Dale K. Hepworth[1], Michael J. Ottenbacher[1], and Charles B. Chamberlain[1]

ABSTRACT.—Field surveys were conducted during 1997 and 1998 documenting the distribution and abundance of Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in Escalante River tributaries. This documented occurrence of native trout in the Escalante River drainage of southern Utah represents an expansion of the known historic range of this subspecies as reported before the 1990s. We found 5 populations of native trout ranging in biomass from 3.0 to 104.2 kg · ha$^{-1}$ and occupying 13.2 km of stream of 130 km of estimated historic habitat. Current distribution and abundance of Colorado River cutthroat trout were compared to early introductions of nonnative trout stocked for sport fishing purposes. Native cutthroat trout have been displaced by nonnative cutthroat trout (*O. c. bouveri*), rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*), and brown trout (*Salmo trutta*) except where they were isolated by physical or biological barriers. Displacement may have been more extensive except for the remoteness of the drainage and relatively recent introductions of nonnative trout. These conditions limited the overall amount of the drainage stocked, numbers of nonnative trout stocked, and time over which stocking occurred. Discoveries of native trout populations within the Escalante River drainage have allowed expanded conservation of this subspecies by adding new populations to what was known to exist and by increasing the known natural range of this fish.

*Key words: cutthroat trout, native trout, Colorado River, Escalante River, drainage, occurrence, abundance, distribution, management, nonnative trout, stocking, history.*

Historically, the Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus;* hereafter referred to as CRCT) was found in coldwater habitats of the upper Colorado and Green River basins. Its northern distribution extended into Wyoming, and it was bounded to the east and west in Colorado and Utah, respectively. Within northern Utah, Kershner et al. (1997) described CRCT from streams on the north slope of the Uinta Mountains, and Cope (1955) stated that CRCT were naturally found in numerous streams on the south slope of the Uinta Mountains. Subdrainages of the Colorado River basin containing trout habitat in central and southern Utah are more fragmented than in northern Utah and separated by greater distances. In these areas historic distribution of CRCT is less certain, but CRCT were known to occur naturally in Fish Lake (Hazzard 1935) at the headwaters of the Fremont River (also known in its lower reaches as the Dirty Devil River). Behnke and Benson (1980) considered the Fremont River to be the southernmost distribution of CRCT in Utah. Prior to 1990 no reports of native trout were made from south of the Fremont River, and systematic surveys were not conducted. The discovery of CRCT in East Boulder Creek (a tributary to the Escalante River, Utah) in 1990 caused speculation that the historic distribution could have extended as far south, on the west side of the Colorado River, as the Escalante River drainage (Behnke 1992). The Escalante River drainage is contiguous with the Fremont River drainage but not located as far south as the San Juan River, Colorado, which is the southern distribution of CRCT on the east side of the basin. If CRCT colonized the San Juan River drainage by moving down the Colorado River, presumably, they also had access to the Escalante River. Nevertheless, it was not known if this single population of fish in East Boulder Creek resulted from an early introduction by man. In 1992 we field identified another isolated population of CRCT in West Boulder Creek that potentially occurs naturally and verified the identification by independent review (Shiozawa and Evans 1994). Young et al. (1996) noted that comprehensive descriptions of the historic range of

[1]Utah Division of Wildlife Resources, Box 606, Cedar City, UT 84720.

CRCT are not available and reported that potential distribution of CRCT could include streams as far south as the San Juan River drainage in northern Arizona and New Mexico.

Similar to other subspecies of cutthroat trout, CRCT have undergone large declines in numbers and range during the past century. Causes of declines include displacement by and hybridization with introduced nonnative trout, an irreversible impact; habitat losses, often at least partially reversible; and overfishing, generally not a significant factor when considered alone (Cope 1955, Behnke and Benson 1980, Jespersen 1981, Behnke 1992, Young 1995a). Kershner et al. (1997) estimated that CRCT have been displaced to <1% of their historic range. Young et al. (1996) defined conservation populations of CRCT as those isolated from nonnative trout by migration barriers in relatively secure situations and concluded that only 20 such populations were known from a total of 318 waters containing CRCT. Although additional populations of CRCT likely exist, surveys need to be conducted for verification. Identification of other populations of CRCT is critical to properly manage these fish and ensure proper recovery efforts.

Our contention was that CRCT were likely native to the Escalante River drainage. We conducted surveys of Escalante River tributaries in 1997 and 1998 to determine abundance and distribution of CRCT within this drainage and assess the likelihood of natural occurrence. In addition, we characterized CRCT occurrence within the drainage relative to nonnative trout and sport fish stocking practices to evaluate impacts of stocking and provide better direction for future management.

## STUDY AREA

The Escalante River drainage, located in Garfield and Kane counties of south central Utah, is one of the most remote regions in the state (Fig. 1). Stegner (1954) characterized the remoteness of the area by noting that the plateau was not explored until 1872 and that the Escalante River was the last large river drainage added to the map of the United States. Headwaters originate on the Aquarius Plateau at elevations in excess of 3350 m (msl), and the Escalante River terminates at Lake Powell at approximately 1128 m. Much of the main stream and tributaries to the Escalante River are in narrow canyons. Access is limited to roads that typically cross drainages at a few locations rather than parallel streams. Previous surveys of trout streams were completed at convenient access sites (McAda et al. 1977).

Much of the main stream of the Escalante River is located within the Glen Canyon National Recreation Area and the Grand Staircase–Escalante National Monument. Trout habitat is largely limited to tributary streams located on the Dixie National Forest, which includes Box Death Hollow Wilderness Area. Lower portions of some trout streams extend onto lands administered by the national monument. Private land comprises about 2% of the drainage and is found mostly around the towns of Escalante and Boulder. The Aquarius Plateau contains numerous small lakes, ponds, and small reservoirs that have been stocked with nonnative trout for angling since at least the 1940s. Many of these lakes were first stocked by pack horse and airplane (Utah Division of Wildlife Resources, hereafter refered to as UDWR, unpublished stocking records), which are still common methods of stocking today.

## METHODS

We initially made field identifications of CRCT by their distinctly different coloration compared to closely related and geographically adjacent Bonneville cutthroat trout (*O. c. utah*), introduced nonnative cutthroat trout (primarily *O. c. bouveri*), and stocked rainbow trout (*O. mykiss*). Coloration of CRCT frequently includes a bright orange or red ventral region that extends from the slash marks under the jaw posterior to the anal fin and is most apparent in adult males. Confirmation of each putative CRCT population was verified by at least one independent review utilizing mitochondrial and nuclear DNA analysis and meristic data (Behnke 1992, Shiozawa et al. 1993, Shiozawa and Evans 1994, Toline, Hudson, and Seamons 1999, Toline, Seamons, and Hudson 1999, Hudson and Davis 2000).

We selected streams to survey by reviewing stocking records from UDWR fish hatcheries, UDWR fish population survey files, and pertinent literature on early fish introductions and access into the area (Popov and Low 1950, Stegner 1954, Cope 1955). Stream surveys were conducted as either field inspections or

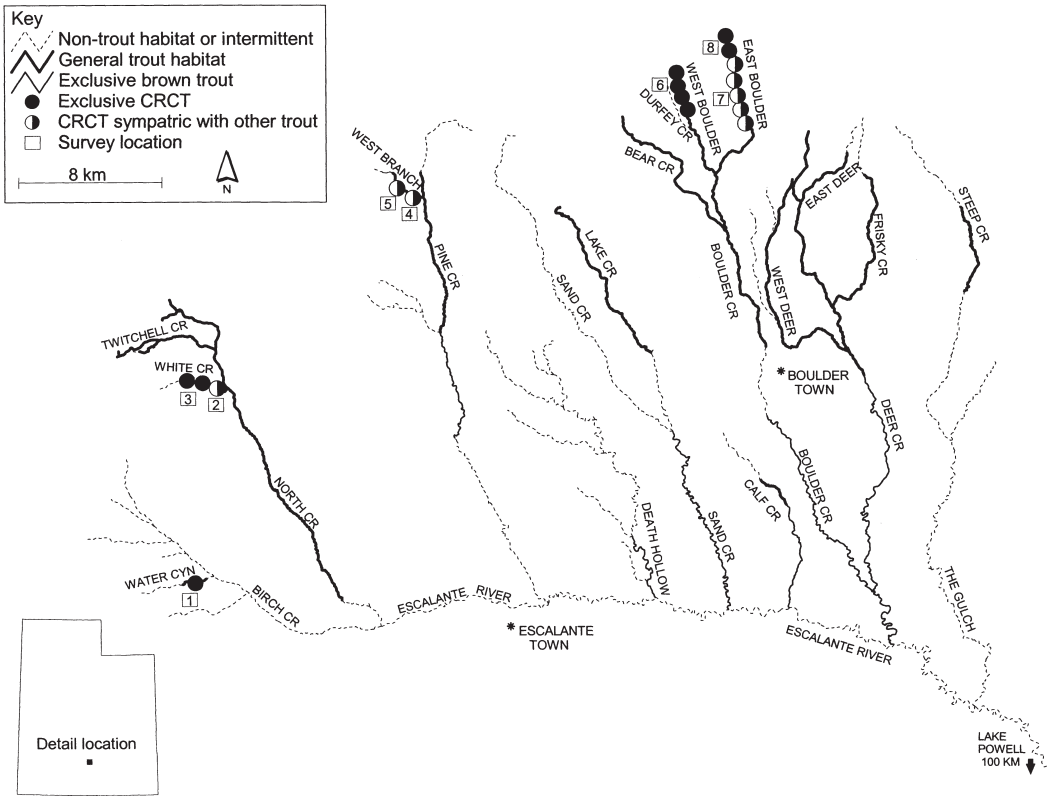


Fig. 1. Map of the upper Escalante River drainage, southern Utah, showing trout habitat and distribution of Colorado River cutthroat trout (CRCT). Survey location numbers refer to corresponding survey data in Figure 2 and Tables 2 and 3.

population estimates. Streams where remnant populations of CRCT may have persisted were field inspected during 1997–98. Field inspections included hiking entire stream lengths to verify trout distributions. Electrofishing gear was used to check for the presence of CRCT and determine upstream and downstream distributions of different fish species. Population estimates were conducted by electrofishing where CRCT were found or already known to occur to determine trout abundance and biomass at specific sites. Distribution and abundance of CRCT were compared to past nonnative trout introductions and current stocking practices on a drainage-wide scale (Fig. 1). Historic conditions were considered to be what likely existed, based on our judgment, at the time of exploration and settlement of Utah in the mid-1800s.

Population estimates were made by the 2-pass removal method (Zippin 1958) with block nets set at the upper and lower ends of 100-m stations. All streams were relatively small, and at least 75% of all captured trout were removed during the first electrofishing pass. We made population estimates in August and September 1998, when young-of-the-year trout were still too small to be efficiently sampled, and thus samples and estimates were restricted to yearling and older trout. Total length (TL, mm) and weight (g) were recorded for all captured trout.

The mean wetted width of streams was determined by taking measurements at 10 randomly selected transects within each electrofishing survey station. Trout biomass by unit area was estimated from mean stream width and site length, estimated trout numbers, and mean trout weight. We selected 2 sites for population estimates on each stream containing CRCT. Survey locations and stream distances were determined with a global positioning system (GPS) unit and U.S. Geological Survey 7.5-minute series topographical maps.

TABLE 1. Summary of 1997–98 field inspections, Utah Division of Wildlife Resources fish population survey files, and stocking records on Escalante River tributaries (CRCT = Colorado River cutthroat trout).

| Stream | Headwater fish species | Survey | Stocking records |
|---|---|---|---|
| Steep Creek | None | Electrofishing, 1977 file report | None |
| Frisky Creek | Brook and rainbow | Electrofishing, 1977 file report | None, but a tributary to Deer Creek |
| West Fork Deer Creek | Brook, rainbow, and nonnative cutthroat | Rotenone, 1995 file report | Nonnative cutthroat trout, 1941[a]<br>Headwater lakes, rainbow trout, 1941<br>Headwater lakes, brook trout, 1956 |
| East Fork Deer Creek | Brook trout and rainbow trout | Electrofishing, 1977 file report | Rainbow trout, 1941<br>Headwater lake, nonnative cutthroat, 1952[a]<br>Headwater lake, brook trout, 1957 |
| Bear Creek | Brook trout | Electrofishing, current study | Rainbow trout, 1942<br>Headwater lake, brook trout, 1957 |
| East Fork Boulder Creek | Remnant CRCT | Electrofishing, current study | Rainbow trout, 1941; probably stocked in lower reaches |
| West Fork Boulder Creek | Remnant CRCT | Electrofishing, current study | Rainbow trout, 1941; probably stocked in lower reaches |
| Durfey Creek | None | Electrofishing, current study | CRCT introduced in 1992, but failed to reproduce |
| Calf Creek | Brown trout and nonnative cutthroat | Electrofishing, 1980 file report | Brown trout, 1967<br>Nonnative cutthroat trout, 1979[a] |
| Sand Creek | None | Electrofishing, current study | Nonnative cutthroat trout, 1988[a] |
| Lake Creek | Brook trout | Electrofishing, 1989 file report | Headwater lake, brook trout, 1957 |
| Pine Creek | Brown trout | Electrofishing, current study | Brown trout, 1947<br>Rainbow trout, 1953 |
| West Branch Pine Creek | Remnant CRCT and brown trout | Electrofishing, current study | None, but a tributary to Pine Creek |
| North Creek | Brook, rainbow, and nonnative cutthroat | Electrofishing, current study | Headwater lakes, rainbow trout, 1942<br>Headwater lakes, brook trout, 1942<br>Headwater lakes, nonnative cutthroat, 1953[a] |
| White Creek | Remnant CRCT | Electrofishing, current study | None |
| Twitchell Creek | Brook trout | Electrofishing, current study | Headwater lakes, brook trout, 1942 |
| Water Canyon | Remnant CRCT | Electrofishing, current study | None |

[a]Nonnative cutthroat trout stocked prior to 1955 were likely from Yellowstone Lake, Wyoming (Cope 1955). Nonnative cutthroat trout stocked after 1955 were from Strawberry Reservoir, Utah, and were the Yellowstone subspecies partially hybridized with CRCT and rainbow trout (Hepworth et al. 1999).

## RESULTS

Five remnant populations of CRCT were found in the 17 headwater streams evaluated (Fig. 1, Table 1). Known populations of CRCT in East and West Boulder creeks were documented as expected, and additional populations of CRCT were found in the West Branch of Pine Creek, White Creek, and Water Canyon. Four streams had good trout habitat, but trout habitat was marginal in Water Canyon because of the predominance of desert washes, turbidity, and warm water. Other streams we surveyed contained populations of brook trout (*Salvelinus fontinalis*), rainbow trout, brown trout (*Salmo trutta*), and nonnative cutthroat trout, or were fishless. Other native fishes found in the drainage include mottled sculpin (*Cottus bairdi*), speckled dace (*Rhinichthys osculus*), flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*C. discobolus*), and roundtail chub (*Gila robusta*), but all occurred downstream from populations of CRCT (Holden and Irvine 1975, McAda et al. 1977, Mueller et al. 1999, UDWR survey files). Other nonnative fishes reported in downstream portions of the drainage include red shiner (*Cyprinella lutrensis*), fathead minnow (*Pimephales promelas*), carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), yellow bullhead (*Ictalurus natalis*), striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and green sunfish (*Lepomis cyanellus*).

Population estimates of CRCT ranged from 2 to 74 fish · 100 $m^{-1}$ of stream (Table 2). When

TABLE 2. Abundance, population estimates, and size of native Colorado River cutthroat trout (CRCT) and sympatric trout species at electrofishing survey sites (100-m stations) within the Escalante River drainage, southern Utah.

| Stream[a] | Survey location (UTM)[b] | Species | Number of trout | | Population estimate (95% confidence) | Length (mm) | | Weight (g) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1st pass | 2nd pass | | Mean | Range | Mean | Range |
| 1. Water Canyon | Lower stream (428135 E 4183725 N) | CRCT | 2 | 0 | 2 (2–2) | 121 | 106–136 | 15 | 10–20 |
| | Upper stream (427820 E 4183705 N) | CRCT | 12 | 0 | 12 (12–12) | 132 | 89–216 | 30 | 8–115 |
| 2. White Creek | Lower stream (431050 E 4193396 N) | CRCT | 21 | 2 | 23 (23–24) | 143 | 80–203 | 33 | 5–90 |
| | | Brook trout | 2 | 1 | 3 (3–10) | 198 | 180–210 | 78 | 50–100 |
| 3. White Creek | Upper stream (429451 E 4194022 N) | CRCT | 8 | 2 | 10 (10–13) | 204 | 164–229 | 101 | 40–150 |
| 4. West Branch Pine Creek | Middle stream (124740737E 4205698 N) | CRCT | 15 | 5 | 22 (20–29) | 141 | 100–200 | 31 | 10–85 |
| | | Brown trout | 58 | 15 | 78 (73–86) | 166 | 88–310 | 55 | 5–300 |
| 5. West Branch Pine Creek | Upper stream (124740646E 4206022 N) | CRCT | 54 | 9 | 65 (63–68) | 162 | 73–287 | 48 | 5–200 |
| | | Brown trout | 1 | 0 | 1 (1–1) | 187 | — | 65 | — |
| 6. West Boulder Creek | Lower stream (456888E 4211787 N) | CRCT | 21 | 4 | 26 (25–29) | 211 | 103–297 | 112 | 10–280 |
| | Middle stream (456717E 4212376 N) | CRCT | 12 | 3 | 16 (15–19) | 229 | 130–300 | 153 | 25–325 |
| 7. East Boulder Creek | Middle stream (460141E 4212766 N) | CRCT | 6 | 1 | 7 (7–8) | 184 | 109–242 | 79 | 10–150 |
| | | Brook trout | 50 | 16 | 73 (66–84) | 198 | 120–243 | 84 | 20–155 |
| 8. East Boulder Creek | Upper stream (459418E 4214666 N) | CRCT | 61 | 11 | 74 (72–79) | 121 | 57–272 | 32 | 2–205 |

[a]Stream numbers refer to data from corresponding survey areas in Table 3 and to locations on Figures 1 and 2.
[b]UTM = Universal Transverse Mercator (metric grid system used on most large-scale land topographic maps).

sympatric with CRCT, brook trout densities ranged from 3 to 73 and brown trout from 1 to 78 fish · 100 $m^{-1}$. Size of CRCT ranged up to 300 mm TL and 325 g. Brook trout in these same areas ranged up to 243 mm TL and 155 g, and brown trout reached 310 mm TL and 300 g.

Biomass of CRCT ranged from 3.0 to 104.2 kg · $ha^{-1}$ (Table 3). In situations where CRCT were isolated from other trout, biomass averaged 61.9 and ranged from 3.0 to 104.2 kg · $ha^{-1}$. When sympatric with nonnative trout, CRCT averaged 34.9 and ranged from 8.3 to 103.4 kg · $ha^{-1}$. In sympatric situations combined totals of native and nonnative trout ranged from 45.3 to 146.1 kg · $ha^{-1}$ and averaged 99.2.

East Boulder Creek had the greatest stream length (5.6 km) occupied by CRCT; 0.8 km was above a barrier and occupied by only CRCT, and below the barrier the trout population was numerically dominated by brook trout (Fig. 2). West Boulder Creek had the greatest stream length occupied exclusively by CRCT (3.2 km) and a high biomass (102 kg · $ha^{-1}$). White Creek had the next longest stream length with an exclusive population of CRCT (2.1 km) and a biomass of 52.2 kg · $ha^{-1}$. The West Branch of Pine Creek had a high biomass of CRCT (103.4 kg · $ha^{-1}$) in the

TABLE 3. Numbers and biomass of native Colorado River cutthroat trout (CRCT) and sympatric trout species at electrofishing survey sites within the Escalante River drainage, southern Utah.

| Stream[a] | Survey location location | Mean stream width (m) | Species | Trout numbers and biomass | | | |
|---|---|---|---|---|---|---|---|
| | | | | Number · km$^{-1}$ | Number · ha$^{-1}$ | Kg · km$^{-1}$ | Kg · ha$^{-1}$ |
| 1. Water Canyon | Lower stream | 1.0 | CRCT | 20 | 200 | 0.3 | 3.0 |
| | Upper stream | 1.4 | CRCT | 120 | 857 | 3.6 | 25.7 |
| 2. White Creek | Lower stream | 2.2 | CRCT | 231 | 1050 | 7.6 | 34.7 |
| | | | Brook trout | 30 | 136 | 2.3 | 10.6 |
| 3. White Creek | Upper stream | 2.0 | CRCT | 103 | 517 | 10.4 | 52.2 |
| 4. West Branch Pine Creek | Middle stream | 3.4 | CRCT | 220 | 647 | 6.8 | 20.1 |
| | | | Brown trout | 778 | 2291 | 42.8 | 126.0 |
| 5. West Branch Pine Creek | Upper stream | 3.0 | CRCT | 646 | 2153 | 31.0 | 103.4 |
| | | | Brown trout | 10 | 33 | 0.7 | 2.2 |
| 6. West Boulder Creek | Lower stream | 2.9 | CRCT | 257 | 886 | 28.8 | 99.3 |
| | Middle stream | 2.3 | CRCT | 157 | 681 | 23.9 | 104.2 |
| 7. East Boulder Creek | Middle stream | 6.7 | CRCT | 70 | 104 | 5.5 | 8.3 |
| | | | Brook trout | 731 | 1090 | 61.4 | 91.6 |
| 8. East Boulder Creek | Upper stream | 3.0 | CRCT | 742 | 2473 | 23.7 | 79.1 |

[a]Stream numbers refer to data from corresponding survey areas in Table 2 and to locations on Figures 1 and 2.

extreme upper end, but these fish were restricted to a small area (0.4 stream km). Brown trout were sympatric with CRCT in the upper reaches of the West Branch of Pine Creek; no CRCT were found in the lower reaches. Water Canyon was the smallest stream sampled. It had a CRCT population (14.4 kg · ha$^{-1}$) likely consisting of <50 adults in 0.7 km of stream.

In total, CRCT occupied 13.2 km of stream and was the only fish found in 6.4 km. The total linear stream distance currently occupied by CRCT represents about 10% of its estimated historic range within the Escalante River drainage (Fig. 1). Nevertheless, populations of CRCT are currently restricted to headwater tributaries. Populations of CRCT are absent from higher-order streams with correspondingly greater amounts of habitat that historically were likely occupied.

## DISCUSSION

Because of its remoteness, stockings of nonnative trout in the Escalante River drainage have occurred mainly since 1950. Popov and Low (1950) reported that rainbow, brook, and brown trout were established in most major river drainages in Utah by the early 1900s but did not document any wild nonnative trout populations in the Escalante River drainage. Although some unrecorded stockings may have occurred in the Escalante River drainage prior to 1940 and UDWR records documented several locations stocked in the 1940s, routine and repeated stockings did not occur until the 1950s.

Forty-nine lakes, ponds, and small reservoirs were stocked with nonnative trout in the Escalante River drainage (UDWR stocking records). Of these, 33 are currently stocked and 12 are connected to perennial streams. The remainder are isolated from wild trout populations. Ten of the stocked lakes are located on the Boulder Top, but there are no self-sustaining trout populations or perennial streams on the plateau. Brook, rainbow, brown, and nonnative cutthroat trout were stocked as early as the 1940s in the Escalante River drainage; brook and rainbow trout were stocked most frequently. Nonnative cutthroat trout were stocked to a lesser extent, and only limited numbers of brown trout were introduced. Nonnative cutthroat trout stocked prior to 1955 were likely from Yellowstone Lake, Wyoming (Cope 1955). After 1955 cutthroat trout were taken from Strawberry Reservoir, Utah, and were predominantly the Yellowstone subspecies but partially hybridized with CRCT and rainbow trout (Hepworth et al. 1999).

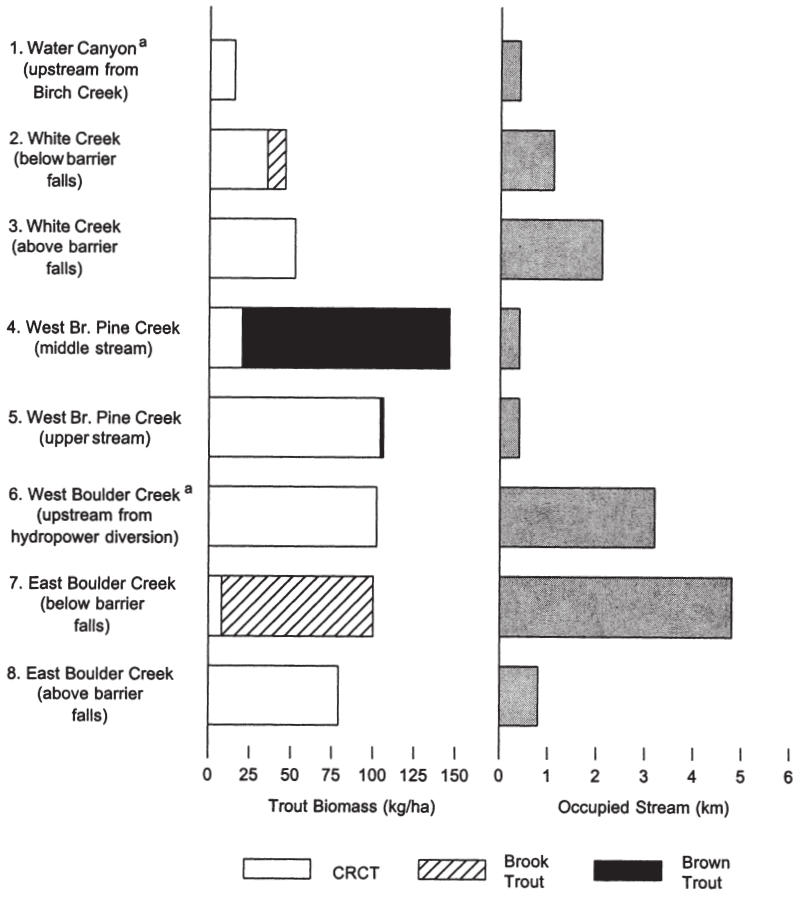


Fig. 2. Approximate stream lengths occupied by native Colorado River cutthroat trout (CRCT) and other sympatric trout species compared to biomass, Escalante River drainage, southern Utah. Footnote a [a] refers to biomass calculated as the mean from 2 survey locations. Stream numbers refer to corresponding survey data in other tables and to locations on Figure 1.

Four of 5 populations of CRCT in the Escalante River drainage are isolated from nonnative trout by physical barriers. The Water Canyon population is spatially isolated from nonnative trout by >16 km of desert washes. White Creek is a steep-gradient, 2nd-order tributary to North Creek and is isolated by barrier falls a short distance above its mouth. There are no records of nonnative trout introduced into either Water Canyon or White Creek. The upper ends of East and West Boulder Creek are isolated from nonnative trout in lakes on the Aquarius Plateau by 180- to 300-m waterfalls and intermittent outflows from the lakes. Outflows from the upper lakes seasonally flow over the rim of the plateau during spring runoff and into perennial streams containing native trout. Although downstream migration barriers are unusual, intermittent waterfalls have functioned as barriers for nearly 50 years despite annual stocking of nonnative trout in upstream lakes. Still, such stockings should be discontinued to prevent any chance of downstream fish movements. East Boulder Creek is isolated from upstream migrations of rainbow and brook trout by a series of steep, cascading falls, protecting the upper 0.8 km of stream. The longest stream section with an isolated population of CRCT (West Boulder Creek) is protected from upstream migration of rainbow and brook trout by a hydropower diversion constructed in 1957. The first reported stocking for Boulder Creek, West Boulder Creek, and East Boulder Creek was rainbow trout in 1941. Only a single stocking report was found for West Boulder Creek, and

a specific location where rainbow trout were released was not given. It is uncertain why nonnative trout did not gain access to the headwaters of West Boulder Creek before 1957, but low numbers of stocked trout, relatively long distances from stocked areas to the headwaters, and the possible presence of temporary barrier falls could have prevented upstream movements before the hydropower diversion was constructed. Rainbow and brook trout became established in the mid- and lower segments of Boulder Creek and displaced native cutthroat trout in these areas.

The West Branch of Pine Creek does not have a physical barrier isolating CRCT from other trout, but brown trout are the only nonnative trout currently found in the stream. Brown and brook trout do not threaten CRCT by hybridization but can competitively displace native trout (Griffith 1988, Behnke 1992). Brook trout generally replace CRCT except in higher, colder, and steeper-gradient sections of streams (DeStasto and Rahel 1994, Young 1995a). This appears to be the case in the headwaters of West Branch of Pine Creek where CRCT have presumably maintained an advantage over brown trout. According to UDWR stocking reports, brown trout were first introduced into Pine Creek in 1947 and rainbow trout in 1953. An established brown trout population may have provided a biological barrier to rainbow trout that protected CRCT in the upper West Branch of Pine Creek. No other recorded stockings occurred in Pine Creek until 1962, when an annual rainbow trout stocking program was initiated downstream from the West Branch near a U.S. Forest Service campground. Despite repeated stockings through 1983, a wild rainbow trout population never became established.

Besides Pine Creek, the only other recorded stocking of brown trout in the Escalante River drainage occurred in Calf Creek in 1967. From Calf Creek, brown trout evidently invaded the lower portions of Death Hollow, Sand, Boulder, and Deer creeks (Fig. 1), using the Escalante River for access. During extended periods of low flow and clear water, we found brown trout relatively common in upper reaches of the river, although it does not provide year-round trout habitat. Except for the upper end of Pine Creek, it does not appear that brown trout displaced native cutthroat trout at other locations. Surveys conducted by UDWR in the 1960s and early 1970s found Calf Creek, lower Boulder Creek, and lower Deer Creek void of trout. These stream sections and Death Hollow are in narrow sandstone canyons, which have frequent flash floods and high summer water temperatures. Although brown trout have survived in these streams since at least the 1980s (UDWR survey files), such locations were unlikely historic year-round habitat for CRCT.

The Escalante River drainage provided naturally fragmented habitat for CRCT, similar to its natural distribution in the upper Colorado and Green River drainages (Behnke and Benson 1980, Behnke 1992). Warm temperatures and high sediment loads restricted CRCT use of the main rivers for much of the year but allowed limited connectivity between tributaries. Although fragmentation was increased by stocking of nonnative fishes and by habitat modification, CRCT likely occupied the Escalante River briefly, thus enabling movement among tributaries in much the same way that introduced brown trout managed to colonize multiple tributaries from the introduction into Calf Creek. Even though connectivity was limited, natural movements of CRCT among streams allowed Escalante River tributaries to function as a metapopulation (Young 1995b). Increased fragmentation, however, has increased the risk of losing isolated populations. Although it may not be feasible to reconnect all CRCT populations within the Escalante River drainage because of habitat degredation and large numbers of nonnative trout, CRCT should persist if populations can be increased within available coldwater habitat and actions taken to exclude nonnative trout from these areas.

Abundance of CRCT in Escalante River tributaries was similar to that reported from other locations. Jespersen (1981) found biomass of CRCT to range from 3.1 to 109.4 kg · $ha^{-1}$ and average 45.1 kg · $ha^{-1}$ in 7 Wyoming streams. Kershner et al. (1997) reported mean abundance of CRCT in 6 Utah/Wyoming streams to be 48 and 11 kg · $ha^{-1}$ in wilderness and nonwilderness areas, respectively. In this study the mean for populations of CRCT that were isolated from nonnative trout was 61.9 kg · $ha^{-1}$, with an upper value of 104.2 kg · $ha^{-1}$. In comparison, 15 southern Utah streams containing native Bonneville cutthroat trout ranged from 6 to 64 kg · $ha^{-1}$ (Hepworth et al.

1997). Nonnative trout biomass for streams in southern Utah can exceed 300 kg · ha$^{-1}$ (UDWR survey files), although Platts and McHenry (1988) reported average biomass for several trout species in small western trout streams to be 54 kg · ha$^{-1}$.

It is possible that a few additional populations of CRCT may persist in unsampled 1st- or 2nd-order tributaries in the Escalante River drainage, but no potential locations are currently known. Although only 5 remnant populations of CRCT were found in the Escalante River drainage, combined they occupy a higher percentage of historic habitat than commonly found elsewhere (Kershner et al. 1997). The discovery of CRCT populations in locations isolated from nonnative trout and in headwater areas generally without histories of nonnative stocking supports our contention that CRCT is native to this drainage. An understanding of the current abundance and distribution of CRCT in the Escalante River drainage in relation to past sport fish introductions will allow better coordination between conservation of CRCT and sport fish management. Current conservation plans include developing a wild CRCT brood stock, increasing the use of CRCT in sport fish programs, and expanding the range of wild CRCT populations by constructing fish migration barriers, removing nonnative trout from specific stream segments and lakes, and transplanting CRCT from remnant sources.

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