Cutthroat Trout: Evolutionary Biology and Taxonomy

Special Publication 36

Trotter, Bisson, Schultz, and Roper

CUTTHROAT TROUT

EVOLUTIONARY BIOLOGY AND TAXONOMY

Special Publication 36

The Western Division AFS Panel on Cutthroat Trout Taxonomy
Patrick Trotter, Peter Bisson, Luke Schultz, and Brett Roper, editors

“It matters what you call a thing”

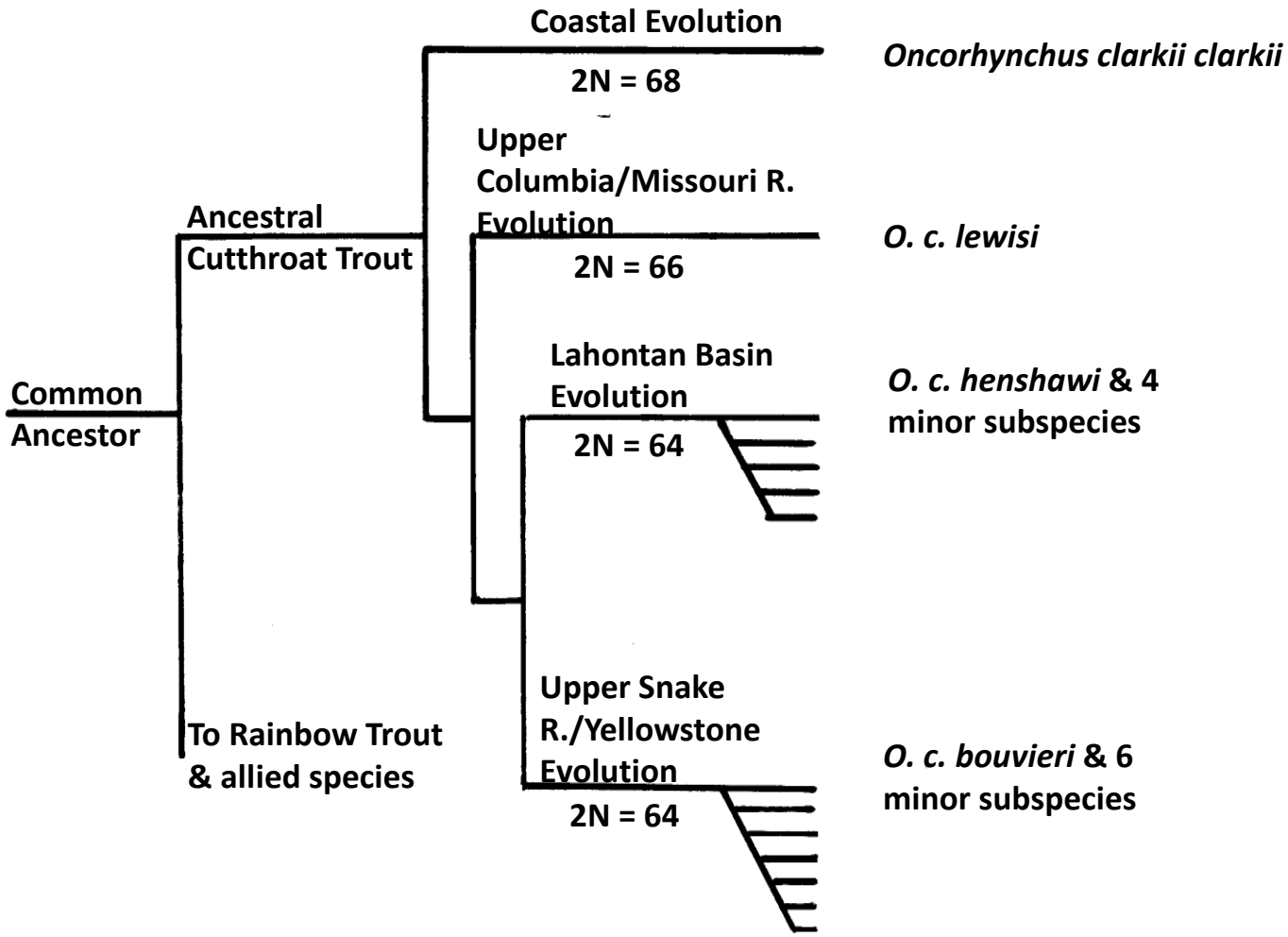
The poet, Solma Sharif

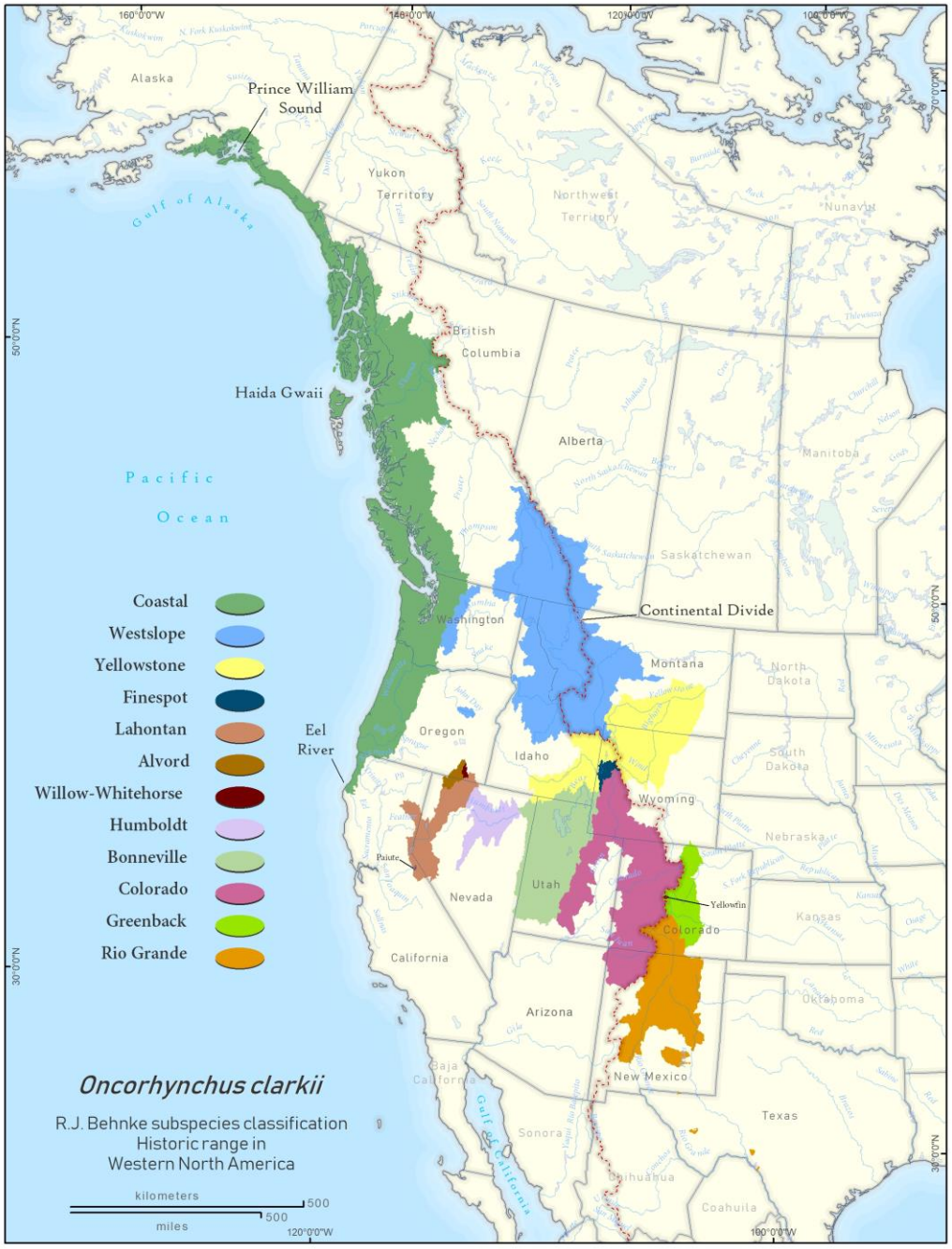
- Satisfies our curiosity & need for order
- Helps describe evolutionary classification
- Foundation for policy & legal considerations

Cutthroat Trout

Behnke (1979):

- Single species with 14 subspecies (12 extant, 2 extinct).
- Inland radiation via Columbia & Snake Rivers.
- Widespread across west.


Coastal Evolution
2N = 68
Oncorhynchus clarkii clarkii
Upper Columbia/Missouri R. Evolution
2N = 66
O. c. lewisi
Ancestral Cutthroat Trout
Lahontan Basin Evolution
2N = 64
O. c. henshawi & 4 minor subspecies
Common Ancestor
Upper Snake R./Yellowstone Evolution
2N = 64
O. c. bouvieri & 6 minor subspecies
To Rainbow Trout & allied species


Alaska
Prince William Sound
Gulf of Alaska
Yukon Territory
Northwest Territory
Nunavut
British Columbia
Haida Gwaii
Alberta
Manitoba
Saskatchewan
Pacific Ocean
Continental Divide
Washington
Montana
North Dakota
Oregon
Eel River
Idaho
South Dakota
Wyoming
Nebraska
Paiute
Utah
Nevada
Yellowfin
Kansas
Colorado
California
Oklahoma
Arizona
New Mexico
Texas
Baja California
Gulf of California
Sonora
Chihuahua
Coahuila
Coastal
Westslope
Yellowstone
Finespot
Lahontan
Alvord
Willow-Whitehorse
Humboldt
Bonneville
Colorado
Greenback
Rio Grande
Oncorhynchus clarkii
R.J. Behnke subspecies classification
Historic range in
Western North America
kilometers
500
500
miles
160°0'0"W
140°0'0"W
120°0'0"W
100°0'0"W
50°0'0"N
30°0'0"N

Greenback Cutthroat Trout

- Two specimen deposited 1856, origin given as 'South Platte, Fort Riley Kansas.'
- Described & named *Salmo stomias* by Cope 1871.
- Named 'Greenback' by Jordan 1889 for trout of South Platte & Arkansas river drainages.

Widespread Stocking and Fallout

- Widespread ‘Greenback’ stocking in response to declines.
- New DNA sequence-based tools reveal ‘Greenbacks’ are mostly Colorado R. Cutthroats or hybrids.
- *stomias* type specimens are really *virginalis.*
- Bear Creek population the only true Greenbacks.
- There appears to be more subspp. than Behnke recognized in southern Rockies.


Colorado R. Cutthroat


Bear Creek Greenback Cutthroat

Could the problem spread?

The Lahontan subspp. (lumped in 1995).

The Yellowstone subspp. (lumped in 2001).

WDAFS-A special panel for a special workshop

- Convene the experts.
- Examine all available systematics evidence.
- Describe Cutthroat Trout evolutionary history.
- Sort out its classification & revise its taxonomy as necessary.

Some Definitions

Systematics: The research on evolutionary differentiation that provides the evidence for…

Classification: Arranging the results of evolution in a hierarchical order.

Taxonomy: Application of classification principles to the naming of organisms in the hierarchical arrangement (ICZN).

Phylogeny: Term often used for the hierarchical arrangement.

The Experts

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Ralph Stearley
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Clarkston, WA

Tommy Williams
NOAA Fisheries

Michael K. Young
USDA Forest Service

The Available Evidence

- The fossil record.
- Geological & geographic changes over time.
- Historical distributions.
- Ecological niches.
- Morphometrics, meristic characters.
- Diagnostic allozymes, mtDNA RFLPs, microsatellites.
- Y chromosome markers.
- Diagnostic DNA sequence based markers.

Current Classification No Longer Scientifically Adequate

- Evolutionary species concept now favored over the biological species concept; changes criteria for assigning taxonomic rank.
- Fossil evidence of Cutthroat Trout in Lahontan Basin ~10 Ma; opens possibilities for interior radiation pathways not realized before.
- Molecular phylogenetics methods reveal greater differentiation in Cutthroat Trout than earlier methods could detect.
- Behnke's 'major' and 'minor' subspecies designations at odds with ICZN naming protocols.

What constitutes a species?

- As many as 26 species concepts published, each with its own delimiting criteria & restrictions.
- Behnke used the Biological Species Concept of Mayr (1969) but relaxed its prohibition against interbreeding.
- Special Workshop Panel used the Unified Species Concept of De Queiroz (2007), an evolutionary species concept with no prohibitions; uses a broad set of evidence to assess if lineages are evolving independently.

The Unified Species Concept

Species: A separately evolving metapopulation lineage. Here, lineage refers to an ancestor-descendent series…through time, and metapopulation refers to an inclusive population made up of connected subpopulations (de Queiroz 2007).

Species: A set of populations connected through time by inheritance, and across a circumscribed geographic range by episodic, periodic, or continuous gene flow (Love Stowell et al. 2018).

Delimiting criteria: Any property that provides evidence of lineage separation, i.e., that the lineages have evolved (or are evolving) independently.

Delimiting criteria: No one property rejects a lineage outright.

The null hypothesis (for each property tested): Lineages being tested are not significantly different based on samples from multiple individuals.

Subspecies, a useful taxonomic rank or not?

- Panel split 50-50 **!!**
- Allowed as a taxonomic rank under species in International Code of Zoological Nomenclature.
- Also allowed by the joint AFS/ASIH Names of Fishes Committee, but use discouraged in favor of common names.
- Rendered meaningless as a taxonomic rank by years of misuse—not aligned with real evolutionary entities.
- Compromise: call them Uniquely Identifiable Evolutionary Units (UIEUs) for now.

Delimiting Properties

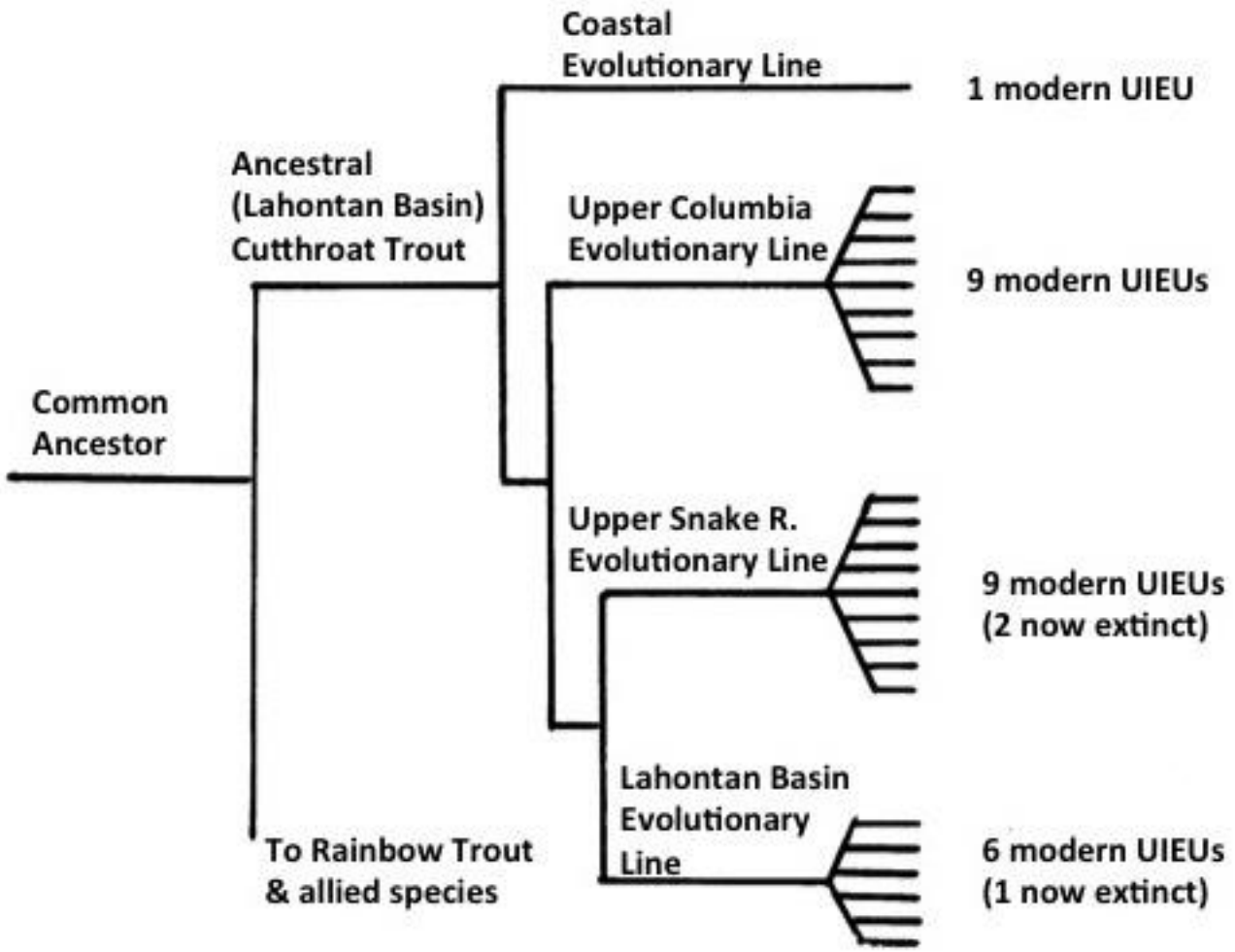
- The fossil record.
- Geological & geographic changes over time.
- Historical distributions.
- Ecological niches.
- Morphometrics, meristic characters.
- Diagnostic allozymes, mtDNA RFLPs, microsatellites.
- Y chromosome markers.
- Diagnostic DNA sequence based markers.

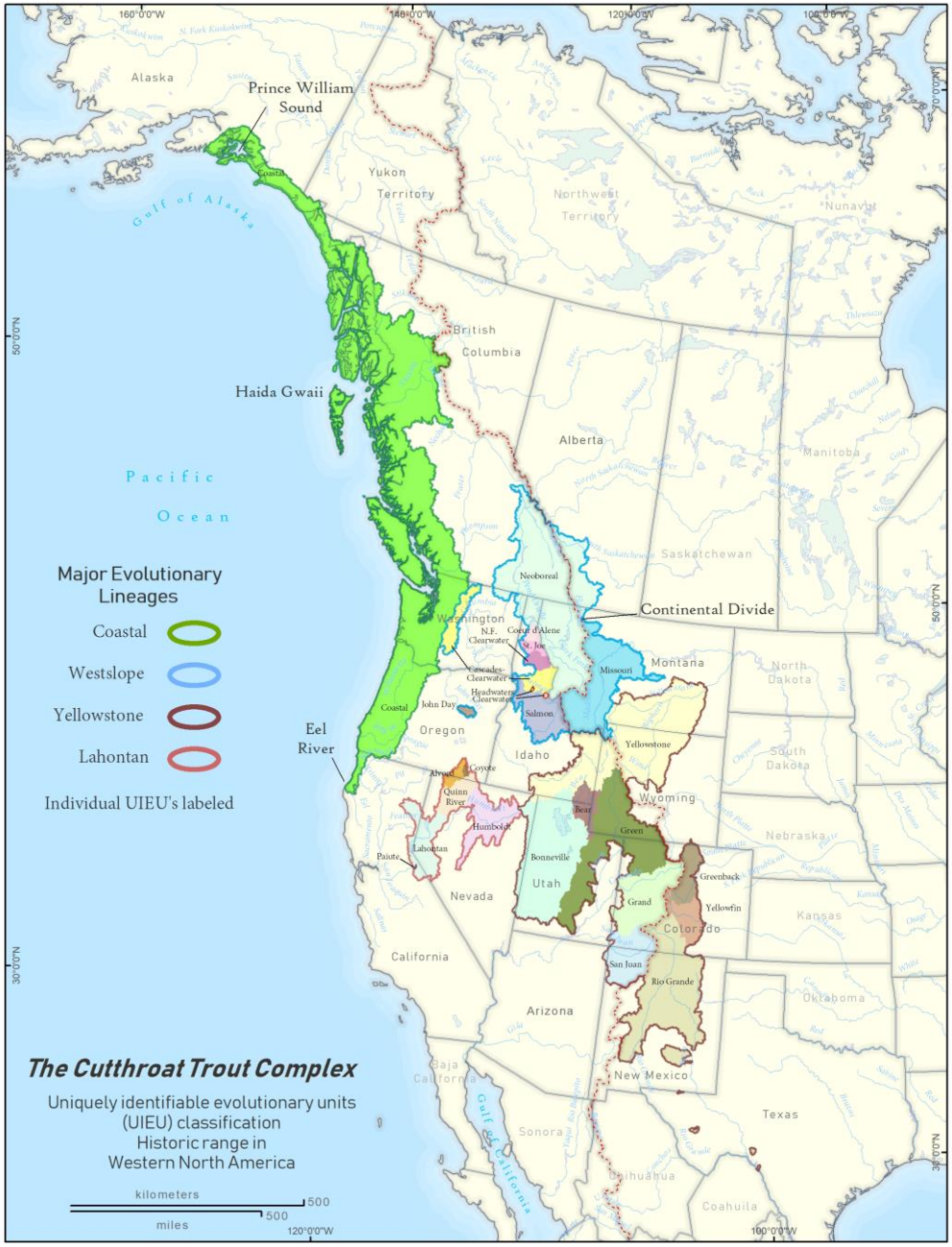
For Cutthroat Trout: Strong argument for 4 full species with 25 uniquely identifiable independently evolving subunits

Cutthroat Trout

WDAFS panel majority (2018):

- 4 species with 25 modern UIEUs (23 extant, ~~3~~ 2 extinct).
- Inland radiation from paleo-Lahontan basin via upper Columbia & upper Snake Rivers.


Coastal
Evolutionary Line
1 modern UIEU
Ancestral
(Lahontan Basin)
Cutthroat Trout
Upper Columbia
Evolutionary Line
9 modern UIEUs
Common
Ancestor
Upper Snake R.
Evolutionary Line
9 modern UIEUs
(2 now extinct)
Lahontan Basin
Evolutionary
Line
6 modern UIEUs
(1 now extinct)
To Rainbow Trout
& allied species


Prince William Sound
Alaska
Yukon Territory
Northwest Territory
Nunavut
Gulf of Alaska
British Columbia
Haida Gwaii
Alberta
Manitoba
Saskatchewan
Pacific Ocean
Major Evolutionary Lineages
Coastal
Westslope
Yellowstone
Lahontan
Individual UIEU's labeled
Neoboreal
Continental Divide
Washington
Coeur d'Alene
N.F. Clearwater
St. Joe
Cascades-Clearwater
Missouri
Montana
North Dakota
Headwaters Clearwater
John Day
Salmon
Coastal
Oregon
Eel River
Idaho
Yellowstone
South Dakota
Abrood
Coyote
Quinn River
Wyoming
Bear
Green
Humboldt
Nebraska
Lahontan
Paiute
Bonneville
Utah
Greenback
Nevada
Grand
Yellowfin
Kansas
Colorado
California
San Juan
Rio Grande
Oklahoma
Arizona
Baja California
New Mexico
Texas
Gulf of California
Sonora
Chihuahua
Coahuila
The Cutthroat Trout Complex
Uniquely identifiable evolutionary units (UIEU) classification
Historic range in Western North America
kilometers
500
miles
500
160°0'0"W
140°0'0"W
120°0'0"W
100°0'0"W
70°0'0"N
50°0'0"N
30°0'0"N
120°0'0"W
100°0'0"W

Coastal Evolutionary Lineage
Oncorhynchus clarkii, Coastal Cutthroat Trout

Lahontan Basin Evolutionary Lineage
Oncorhynchus henshawi, Lahontan Cutthroat Trout

Upper Columbia/Missouri Evolutionary Lineage
Oncorhynchus lewisi, Westslope Cutthroat Trout

Upper Snake/Yellowstone Evolutionary Lineage
Oncorhynchus virginalis, Rocky Mountain Cutthroat Trout

Evolutionary Biology & Taxonomy—Always a Work In Progress

Acceptance and recognition of the 4-species classification of Cutthroat Trout?

Formal decision on the ‘subspecies’ as a recognized taxonomic rank below species in Cutthroat Trout—a job for the joint AFS/ASIH committee?

Continue work on resolution of the finer points of Cutthroat Trout subunit systematics.

Collaborative exam of all 25 identifiable subunits in a common study with a common set of morphological and molecular markers.

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