Cutthroat trout genetics:
Exploring the heritage of Colorado’s state fish
Across the great divide: genetic forensics reveals misidentification of endangered cutthroat trout populations

JESSICA L. METCALF, VICTORIA L. PRITCHARD, SARAH M. SILVESTRI, JAZMIN E. JENKINS, JOHN S. WOODS, DAVID E. COWLEY, PAUL EVANS, DENNIS D. SHIOZAWA and ANDREW P. MARTIN

*Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO 80309, USA, "Department of Fishing and Wildlife Sciences, New Mexico State University, Las Cruces, NM 88003, USA, #Pikes Peak Molecular, LLC, Boulder, CO 80305, USA, "Department of Microbiology and Molecular Biology Brigham Young University, Provo, UT 84602, USA, #Department of Biology, Brigham Young University, Provo, UT 84602, USA.

Abstract

Accurate assessment of species identity is fundamental for conservation biology. Using molecular markers from the mitochondrial and nuclear genomes, we discovered that many putatively native populations of greenback cutthroat trout (Oncorhynchus clarkii stomias) comprised another subspecies of cutthroat trout, Colorado River cutthroat trout (Oncorhynchus clarkii clarkii). This error can be explained by the introduction of Colorado River cutthroat trout throughout the native range of greenback cutthroat trout in the late 19th and early 20th centuries by fish stocking activities. Our results suggest greenback cutthroat trout within its native range be at a higher risk of extinction than ever before despite conservation activities spanning more than two decades.

Keywords: AHP, conservation genetics, cutthroat trout, endangered species, forensics, microsatellites

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Introduction

Cutthroat trout (Oncorhynchus clarkii) are widely distributed throughout the drainage basins of inland western North America. Since the first description of the species in 1861 from the upper Pecos River in New Mexico, 12 subspecies have been described based on morphology, genetics, and geography (Belshaw 2002). Of these, two have gone extinct within the last century, seven are listed under the Endangered Species Act as Threatened or Endangered, and many are candidates for federal protection. One of the federally protected subspecies is the greenback cutthroat trout (Oncorhynchus clarkii stomias). The historic native range of greenback cutthroat trout included streams and lakes of Colorado's South Platte and Arkansas River drainages on the east side of the Continental Divide. Over the last 150 years, the species range declined from over 13,000 km of lakes, rivers, and streams to about 75 km (Young & Hartig 2001). This decline occurred as a consequence of mining pollution, fishing pressure, and displacement by nonnative salmonids introduced by state and federal hatcheries and private enterprises for recreational and sustainable fisheries (Young & Hartig 2003). By 1915, greenback cutthroat trout persisted in only a handful of tributaries of the upper Arkansas River and in 1937, the subspecies was declared extinct.

In the 1980s, the subspecies was resurrected when a putative pure population was discovered in a headwater stream of the South Platte River. Subsequently, additional native greenback cutthroat trout populations were found in high-elevation streams above 2000 m of the South Platte and Arkansas River drainages. These discoveries prompted federal protection for the subspecies under the US Endangered Species Act (USEWSA 1978) and a management and restoration plan was implemented. Over more than two decades, greenback cutthroat trout were propagated in hatcheries, appropriate habitats were identified and cleared of nonnative salmonids, and large numbers of cutthroat trout were reintroduced in an attempt to reach the conservation goal of 20 self-sustaining greenback cutthroat trout populations (Young & Hartig 2003). In many places, populations were subject to regular monitoring and habitats received...
But what about this one?
Cutthroat trout west of the Divide

• Since 2007 - Fin tissues from over 7900 fish out of 384 waters on west slope

• Genetic tests on 6421 samples

• Have identified 50 west slope populations with significant “Lineage GB” influence
USFWS Fishery Biologist Chris Kennedy
Trappers and Marvine Lakes
26 million from 1914-1925

Grand Mesa Lakes
29 million from 1899-1909
Native Range

O.c. pleuriticus

O.c. stomias

O.c. macdonaldii (extinct since 1904)

O.c. virginalis

Yampa River

South Platte River

Arkansas River

San Juan River

Rio Grande River
CU Genetic Study

- Compare the genetic composition of existing cutthroats in Colorado to historical samples (museum specimens) collected prior to 1900.

- Describe and test hypotheses concerning the geographic origin, evolution, and distinction of cutthroats in Colorado.
Museum DNA project

Isolated DNA from historic collection efforts

Hayden - 1871

Jordan - 1889

Cope - 1874

Hammond - 1856
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<th>Location</th>
<th>Collector</th>
<th>Year</th>
<th>Institution</th>
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Museum DNA project

DNA degraded - use short pieces to recreate ND2 gene
Arkansas Basin

- The authors conclude that the “yellow fish” represent yellowfin cutthroat trout (*O. c. macdonaldivi*), which is likely the cutthroat native to the Arkansas River drainage (not just at Twin Lakes).

- There are no modern representatives of this lineage and is assumed to be extinct.

- Two of the Arkansas museum samples revealed specimens of “green fish”, which will be discussed later.
Rio Grande Basin

• “Orange fish” are recognized by the authors as an evolutionary distinct lineage corresponding to Rio Grande cutthroats (*O. c. virginalis*) that inhabit this drainage and were first described in 1853.

• No other museum samples exhibited genetic fingerprint similar to the orange fish outside of the Rio Grande basin.
San Juan Basin

- The “red fish” were represented by one museum collection (two fish).
- Although there may be need for further resolution, this appears to be the native cutthroat of the San Juan River drainage.
- There are no modern representatives of this lineage and it is presumed to be extinct.
Colorado & Gunnison
Gunnison-Colorado Basins

- Museum samples for the “green fish” were primarily found in these two basins, but were also found in the upper Arkansas River drainage.
- Geology and temperature gradients of the Gunnison and Colorado basins may have allowed cutthroat movement between them.
- However, geological separation between west slope (G-C basin) and east slope (Ark) makes it unlikely that green fish were native to upper Arkansas, rather the collections found in the Arkansas in 1889 were more likely influenced by early stocking.
- Some uncertainty exists and further taxonomic resolution may be necessary, but CU scientists suggest that this may be an undescribed distinct taxon.
- May be a genetic variant of “blue fish”.

Yampa Basin

- The museum collections for “blue fish” were found in both the Yampa basin (one collection) and in the Colorado River (one collection).
- But based on historical and modern data, the Yampa basin appears to be inhabited by Colorado River cutthroat (*O.c. pleuriticus*).
- The type specimen for Colorado River cutthroat was collected in the Green River basin (WY) which encompasses the Yampa basin.
- No museum collections of “green fish” have been found in the Yampa basin.
- After extensive testing, no other Colorado native cutthroats (besides *O.c. pleuriticus*) have been found to currently exist in the Yampa River drainage.
South Platte Basin

- No museum specimens corresponding to the genetics of the “purple fish” were found outside of the South Platte drainage.
- The study advances the theory that this is the native cutthroat of the South Platte River drainage.
- It is represented by one modern population found in the Arkansas River drainage (Bear Creek).
- Because early taxonomists clearly designated *O.c. stomias* as native to the South Platte River, the Bear Creek fish will likely retain the name “greenback” cutthroat and the native fish to the South Platte.
- Some taxonomic confusion existed around the type specimens for *O.c. stomias*, but has been largely resolved with sleuthing of the historical records.
Bear Creek

- US Signal Corps – interested in constructing a observation post and weather station (1873)
- Determined best route to Pikes Peak was up Bear Creek drainage.
- Built trail along Bear Creek to the summit of Pikes Peak in August 1873 – longer but better
- 18 miles – two day trip
Bear Creek – Jones Park

- Joseph C. Jones homesteaded 160 ac in 1874
- Interested in establishing inn
- Rev. Roselle Cross – “Jones...strode back to the work of digging stones out of his fish pond” (1882).
- But where did his fish come from??
Bear Creek – where’s the fish?

• Most streams were barren of fish
  – Fountain Creek no trout until stocked in 1885 (CFC 1886)
  – Fountain/Ruxton only brook trout (Jordan 1889)
• No hatcheries at that time at state (1881) or federal (1889).
• Col. George De La Vergne (1879 CS Gazette-Telegraph)
• Dr. William Bell (Rocky Mtn News 1875)
• Only streams with trout were Beaver and Trout creeks
• But Trout Creek closest…..and in upper South Platte basin
Meristic Study - CSU

- Genetics may not be the sole factor in determining taxonomic distinctions.
- Morphological traits have been considered by courts to determine sub-species status.
- The objective of this study is to determine if cutthroat trout lineages identified by distinct genetic lineages possess unique phenotypic traits that are associated with each.
- Potentially useful in determining the validity for subspecies designation by the USFWS.
• Query core populations from three cutthroat GIS databases
• Randomly select three populations from each GMU
  – Require each have unique 8-digit HUC
  – 24 from first to characterize within population variation
  – 12 from remaining two for characterizing between population variation
Where do we go from here??
What Happens After Publication of Genetic and Meristic Studies?
Overview of ESA Evaluation Process of Recent Cutthroat Trout Research in Colorado

1. Evaluate Research
2. Evaluate Classification of Cutthroats (FWS)
3. Status Review (FWS)
4. Rulemaking, if necessary (FWS)

Genetic Study
Meristic Study
Step 1. Evaluate Research

Conduct a 3-day Workshop with genetic and taxonomic experts

- Peer review topics to be analyzed:
  1) Are conclusions reached by two studies logical and supported by evidence provided in reports?
  2) Is there agreement between the conclusion of the genetic study and the meristic study?
  3) Does the variation identified in the studies rise to the level of subspecies?
  4) How do conclusions in these studies compare with other cutthroat genetic and meristic studies?

- Closed session, but portion of workshop will provide opportunity for input from members of public
- Coordinated by FWS
- Estimated Timeframe: Spring 2013
Step 2. Evaluate Classification of Cutthroats

- Evaluate lineages and ranges of cutthroats identified in studies
- Include results of Workshop
- Consider recommendations of Recovery Teams (greenback, Co River, and Rio Grande)
- Conducted by FWS
Step 3. Status Review

• FWS evaluates whether threats occur to any “listable” entities
  – A. Present or threatened destruction, modification or curtailment of its habitat or range
  – B. Over-utilization for commercial, recreational, scientific purposes
  – C. Disease or predation
  – D. The inadequacy of existing regulatory mechanisms
  – E. Other natural or manmade factors affecting it continued existence

• FWS evaluates risk of extinction
  – Evaluate factors affecting populations trends
  – Evaluate vulnerability and resiliency of species (recruitment, survival, population levels)
  – Explore and document uncertainties
  – Estimate extinction likelihood within the foreseeable future
Step 3. Status Review (cont’d)
• Status review will evaluate all identified cutthroats in Colorado and determine which subspecies or Distinct Population Segments (DPS) warrant listing or change in listing status

Step 4. Rulemaking, if necessary
• The Service will conduct rulemaking (if necessary) to assign appropriate listing status to any species, subspecies, or DPSs that are determined to be warranted for listing.
• This action would include proposed and final rules, public input, peer review, etc.
• Note – current listing status will remain in place until rulemaking process is complete