Study clarifies diversity, distribution of cutthroat trout in Colorado

September 24 2012

This is a geenback cutthroat trout from Bear Creek near Colorado Springs, Colo. Credit: Doug Kreiger, Colorado Parks and Wildlife

A novel genetic study led by the University of Colorado Boulder has helped to clarify the native diversity and distribution of cutthroat trout in Colorado, including the past and present haunts of the federally endangered greenback cutthroat trout.

The study, led by CU-Boulder postdoctoral researcher Jessica Metcalf, was based largely on DNA samples taken from cutthroat trout specimens preserved in ethanol in several U.S. museums around the country that were collected from around the state as far back as 150 years ago. The new study, in which Metcalf and her colleagues extracted mitochondrial DNA from fish to sequence genes of the individual specimens and compared them with modern-day cutthroat trout strains, produced some startling results.

The biggest surprise, said Metcalf, was that the cutthroat trout native to the South Platte River drainage appears to survive today only in a single population outside of its native range—in a small stream known as Bear Creek that actually is in the nearby Arkansas River drainage. The strain from Bear Creek is thought to have been collected from the South Platte River drainage in the 1880s by an early hotelier who stocked the fish in a pond at the Bear Creek headwaters to help promote an early tourist route up Pikes Peak.

"We thought one way to get to the question of which cutthroat trout strains are native to particular drainages was to go back to historical samples and use their DNA as a baseline of information," said Metcalf of the chemistry and biochemistry department and a former postdoctoral researcher at the Australian Centre for Ancient DNA. "Our study indicates the descendants of the fish that were stocked into Bear Creek in the late 1800s are the last remaining representatives of the federally protected greenback cutthroat trout."

A second, key set of data was all of the Colorado cutthroat trout stocking records over the past 150 years, a task spearheaded by study co-author and fish biologist Chris Kennedy of the U.S. Fish and Wildlife Service. Between 1889 and 1925, for example, the study showed that more than 50 million cutthroat trout from the Gunnison and Yampa river basins were stocked in tributaries of all major drainages in the state, jumbling the picture of native cutthroat strains in Colorado through time and space.

Originating from the Pacific Ocean, cutthroat trout are considered one of the most diverse fish species in North America and evolved into 14 recognized subspecies in western U.S. drainages over thousands of years. In Colorado, four lineages of cutthroats were previously identified: the greenback cutthroat, the Colorado River cutthroat, the Rio Grande cutthroat and the extinct yellowfin cutthroat.

The museum specimens used in the study came from the California Academy of Sciences, the Smithsonian Museum of Natural History in Washington, D.C., the Academy of Natural Sciences in Philadelphia and the Harvard University Museum of Comparative Zoology. Colorado cutthroat trout specimens were collected by a number of early naturalists, including Swiss scientist and former Harvard Professor Louis Agassiz and internationally known fish expert and founding Stanford University President David Starr Jordan.

The new study, published online today in *Molecular Ecology*, follows up on a 2007 study by Metcalf and her team that indicated there were several places on the Front Range where cutthroat populations thought to be greenbacks by fish biologists were actually a strain of cutthroats transplanted from Colorado's Western Slope in the early 1900s.

Other co-authors on the new study included CU-Boulder Professor Andrew Martin and CU-Boulder graduate students Sierra Stowell, Daniel McDonald and Kyle Keepers; Colorado Parks and Wildlife biologist Kevin Rogers; University of Adelaide scientists Alan Cooper and Jeremy Austin; and Janet Epp of Pisces Molecular LLC of Boulder.

"With the insight afforded by the historical data, we now know with a great deal of certainty what cutthroat trout strains were here in Colorado before greenbacks declined in the early 20th century," said Martin of CU's ecology and evolutionary biology department. "And we finally know what a greenback cutthroat trout really is."

Metcalf and her colleagues first collected multiple samples of tissue and bone from each of the ethanol-pickled trout specimens, obtaining fragments of DNA that were amplified and then pieced together like a high-tech jigsaw puzzle to reveal two genes of the individual specimens. The tests were conducted on two different continents under highly sterile conditions and each DNA sequencing effort was repeated several times

for many specimens to ensure accuracy in the study, Metcalf said.

Roughly half of the study was conducted at CU-Boulder and half at the Australian Center for Ancient DNA at the University of Adelaide, where Metcalf had worked for two years. "By conducting repeatable research at two very different, state-of-the-art laboratories, we were able to show the Bear Creek trout was the same strain as the cutthroats originally occupying the South Platte River drainage."

The Bear Creek trout strain is now being propagated in the Colorado Parks and Wildlife hatchery system and at the USFWS Leadville National Fish Hatchery.

In addition to identifying the Bear Creek cutthroat trout, Metcalf and her colleagues discovered a previously unknown cutthroat strain native to the San Juan Basin in southwestern Colorado that has since gone extinct. The study also confirmed that the yellowfin cutthroat, a subspecies from the Arkansas River headwaters that grew to prodigious size in Twin Lakes near Leadville, also had gone extinct.

Fortunately, most fish preserved by naturalists before 1900 were "fixed" in ethanol, which makes it easier for researchers to obtain reliable DNA than from fish preserved in a formaldehyde solution, a practice that later became popular. Prior to the new study—which included DNA from specimens up to about 150 years old—scientists working in ancient DNA labs had only performed similar research on ethanol-preserved museum vertebrate specimens less than 100 years old.

"One of the exciting things to come from this research project is that it opens up the potential for scientists to sequence the genes of other fish, reptiles and amphibian specimens preserved in ethanol further back in time than ever before to answer ecological questions about past diversity and distribution," said Metcalf, who conducts her research at CU's

BioFrontiers Institute.

Funding for the study was provided by agencies of the Greenback Cutthroat Trout Recovery Team, including the USFWS, the U.S. Forest Service, the Bureau of Land Management, the National Park Service and Trout Unlimited.

"I think in many cases success depends less on the application of a new technology and more on the convergence of people with shared interest and complementary skills necessary for solving difficult problems," said Martin. "Our greenback story is really one about what can be discovered when dedicated and talented people collaborate with a shared purpose."

"We've known for some time that the trout in Bear Creek were unique," said Doug Krieger, senior aquatic biologist for Colorado Parks and Wildlife and the Greenback Cutthroat Trout Recovery Team leader. "But we didn't realize they were the only surviving greenback population."

The decline of native cutthroats in Colorado occurred because of a combination of pollution, overfishing and stocking of native and non-native species of trout, said Metcalf. "It's ironic that stocking nearly drove the greenback cutthroat trout to extinction, and a particularly early stocking event actually saved it from extinction," she said.

Provided by University of Colorado at Boulder