EVALUATION OF 1982 COLLECTIONS OF CUTTHROAT TROUT FROM NEW MEXICO

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ABSTRACT

A total of 112 specimens from 11 samples were examined and evaluated for purity as native cutthroat trout, Salmo clarki virginalis. Only a single specimen exhibited obvious hybrid traits in external appearance. All samples are rated as grade A or B in relation to degree of purity, but all samples are essentially grade A in phenotypic appearance. "Purity gradients" exist in some drainages. The cutthroat trout found in different segments of a drainage are not homogeneous and reflect different degrees of a hybrid influence. It is assumed that the slight hybrid influence detected in some samples was initiated long ago and has long since stabilized. Samples from Peralta Creek taken 15 years apart do not differ. The size distribution of the specimens is illustrated and some inferences are made relevant to life history and management.

ASSESSMENT OF 1982 COLLECTIONS

Canones Creek

Tributary to Rio Chama, Rio Arriba County.- There are two Canones creeks tributary to the Rio Chama. The Canones Creek under discussion is the smaller and more southerly of the two. Two tributaries, Chihuahuenos and Polvadera creeks, join above the village of Canones. Two collections were made in 1982.

Upper Canones Creek, above barrier. The 11 specimens of this collection appear identical to 6 specimens collected in 1968 (the basis of one of the first discoveries of Salmo clarki virginalis in New Mexico), and are also virtually identical to 1974 samples from Chihuahuenos and Polvadera creeks The spotting pattern of relatively large spots concentrated on the caudal peduncle with smaller spots generally restricted above the lateral line anteriorly, is uniform, typical of virginalis. Smaller, yearling specimens exhibit a more even distribution of small, oblong spots. Evidently, the typical spotting pattern diagnostic of virginalis is not developed until age II. The taxonomic characters are typical for S. c. virginalis with no indication of a hybrid influence. It should be mentioned that basibranchial teeth could only be verified in 7 of the 11 specimens. A thick layer of skin over the basibranchial plate completely covered the teeth and I suspect that the microscopic teeth were lost when the skin was removed in the 4 specimens in which no teeth could be found. Thus, in this case, in view of the other taxonomic characters and the ideal and uniform spotting pattern, I rate the Canones Creek population above the barrier as grade A.

Lower Canones Creek, below barrier. A sample of 9 specimens from below the barrier consists of 8 cutthroat trout and 1 obvious rainbow x cutthroat hybrid. This is an unusual sample in that the 8 cutthroat trout are relatively uniform among themselves, characteristic of a cutthroat population that had been exposed to hybridization, but the slight hybrid influence has become stabilized (as a grade B- population). The obvious hybrid appears typical of a first generation hybrid and is completely distinctive from the 8 cutthroat specimens in phenotypic appearance and taxonomic characters (table 1, figure 1), to such a degree that I conclude that the hybrid must have been produced in a downstream section far removed from this collection site. If similar hybrids are frequent downstream and

Table 1. Selected taxonomic characters of 2 cutthroat trout samples collected from the Rio Grande drainage, New Mexico, in 1982.

Locality	Gillrakers	Branchiostegal rays	Scales; above lat. line, lat.ser.	Pyloric caeca	Grade
Canones Crk. above barrier N=11	16-19(17.9)	R. 9-11(10.0) L. 9-12(10.5)	38-43 (40.5) 146-167(158.2)	33-46(40.1)	A
Canones Crk. below barrier N=8	16-18(17.3)	R. 8-10 (9.3) L. 9-11(10.0)	37-43 (39.0) 143-156(146.9)	36-43(39.4)	B-
Obvious hybrid N=1	20	R. 12 L. 12	36 141	56	D
Upper Rio Las Perches N=10	18-20(18.8)	R. 9-11 (9.9) L.10-11(10.2)	38-42 (40.5) 156-178(165.3)	36-57(46.8)	B+
Upper Rio Las Vacas N=11	17-21(18.0)	R. 9-11 (9.8) L. 9-11(10.0)	37-40 (38.7) 143-164(153.2)	33-51(40.9)	B+
Middle Las Vacas N=8	18-20(18.9)	R. 9-11(10.0) L.10-11(10.5)	36-40 (38.7) 137-152(145.1)	38-46(43.0)	B-
Upper Peralta Crk. N=20	18-22(20.0)	R. 9-11(10.2) L.10-12(11.1)	38-44 (40.3) 138-176(155.2)	30-44(38.5)	B+
Vermejo Park					
Comanche Crk. N=4	17-19(17.8)	R. 9-10 (9.8) L. 9-11(10.0)	38-43 (40.3) 155-174(165.8)	38-46(42.0)	A-
Las Cueva Crk. N=9	17-20(18.0)	R. 9-10 (9.3) L. 9-11 (9.4)	37-43 (40.1) 158-176(167.3)	34-48(39.2)	A-
Little Costilla R. N=10	17-20(18.4)	R. 9-11 (9.8) L. 9-11(10.2)	38-43 (40.0) 152-172(161.5)	34-45(40.6)	A-
Powderhouse Crk. N=10	18-20(19.2)	9-10(9.9) 10-10(10.0)	39-43 (40.9) 144-178(162.3)	33-48(38.5)	A-
McCrystal Crk. N=10	16-18(17.0)	10-10(10.0) 10-11(10.8)	38-45 (41.3) 153-172(162.7)	24-33(29.5)	A-

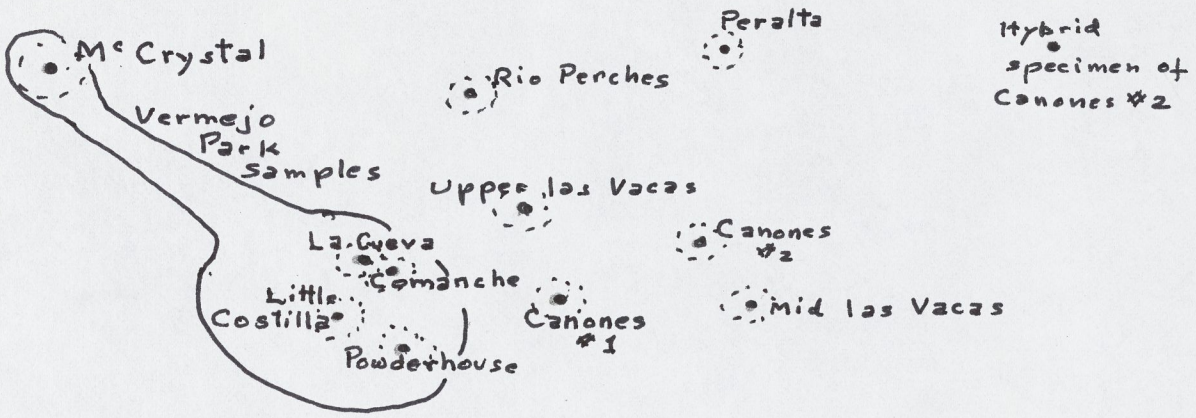

Figure 1. Two dimension representation of samples based on similarities and differences of taxonomic characters. Only group centroids are used and variation within a sample is not depicted. Vermejo Park samples group closely together with exception of McCrystal sample. The McCrystal sample differs maximally from all others, but not in the direction of a hybrid influence. The distinctness of the hybrid specimen from lower Canones Creek is apparent and indicates that the hybrid was not part of the population from which the Canones no. 2 sample was drawn but had migrated into it from a downstream area.

if they migrate upstream with any frequency to spawn with the slightly hybridized population, it would be expected that an increased hybrid influence would become more apparent in the future. However, lower Canones Creek has a long history of stocking with non-native trouts. Since at least 1928, brook, brown, rainbow, and non-native cutthroat trout were stocked (also Chihuahuenos Creek stocked with brown trout in 1931 and cutthroats in 1969, and Polvadera Creek with cutthroats in 1962). After 1950, regular annual plants of catchable-size rainbow trout were stocked into lower Canones Creek. With such a history, the finding of a grade B sample of cutthroat trout from below the barrier in 1982, strongly suggests that the native cutthroat trout genotype is highly adapted and has resisted the incorporation of non-native genes into the population (also, it can be assumed that a constant influence of pure cutthroat trout occurs from above the barrier). The cutthroat specimens from below the barrier, in comparison to the grade A sample from above, have smaller, more irregular, somewhat more profuse spotting, indicative of a slight hybrid influence, and average fewer scales in the lateral series (147 vs. 158).

Propst and McInnis (1975) and Stork (1975) highlighted the Canones Creek watershed as an example of extreme environmental degradation from a long history of livestock overgrazing. In 1971 the Santa Fe National Forest developed a Rio Grande cutthroat trout Habitat Management Plan that called for intensive management of livestock including fencing of riparian areas, if necessary, to improve habitat conditions for Rio Grande cutthroat trout. The Canones Creek watershed would appear to be well suited to serve as a model watershed rehabilitation project designed to enhance abundance of S. c. virginalis. The status of rainbow x cutthroat hybridization should be determined in sections of Canones Creek further downstream from the barrier and the degree of hybrid influence in the lower sections of Polvadera Creek might be checked.

Upper Rio Las Perches. A headwater tributary to Rio las Vacas (tributary to Rio Grande via Jemez River) in San Pedro Parks Wilderness Area of Santa Fe National Forest, Rio Arriba County. A sample of 10 specimens that uniformly exhibit the typical S. c. virginalis spotting pattern. However, the high number of pyloric caeca, averaging 48, with 3 specimens possessing 52, 56, and 57 caeca--typical of rainbow trout--and 4 of 10 specimens lacking basibranchial teeth, denote a hybrid influence in this population. The taxonomic characters of the 10 specimens (table 1) are virtually identical to the characters of 15 specimens collected in 1974 from the las Perches (Stork 1975), indicating that a hybrid influence has not increased during the past 8 years. I would rate the las Perches population as grade B, but as a phenotypic representation of S. c. virginalis they are superior to the lower Canones Creek B population. Evidence of hybridization is not apparent from external appearance in the las Perches specimens. A hybrid influence is only manifested in the numbers of pyloric caeca and suppression of basibranchial teeth. For practical purposes, this population should be classified as S. c. virginalis (about 90%+ pure). I noted well developed fat deposits around the pyloric caeca denoting good feeding conditions allowing for storage of surplus energy as fat.

Upper Rio Las Vacas. These 11 specimens are beautiful examples of S. c. virginalis. They exhibit large (almost Pecos-like), very pronounced spots on the caudal peduncle. The taxonomic characters are typical of virginalis with the exception of low scale counts (means of 153.2 in lateral series and 38.7 above lateral line). All 10 specimens more than 100 mm

have basibranchial teeth. Stork (1975) described a sample of 7 specimens from the Rio las Vacas (probably from more downstream location). Stork's sample had similar taxonomic characters but 3 of 7 specimens lacked basibranchial teeth. In view of the slightly hybridized population in the Rio las Perchas and the more hybridized population downstream in the Rio las Vacas (following analysis), it must be assumed that the cutthroat trout in the headwaters of the Rio las Vacas have been exposed to hybridization. Unless a physical barrier exists, gene flow can be expected to occur throughout the las Vacas drainage. Due to the typical absence of considerable movement in resident stream populations and different selective pressures in different parts of the drainage in relation to temperature, size of stream, etc., the potential for gene flow has not resulted in a "homogenized" las Vacas drainage cutthroat trout as can be noted in the differences in the genetically determined taxonomic characters between the samples from the las Perchas and the upper and middle las Vacas. Thus, purity gradients exist within the drainage. These gradients of continuous variation introduce a problem for accurate classification of samples based on a discrete or discontinuous grading system--A, B, C. With this consideration I would upgrade the B grade to "B+" for the upper las Vacas (and also for the sample from the las Perches) to denote they are more pure (have fewer genes of non-native trout) than the trout found lower in the drainage as represented by the following sample.

Middle Las Vacas. This sample of 8 specimens show no outward appearance of hybridization but have lower scale counts (average of 145; 8 fewer than upper las Vacas, and 20 less than las Perches samples) and 3 of 8 specimens lack basibranchial teeth. Perhaps the lower section of the Rio las Vacas was more directly exposed to the stocking of hatchery trout. However, the specimens are uniform in appearance and the taxonomic characters do not exhibit great variation, indicating the hybrid influence is of long standing and has become "stabilized." A recent or continuing increasing hybrid influence can typically be detected by great phenotypic variability and extreme values (outliers) in taxonomic characters.

As discussed above, I would rate the middle las Vacas sample as "B-: to denote the purity gradient existing in the drainage, however, their phenotypic appearance does not differ from grade A virginalis.

Upper Peralta Creek. Sample of 20 specimens. Peralta Creek is a direct tributary to the Rio Grande in Sandoval County. The data were compared with a sample of 7 specimens collected from Peralta Creek ("below falls") in 1967. The samples are very similar; only that the 1982 sample averages a few more scales (155 vs. 148)--indicating little or no change in the genotype of Peralta Creek cutthroat trout over the past 15 years. In the 1967 sample, 2 of 7 specimens lacked basibranchial teeth; in the 1982 sample, 6 of 20 specimens lack these teeth. Phenotypically, there is no obvious indication of a hybrid influence, but the absence of basibranchial teeth in about 30 percent of the specimens indicates the lingering effect of hybridization with rainbow trout. Similarity between the 1967 and 1982 samples demonstrates that the exposure to hybridization occurred long ago and has long since become stabilized at a low level. I would rate the Peralta Creek specimens as B+, but note that they stand apart from all other samples by possessing the highest number of gillrakers (18-22, mean of 20.0). This could possibly be the result of influence of the past introduction of Yellowstone Lake cutthroat trout; but, if this were the case, the Yellowstone influence would also be expected to be expressed in greater development of basibranchial teeth.

Vermejo Park. Five samples were examined from Vermejo Park. Four of these samples, Little Costilla Creek, La Cueva Crk., Powderhouse Crk., and Comanche Crk., are very similar to each other. These streams are tributaries to the Costilla River. The specimens of one sample, McCrystal(?) Creek (label damaged), are quite distinctive in appearance and in taxonomic characters from all others. This population has probably been long isolated from the cutthroat trout of the Costilla River drainage. McCrystal(?) Crk. was not found on any of my maps and I suspect it may be a tributary in the Canadian River drainage. No clear evidence of hybridization was found in any of these samples. The cutthroat trout native to the Costilla River drainage, of all New Mexico cutthroat trout, are geographically most proximate to the type locality of the holotype specimen on which the name virginalis is based--a tributary to Trinchera Creek, about 50 miles to the north.

Little Costilla River. Surprisingly, the 10 specimens making up this sample, as well as all other Vermejo Park specimens, are beautiful examples

of S. c. virginalis. I found this surprising in light of the long history of non-native trout introductions in Vermejo Park. I had previously seen obvious rainbow-cutthroat hybrids from the Little Costilla River above Costilla Lake and Propst (1977) found 16 of 20 specimens from above Costilla Lake to lack basibranchial teeth. Another surprising aspect is that the "purity gradient" in the Little Costilla River drainage apparently occurs in a downstream direction--most hybridized population in lake and above, purest populations downstream from the lake.

The spotting pattern and overall phenotypic appearance are wholly typical of virginalis without indication of hybrid influence. The other taxonomic characters are also wholly typical of virginalis. I found basibranchial teeth in 8 of 9 specimens more than 100 mm TL. I rate this sample as "A-". The "-" modifier denotes the long history of exposure to hybridization. It can be assumed that the native cutthroat trout population in the Little Costilla River is highly adapted for this environment to such a degree that there is strong selection against the incorporation of non-native genes into its genome.

The collection of the sample was made May 26. I noted that the two largest females of 182 and 184 mm TL, had not yet spawned. Two smaller females of 160 and 166 mm had spawned. The two larger females were probably repeat spawners that required additional time to fully mature their ova. Two sexually mature males (172, 187 mm) had partially spawned. Their testes were not turgid, somewhat deflated, but they were capable of further fertilization.

Comanche Creek. Only 4 specimens in this sample. These specimens appear virtually identical to specimens of sample from Las Cueva Creek. All characteristics, internal and external, typical of virginalis. Three of 4 specimens with basibranchial teeth but with the thickened skin over the basibranchial plate may have prevented detection of teeth in the fourth specimen. The sample size is too small for an authoritative grade, but tentatively assigned "A-" with assumption that there is no barrier preventing interchange of fish between Little Costilla River and Comanche Creek.

La Cueva Creek. A sample of 9 specimens but only 4 of which are more than 100 mm TL. As mentioned, these specimens and specimens from Comanche

Creek appear virtually identical, and are similar to Little Costilla specimens, but with slightly higher scale counts. All 4 specimens more than 100 mm have basibranchial teeth. Only 1 of 5 specimens less than 100 mm have these teeth. Cutthroat trout develop basibranchial teeth during their first and/or second year of life. If a specimen has the hereditary basis for basibranchial teeth they should be established by the size of 100 mm, but there is variability from population to population in relation to size at which these teeth appear. For the same reasons given for the Comanche Creek sample, I rate this ample as "A-" but suggest the possibility of the occurrence of a pure "A" population in La Cuerva (and Comanche) Creek if a barrier prevents mixing from the Little Costilla River.

Powderhouse Creek. All 4 samples from the Little Costilla drainage are very similar but the sample of 10 specimens from Powderhouse Creek is more similar to the Little Costilla River sample than either of them are to the La Cueva and Comanche creeks samples. Eight of 10 specimens with basibranchial teeth. Rated A- similar to other Vermjo Park samples.

McCrystal(?)Creek. The name of this creek was not verified. The label had partially washed and faded. No "McCrystal" Creek was located on maps available to me. I suspect that this sample was taken from the Canadian River drainage. These specimens are strikingly different from other samples. In general appearance, the spots are large and sparse. About 10 large spots occur on the posterior part of the body and about 10 are found anterior to the dorsal fin. Ths number of pyloric caeca, 24-33 (29.5) is considerably less than any other sample. The number of gillrakers, 16-18 (17.0) is also the lowest found in the 1982 collections. The number of right and left branchiostegal rays are more than other samples except Peralta Creek. Scale counts are typical of virginalis. Basibranchial teeth found in 8 of 10 specimens.

Although these specimens are quite unique, their uniqueness can not be explained as a result of a hybrid influence. The low numbers of pyloric caeca and gillrakers are extreme values opposite from what expected from a hereditary influence from rainbow trout and/or Yellowstone cutthroat trout. I conclude that "McCrystal" Creek contains a virtually pure population of native cutthroat trout and rate it as "A-". If this population is in the Canadian River drainage, it is especially significant because of the

rareness of known populations of native cutthroat trout in this drainage.

I would mention that these specimens had deep, plump bodies with relatively small heads, indicating excellent feeding conditions in this stream. The stomachs and intestines were well filled. More than half of the food volume was of terrestrial origin--grasshoppers, ants (also pine needles). Perhaps this stream has vigorous growth of riparian vegetation which may be a factor promoting the input of terrestrial insects into the trout's diet.

Summary of Taxonomic Analysis

Analysis of the 1982 samples gives cause for an optimistic outlook concerning the status of S. c. virginalis in New Mexico. Of 112 specimens examined, a hybrid influence was apparent in the external appearance of only one specimen (from lower Canones Creek), all other specimens had the typical spotting pattern and general appearance of native cutthroat trout. Of special significance is the finding that native cutthroat trout have persisted and resisted the effects of hybridization in areas subjected to a long history of non-native trout stocking such as the las Vacas drainage and the streams of Vermejo Park. In such situations, "purity gradients" exist. The impacts of hybridization as expressed in taxonomic characters differ in different sections of the drainage.

Several characters were recorded for each specimen but the characters selected for emphasis to assess genetic purity are those that have been found in previous studies to be most sensitive for the diagnosis of a hybrid influence from rainbow trout and/or Yellowstone Lake cutthroat trout. S. c. virginalis typically has the lowest values of branchiostegal rays on both the right and left sides and this character alone separated it from all other subspecies. Peralta Creek specimens have the highest branchiostegal ray counts (10.2, 11.1) and this may be a manifestation of a slight hybrid influence. The Peralta sample also has the highest gillraker count (20.0), possibly influenced by non-native cutthroat trout hybridization, but the spotting pattern of the 20 specimens is quite uniform and quite typical of S. c. virginalis. Comparisons with a collection made in 1967 reveal that the Peralta Creek population has remained unchanged during the past 15 years--and this is also true for Canones Creek above the barrier.

There is no way that a population can be known to be absolutely pure. Genes from rainbow trout or non-native subspecies of cutthroat trout, in most cases, were incorporated into native populations many generations back and have become more-or-less "stabilized." These hybrid genes may be expressed as extreme values in some characters of some specimens or they may not be apparent in any taxonomic character. No two populations seem to manifest a hybrid influence in an identical manner. Basibranchial teeth is the character that is generally the most sensitive to a hybrid influence. A slight rainbow trout hereditary influence acts to suppress these teeth and a Yellowstone cutthroat trout influence increases their numbers and development. In all samples graded B+ or A-, no hybrid influence could be detected in spotting pattern or overall phenotypic appearance. In the B- samples (lower Canones Creek and mid-las Vacas), a slight difference in spotting pattern is not readily apparent and becomes evident only on close and critical comparison.

The "McCrystal" Creek sample is emphasized for special recognition. It is highly unique in appearance (very sparse, large spots) and taxonomic characters (lowest numbers of pyloric caeca and gillrakers). This sample is of additional significance if it occurs in the Canadian River drainage.

The native occurrence of cutthroat trout in the Canadian River crainage has never been adequately documented. In the September 14, 1876 issue of Forest and Stream magazine a reader wrote to inquire, ". . . do brook trout occur in northwest Texas?" The reply was: "They are caught in headwaters of the Canadian River that rise in the Ratoon (sic) Mountains." An 1877 issue of this magazine referred to the Vermejo River as an excellent trout stream. Although cutthroat trout populations that are relatively unhybridized are very rare in the Canadian River drainage, all I have examined are definitely of S. c. virginalis origin. From all of this evidence, I believe it can be reasonably concluded that S. c. virginalis.is native to the Canadian drainage.

Biological Notes

Figure 2 illustrates the size distribution of the specimens in the 11 samples. It is recognized that the sampling was not conducted in a manner to obtain a size-age structure of the populations and angling mortality.

may cause a scarcity of larger, older individuals. Some useful information can be interpreted from the size distribution, however, that can be applied to management. First, it can be noted that in these populations only a small proportion of fish exceed 8 inches. A minimum size limit of 10 inches would have protected every specimen. A 10 inch regulation fishery would essentially be a "non-kill" fishery on these streams, and have virtually no impact on the population. In these populations characterized by slow growth, spawning occurs for the first time in females of about 150-200 mm, completing their third year of life (initiation of third annulus). Some females in the Little Costilla River had not yet spawned by May 26. Depending on water temperature (when water temperature exceeds 42-45°F), interior subspecies of cutthroat trout spawn from April through July. In New Mexico I assume most spawning occurs in May - early June. Allowing 30 days of incubation and 10-14 days for yolk absorption and emergence, young-of-the-year cutthroat trout of about 30 mm will first appear about early - mid July in most New Mexican streams. The following year in May-June at the age of I, they should range in size from 60 to 100 mm. Growth is relatively slow and unless there are "large volume" types of habitats such as large, deep pools or beaver ponds that would act to reduce competition between older, larger trout and younger, smaller individuals, relatively few specimens will live more than 4 years and exceed 10 inches in these small streams.

This relatively slow growth, characteristic of inland cutthroat trout in small mountain streams, is, however, more rapid than typical of coastal cutthroat trout, S. c. clarki, with similar life histories in similar habitats (Cooper 1970, Hartman and Gill 1968, Nichols 1978). Coastal cutthroat trout populations resident in small streams typically spawn at end of second year of life at 100-120 mm and seldom exceed age III and 175 mm in size. The coastal cutthroat trout has existed in unglaciated regions for a longer period than the inland sugbspecies. One aspect of long adaptation to small environments may be a short life span with early sexual maturity at a small size--similar to brook trout, Salvelinus fontinalis. On the Pacific Coast, the native cutthroat trout is the dominant species in small, headwater streams and introduced brook trout are relatively rare. Throughout the Rocky Mountain region and in the Great Basin, brook trout have largely replaced native cutthroat trout in

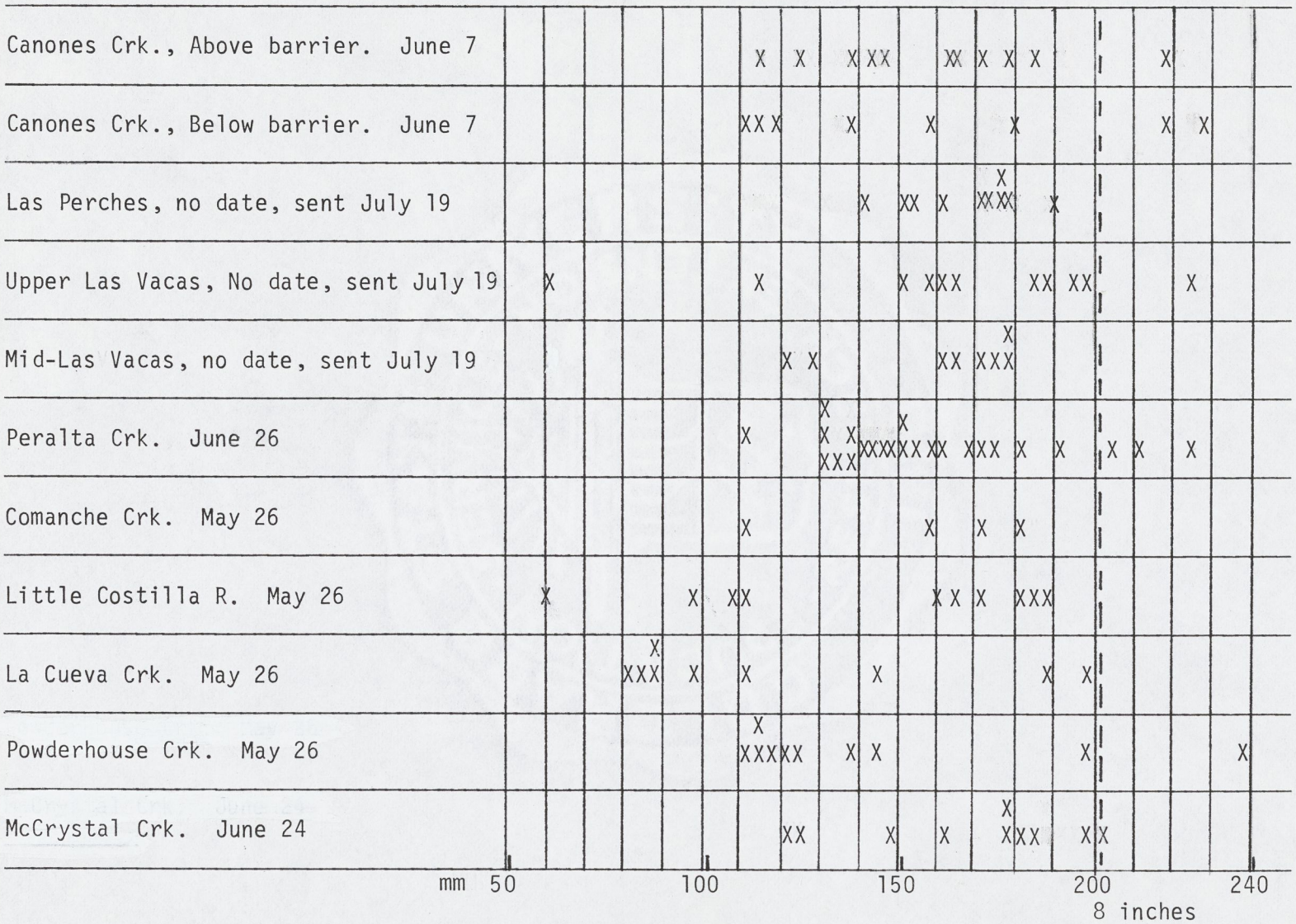

Figure 2. Length distribution of specimens.

small tributary streams. The older age at maturity and larger size of native interior cutthroat trout, although advantageous from a fisheries management point of view, is probably a disadvantage in competition with brook trout.

In streams subjected to angling where native cutthroat trout occur with brook trout and especially brown trout, there will be a differential harvest favoring the non-native trout--the cutthroat trout is most vulnerable to angling exploitation. This bias could be reversed, if regulations were set to return all cutthroat trout caught and retain statewide regulations on non-native trouts. Such a regulation designed to favor the native greenback cutthroat trout over the non-native brook trout in Hidden Valley Creek of Rocky Mountain National Park was tried in 1982. Angling was restricted to fly fishing. The anglers were instructed to keep all brook trout caught and return all cutthroat. Electrofishing prior to angling revealed that brook trout were dominant over cutthroat trout by a 3:1 ratio; however, in 8 days of angling, 630 cutthroat trout were caught and released and 295 brook trout were caught (50% of the total catch occurred on the first day). The experiment was not a great success because the fly-fishing-only regulation and no-kill regulation on cutthroat trout highly biased the composition of the participating anglers. Many, if not most, of the anglers would kill no trout and 60% of the brook trout caught were also returned to the water. Such a special regulation fishery would need an educational effort to impress on the anglers that the objective of the regulations is the removal of non-native trout.

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