Cutthroat Trout Management: A Position Paper

Genetic Considerations Associated with Cutthroat Trout Management

photo by Dale Hepworth, UDWR

December 29, 2000

Developed by:

Colorado Division of Wildlife
Idaho Department of Fish and Game
Montana Fish, Wildlife and Parks
Nevada Division of Wildlife
New Mexico Game and Fish
Utah Division of Wildlife Resources
Wyoming Game and Fish Department

Publication Number 00-26
Utah Division of Wildlife Resources
1594 W. North Temple
Salt Lake City, Utah
John Kimball, Director

ACKNOWLEDGEMENTS

The development of this position paper is the direct result of an Inland Cutthroat Trout Meeting organized by the Utah Division of Wildlife Resources and held in Salt Lake City on February 23-24, 2000. The purpose of this meeting was to discuss issues associated with the genetic management of inland cutthroat trout populations as they relate to conservation and recovery of these subspecies. The Utah Division of Wildlife Resources would like to acknowledge the specific individuals who participated in this important meeting that led to the development of this position paper:

Idaho Department of Fish and Game
Virgil Moore
Steve Yundt
Will Reid

Montana Fish, Wildlife and Parks
Larry Peterman
Ken McDonald

Nevada Division of Wildlife
Gene Weller

New Mexico Game and Fish
Yvette Paroz
David Cowley (EnviroStat)

Utah Division of Wildlife Resources
Randy Radant
Tom Pettengill
Michael Hudson

Wyoming Game and Fish Department
Ron Remmick
John Kiefling

U.S. Fish and Wildlife Service
Chuck Davis
Janet Mizzi
Yvette Converse

U.S. Forest Service
Bruce May
Dan Duffield

Invited Technical Experts
Don Campton, USFWS
Robb Leary, University of Montana
Anna Toline, Conservation Associates
Dennis Shiozawa, Brigham Young University

Other
Leo Lentsch, Conservation Associates

In addition, an Interstate Cutthroat Trout Technical Committe was established to develop the specific genetic criteria required to identify conservation populations. These criteria have been included as part of this position paper. Members of this committee included:

Tom Nesler, Colorado Division of Wildlife
Mark Gamblin, Idaho Department of Fish and Game
Ken McDonald, Montana Fish, Wildlife and Parks
Anita Cook, Nevada Division of Wildlife
David Cowley, EnviroStat/New Mexico Game and Fish
Michael Hudson, Utah Division of Wildlife Resources
Ron Remmick, Wyoming Game and Fish Department

TABLE OF CONTENTS

LIST OF FIGURES

Cutthroat Trout Management: A Position Paper
Genetic Considerations Associated with Cutthroat Trout Management

Introduction

A common challenge associated with modern management of all inland cutthroat trout is dealing with contamination of the native gene pool through introgression with introduced non-native trout, specifically rainbow trout and cutthroat trout stocked in habitats outside of their historic ranges. With the advent of the Endangered Species Act (ESA) and a heightened awareness that native fish biodiversity provides a valued component to the fishery resources, fishery managers in the western states are faced with the challenge of conserving native cutthroat trout and at the same time providing for the growing sport fishery demands of a public that wants to enjoy fishing for both native and non-native trout.

Introductions of non-native trout into environments that historically supported cutthroat trout as the only native salmonid, began in the late 1800's with the efforts of the US Fish Commission. Under the direction of the Commission, hatcheries were constructed and a delivery system was organized around the newly completed railway system. These non-native introductions were conducted in response to dramatic declines in native trout populations and pressure exerted by the citizenry for an improved fishery. Conventional wisdom at the time focused on introductions of many different non-native trout to fill the voids created from overexploitation and habitat degradation. The early views on fishery management also included consideration, as evidenced by the following quote, that introgression was a beneficial result of trout introductions.

> *``The mountain trout is a native of the rocky mountain region, and by many sportsmen is considered the chief of his tribe, for both food and qualities of gameness. In habits this most popular fish differs little, if any, from the rainbow, as they spawn during the same month of the year and seek the headwaters for that purpose. These two varieties cross very readily, so that it is difficult now to find these distinct species, except at the hatchery, where, of course, they are kept carefully separated for breeding. It has become a well known fact to all students of fish life and culture, that crossing is beneficial. The same effect is produced as in the human and animal kingdoms, where it is now fully understood that interbreeding [tr., inbreeding] begets a stunted and less vigorous progeny. Before the introduction of the rainbow and mountain trout from other waters into the New Mexico streams it was a rare catch that landed a trout that exceeded four pounds in weight; the constant interbreeding [tr., inbreeding] had tended to decrease the size, but with the introduction of trout from streams in other sections there has been a decided and very noticeable change in the size and condition of these fishes in our waters. The interbreeding of the rainbow and mountain trout has had the same effect."* (p. 33, Thomas P. Gable. 1912. First Report of Game and Fish Warden of New Mexico, 1909-1910-1911. New Mexico Printing Office, Santa Fe).

As a responsibility identified by state statute, the various state fish and wildlife management agencies continue to balance the demands of native trout conservation and sport fishery management. Preservation of the native cutthroat trout genome and conservation of the traits and characteristics that make cutthroat trout such a unique fish are essential components of this overall fishery management responsibility. This document is primarily focused on the important aspects of cutthroat trout management dealing with preservation of the native cutthroat trout genome and conservation of populations that exhibit the unique genetic, ecological and behavioral attributes associated with native cutthroat trout. The components of this position paper represent a consensus of opinion of the various state fishery management agencies that

attended a special meeting held in Salt Lake City during February, 2000. States represented were Idaho, Montana, Nevada, New Mexico, Utah and Wyoming. Colorado had planned to attend but last minute travel restrictions prevented attendance. The intent of the meeting and this position paper is to develop a greater level of understanding associated with preservation and conservation of the unique genetic attributes of native cutthroat trout and to implement a more unified management approach associated with genetic considerations of cutthroat trout management.

The approaches and management direction contained in this position paper should be readily applicable to all inland cutthroat trout, including those already listed under ESA. The states that participated in the development of this position paper encourage the US Fish and Wildlife Service and the other states involved in cutthroat trout management to adopt the findings contained in the paper.

Cutthroat Trout Management Categories

Management of cutthroat trout must include consideration of the genetic conditions and characteristics that contribute to the maintenance of the attributes that make cutthroat trout a unique fish and a valued component of the fish community. This is particularly true for efforts to ensure the long-term preservation of the various cutthroat trout subspecies and their unique genotypes. Of equal importance is the conservation of ecological and behavioral traits specific to the various populations. Consideration of genetics will likely become more important and pertinent with continued efforts to understand the importance of many ecological and behavioral adaptations expressed by the various cutthroat trout populations.

Management of cutthroat trout is composed of two distinct but equally important components that must be addressed in a concise and coordinated manner. These components include the conservation element and the sport fishery or recreational fishery element of cutthroat trout management. In total, actions and activities undertaken in both areas define cutthroat trout management. Use of these discrete categories will facilitate development of specific management approaches for the various cutthroat trout populations. These elements of management and conservation are portrayed in Figure 1.

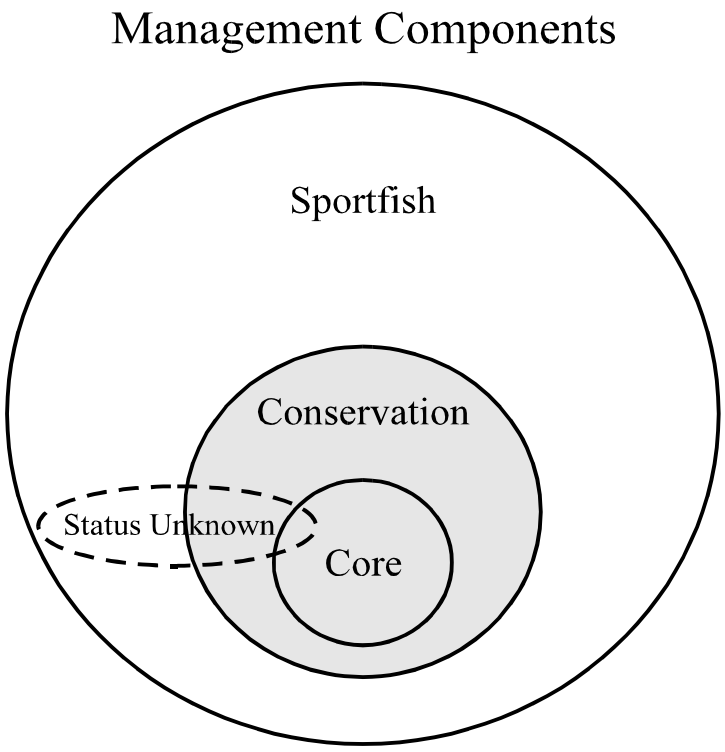

Figure 1. Representation of population management designations for inland cutthroat trout subspecies.

The intent of the management components diagram (Figure 1) is not to completely isolate the management elements from one another. It is recognized that all known cutthroat trout populations are considered under this management diagram. This includes those managed primarily for sport fishery purposes and those managed under a conservation focus. It is also recognized that all cutthroat trout populations are considered to have value under this management approach. The intent of cutthroat trout management is to develop conditions under which all populations can potentially provide benefits to the public (e.g. angling and /or viewing). It is probable that certain populations originally identified under cutthroat trout sportfish management may be targeted for conversion to conservation populations.

Cutthroat Trout Conservation Management Components

As identified in the management components diagram (Figure 1), there are two components associated with conservation of cutthroat trout. The first component (core conservation populations) addresses preservation and management of genetically pure populations that serve as representatives of the historic genome of a cutthroat trout subspecies (e.g. there has been no detectable introgression between individuals of different species and/or subspecies). The other component (conservation populations) is associated with conservation of populations that retain the respective cutthroat trout phenotype, that have slight genetic introgression and have unique genetic, ecological or behavioral attributes.

Preservation of Historic Genome

The primary management goal for core conservation populations is to facilitate long term persistence of each subspecies in a genetically pure condition. These populations are composed of individuals that have been determined to be >99% pure, from a genetic standpoint (i.e. no detectable introgression), and phenotypically true. These core conservation populations represent cutthroat trout that have not been impacted by genetic alteration linked to human intervention and they serve as the core of the cutthroat trout management effort.

Core conservation populations will serve as the primary source of gametes for introductions and re-introductions through transplants and brood stock development. Care should be taken to utilize only those populations that exhibit desirable population characteristics (e.g. large population size, full representation of age classes and successful annual reproduction) for range expansion. Identification of core conservation populations will require complete genetic analysis (as defined in this document) to validate genetic purity. As a matter of consistency and genetic preservation, core conservation populations should not be targeted to receive genetic material from other population sources unless there is evidence that inbreeding depression, random genetic drift or other factors have put the population in jeopardy. For many cutthroat trout subspecies, it may be beneficial to replicate these populations as a means of preserving the genetic diversity of the subspecies.

Potential management actions related to the conservation and preservation of core conservation populations include, but are not necessarily limited to the following: 1. Prevention of all non-native fish stocking having the potential to impact these populations; 2. Managing sport fishing and harvest; 3. Removal of and protection from non-native competitors; 4. Habitat restoration and enhancement; 5. Removal of gametes and individuals for genetic founders in range expansion efforts; and, 6. Collection of gametes for brood stock development.

Long-term persistence of core conservation populations will be enhanced by the development of metapopulations. Habitat quality is a critical component that contributes to the overall well-being of these populations. It is imperative that habitat conditions be optimized to allow the respective populations the opportunity to express the desired population characteristics.

For most core conservation populations, it would be beneficial to develop population specific conservation plans that address the specific actions necessary to protect and maintain the population. These population specific conservation plans would be considered to be a part of the overall conservation strategy for the subspecies.

Conservation of Unique Genetic, Ecological, and Behavioral Characteristics

The primary management goal for conservation populations is to preserve and conserve unique ecological and behaviorial characteristics of the subspecies that exist on a population by population basis. These populations retain all of the phenotypic attributes associated with the subspecies, though they exist in a slightly introgressed condition. In general, these populations have less than 10% introgression, but introgression may extend to a greater amount depending upon circumstances and the values and attributes to be preserved.

The unique ecological, genetic and behavioral attributes of significance include but are not limited to: 1. Behavioral characteristics demonstrated by fluvial or adfluvial life histories; 2. Genetic predisposition for large size; and, 3. Ecological adaptation to extreme environmental conditions. There is a high probability that certain ecological and behavioral attributes are genetically linked to some degree. Conservation and protection of the desired attributes will likely require a fairly detailed understanding of the genetic make up of these populations.

Conservation populations include situations where genetically pure individuals co-exist with introgressed individuals or they occur as hybrid swarms. As a matter of consistency and genetic preservation, these populations should not be targeted to receive genetic material from other population sources unless there is evidence that the unique population attribute can be protected and maintained.

Potential management actions related to the conservation and preservation of conservation populations would be the same as items 1- 4 for core conservation populations. In addition, these populations may be considered as sources for introductions or re-introductions if the objective is to duplicate the unique ecological, genetic or behavioral attribute. These populations should not be used to develop a brood stock for subspecies preservation purposes but they may contribute to maintenance of a recreational or sport fishery hatchery brood. However, in situations where a pure component exists within an introgressed population, the pure component may be used in brood stock development or as population founders after a complete genetic evaluation is completed.

As with the core conservation populations, long-term persistence of conservation populations will be enhanced by the development of metapopulations. Habitat quality is a critical component that contributes to the overall well-being of these populations. It is imperative that habitat conditions be optimized to allow the respective populations the opportunity to express the desired population characteristics.

Conservation populations may be targeted for conversion to core conservation population status by eradication and reintroduction or genetic replacement.

Cutthroat Trout Sport Fishery Management Component

The primary management focus of cutthroat trout sport fish populations is on the recreation benefits to the public. These populations, at a minimum, meet the species phenotypic expression defined by morphological and meristic characters of cutthroat trout. Further genetic analysis may be warranted if the population is to receive consideration for conservation management.

Cutthroat trout sport fishery populations may be maintained as wild or hatchery assisted populations and in some situations these populations would be associated with maximizing recreational opportunity. Potential management actions and requirements would be linked to those needed to meet the specific recreational objectives.

These populations also exist in a wide array of habitat conditions that include isolated headwater stream reaches, larger riverine environments and larger lakes and reservoirs. Due to the fact that cutthroat fisheries can be overfished, angling and harvest regulations should consider the

potential of over utilitzation of cutthroat trout. It is important that habitat for wild and certain hatchery assisted populations be optimized to allow the respective populations the opportunity to express desired population characteristics suitable to meet the sport fishery objectives.

Quantifying Introgression

An Ad-hoc Intercross Technical Committee was put together for the purpose of addressing issues regarding a unified approach to quantifying introgression. This committee has made recommendations that were adopted by all the states involved in regards to 1) the numerical formula to quantify the degree of introgression present in a population, 2) the genetic analysis techniques that are appropriate for quantifying the degree of introgression present in a population, and 3) the sample size that is appropriate to ensure an accurate estimate of the degree of introgression present in a population. This standardized approach among the states is indicative of the commitment that exists to conserve the native inland cutthroat trout subspecies.

Introgression formula

The following formula will be used to quantify the degree of introgression present in a population:

$$\% \text{ introgression} = \frac{\text{(Total number of nonnative alleles in sample)}}{\text{(total number of alleles per individual)X(total number of individuals)}} \times 100$$

This formula will aid in providing uniformity among the states in reporting the degree of introgression present in a population. Any analysis that is done beyond this and is scientifically sound is left to the discretion of the respective state.

Genetic Analysis Techniques

The use of both allozymes and nuclear DNA analyses (e.g., microsatellites, RAPDs, PINEs) will be accepted at this time. However, all markers used, must be diagnostic for the nonnative species/subspecies for which introgression is being tested.

While the use of allozymes may be adequate for quantifying interspecific introgression, it is understood that the application of this technique for quantifying intraspecific introgression is limited. Thus, as the database for available DNA markers increases, the standardized use of these markers with specific subspecies of inland cutthroat trout may increase.

Genetic Sample Size

A genetic sample size of at least 460 (genetic sample Size = # of individuals x # of diagnostic markers x # of diagnostic alleles per locus) will be required to quantify the degree of interspecific hybridization within 1% for core conservation populations with 99% confidence. For example, if there are eight markers and two alleles per locus being used for molecular analysis, then a sample size of at least 29 individuals will be required to provide 99% confidence that the population is within 1% of the determined level of interspecific hybridization. A genetic sample size of at least 230 will be required to quantify the degree of interspecific hybridization within 1% for conservation populations with 90% confidence. In situations where allozyme analysis is required, consideration will be given to the long-term health of the population. If collection of a full sample may jeopardize a population, the full sample may be collected over two or more years. There will be no stipulation on the genetic sample size required to quantify levels of intraspecific hybridization at this time. However, the markers must be diagnostic and development of additional markers diagnostic among subspecies must continue. The development of nuclear DNA markers is strongly encouraged to allow for non-lethal sampling of populations.

Definitions

Brood Stock - A captive or wild population established for the collection of gametes to provide individuals for augmenting populations.

Conservation Population - A reproducing and recruiting population of native cutthroat trout that is managed to preserve the historical genome and/or unique genetic, ecological, and/or behavioral characteristics within specific populations and within geographic units. Populations should be further defined by quantifying introgression as outlined in this position paper. In general, a conservation population is at least 90% cutthroat trout, but may be lower depending on circumstances. Designation of conservation populations and the protections afforded them will be determined through basin analysis individually by the states responsible for their management.

Core Conservation Population - A conservation population that is >99% pure and represents the historic genome of the native cutthroat trout.

Eradication - The intentional removal of a population from a waterbody through mechanical, chemical or other means to provide for reintroduction of a native cutthroat trout population.

Genetic Replacement - The augmentation of an introgressed population with offspring from the pure component of that population or another population that represents the historic genome of the native cutthroat trout. This action provides for a ``flooding" of the population gene pool with native cutthroat trout genes, resulting in an overall decrease in nonnative genes.

Genetic Sample Size - # of individuals x # of diagnostic markers x # of diagnostic alleles per locus.

Introduction - Release of cutthroat trout into historically unoccupied sites for promoting conservation or sportfishing purposes.

Introgression - Reproduction between native cutthroat trout and other salmonids, commonly rainbow trout or other nonnative cutthroat trout subspecies. Varying degrees of introgression occur among populations; hence some introgressed populations may offer genetic, ecological, or behavioral value to native cutthroat trout conservation efforts.

Metapopulation - A collection of localized populations that are geographically distinct yet are genetically interconnected through natural movement of individuals among conservation populations.

Population - Any waterbody in which cutthroat trout have been found. Populations are geographically distinct. For example, tributaries of a stream are considered separate populations and may constitute a metapopulation.

Reintroduction - Release of cutthroat trout into historically occupied sites for the purpose of reestablishing populations.

Sportfish Population - A population of cutthroat trout that is managed to provide sportfishing opportunities and with the intention of meeting a public recreational demand. These populations are maintained in addition to conservation populations and may be managed in concert with other sportfish objectives.

Transplant - Removal of cutthroat trout individuals from a naturally occurring population and subsequent release of individuals into other waterbodies.

References

Allendorf, F.W. and P. Spruell. 1999. Genetics, wild trout, whirling desease: first do no harm. In. Whirling Disease Symposium, Univ. of Montana. pp. 1-3.

Allendorf, F.W. and R.F. Leary. 1988. Conservation and distribution of genetic variation in a polytypic species: the cutthroat trout. Conservation Biologgy 2:170-184.

Allendorf, F.W. and R.F. Leary. 1986. Heterozygosity and fitness in natural populations of animals. p. 57-76 In: M.E. Soule, editor. Conservation biology: the science of scarcity and diversity. Sinauer Assoc., Sunderland.

Allendorf, F.W. and N. Ryman. p 141-159 In: N. Ryman and F. Utter, editors. Genetics and Fishery Management. Univ. Washington Press, Seattle, Washington.

Cowley, D. 2000. Management Classification of Intercrossed Populations of Native Sport Fish Species in New Mexico. New Mexico Department of Game and Fish.

Fisher, R.A. 1930. The general theory of natural selection. Oxford University Press. Oxford.

Griffith, B., J.M. Scott, J.W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477-480.

Leary, R.F., F.W. Allendorf and S.H. Forbes. 1993. Conservation genetics of bull trout in the Columbia and Klamath River Drainages. Conservatiion Biology. 7:856-865.

Meffe, G.K. 1992. Techno-arrogance and halfway technologies - salmon hatcheries on the Pacific coast of North America. Conservation Biology. 6:350-354.

Nei, M. 1975. Molecular population genetics and evolution. Mmerican Elsevier, New York.

Phillipp, D.P. and J.E. Clausen. 1995. Fitness and performance differences between two stocks of largemouth bass from different river drainages within Illinois. Am. Fish. Soc. Sym. 15: 236-243.

Price, D.J. 1985. Genetics of susceptibility and resistance to disease in fish. Journal of Fish Biology 26:509-520.

Scudder, G.G.E. 1989. The adaptive significance of marginal populations: a general perspective. In: C.D. Levings, L.B. Holtby, and M.A. Henderson, editors, pp. 180-185. Proceeding of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Canadian Special Publication of Fisheries and Aquatic Sciences. 105pp.

Winter, B.D. and R.M. Hughes. 1997. Biodiversity position statement - corrected version. Fisheries 22: 16-23.

Wright, S. 1932. The roles of mutation, inbreeding, crossbreeding, and selection in evolution. Proc. of the Sixth International Congress of Genetics 1: 356-366.]