

## BOOK REVIEW

**Cutthroat Trout: Evolutionary Biology and Taxonomy.** Edited by Patrick Trotter, Peter Bisson, Luke Schultz, and Brett Roper. American Fisheries Society, Special Publication 36, Bethesda, Maryland. 2018. 386 pages. US\$79 (\$55 for American Fisheries Society members) (paper).

Fishes in the freshwaters of the western United States are particularly challenging taxonomically. Tectonic activity over the past 15 million years has resulted in periods of geographic isolation of drainage basins (Flint 1971) and the fishes in them, followed by periods of reunification. The episodes of long-term isolation in many cases led to genetic differentiation among populations of fishes, and the reunification that followed led to mixing and hybridization of the previously isolated populations. The result in wide-ranging species and clades is typically a confusing amalgamation of genetic and morphological variation among populations that confounds the efforts of taxonomists to describe the diversity through the use of scientific names (Smith et al. 2010). Clear examples of this confusion today are Cutthroat Trout *Oncorhynchus clarkii*, Tui Chub *Siphateles bicolor*, Speckled Dace *Rhinichthys osculus*, and mountain suckers *Pantosteus*. Each of these taxa is wide ranging and highly variable, and each has a taxonomy that fails to represent the diversity.

Taxonomic treatments have profound scientific, management, and protection implications, and in the case of Cutthroat Trout are particularly important from a human perspective because Cutthroat Trout are prized sport fishes and because all 12 of the extant subspecies are listed as threatened under the U.S. Endangered Species Act or are considered candidates for listing by federal or state agencies.

*Cutthroat Trout: Evolutionary Biology and Taxonomy* is an end-product of discussions that began with a panel of experts at the annual meeting of the American Fisheries Society in August 2015. The panel reviewed the history of the taxonomy of Cutthroat Trout, which for the past 40 years has been based on the work of Robert J. Behnke (e.g., Behnke 2002), who considered populations of Cutthroat Trout to belong to one species with 14 subspecies (two of which are extinct). It seems that Behnke never explicitly explained his rationale for treating taxonomically recognizable populations as subspecies rather than as species, although we can assume that he preferred to emphasize the close relationships and similarities, rather than the differences, among the forms of Cutthroat Trout as a way of clearly separating them from other species of trout. However, the subspecies are highly variable morphologically,

and recent studies based on molecular data disagree with current taxonomy.

This book does a spectacular job of reviewing published and otherwise available information relevant to the diversity of Cutthroat Trout, including the fossil record, geological and ecological factors affecting diversification, morphological and genetic variation, and phylogenetic relationships. The authors and their collaborators also reviewed species concepts and delimitation criteria and debated the usefulness of subspecies as a taxonomic rank. They adopted the “unified species concept” (USC) of de Quieroz (2007) as the one by which variation among Cutthroat Trout should be assessed. The USC emphasizes temporal as well as spatial connectivity among populations, which appealed to the authors because

a key aspect of the existence of metapopulations is that movement of individuals among the populations maintains the integrity or cohesion of the species through time and across space. [page 35]

This point of view appears to be particularly relevant for Cutthroat Trout and other species in the freshwaters of the western United States.

After analyzing data—in particular phylogenetic inferences—the authors proposed a new classification that recognizes four major evolutionary lineages as species: the Coastal Cutthroat Trout *Oncorhynchus clarkii*; the Lahontan Basin Cutthroat Trout *O. henshawi*; the Westslope Cutthroat Trout *O. lewisi* in the upper Columbia and Missouri rivers; and the Rocky Mountain Cutthroat Trout *O. virginialis* in the upper Snake and Yellowstone rivers. Within these four species, 25 “uniquely identifiable evolutionary units,” some with valid names available, also were recognized.

This new classification was described in detail by Markle (2018:181–197) as an “interim classification” to emphasize the fact that all classifications are hypotheses and subject to revision as new data become available. Markle noted that analyses have consistently identified four major lineages, which Behnke had treated as “major subspecies.” In addition to recognizing four lineages as species, the proposed classification continues to recognize Behnke’s “minor subspecies” as subspecies.

Although the consensus of the authors, panelists, and collaborators (listed near the front of the book) was a classification that included species, subspecies, and other “uniquely identifiable evolutionary units,” some argued for abandonment of the recognition of subspecies (e.g., Love Stowell et al. 2018:33–51). In contrast, others felt that retaining formal

names for some subpopulations of species would emphasize diversity relevant to management and conservation.

Edited books often fail to meet their goal, in part because of large variation among chapters in writing style and content. This one is an exception. It is clearly written from beginning to end and covers the large and interesting variation in Cutthroat Trout extremely well. This a major landmark in the study of one of North America's most spectacular and important fishes, as well as an excellent review of the often-difficult process that taxonomists face in trying to accurately express the diversity of nature within the constraints of human language. The authors acknowledged that the entire Cutthroat Trout complex needs taxonomic revision. This book will almost certainly stimulate more research on Cutthroat Trout. Let's hope that happens soon—and that this book and the research it stimulates lead to revisions of other confusing western North American freshwater fishes.

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## REFERENCES

- Behnke, R. J. 2002. Trout and salmon of North America. Free Press, New York.
- de Quieroz, K. 2007. Species concepts and species delimitation. *Systematic Biology* 56:879–886.
- Flint, R. F. 1971. Glacial and quaternary geology. Wiley, New York.
- Love Stowell, S. M., J. L. Metcalf, D. F. Markle, and A. P. Martin. 2018. Species conceptualization and delimitation: a framework for the taxonomic revision of Cutthroat Trout. Pages 33–51 in P. Trotter, P. Bisson, L. Schultz, and B. Roper, editors. Cutthroat Trout: evolutionary biology and taxonomy. American Fisheries Society, Special Publication 36, Bethesda, Maryland.
- Markle, D. F. 2018. An interim classification of the Cutthroat Trout complex, *Oncorhynchus clarkii* sensu Lato, with comments on nomenclature. Pages 181–197 in P. Trotter, P. Bisson, L. Schultz, and B. Roper, editors. Cutthroat Trout: evolutionary biology and taxonomy. American Fisheries Society, Special Publication 36, Bethesda, Maryland.
- Smith, G. R., C. Badgley, T. P. Eiting, and P. S. Larson. 2010. Species diversity gradients in relation to geological history in North American freshwater fishes. *Evolutionary Ecology Research* 12:693–726.