

**COLORADO RIVER CUTTHROAT TROUT BROOD OPERATIONS IN THE
SOUTHERN REGION (LOWER COLORADO RIVER GMU) IN 2022**

A Sport Fish and Native Cutthroat Trout Restoration Project



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INTRODUCTION

A wild brood stock of Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) (CRCT) was developed as a cooperative effort between the Utah Division of Wildlife Resources (DWR) and Dixie National Forest at Dougherty Basin Lake in the late 1990s. Dougherty Basin Lake covers 3.7 acres at an elevation of 9,720 ft (2,963 m) and is located on the southwest slope of Boulder Mountain (Figure 1). Access is gained by a 0.75-mile foot trail from Barker Reservoir at the end of the North Creek Road. The inlet spring is about 0.25 mile upstream from the lake and rarely exceeds a temperature of 46° F (8° C) during the year. The outlet from Dougherty Basin flows for about 0.25 mile before entering Tall Four Reservoir (0.67 acres) and then from Tall Four into a sink hole. The two lakes are thus isolated from other systems containing wild trout. Springs below Tall Four originate from the sink hole and flow into other headwater lakes, eventually becoming part of North Creek, an Escalante River tributary. The canals feeding Dougherty Basin Lake and Tall Four Reservoir were constructed prior to 1960 and are maintained by DWR to provide stable water levels in the lakes for fish habitat. The brood population has been maintained with annual stocking of 1,000 CRCT in Dougherty Basin Lake (Table 1) and 100 CRCT in Tall Four Reservoir.

The brood project began in 1997-99 when wild CRCT were transplanted to Dougherty Basin Lake from the east and west forks of Boulder Creek. (Approximately 80% of the original transplanted fish came from the east fork.) Both Boulder Creek and Dougherty Basin Lake are located in the Escalante River drainage, where remnant CRCT were first discovered in the mid-1980s (Behnke 1992). By 2013, a total of seven remnant populations of native cutthroat trout had been found throughout this drainage (Hepworth et al. 2001, Hadley et al. 2008, Hadley et al. 2014). The CRCT brood stock is part of a native trout conservation program outlined in cooperative agreements (CRCT Conservation Team 2020) and strategies (CRCT Coordination Team 2020, Utah CRCT Team 2020). The Dougherty Basin brood was intended to provide a source of fish to establish new CRCT conservation populations and augment flat-water sport fisheries associated with those populations. In addition, it was hoped that enough CRCT could be produced to increase sport fishing opportunities for native trout within the historic range of CRCT in the Lower Colorado River Geographic Management Unit (GMU).

Eggs have been collected from CRCT in Dougherty Basin Lake since 1999. Annual production of the brood has ranged from less than 2,000 to nearly 20,000 fish stocked throughout waters in the Southern Region. In an effort to produce additional eggs, a brood operation was also conducted at Kolob Reservoir from 2010 to 2014. Egg-take logistics were difficult and variable at Kolob, however, leading to returns much lower than what was anticipated and the brood operation was abandoned. Also beginning in 2014, improvements made to the trap at Duck Fork Reservoir in the Southeastern Region (Lower Green River GMU) allowed for the collection of an excess of CRCT eggs. The resulting fry were offered to help fill sport fish quotas in the Southern Region. For the first time, all cutthroat sport fish needs in the Colorado River drainage in the region were filled by CRCT. Previously, shortages were met by excess Bonneville cutthroat trout produced at Manning Meadow Reservoir. A new sport fish management plan developed for Boulder Mountain lakes in 2014 recommended that only CRCT be stocked in Colorado River basin waters (Boulder Mountain Sport Fish Advisory Committee 2014). The stocking of CRCT from Duck Fork was instrumental in addressing all of these concerns and has provided more than 50% of the total CRCT stocking in the southern region during most years since 2014.

Since 2017, the Dougherty Basin brood operation has experienced a high amount of

variability in a number of factors that influence egg and fish production, including numbers of female CRCT trapped and spawned, percentage of trapped females that contributed eggs, and number of eggs produced per female. Despite all this variability among multiple factors, the total number of eggs produced has been surprisingly consistent, at 23,000 to 26,000. Variability has been the only constant during the more than 20 years of operation at Dougherty Basin. Mean CRCT production over that time (less than 9,000 fish) fills less than 30% of the annual requested stocking quota and even the best egg takes from 2013 to 2017 did not meet half of the request. Even with improved levels of eye-up and rearing experienced since 2018, the current trend in reduced egg collection keeps final production well below what is requested. Such mediocre results, yielded from such a significant investment of time and resources, have demonstrated that the Dougherty Basin wild brood will likely never come close to meeting egg needs, and magnify the crucial need to develop an alternative source for CRCT production in southern Utah. Since 2018, an effort has been made to establish a captive brood at the Mammoth Creek Hatchery. That captive brood plan also prompted the development of a spawning protocol which identifies the purpose of the progeny from egg takes at Dougherty Basin under five scenarios:

- **Scenario 1: Wild broodstock are used to produce sport fish (attached to conservation populations)**
 - These fish are considered conservation because the waters they are stocked in are connected to streams with conservation populations and the stocked fish could intermix with those conservation populations.
 - This scenario comprises 30% of projected annual CRCT quotas.
- **Scenario 2: Wild broodstock are used to produce sport fish (separate from conservations populations)**
 - These fish are not used for conservation purposes.
 - These lakes are not connected to current CRCT stream populations and may be stocked with CRCT from other brood sources outside the GMU (eg. Duck Fork).
 - This scenario comprises 50% of projected annual CRCT quotas.
- **Scenario 3: Wild broodstock are used in Fish Restoration Projects**
 - The goal is to produce fish for repopulating or restoring conservation populations.
 - Requirements for this scenario are short-term and irregular, though they may comprise a significant portion of any year's brood production. In addition, transfer of adult CRCT from remnant stream populations is combined with brood production to ensure genetic diversity in newly restored conservation stream populations.
- **Scenario 4: Wild broodstock are used to develop captive brood program**
 - The goal is to produce fish to be used for hatchery propagation, future restoration projects, and sport fish stocking purposes (scenarios 1-3).
 - This scenario comprises 7% of projected annual CRCT quotas.
- **Scenario 5: Wild broodstock maintenance**
 - The goal is to produce fish to be used to replace fish in the current wild broodstock (Dougherty Basin Lake and Tall Four Reservoir), as well as develop new wild broods (Lower Barker and North Creek reservoirs).
 - This scenario comprises 13% of projected annual CRCT quotas during the next five years.

For many years, CRCT eggs collected at Dougherty Basin have experienced fluctuating levels of survival through eye-up, hatching, and rearing. Inbreeding stress caused by years of collecting eggs from small groups of fish – compounded by an original founding by less than 300 individuals – was identified as a potential factor contributing to poor egg survival by staff at the Fisheries Experiment Station (FES) (Wagner and Oplinger 2012). They recommended that egg-take at brood locations where less than 200 fish were spawned in a given year focus on maximizing genetic diversity through strategic spawn pairings. Single-mated pairings (ie. one female to one male) were implemented at Dougherty Basin from 2015 to 2017. Beginning in 2018, a modified factorial spawn design was prescribed, where eggs from five females are pooled, mixed, then split into five equal lots, which are then fertilized by five individual males. In addition to altering fertilization strategy, CRCT from remnant populations not previously represented in the brood – primarily Pine Creek – have been periodically introduced to Dougherty Basin since 2014 (Table 1). These wild fish have contributed gametes to egg take operations during most of those years and have likely increased the genetic diversity of the brood satisfactorily.

Improvements to fish collection and handling at the trap, egg collection and transport, and infrastructure at the Fountain Green isolation facility have generally improved eyeing success for Dougherty Basin eggs in recent years. Instances of lower eyeing success (less than 50%) during the last ten years have typically been attributed to logistical issues during egg collection where specific problems were identified (Hadley 2017, 2018). The potential causes of poor egg survival varied from delayed fertilization, to physical damage during mixing, to dripping water on the eggs before fertilization. Efforts to address these identified issues at the trap have yielded improved eye-up in most recent years.

For many years, Dougherty Basin CRCT fry repeatedly experienced high rates of mortality during rearing due to encephalitis (inflammation in and around the brain). Previous spawning reports discussed in detail factors that may have contributed to these outbreaks (Hadley 2020). Because there is no direct treatment for encephalitis, mitigation has focused on reducing stress during outbreaks and ensuring that water temperatures remain at or below 55° F (13° C) as much as possible. Thanks to these mitigation efforts and infrastructure improvement, Fountain Green Hatchery achieved improved rearing success from 2018 to 2021, with 57-80% of eyed eggs reaching stocking. These were the highest rearing rates observed since they started raising Dougherty Basin CRCT in 2013.

Captive brood development dictated that a portion of eyed eggs was shipped to FES each year from 2018 to 2020 for quarantine during testing for bacterial kidney disease (BKD). Installation of a water chilling system there improved egg survival over extremely poor returns of the 2016 and 2017 cohorts. However, rearing success was still much lower than that at Fountain Green, with only 23-25% of eyed eggs surviving until they could be transferred to Mammoth Creek Hatchery during the subsequent spring. The near complete loss of the 2020 brood cohort in January 2021 (Hadley 2021), combined with rearing results for the previous years, led DWR administrative staff to the decision that Dougherty Basin CRCT brood needed to be isolated for BKD testing at a facility other than FES. A new isolation facility specifically designed to isolate small lots of fish was built at Fountain Green Hatchery in summer 2021. This new facility provided the opportunity to keep Dougherty Basin CRCT at the same installation until delivery to the Mammoth Creek Hatchery during the following spring. The first use of this new isolation facility was very successful, as the 2021 brood group experienced little loss during isolation and 2,574 fish were delivered to Mammoth Creek Hatchery in March 2022.

While CRCT eggs and fry have experienced improving trends in eye-up and rearing

survival, brood production has been limited by reduced CRCT brooder catch during trapping – and, therefore, reduced egg take – since 2017. Record high trapping catches from 2014 to 2016 yielded the only egg collection totals (60,000-75,000) in the history of the brood that could have reasonably fulfilled all requested stocking quotas for southern Utah. Variabilities in egg and fry survival, however, yielded a final stocking production that was not much greater than any other of the best years at Dougherty Basin. While egg and fry survival improved in the ensuing years, catch results dropped precipitously. Continual adjustments to trapping strategy and techniques were made to improve catch success, but these yielded only temporary and minor increases. It is not entirely clear why so many more adult CRCT were trapped during 2014 to 2017. All trapping methods caught more fish during those years, indicating that CRCT may have simply been more abundant and are experiencing lower survival since that time. While overall catch has decreased, catch and contribution of wild Pine Creek CRCT has maintained, indicating that a decrease in abundance may have resulted from lower survival of CRCT fingerlings after stocking.

One factor that may have contributed to reduced CRCT survival and abundance in Dougherty Basin Lake was the increase in brook trout abundance observed in recent years. For many years, the brook trout population remained at a low density, producing a small number of fish that experienced accelerated growth but didn't exert overt competition pressure on CRCT. Since 2018, however, the number of brook trout caught during the spawning operation has increased and those fish have exhibited poorer body condition and slower growth than what was generally observed in the past. The increased density and reduced condition and growth suggested that the brook trout population may have increased to a point where it could be having a negative impact on CRCT growth and/or survival.

METHODS

Fish traps (Fig. 2) were installed on May 24, 2022, in the inlet and outlet at Dougherty Basin Lake to capture out-migrating CRCT. Traps consisted of portable aluminum frames with removable rods spaced 0.5 inches apart. These frames could be adjusted to various stream widths and depths and were set to funnel trout into holding compartments. A trap is also typically set in the inlet at Tall Four Reservoir. The lake level was very low in 2022, however, preventing possible upstream movement, so the trap was not set. Two small fyke nets were set in Dougherty Basin Lake, and one set in Tall Four Reservoir (Fig. 3). These nets were allowed to fish through the entirety of the operation. The net at Tall Four caught no fish in the first three days of collection and was moved to Dougherty Basin for the remainder of the operation. DWR personnel were stationed at Barker Reservoir (trailhead to Dougherty Basin Lake) for 24 hours per day while traps were in operation. Traps and fyke nets were checked once or twice a day from May 24 through June 12 and fish captured were transported to live cages. CRCT were held in live cages in the lake until they were ready to spawn or until the project ended.

Egg collection was conducted on May 31, June 6, and 14, 2022 (Table 2) and was supervised by personnel from the Egan brood station. On spawning dates, all captive fish were sorted and ripe CRCT were spawned using standard state methods. The modified factorial spawning strategy was implemented during all egg takes: eggs were collected from five females on a cloth screen, with ovarian fluid being collected underneath for pathogen testing. The eggs were then gently mixed with a rubber spatula and separated evenly into five bowls. Milt from a single male was filtered across a metal screen to remove feces, then combined with diluent and a single lot of eggs, and allowed to fertilize for 5-10 minutes. Eggs were rinsed with clean hatchery water and water-hardened for one hour, then transported to Fountain Green Fish Hatchery for

eyeing. Eggs were treated with an iodine solution prior to loading for transport to Fountain Green and again at the hatchery. Following eye-up, all eggs remained at Fountain Green for hatching and rearing.

Disease certification was completed as required by standard protocol. A total of 60 trout (including CRCT and brook trout) collected during trapping were used in disease testing. Samples of ovarian fluid were taken from all females spawned (samples were combined from groups of five females). All samples were analyzed at FES. The inlet and outlet were also inspected for the presence of aquatic invasive species per UDWR protocols.

RESULTS & DISCUSSION

The dates of trap installment and first spawn were slightly earlier in 2022 than what has been typically experienced at Dougherty Basin Lake (Table 2) due to the early melt of a reduced snowpack. Table 3 summarizes results of the spawning operation in 2022. The total number of CRCT trapped in 2022 represented an increase over the previous two years, though the number of females spawned still remained well below average (Table 4). 24,933 eggs were collected over three takes in 2022. This total fell within a consistent range (23,000-26,000) that has been observed since 2017 (Fig. 4). Most spawners measured between 260 mm and 380 mm (Fig. 5). A concerted effort to avoid spawning very small, but mature, fish in recent years has yielded an increase in mean female spawner length (Fig. 6) as well as mean number of eggs produced per female (Fig. 4). The third egg take, however, yielded smaller females, on average, as well as lower eggs per female and smaller eggs (ie. higher eggs/oz) (Table 3). For the second consecutive year, female CRCT spawned were larger on average than males though this difference was smaller than that observed in 2021. Mean female and male length tend to follow similar trends over time and the difference in mean size between sexes has typically been relatively low. Twenty-seven CRCT (11 female, 16 male) introduced from Pine Creek contributed gametes to the 2022 egg take (Table 5). Pine Creek fish made up 26% off all female CRCT spawned and 36% of the males, similar to what has been observed since 2019. Pine Creek fish contributed gametes to every lot of eggs. It should be noted, however, that about 1/3 of the Pine Creek fish were spawned during the third egg take, which experienced lower overall success.

Eye-up rate for eggs collected during 2022 was 76%, which ranks among the highest values observed during the brood operation (Table 4, Fig. 7). Eye-up for the third take was only 33%, however, so the high overall mean was driven primarily by much greater success in the first two takes (Table 3). Eye-up of eggs collected during third and fourth takes has typically been lower at Dougherty Basin, likely due to poor egg quality among late spawners, as well as increased incidence of logistic complications when spawning small groups of fish that may not ripen. In 2022, this third egg take was comprised of more small females, as well as a higher percentage of Pine Creek fish. This low eye-up from this third take exemplifies that small eggs taken from small, though mature, females are of lower quality and will be less likely to fertilize. Rearing success at Fountain Green Hatchery was highly variable among the three lots. The first group experienced good survival during rearing and supplied the majority of fish stocked during fall 2022. The second, larger group, however, showed poor development due to a struggle to transition to artificial feed and experienced a high mortality rate. The diagnosis from FES was a potential congenital deficiency and/or genetic abnormality associated with this wild brood group (Wade Cavendar, pers. comm.). That group also exhibited excess mucus and fungus on the skin that was associated with the detection of the parasite *Ciladenella*. The group containing the

parasite was treated with a combination of formalin and salt. It was believed that this parasite contributed little to the overall mortality. The total rearing success of 24% across all spawn groups yielded only 4,480 fish from Dougherty Basin production for stocking in fall 2022. Production at the Duck Fork trap yielded less than what was anticipated in 2022 and all those fish were needed to fill quotas in the southeast region (Table 6). Production from the captive brood at Mammoth Creek Hatchery (discussed more below) yielded an additional 1,158 CRCT for stocking. A newly revised Boulder Mountain Sport Fish Management Plan finalized in spring 2022 prescribed reduced CRCT stocking quotas in several waters (Boulder Mountain Sport Fish Advisory Committee 2022). Even with this reduction, however, the total of 5,638 CRCT stocked in fall 2022 filled only 22% of the adjusted total request. Several large quotas were cancelled entirely.

Contribution of “wild” gametes to the brood from Pine Creek CRCT has increased to nearly one third of all spawners in 2022 (Table 5). The genetic diversity provided by these fish should benefit the captive brood program. BYU geneticist Paul Evans (personal comm.) previously stated that even a 5% proportion of wild fish annually could provide enough diversity to avoid a genetic bottle neck. The cohorts from 2018 to 2022 met and surpassed that rough threshold.

A total of 14 brook trout were captured in fyke nets set in Dougherty Basin Lake during the 2022 brood operation. Brook trout catch continued to decline from the high observed in 2019 (Table 7), indicating that the large cohort observed in recent years is declining as it ages. Careful documentation of brook trout caught during the spring CRCT trapping should continue in order to monitor brook trout population dynamics and inform potential impacts to the CRCT brood.

CAPTIVE BROOD

Due to the progression of the operation in 2022, a thorough review of the Mammoth Creek Hatchery captive brood will be presented here. The first captive brood group, spawned in 2017, was isolated at FES and delivered to Mammoth Creek Hatchery in spring 2018. This group had suffered catastrophic losses while in isolation, so only 33 fish remained when delivered to Mammoth Creek. The next three groups (2018, 2019, 2020 cohorts) were also isolated at FES and ranged from 322 to 482 fish. These fish were all received at Mammoth Creek in fair condition, with stress exhibited by fin wear and swollen eyes (“pop-eye”) in approximately 5% of the group. After delivery to the captive brood station, all groups showed little mortality over the ensuing years.

The 2017 cohort exhibited no development of eggs or milt in spring 2020 (ie. age 3). In 2021, neither the 2017 nor 2018 cohort exhibited gamete development. It was determined that the groups were being exposed to 24 hours of light in the hatchery building, which disrupted the photoperiod and egg production. The two groups were combined and moved to an outside building where they were exposed to natural light. Due to this change the fish produced viable gametes in spring 2022. Health condition was observed to improve after the move to the outdoor raceway, thanks to the lack of handling and reduced crowding.

The first egg takes from the Mammoth Creek captive Dougherty Basin brood were conducted in 2022, from March 30 to June 7 (Table 8). Eggs were collected every two weeks; more frequent collection was not possible due to insufficient space to isolate multiple lots of eggs in the hatchery, as well as insufficient manpower to conduct weekly takes. Cohorts were cross-paired (ie. 2018 females x 2019 males and vice versa) to avoid spawning siblings together. (Because the 2017 cohort was added the 2018 cohort – and made up less than 10% of the combined total – this combined group will be referred to as the “2018 cohort”.) A total of 57,679

eggs was collected over the six spawn dates. The first take yielded the highest number of eggs and egg numbers decreased steadily over the subsequent dates, until an increase was again noted in the final take. The 2019 (3-year-old) cohort supplied the bulk of the eggs on March 30. The disparity between groups was much smaller for the remaining takes, until the last date on June 7 when the older group (2018) produced twice as many eggs.

The number of green eggs collected at Mammoth Creek Hatchery was more than double that produced by Dougherty Basin in 2022. However, poor egg quality led to very poor eye-up, averaging just 9% (Table 8). Eye-up was best for the 2019 cohort during the first take, then decreased in subsequent dates. The final two egg takes yielded no viable eggs. (Eggs from the two cohorts could not be held separately after the first take due to an insufficient number of eyeing jars.) The most obvious problem observed was inconsistency in egg quality within individual fish. A number of females expressed old, ripe, and green eggs all at once. Many of these fish were from the 2017/2018 cohort that experienced a delayed photoperiod in 2021. Some of the old eggs observed in 2022 were likely eggs that matured after the fish were moved out to the exterior raceways in 2021 and weren't expelled. These dead eggs were counted as green eggs, but were never viable. Holding eggs from 2021 adjacent to eggs produced in 2022 in the body cavity may have impacted the survival of new eggs. Hatchery staff also expressed a concern that additional overripe eggs resulted from the egg-take frequency. (At Dougherty Basin, egg takes are conducted at least once per week and the peak spawning window lasts no more than three weeks.) These factors, as well as the prevalence of green eggs that also didn't fertilize, likely all contributed to the poor eye-up in 2022.

As noted previously, Mammoth Creek Hatchery stocked 1,158 CRCT produced in 2022 in three waters in the fall. In addition, 2,000 fish were held at the hatchery as the next replacement brood group. The 2017/2018 cohort was cycled out of the brood and stocked in Lower Barker Reservoir in late June. As of December 1, 2022, the Mammoth Creek Hatchery is holding four brood groups, produced from 2019 to 2022 (Table 9). The two older groups – those that will be spawned in 2023 – are smaller in number than the younger groups. The younger cohorts also exhibit healthier condition compared to the older, smaller lots. It is hoped that egg production will significantly improve as these younger cohorts mature, as older lots are cycled out of the brood, and as personnel gain experience with captive egg collection from the Dougherty Basin brood. The most prevalent observation gained so far in cutthroat trout propagation at the Mammoth Creek Hatchery is that each brood is different and experiences its own unique set of challenges.

FUTURE BROOD STRATEGY

As the development of the captive CRCT brood has continued, administrative and regional staff coordinated to devise a strategy for maintaining the captive brood into the future. The primary concerns that this strategy is intended to address are: 1) maintaining genetic diversity, 2) reducing the threat of hatchery domestication, and 3) lessening the workload to maintain pathogen testing. While the specific schedule of work is still being determined and will depend on the pending success of the captive brood, the strategy will prescribe a cycle where collection of eggs at the wild brood can be suspended for nine years (about two “generations”) at a time. This means that three to four cohorts of CRCT produced by the wild brood would support brood replacement, followed by nine cohorts of fish produced by the captive brood. It is felt that this cycle will not yield a significant increase in domestication. Following this cycle, the entire brood would be replaced by spawn from three to four cohorts at a wild brood. Collection at

Dougherty Basin will continue until the captive brood begins producing eggs and the combined production exceeds all requested stocking needs.

The captive brood strategy should help to significantly reduce the amount of time and effort employed in trapping fish, collecting eggs, and maintaining pathogen clearance for gamete production. In addition, wild gene infusion will be conducted regularly from another population (ie. Pine Creek, forks of Boulder Creek) to the wild brood to continually ensure genetic diversity is maintained or increased. As possible and feasible, pathogen clearance for the captive brood, wild brood, and wild gene sources will be scheduled to avoid overlap.

The brood strategy requires maintenance of a wild brood in order to maintain genetic diversity long-term and avoid hatchery domestication. However, it is clear that Dougherty Basin Lake has struggled to produce sufficient production and presents a variety of logistic challenges that make it an inefficient brood. Regional staff have been exploring ideas for other waters that could potentially replace Dougherty Basin as a wild brood and discussed these options with the Boulder Mountain Sport Fish Advisory Committee in early 2022. The committee met to review and revise the Boulder Mountain management plan, providing the opportunity to discuss the impact of CRCT brood operation and development on anglers and gain support for these activities in the future. This discussion yielded support from the committee for developing new wild broods in two waters in the North Creek drainage: Lower Barker and North Creek reservoirs. Both reservoirs have road access and would present much easier logistics for brood operation. Stocking in Lower Barker Reservoir was converted to sterile hybrid trout (tiger and splake) about 10 years ago and experimental stocking of CRCT began in 2022 to evaluate their performance alongside the hybrids. A CRCT restoration project was commenced in 2022, with the first chemical removal of nonnative fish from North Creek Reservoir and North Creek upstream. Following a second removal in 2023, CRCT will be established in the drainage, with the reservoir at the downstream end of the population. A self-sustaining population of nonnative cutthroat trout previously persisted in North Creek Reservoir for nearly 20 years, indicating that the reservoir could support a future CRCT brood operation. Water level fluctuation and low water volume due to siltation present the greatest challenges to CRCT in North Creek Reservoir. The previous nonnative cutthroat trout population showed the ability to thrive despite these challenges. In addition, regional staff met with the New Escalante Irrigation Company in 2022 to discuss CRCT restoration and potential avenues of cooperation. The discussion generated ideas for future stream habitat work to reduce erosion in North Creek and sediment load flowing into the reservoir, as well as the potential for dredging the reservoir to gain more water volume and reduce the impacts of water fluctuation.

RECOMMENDATIONS FOR BROOD OPERATION

1. Efforts should continue to maintain improved egg and fry survival during every step of brood operation: trapping, spawning, transport, eyeing, and rearing. Full and unimpeded communication among regional, administrative, and hatchery personnel will be critical in ensuring that the best practices are being implemented.
2. Set fyke nets near the beginning of the brood operation and run through the final egg take. Net locations and orientation (floating vs diving) should be altered frequently to avoid depressed catch due to net avoidance and localized depletion. Catch and length data of brook trout should be recorded.
3. Maintain the current stocking rate of 1,000 CRCT at Dougherty Basin and 100 CRCT at Tall Four.

4. Continue use of larger cages for holding trapped CRCT. These cages should be meticulously inspected for holes and repaired. Immature fish, spent females, and excess males may be retained in these larger live cages to prevent recapture. A few well-maintained small cages should also be used to hold brook trout for inclusion in the pathogen sample.
5. Egg-take protocols at Dougherty Basin should be reviewed and modified as necessary to comply with approved statewide protocols and ensure that best methods are employed.
6. During egg take, hold CRCT in oxygenated live wells next to the egg take table to reduce excessive handling and delayed fertilization. Set up a tarp over the table to prevent sun exposure if trees provide insufficient shade.
7. The canal between Dougherty Basin and Tall Four should be monitored and improved as needed to maintain water level at Tall Four. The sinkhole in Tall Four should also be monitored.
8. Survey brook trout spawning activity in the fall and conduct removal when possible.
9. CRCT from Duck Fork brood production should be stocked only in sport fish waters.
10. Continue coordinated development of the captive Lower Colorado CRCT brood, along with its protocol and strategy.
11. Continue activities to develop new wild CRCT broods in Lower Barker and North Creek reservoirs.
12. Suspend the egg take operation at Dougherty Basin Lake once the captive brood at Mammoth Creek Hatchery produces at least 13,000 fingerling CRCT (75th percentile of historic wild brood production) for fall stocking in two consecutive years. This figure will provide confidence that the captive brood is producing better than the wild brood and covers almost all conservation stocking requests.

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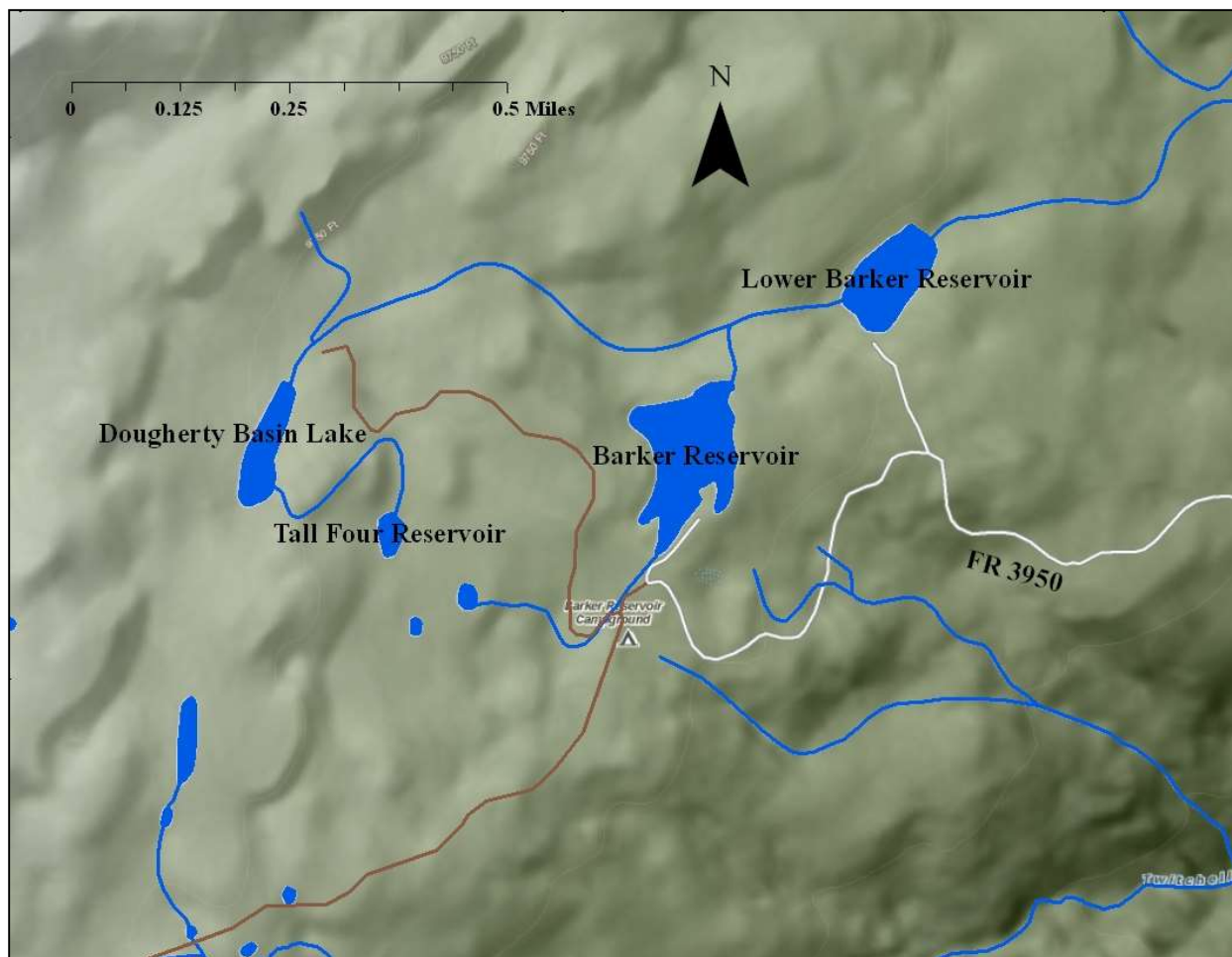


Figure 1. Map of Dougherty Basin Lake, Tall Four Reservoir, and the surrounding area.



Figure 2. Portable fish traps installed in the Dougherty Basin Lake inlet (top) and outlet (bottom).



Figure 3. Fyke net used to collect spawning Colorado River cutthroat trout at Dougherty Basin Lake.

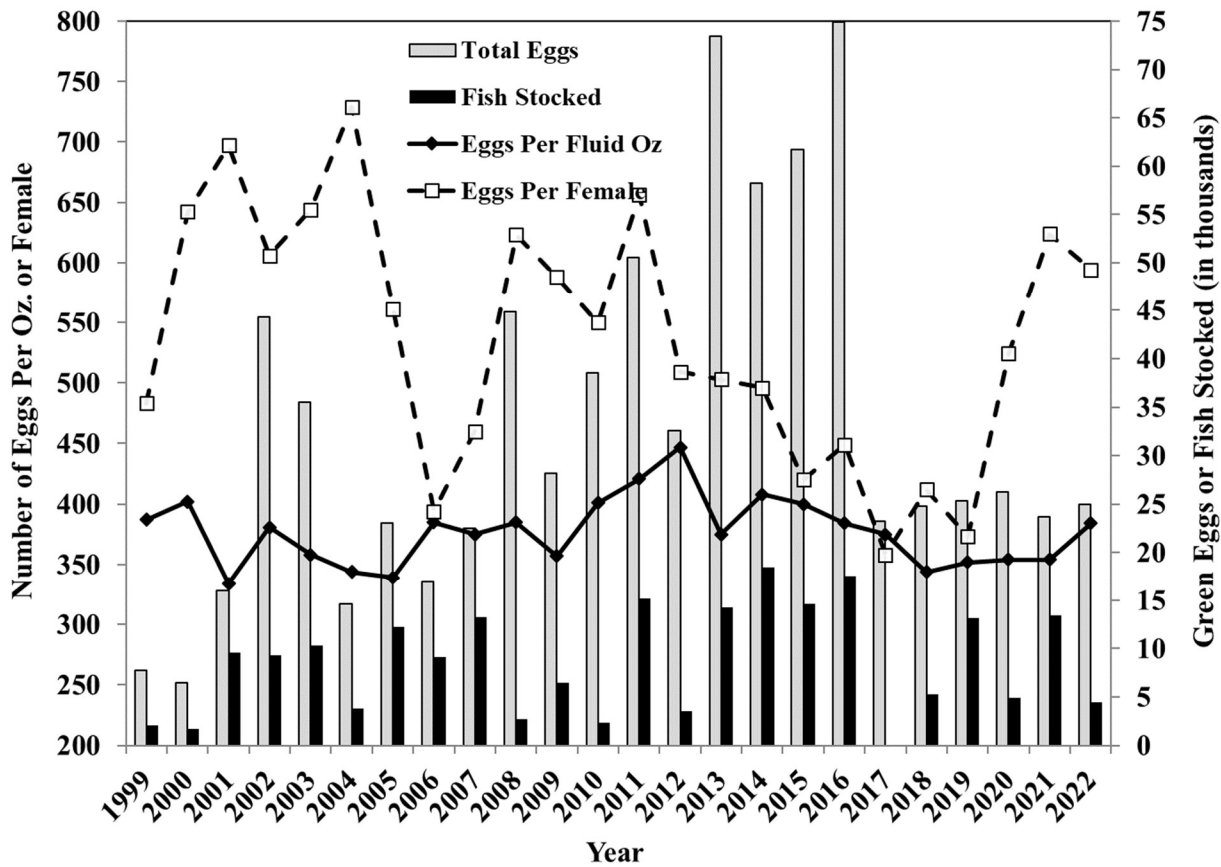


Figure 4. Total number of Colorado River cutthroat trout eggs collected during the brood operation at Dougherty Basin Lake, 1999-2022, as well as measures of eggs per fluid ounce, eggs per female, and numbers of fish stocked from the egg collection.

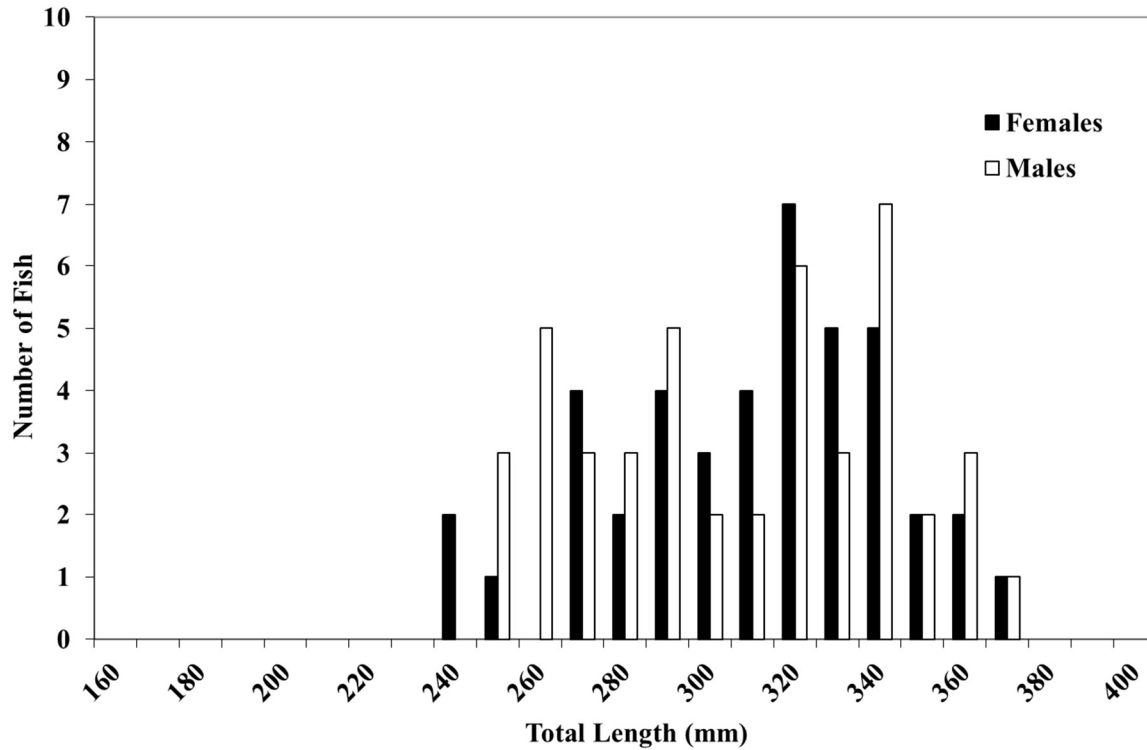


Figure 5. Distribution of total length (mm) of female and male Colorado River cutthroat trout spawned at Dougherty Basin Lake in 2022.

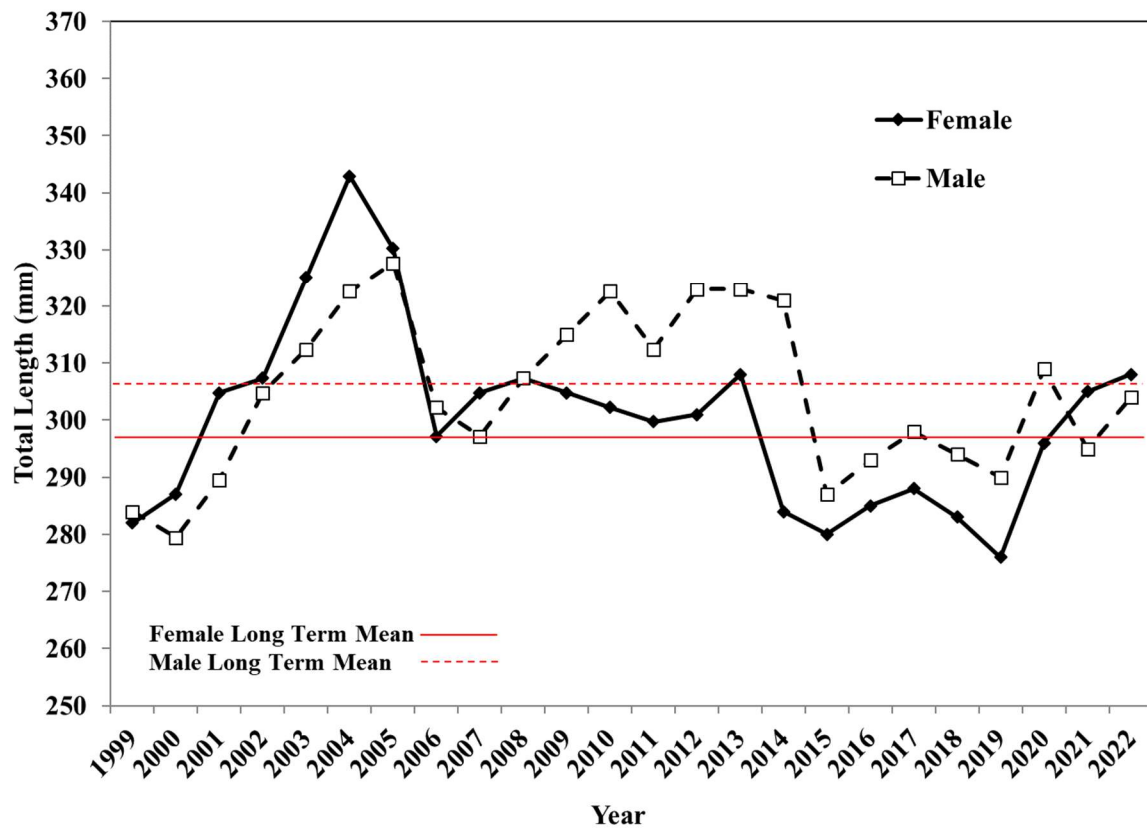


Figure 6. Mean total length (mm) of female and male Colorado River cutthroat trout spawned at Dougherty Basin Lake, 1999-2022.

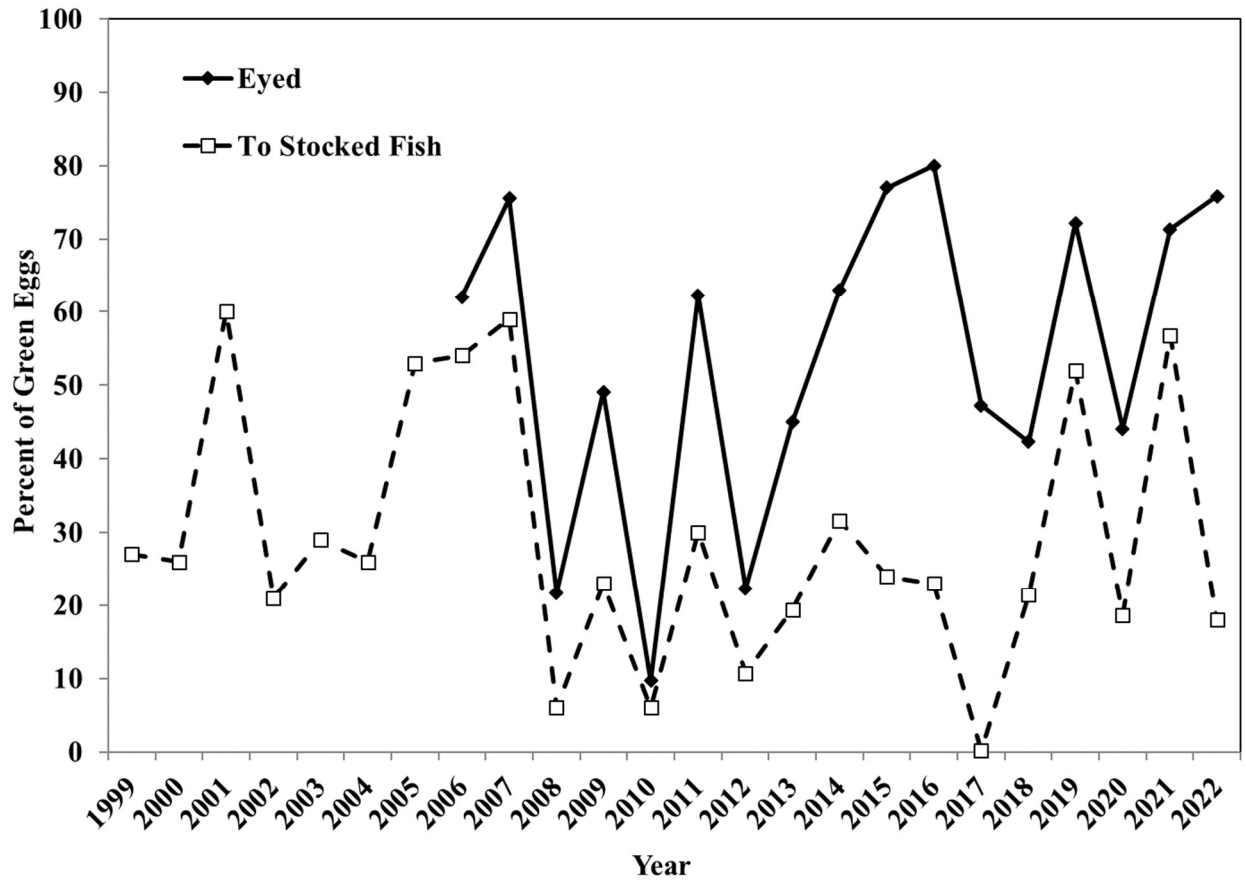


Figure 7. Percent of green eggs collected at Dougherty Basin Lake, 1999-2022, which reached the eye-up and stocking stages.

Table 1. Total number, size, and/or source of Colorado River cutthroat trout stocked in Dougherty Basin Lake, Utah, as brood stock, 1997-2022. Transplants were of various sizes and ages, holdovers were age 1 (approximately 5-6 inches in mean total length), and fry were age 0 (approximately 2 inches mean total length).

	Number of fish stocked		
	Transplants	Holdovers	Fry
1997	105 ^a	--	--
1998	107 ^a	--	--
1999	45 ^b	--	--
2000	--	250	--
2001	--	350	699
2002	--	--	226
2003	--	--	831
2004	--	--	1,032
2005	--	250	1,000
2006	--	--	1,000
2007	--	--	1,009
2008	--	--	1,003
2009	--	--	1,002
2010	--	--	1,014
2011	--	--	1,001
2012	--	--	999
2013	--	--	1,023
2014	170 ^c	--	997
2015	--	--	1,015
2016	--	--	1,045
2017	234 ^d	--	--
2018	115 ^d	--	1,000
2019	--	--	986
2020	171 ^d	--	987
2021	--	--	1,000
2022	--	--	1,024

^a – Transferred from East Fork Boulder Creek.

^b – Transferred from West Fork Boulder Creek.

^c – 120 transferred from Pine Creek (right pelvic clip), 50 from White Creek (left pelvic clip).

^d – Transferred from Pine Creek (adipose clip).

Table 2. Colorado River cutthroat trout spawning times at Dougherty Basin Lake, 1999-2022.

Year	Trap operation dates		Dates spawned		Number of days spawned	Lake water temp (F)	
	Begin	End	First	Last		First spawn	Last spawn
1999	15 June	23 June	17 June	23 June	2	55	58
2000	1 June	12 June	5 June	12 June	2	58	52
2001	25 May	13 June	6 June	13 June	2	58	60
2002	21 May	12 June	30 May	12 June	3	61	60
2003	29 May	24 June	10 June	24 June	3	58	57
2004	28 May	22 June	8 June	22 June	3	60	58
2005	8 June	28 June	20 June	28 June	3	55	54
2006	26 May	14 June	8 June	13 June	2	55	58
2007	29 May	12 June	5 June	12 June	2	52	54
2008	6 June	17 June	12 June	17 June	2	50	55
2009	2 June	16 June	8 June	16 June	3	50	50
2010	7 June	14 June	9 June	14 June	2	58	54
2011	8 June	20 June	14 June	23 June	3	56	56
2012	23 May	4 June	30 May	4 June	2	45	51
2013	28 May	10 June	3 June	10 June	2	55	52
2014	27 May	9 June	3 June	13 June	3	54	47
2015	26 May	11 June	1 June	11 June	4	48	^a
2016	1 June	13 June	6 June	13 June	2	52	^a
2017	31 May	12 June	6 June	12 June	2	55	^a
2018	30 May	11 June	5 June	11 June	2	51	^a
2019	10 June	1 July	17 June	1 July	3	49	^a
2020	27 May	15 June	8 June	15 June	2	^a	^a
2021	24 May	7 June	1 June	7 June	2	54	55
2022	24 May	14 June	31 May	14 June	3	52	56
Mean	30 May	15 June	7 June	15 June	-	54	55

^a – Temperature not recorded.

Table 3. Colorado River cutthroat trout spawning results at Dougherty Basin Lake in 2022.

Date	Lake water temp (F)	Females spawned	Mean Female TL (mm) (n)	Mean Male TL (mm) (n)	Total eggs	Eggs per fluid ounce	Mean eggs per female	Percent green eggs eyed
May 31	52	15	326 (15)	297 (17)	9,438	363	629	92
June 6	52	21	307 (21)	313 (22)	12,771	387	608	73
June 14	56	6	268 (6)	291 (6)	2,724	454	454	33
Total	--	42	308 (42)	304 (45)	24,933	384	594	76

Table 4. Colorado River cutthroat trout spawning totals at Dougherty Basin Lake, Utah, 1999-2022.

Year	Total number of trout trapped					Number females trapped	Number females spawned	Percent trapped females spawned	Mean TL (mm)		Eggs per fluid ounce	Mean eggs per female	Total eggs	Percent green eggs eyed	Percent eggs to stocked fish	Number fish stocked
	Inlet	Outlet	Fyke nets	Tall Four	Total				Female	Male						
1999	31	11	--	--	42		16		282	284	387	483	7,734		27%	2,088
2000	12	9	--	--	21		10		287	279	402	642	6,428		26%	1,671
2001	149	35	--	--	184		23		305	290	334	697	16,032		60%	9,619
2002	245	52	--	15	312		73		307	305	381	606	44,258		21%	9,294
2003	130	78	--	--	208		66		325	312	358	644	35,479		29%	10,289
2004	94	50	--	--	144		20		343	323	344	729	14,589		26%	3,793
2005	46	36	48	--	130		41		330	328	339	561	23,022		53%	12,202
2006	32	68	105	32	237		43		297	302	385	394	16,927	62%	54%	9,141
2007	13	23	81	55	172		49		305	297	375	460	22,516	76%	59%	13,284
2008	9	22	121	103	255		72		307	307	385	623	44,880	22%	6%	2,693
2009	9	30	63	49	151		48		305	315	357	588	28,215	49%	23%	6,489
2010	7	6	134	79	226		70		302	323	401	550	38,496	10%	6%	2,310
2011	32	31	155	38	256		77		300	312	421	656	50,520	62%	30%	15,156
2012	15	37	71	38	239	110	64	58	301	323	447	509	32,598	22%	11%	3,488
2013	32	31	253	16	332	177	146	82	308	323	375	503	73,476	45%	19%	14,254
2014	26	27	259	163	475	243	118	49	284	321	408	496	58,253	63%	32%	18,500
2015	76	59	436	121	692	349	147	42	280	287	400	420	61,723	77%	24%	14,600
2016	157	85	358	128	728	364	167	46	285	293	384	449	74,930	80%	23%	17,559
2017	90	34	102	40	266	131	65	50	288	298	375	358	23,262	47%	<1%	34
2018	15	16	171	56	258	132	60	45	283	294	344	412	24,744	42%	21%	5,290
2019	24	4	308	43	379	186	68	37	276	290	352	373	25,344	72%	52%	13,112
2020	12	8	126	--	146	66	50	76	296	309	354	524	26,214	44%	19%	4,894
2021	2	14	110	72	198	82	38	46	305	295	354	624	23,702	71%	57%	13,450
2022	27	0	188	0	215	106	42	40	308	304	384	594	24,933	76%	18%	4,480
Means	54	32	172	62	261	177	66	52	297	306	377	537	33,262	54%	29%	8,654

Table 5. Colorado River cutthroat trout introduced from remnant populations and spawned at Dougherty Basin Lake, 2015-2022.

<u>Year</u>	<u>White Creek</u>		<u>Pine Creek</u>		<u>Total</u>
	<u>Female</u> <u>(% total)</u>	<u>Male</u> <u>(% total)</u>	<u>Female</u> <u>(% total)</u>	<u>Male</u> <u>(% total)</u>	
2015	3 (2%)	0	0	1 (0.7%)	4
2016	0	1 (0.7%)	5 (3%)	2 (1.4%)	8
2017	0	1 (2.3%)	1 (1.5%)	0	2
2018	0	0	6 (10%)	5 (8.3%)	11
2019	0	0	13 (19%)	20 (31%)	33
2020	0	0	10 (20%)	16 (32%)	26
2021	0	0	10 (26%)	13 (31%)	23
2022	0	0	11 (26%)	16 (36%)	27
Total	3 (<1%)	2 (<1%)	56 (9%)	73 (12%)	134

Table 6. Colorado River cutthroat trout produced at the Duck Fork brood stocked for sport fishing purposes in the Southern Region.

<u>Year</u>	<u>Number</u> <u>Stocked</u>	<u>Number</u> <u>of</u> <u>Waters</u>	<u>Percent</u> <u>of Total</u> <u>CRCT</u>
2014	23,209	5	56%
2015	16,000	3	52%
2016	26,700	7	60%
2017	29,701	9	100%
2018	28,500	7	86%
2019	29,979	10	70%
2020	0 ^a	0	--
2021	10,905	6	45%
2022	0 ^b	0	--
Mean	18,305	5	59%

^a – Duck Fork trap not operated in 2020.

^b – All Duck Fork production stocked in Southeast Region in 2022.

Table 7. Numbers of brook trout collected during spawn operations at Dougherty Basin Lake, 2018-2022.

Year	Brook Trout Captured
2018	22 ^a
2019	53
2020	35
2021	32
2022	14

^a – Minimum number, as not all captures were recorded.

Table 8. Colorado River cutthroat trout spawning results at Mammoth Creek Hatchery in 2022.

Date	Cohort ^a	# ♀	Green Eggs		Eyed Eggs ^b		Eye-up
			Eggs/Oz	Eggs	Eggs/Oz	Eggs	%
3/30/22	2019	30	479	11,975	479	2,874	24
	2018	6	423	4,230	423	423	10
4/12/22	2019	20	454	6,356	412	824	6
	2018	27	369	7,749			
4/26/22	2019	11	536	6,968	467	467	4
	2018	38	398	5,174			
5/10/22	2019	9	557	3,342	463	463	6
	2018	36	369	4,059			
5/24/22	2019	4	653	1,306	554	0	0
	2018	5	454	1,816			
6/7/22	2019	3	536	1,608	526	0	0
	2018	3	516	3,096			
Total		192	451	57,679	459	5,051	9
2019		77	501	31,555			
2018		115	402	26,124			

^a – The 2018 cohort also included some individuals from 2017 (<10%).

^b – Limited space precluded keeping egg lots separate by parent cohort after the first take.

Table 9. Colorado River cutthroat trout captive brood groups held at Mammoth Creek Hatchery, as of December 1, 2022.

Cohort	Age	Count	Mean Length (in)	Egg Source	Isolation Facility
2019	4	303		DB	FES
2020	3	256		DB	FES
2021	2	2,524	9.97	DB	FG
2022	1	2,001	4.26	MC	MC