Probable Rediscovery of the Original Pyramid Lake Cutthroat Trout

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Abstract: The circumstantial evidence is convincing that a population of cutthroat trout, inhabiting an unnamed stream in the Pilot Peak Range of Utah-Nevada, represents the original Pyramid Lake genotype of S. c. henshawi. This has considerable significance in regards to propagation, since the world record cutthroat trout is of this unique genotype.

Salmo clarki henshawi, the cutthroat trout native to the Lahontan basin of Nevada and California, evolved in pluvial Lake Lahontan, a late Pleistocene lake, comparable in size to present day Lake Erie.

As the only large predator among several potential cyprinid and catostomid forage species, the selective pressures determining the evolutionary divergence of S. c. henshawi, resulted in, perhaps, the largest and most highly predaceous trout native to western North America (Behnke and Zarn 1976). Only the population of Pyramid Lake, Nevada, continued to exist with the full array of the Lahontan basin fish fauna, after the final desiccation of Lake Lahontan about 8,000 years ago. After the final desiccation of Lake Lahontan, S. c. henshawi stocks persisting in streams of the Lahontan basin evidently were ill adapted by virtue of an evolutionary heritage as a large, lacustrine predator and rapidly disappeared after non-native trouts were introduced. Only a few, small, headwater streams isolated by barrier falls still contain S. c. henshawi and two

native lacustrine populations still exist in Independence Lake, California and in Summit Lake, Nevada. Although "S. c. henshawi" has been propagated in large numbers since the 1950's, the bulk of hatchery produced Lahontan cutthroat trout are derived from Heenan Lake, California, from a stock originating from the Carson River, but which is slightly hybridized with rainbow trout (Behnke and Zarn 1976). The taxon S. c. henshawi was formerly recognized as an endangered species under the 1973 Endangered Species Act, but its status was changed to "threatened" in 1976 to facilitate management and to allow angling.

The uniqueness of the Pyramid Lake population lies in the fact that this stock persisted in a continuous lake environment for several thousands of years (50,000-100,000 years). Pyramid Lake is the only lake in the Lahontan basin that has maintained a direct continuity from pluvial Lake Lahontan. The evolutionary programming associated with a continuous environment endowed the native trout of Pyramid Lake with specialized adaptive features reflected in their behavior and physiology to maximize efficiency of energy conversion and utilization of the entire environmental resources.

The evolutionary selective factors acting to specialize the Pyramid Lake cutthroat trout for the large lake environment and to feed on the abundant schools of forage fish (which attain lengths of 15-18 inches) were responsible for making this fish the largest trout native to western North America. The official world record cutthroat trout, taken from Pyramid Lake, weighed 18.6 kg (41 lbs), but it is a common belief among the older Pauite Indians around Pyramid Lake that much larger trout were once regularly caught by the Indian fishermen.

Wheeler (1969) reported a trout of 28.2 kg (62 lbs) taken in 1916 in the Indian fishery. Sumner (1940), observing the final spawning run of cutthroat trout from Pyramid Lake in 1938, recorded the average weight of the trout in the run to be 9.1 kg (20 lbs). Since 1955 millions of S. c. henshawi of Heenan Lake origin and in more recent years, supplemented by the offspring of Summit Lake trout, have been stocked into Pyramid Lake to support a trophy fishery, but relatively few specimens in excess of 9.1 kg (20 lbs) have been taken in the last 20 years.

The demise of the original Pyramid Lake trout began in 1906 with the closure of Derby Dam, part of the Bureau of Reclamation's Newlands irrigation project. This dam blocked the Truckee River, the only spawning stream tributary to Pyramid Lake, about 30 miles above the lake. In the 1920's more and more of the Truckee River was diverted at the dam and complete dewatering frequently occurred. Successful spawning became sporadic with the last known run leaving the lake during the high water year of 1938. No water was available in subsequent years and the unique Pyramid Lake genotype of this magnificent trout was believed extinct. The presumed extinction of the original Pyramid Lake cutthroat trout population with the loss of such a unique genetic resource has been cited by Trojnar and Behnke (1974) and Behnke and Zarn (1976) to illustrate the practical values of preserving genetic diversity within a species or subspecies.

Millions of eggs from Pyramid Lake cutthroat trout were taken by the Nevada Fish Commission and later by the U.S. Bureau of Fisheries during a period from about 1885 to 1930 (Behnke 1971). There is the possibility that an introduction of the original Pyramid Lake cutthroat may have persisted in some remote, unknown waters, and its discovery would again offer the opportunity to utilize this genotype in modern fisheries management.

We believe that an unusual cutthroat trout population discovered in a small stream on Pilot Peak, Nevada-Utah, in 1977, does represent an introduced population of S. c. henshawi of Pyramid Lake origin.

Pilot Peak lies at the western edge of the Bonneville salt flats on the Utah-Nevada border, north of the city of Wendover. Its maximum elevation is 3513 m (10,716 ft). Two perennial streams drain its eastern slopes, Bettridge Creek and an unnamed stream in Morrison Canyon called Donner Creek by Hickman and Duff (1978). The name was suggested by neighboring Donner Springs, the first source of freshwater found by the ill-fated Donner party in 1846 after crossing the searing desert floor of the Bonneville basin.

Donner Creek is the water supply for the city of Wendover and is diverted at about 5900 ft. elevation. Above the diversion point, Donner Creek is perennial for about 3.2 km (2 mi), with about half of this length in Nevada and half in Utah.

The first report of an unusual type of cutthroat trout in Donner Creek was by personnel of the Utah Division of Wildlife Resources during a BLM-UDWR cooperative survey of the Pilot Peak area in April, 1977.

The senior author, assisted by Mr. Donald Duff, BLM Utah State Fisheries Biologist, collected 17 specimens from Donner Creek in June and August, 1977 as part of a BLM funded research project on the native trout of the Bonneville basin (Hickman 1978a).

Although Pilot Peak is in the Bonneville basin, the trout of Donner Creek are Lahontan cutthroat trout, S. c. henshawi, not the S. c. utah, the native trout of the Bonneville basin, and thus they are obviously introduced.

Fortunately, S. c. henshawi, is the most conspicuously differentiated subspecies of Salmo clarki. Three characters, in particular, allow for positive identification of this subspecies: The more-or-less uniform distribution of moderately large, roundish spots over the sides of the body and onto the ventral surface; the high number of gillrakers (21-28 with modal and mean values typically 23-25 vs. typically 17-21 in other subspecies); and the high number of pyloric caeca (typically 45-80 in henshawi vs. 25-50 in other subspecies).

The typical henshawi spotting pattern is apparent on the Donner Creek cutthroat trout specimens. The gillraker counts on 17 specimens ranges from 24-29 with a mean of 26.1. The number of pyloric caeca ranges from 57-77 with a mean of 66.0. The gillraker count is higher than that of any known sample of S. c. henshawi. Snyder (1917) reported gillraker counts of 22-27 (23.6) for 45 Pyramid Lake cutthroat trout from the Truckee River. It is possible that there is a direct environmental (non-genetic) component which increases the gillraker number in the present population in Donner Creek by about 10% above the assumed source stock, but we believe the largest part of the increased number of gillrakers is due to the "founder's principle", whereby a new population is started from a few individuals and these individuals carry skewed values toward one extreme or the other, rather than modal values in some characters such as gillraker number. Evidently, this has occurred in a subgroup of the Bonneville cutthroat trout, native to the Snake Valley region. The parent population in Pine Creek, Nevada, averages 22 gillrakers, a population introduced into Hampton Creek averages 21 and a population in Goshute Creek averages 20 (Wernsman 1973), or about a 10% change between the Pine Creek parent

population and a population derived from a few individuals transplanted from Pine Creek into Goshute Creek.

Although there is no possible method of taxonomic comparison to verify Pyramid Lake as the source of the Donner Creek population of S. c. henshawi, the circumstantial evidence is convincing that the original introduction was made from eggs collected from S. c. henshawi of Pyramid Lake.

The city of Wendover is partly in Nevada and partly in Utah. Evidently, many years ago a Nevada resident from the Wendover area had a shipment of trout sent to him by the Nevada Fish Commission and some were stocked into Donner Creek, which, at the time, was barren of fish. Many small streams, similar to Donner Creek, in the Lahontan and Bonneville basin were barren of fish in historical times. This is due to the steep gradient of the watersheds making the small streams vulnerable to scouring and elimination of fish life from catastrophic floods. The above mentioned Hampton Creek and Goshute Creek are examples where the introduced rainbow trout populations were eliminated by floods about 1950, thereby providing the opportunity to introduce the rare Bonneville cutthroat trout and establish new populations (Hickman 1978b).

If the person who originally introduced trout into Donner Creek obtained the stock from the nearest natural source, he would have introduced the Bonneville cutthroat trout, S. c. utah (assuming the time period was sufficiently early, before brook, brown and rainbow trout replaced the native cutthroat trout from virtually the entire Bonneville basin). The nearest geographical source of native trout in the Lahontan basin is the Humbolt River drainage which has a native cutthroat trout

differentiated from S. c. henshawi by a lower number of gillrakers, averaging 21 instead of 23-25 (Behnke and Zarn 1976).

About 1955 the Heenan Lake cutthroat trout began to be propagated in Nevada as S. c. henshawi. Prior to this it appears that Pyramid Lake was the sole source of S. c. henshawi propogated in Nevada. More than a million eggs of Pyramid Lake trout were shipped to several eastern Nevada counties in 1910 (Miller and Alcorn 1946). Apparently the last egg taking operation using Pyramid Lake trout was the 1929-1930 season when 3,000,000 eggs were taken as discussed in the Centennial Issue of Nevada Wildlife (Vol. 5, No.'s 4-7).

Mr. Howard Gibson, retired water master of Wendover, told the senior author that cutthroat trout were in Donner Creek when he commenced work in 1952. Mr. Patrick Coffin, regional fisheries biologist, Nevada Department of Fish and Game, wrote that there are no records of fish stockings for the Pilot Peak area.

Mr. Kendall Kimber, Conservation Officer with the Utah Division of Wildlife Resources at Snowville, Utah, wrote that Bettridge Creek (immediately to the north of Donner Creek) was stocked with rainbow trout in the early 1940's. In 1957 Mr. Kimber was told by Mr. Pete McKeller, an elderly rancher and long-time resident of the Pilot Peak area that Morrison Canyon (Donner Creek) "always had native trout."

We examined 22 specimens from Bettridge Creek and found them to be typical of rainbow trout with the exception that one specimen has a basibranchial ("hyoid") tooth -- a cutthroat trout characteristic and evidence that a previous cutthroat trout population had been hybridized and replaced in Bettridge Creek by rainbow trout. There is no evidence

of rainbow trout hybridization in the Donner Creek specimens. All 17 specimens possess basibranchial teeth. A rainbow trout influence would not only decrease the basibranchial teeth number but would also decrease, not increase, the gillraker number.

It is relatively certain then that Donner Creek was stocked with S. c. henshawi long before 1950, during the time when the only source of S. c. henshawi used in propogation in Nevada was the cutthroat trout of Pyramid Lake. In addition to taxonomic and historical evidence cited above, a computer analysis (multiple discriminant function analysis) compared the Donner Creek cutthroat trout with several other cutthroat trout subspecies, and clearly associated the Donner Creek specimens with S. c. henshawi (Hickman 1978a).

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UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

BIOLOGICAL LABORATORY
2725 MONTLAKE BOULEVARD EAST
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August 19, 1965

Dr. Robert Behnke
925 Mendocino Avenue
Berkeley, California

Dear Dr. Behnke:

Enclosed is a copy of a draft for a short manuscript regarding the cutthroat data about which I wrote to you earlier. Thank you for your detailed reply. It has been very useful. I would appreciate any comments you might have regarding the content and accuracy of this manuscript.

Sincerely yours,

Fred M. Utter

Fred M. Utter

Enclosure
M.S.

SEROLOGICAL EVIDENCE FOR INBREEDING IN SUMMIT LAKE LAHONTAN CUTTHROAT TROUT

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The Lahontan cutthroat trout (Salmo clarkii henshawi) has historically represented a major inland sub-species. The effects of civilization and indiscriminate stocking practices have drastically reduced the habitat where pure Lahontan cutthroat can be found. Through historical research and meristic evidence Behnke (1960) found that the Heenan Lake, California, Lahontan cutthroat, the major source for propagation in California and Nevada, while superficially a typical Lahontan fish, most likely contains some rainbow trout genes. Summit Lake, Nevada, contains what Behnke considers a pure type of Lahontan cutthroat. The Summit Lake cutthroat population is therefore a valuable source of materials for

artificial propagation. In recent years, fry survival has been increasingly reduced from matings between Summit Lake cutthroat. In out-breedings of Summit Lake fish with other cutthroat varieties, the fry survival has been excellent, however. This has led biologists to suspect that increasing inbreeding has occurred in the Summit Lake Lahontan strain which is threatening its survival.

The work presented here is an attempt to investigate the possibility of inbreeding through blood grouping techniques. Blood grouping in higher vertebrates has shown that blood groups may reflect individual variations of a single locus and that they usually are resistant to environmental influences (Race and Sanger, 1962). Similar advantages have been demonstrated in fish blood groups where such data have been available (Cushing, 1964). Bingham (1963) presented evidence for strain specific blood group antigens of cutthroat trout using antisera from rainbow trout (Salmo gairdneri) immunized with cutthroat tissue preparations. Ridgway (1962a, 1962b, 1964) has demonstrated numerous blood groups in rainbow trout and Pacific salmon (Oncorhynchus species) using rainbow trout isoimmune sera.

Selected rainbow trout isoimmune sera were used in this study because of their ability to detect individual variations in various salmonid species. Ridgway (1962b) presented evidence that antibody specificities of rainbow trout isoimmune sera under simple genetic control. Additional evidence, as yet unpublished, has accumulated supporting these observations. A uniform reaction picture would therefore be anticipated when red blood cellls from an inbred population were tested with these reagents as a reflection of the genetic homogeneity of the inbred group.

Red blood cells were tested from 19 Summit Lake fish and 20 fish from the Catnip Reservoir, which was stocked with Heenan Lake cutthroat. Cells were collected in a citrate solution from anesthetized adult fish which were bled by cardiac puncture and subsequently released. The cells were kept on ice between the times of collection and testing, four days later. Serological tests were made using the capillary tube agglutination method of Chown and Lewis (1946).

Out of 40 reagents screened for reactivity with the cutthroat trout cells, 24 either did not react with any of the cells or reacted very weakly with cells from a few individuals. Six of the reagents reacted with all cells tested. The remaining ten reagents reacted variably with cells from different trout. These reactions are listed in table 1. The first six reagents listed in table 1 were pools of numerous bleeding of isoimmunized rainbow trout. These reagents had been absorbed with selected rainbow trout cells so that the large majority of antibodies in a given reagent were of a single specificity. The remaining four reagents were single bleedings of iso-immunized rainbow trout which had not been absorbed so that multiple antibody specificities may be present (Ridgway, 1962b).

It is evident that the cells from the Summit Lake trout reacted much more uniformly with a given reagent than did the Catnip Reservoir cells. Seven out of the ten reagents reacted with either all or none of the Summit Lake cells. Only one fish out of 19 reacted qualitatively differently from the remainder with each of the remaining three reagents. The reactive strengths of the Summit Lake cells were also uniform. The reactive uniformity of the Catnip Reservoir cells, both qualitatively and quantitatively, was less for each reagent.

These dats support the hypothesis of inbreeding in the Summit Lake cutthroat trout. The high or low frequency of reaction with a given reagent indicates a high or low frequency of the gene determining the presence of the component which that reagent detects. Where reactions occur, the uniform reactive strengths suggest possible homozygous conditions by the absence of detectable dosage effects. The Catnip Reservoir data reflect a mixture of genotypes with intermediate reactive frequencies and considerable quantitative fluctuations where reactions occur.

The relatively simple techniques used in this work can be usefully applied by hatchery biologists or technicians on similar problems. Indications

of inbreeding of brood stock could be detected and remedial measures taken before excessive losses of progeny developed. Isoimmune reagents could be produced at most hatcheries without involving a great deal of time or space. The multi-species reactions of many of the rainbow trout isoimmune reagents indicates that sufficient reagents can be produced in the more hardy salmonid species for blood-grouping work throughout the family.

An extension of routine blood group testing for inbreeding in hatcheries could be the development of "blood lines" where different lots of fish would be bred for particular blood group patterns. Blood groups have proven highly valuable in identification and registration of various domestic animals (Stormont, 1958). By selecting for given blood types in breeding programs, it is feasible that hatcheries may identify individuals from various strains by red blood cell reactive patterns. Inbreeding only for red blood cell antigens should theoretically have a minimal effect on survival.

Though not pertinent to the objectives of this study, it is interesting to compare the reaction frequencies of the Summit Lake and the Catnip Reservoir cells with individual reagents. Chi square tests were made between the two groups, comparing the reactions of the ten reagents of table 1. Seven of the tests were significant at the 1% level and the remaining three were significant at the 5% level. Reagents 297 and 507 were particularly discriminating for the two groups. These preliminary data suggest that these distinct differences may have implications for management. Relative fry survival or degree of interbreeding might be estimated in areas where both Heenan Lake and Summit Lake fish have been planted.

This study demonstrates a further application of the rapidly expanding use of serological methods in fisheries research and management which has been seen during the past 15 years. We are continuing our research into the various specificities of the rainbow trout isoimmune sera and their genetic inter-relationships. We hope that the results presented may lead to further practical use of serological methods by other investigators.

Table 1.--Reactions of Catnip Reservoir and Summit Lake cutthroat trout red blood cells with ten rainbow trout isoimmune reagents

Reagent	Cells: Catnip Reservoir 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Summit Lake 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	*	20	Summation: Catnip +	0	%+	Summit +	0	%+
260	2	1	0	0	0	2	1	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	7	13	35	1	18	6
269	2	2	0	0	2	2	0	1	1	2	0	1	1	0	0	2	1	2	0	tr	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	-	2	13	7	65	19	0	100
297	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	tr	1	tr	tr	1	1	1	1	1	1	tr	1	-	0	0	20	0	18	1	94
304	1	1	0	0	0	2	1	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	7	13	35	0	19	0
306	0	0	1	1	1	0	tr	0	1	1	0	0	0	1	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	-	2	7	13	35	19	0	100
316	2	2	tr	2	0	2	2	tr	0	1	1	1	1	tr	tr	0	1	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	-	2	14	6	70	19	0	100
393	0	tr	1	1	1	2	1	1	0	tr	tr	tr	1	1	1	2	0	0	tr	tr	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	-	2	16	4	80	19	0	100
412	0	1	0	2	0	2	0	1	tr	2	tr	tr	tr	0	0	tr	0	0	tr	tr	1	1	1	1	tr	1	1	1	tr	1	1	1	1	1	1	1	1	1	-	1	12	8	60	19	0	100
417	tr	1	0	1	0	2	0	1	tr	2	0	1	1	0	tr	tr	1	tr	1	tr	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	-	2	15	5	75	19	0	100
507	2	3	1	2	1	2	1	2	2	2	0	2	0	2	2	2	tr	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	-	0	18	2	90	1	18	6

3 - Very strong reaction
2 - Strong reaction
1 - Distinct reaction
tr- Weak reaction
0 - No reaction

* Sample hemolyzed.

December 20, 1965

Mr. Fred M. Utter
Bureau of Commercial Fisheries
Biological Laboratory
2725 Montlake Boulevard East
Seattle, Washington 98102

Dear Mr. Utter:

I recently returned to Berkeley and while going through my last year's accumulation of mail, found a copy of your paper: "Serological Evidence for Inbreeding in Summit Lake Lahontan Cutthroat Trout."

I am pleased that you plan to publish your work. My only comment on your paper concerns the idea that inbreeding of Summit Lake trout has reduced their fertility and threatens their existence A small, homogeneous population such as the trout of Summit Lake, subjected to a relatively stable environment, will, by natural selection, produce a genotype of reduced heterozygosity. This genotype, however, is highly specialized for its particular environment. Natural selection would operate to remove genes producing reduced viability in nature: however, such a genotype may be quite ill adapted to a hatchery environment.

An article by Kallman (Copeia, 1964, no. 3:513-22) discusses inbreeding and homozygous genotypes of small isolated populations of platyfish.

I think it is extremely doubtful that any natural population can "inbreed" itself out of existence, unless there is such a sudden change in environmental conditions that a population of low variability cannot adapt rapidly enough.

I am most interested in the progress of serological investigations and would appreciate reprints of your articles when they appear.

Sincerely,

Robert J. Behnke

RJB:pg