Distribution, Systematics and Biology of the Bonneville Cutthroat Trout, *Salmo clarki utah*

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ABSTRACT

When white explorers first entered the Bonneville Basin they encountered a multitude of wildlife species. One organism which was particularly noticeable was the resident trout *Salmo clarki utah*. These early explorers found cutthroat trout in nearly all aquatic environments encountered in their journeys through the Bonneville Basin drainage.

Cutthroat trout found in area streams and lakes were descendants of a large spotted cutthroat that entered the Bear, Yellowstone and Colorado river drainages sometime prior to formation of Shoshone Falls, Idaho. Movement into the Bonneville Basin occurred with the diversion of Bear River into its present drainage system. Lake Bonneville provided an extremely large environment allowing the new cutthroat population to expand into areas of suitable habitat. Final desiccation of Lake Bonneville left many drainages isolated from each other and allowed for slight differences between the various populations.

Within a short time following colonization of the Bonneville Basin, cutthroat populations began to decline. Lake populations were impacted by unregulated commercial fishing and stream populations were affected by irrigation diversions which dewatered many miles of stream channel. Nearly all populations were finally impacted by the introduction of non-native trout forms, particularly rainbow trout. This decline and replacement of cutthroat populations resulted in near extinction of the unique Bonneville cutthroat. Relic populations, however, have been located in a few small isolated streams in Utah, Wyoming and Nevada. These populations have developed in and adapted to these marginal habitats.

Programs to protect these populations are being developed and use of this endemic cutthroat form in modern fisheries management is being evaluated. Many of the characteristics exhibited by Bonneville cutthroat may prove beneficial in developing additional fisheries in marginal waters.

DISTRIBUTION, SYSTEMATICS AND BIOLOGY OF THE BONNEVILLE CUTTHROAT TROUT, *SALMO CLARKI UTAH*

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INTRODUCTION

The original range of cutthroat trout (*Salmo clarki*) extended from Alaska to Northern California, throughout the Intermountain area and east to the Upper Missouri, Platt, Colorado, and Rio Grande drainages. Native stocks were also found in the headwaters of South Saskatchewan River, Alberta, Canada (Sigler and Miller 1963). Cutthroat trout found throughout this very large range represented a number of subspecies (Table 1).

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The Intermountain area, including Utah, contained only one endemic salmonid — the cutthroat trout. As discussed by Behnke (1976a), early workers felt that this native trout form was represented by two subspecies (Figure 1): *S. c. utah* of the entire Bonneville Basin and *S. c. pleuriticus* of the Colorado River Basin (Tanner and Hayes 1933; Platts 1957; Sigler and Miller 1963). In light of habitat complexity that existed in the Bonneville Basin before and following desiccation of Lake Bonneville and because a small portion of Northwestern Utah is drained by the Raft River, a tributary to the Upper Snake of the Columbia River drainage, the possibility exists that three, and potentially four, subspecies actually represented the native cutthroat trout in Utah (Behnke 1976a).

This report summarizes and discusses the biology and potential management of *S. c. utah* the Bonneville or Utah cutthroat, which historically was the dominant subspecies of cutthroat trout found in Utah and the Bonneville Basin.

Table 1.

Ranges of various subspecies of cutthroat trout in its native range, Western United States.

Subspecies	Common Name	Range
S. c. utah	Bonneville or Utah cutthroat	Lake Bonneville drainage basin — Utah, Wyoming, Idaho, and Nevada
S. c. pleuriticus	Colorado River or Green River cutthroat	Colorado River drainage basin — Wyoming, Utah, and Colorado
S. c. stomias	Greenback cutthroat	South Platt and Arkansas River drainages — Colorado and small area in southeastern Wyoming
S. c. henshawi	Lahontan cutthroat	Lahontan basin containing Walker, Carson, Truckee, and Humbolt river systems
S. c. seleniris	Paiute trout	There is some question on entire range but the likely distribution was the Silver King drainage, California
S. c. lewisi	West slope or East slope cutthroat	Found in upper Missouri basin and in much of the upper Columbia River drainage
S. c. clarki	Coastal cutthroat	Coastal rivers from Alaska to northern California
S. c. bouvieri	Large-spotted cutthroat (This has not officially been designated as a subspecies but this is the oldest name (1883) attached to this cutthroat form.)	Upper Snake and Yellowstone River drainages, Wyoming
S. c. virginalis	Rio Grande trout	Upper Rio Grande River drainage, Colorado; Upper Columbia River drainage, British Columbia
S. c. alpestris	Mountain cutthroat	Upper Columbia River drainage, British Columbia
S. c. macdonaldi	Yellow fin trout	Twin Lakes, Colorado; very likely this cutthroat form is extinct.

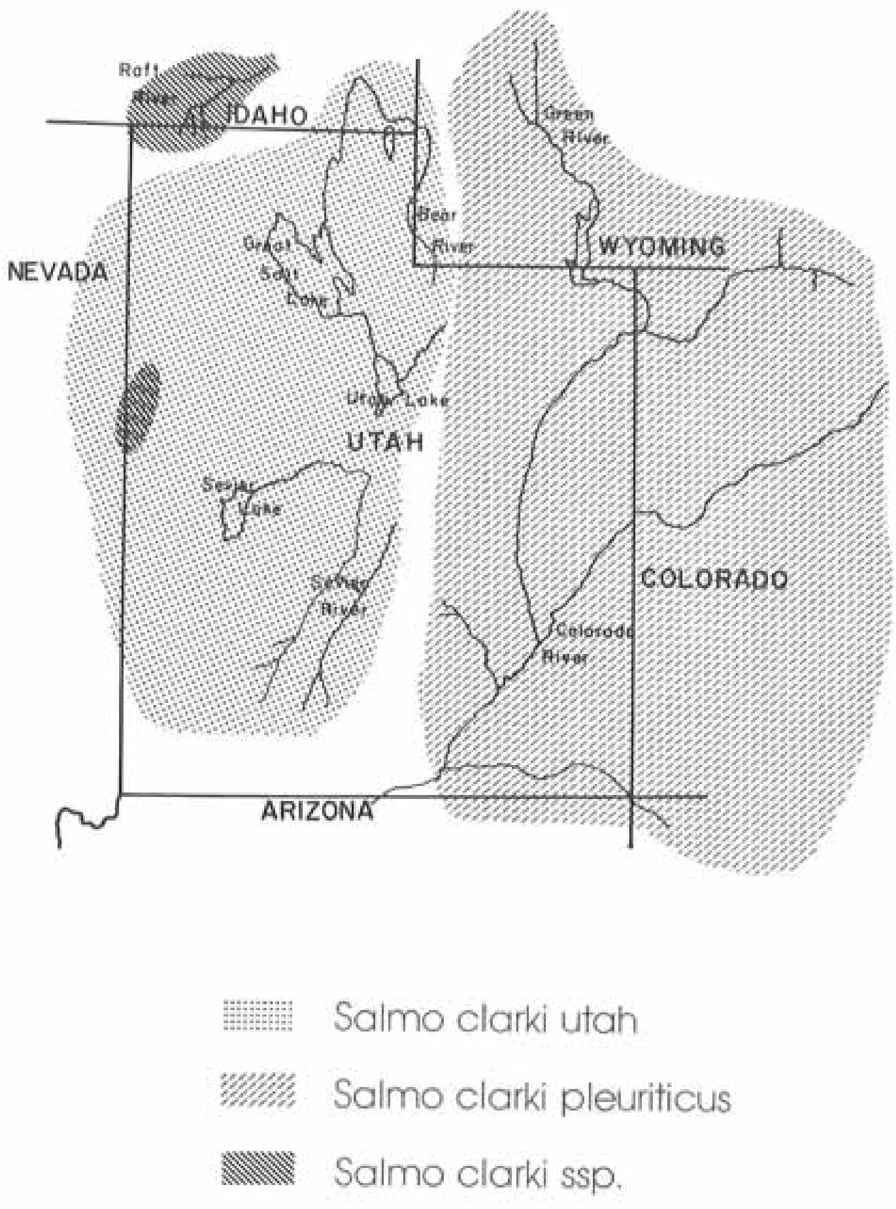

Figure 1. Historical range of various subspecies of cutthroat trout in Utah and adjoining states.

DISTRIBUTION

Historical

The historical distribution of cutthroat trout was closely related to catastrophic land-mass changes which occurred during prehistoric times. These changes in drainage configuration allowed for movement of cutthroat trout from coastal tributaries to interior drainages. Roscoe (1974) described possible movement of an ancestral form of cutthroat trout to the Upper Snake River from the Columbia River system. This movement of large spotted cutthroat would have occurred sometime prior to formation of Shoshone Falls. These fish subsequently invaded the Bear, Yellowstone, and Colorado river drainages as well as other interior river systems. Lava flows that occurred during the Pleistocene epoch permanently blocked the Upper Snake drainage creating Shoshone Falls, thus preventing fish passage and isolating the Snake River headwaters from the remainder of the Columbia drainage.

Hickman (1977) discussed another major land disturbance which was likely responsible for initial cutthroat movement into the Bonneville Basin. This event was a major lava intrusion in a canyon of the Bear River that caused river flow to be diverted into the Bonneville Basin. In addition to the new source of water from the Bear River, heavy amounts of rainfall and glacial melt caused the lake basin to fill. Lake Bonneville at its highest level was 558 km (346 miles) long, 234 km (145 miles) wide and covered 51,152 sq. km (19,750 sq. mi.). The greatest depth of the lake was approximately 564 m (1,850 ft). Because of excessive runoff, Lake Bonneville eventually overflowed the northern rim at Red Rock Pass (Bright 1963; Broecker and Kaufman 1965). This washout was named the Bonneville River and was of such a magnitude that it cut a pass through the rim which lowered the lake level by 101 m (330 ft) (Malde 1968). It should be noted that these processes of raising and lowering transpired 12,000 to 30,000 years ago over prolonged periods of time. Inundation of the Intermountain area allowed cutthroat to penetrate to headwaters of many tributary systems of the Bonneville Basin. Subsequent to that period of excessive runoff, annual precipitation was not sufficient to maintain the volume of the lake and its level began to lower. Final desiccation occurred 8,000 years ago (Broecker and Kaufman 1965), leaving numerous drainages in the Bonneville Basin isolated from each other. As pointed out by Hickman (1977), cutthroat trout of the Bonneville Basin and their ancestral relatives of the Upper Snake River have been separated from each other for 30,000 years or less. This may explain the limited amount of differentiation between the two forms. Final desiccation of Lake Bonneville also segregated many populations of Bonneville cutthroat which remained isolated until white settlers moved into the Bonneville Basin.

One of the earliest recorded accounts that specifically referred to native trout in Utah came from specimens observed from the Bear River during the Townsend Journey of 1833-34 (Thwaits 1907). Subsequent reports, by other early surveyors and investigators, further described distribution of *S. c. utah* during the mid- and late 1800's.

Stansbury (1852), during an 1848 exploration and survey of the Great Salt Lake Valley of Utah, gave the following account of Utah Lake: "The lake abounds in fine fish, principally, speckled trout of great size and exquisite flavour." Stansbury also mentions abundance and size of speckled trout in the Bear River, near Medicine Butte, Wyoming, and the streams of Cache Valley, Utah. The southernmost extension of *S. c. utah* range was the headwaters of the Sevier River (Yarrow 1874). Based on historical accounts, it is evident that Bonneville cutthroat trout were widely distributed throughout the entire Bonneville Basin, inhabiting the drainages of the Bear, Black's Fork, Timpanogos (Provo), Weber and Sevier rivers. These fish were also found in the Beaver River

(Escalante Desert) and Snake Valley drainages which flowed into Lake Bonneville but became closed basins following desiccation of the lake.

The decline in numbers of Bonneville cutthroat trout following entry of pioneer settlers into the basin was very marked and rapid (Yarrow 1874; Siler 1884; Woodruffe 1892.) Initial decline in once abundant populations resulted from overharvest. This was particularly true of lake populations which received heavy pressure from commercial fishing. Trout was a highly prized food source by early settlers and miners in Utah and this readily available local market created heavy pressure on trout populations in the area. It was estimated that an average daily seine haul from Utah Lake was 68 kg (150 lbs) for summer periods and 18 kg (40 lbs) during the winter (Yarrow 1874). During the Wheeler expedition of 1872, Dr. Yarrow interviewed a Mr. Madsen who had been fishing Utah Lake commercially since 1854. Mr. Madsen indicated that his harvest had been decreasing annually because of increased commercial fishing.

Some early laws were enacted to provide protection to fish populations, but because of the lack of enforcement, greedy individuals continued to overharvest lake populations of *S. c. utah*. The conclusions drawn by Dr. Yarrow (1874) was well stated: "In conclusion, it may be stated that the Utah Lake trout is of vast economic importance to the settlers of the Great Salt Lake Valley, supplying as it does a comparatively cheap and most excellent article of sustenance, and one to the preservation of which special attention should be speedily given, since, if means are not shortly taken to prevent the destructive methods of fishing now employed the species must become extinct after a few years."

Loss of habitat also hastened the decline of cutthroat populations. Under the leadership of Brigham Young, Mormon pioneer leader, settlements were established throughout the Bonneville Basin. Water became a prerequisite to settlement and most basin streams were altered by water diversions to meet culinary and irrigation needs. Many miles of streams inhabited by Bonneville cutthroat were impacted by colonization of the basin.

The final event which drastically influenced *S. c. utah* was introduction of rainbow trout (*Salmo gairdneri*) in 1883 and other nonresident trout forms into Utah waters (Sigler and Miller 1963). These introductions and the hybridization that resulted, greatly influenced genotypical and morphological characteristics of native cutthroat trout in Utah.

It was evident that within 100 years following settlement of the Bonneville Basin, native trout had been reduced to a point where many writers believed that *S. c. utah* was extinct (Miller 1950; Cope 1955; Sigler and Miller 1963).

Present

There is recent evidence that remnant populations of *S. c. utah* still exist in a few isolated streams within Nevada, Utah and Wyoming (Behnke 1970, 1973a, 1973b, 1975a, 1975b, 1976a, and 1976b). In all cases, these remaining populations are confined to small streams with limited habitat (Table 2). In spite of the environmental extremes, *S. c. utah* still exist but their numbers and growth are suppressed by marginal habitat conditions. The survival of present native cutthroat populations that thrive even under adverse environmental conditions illustrates the adaptive ability of this subspecies to exist under wide variety of habitat conditions.

TAXONOMIC DESCRIPTION

Early efforts to describe native trout in Utah were frustrated by the lack of diagnostic criteria for comparisons and the amount of hybridization that had resulted from introduction of other subspecies of cutthroat and rainbow trout (Tanner and Hayes 1933; Behnke 1976a). Tanner and Hayes stated, "The exact identity of the trout in this state as they existed when the first explorers entered is still a puzzle and is becoming more difficult to solve because of the scarcity of native fish and the mixing of introduced forms."

Early nomenclature also added to the taxonomic difficulty. Problems associated with nomenclature center around the many specific and subspecific names (*mykiss*, *purpuratus*, *virginalis*, *spilarus*, *pleuriticus*, and *utah*) that were applied to Bonneville Basin cutthroat. As indicated by Behnke (1973a), *Salmo utah* was proposed by Suckley (1874), to distinguish between trout in Utah Lake from *S. virginalis* in streams of the Bonneville Basin; the separation was based primarily on coloration and spotting pattern. It should be noted, however, that morphological differences in coloration between lake and stream populations can be due to various factors. Protective coloration is an adaptation that an animal uses to camouflage itself in its environment. The silvery sheen of fish from lake environments occurs when guanine deposition replaces the normal spotting pattern.

Behnke (1970) indicated that the published account of *S. utah* (Suckley 1874) establishes the name *utah* as the earliest name applied solely to trout of the

Table 2.
Habitats that contain known populations of *S. c. utah*.

Stream	Location	Remarks
Trout Creek	Deep Creek Mountains, Western Utah	Small desert stream with a mean discharge of .14 m³s (5 cfs); relatively steep gradient subject to some flooding; length 1.8 km (6.7 miles) consisting of plunge-pool habitat.
Pine Creek	Eastern Nevada	Very small with a discharge less than .028 m³s (1 cfs); relatively steep gradient; length 4.8 km (3 miles).
Goshute Creek	Eastern Nevada	Discharge .028 to .056 m³s (1 to 2 cfs); length 2.4 km (1.5 miles); very prone to flooding.
Hendrys Creek	Eastern Nevada	Discharge generally less than .028 m³s (1 cfs); length 4 km (2.5 miles). Upper one-half of stream with very steep gradient.
Raymond Creek	Bear River Drainage, Wyoming	Small stream with relatively steep gradient; lower reaches have seasonally high temperatures; could be judged as harsh trout habitat.
Giraffe Creek	Bear River Drainage, Wyoming	Similar to Raymond Creek
Reservoir and Water Canyon	Pine Valley Mountain, Southeastern Utah	Very small streams with steep gradient comprising a plunge-pool habitat; discharge would be generally less than .14 m³s (5 cfs); habitat consists of small and shallow pools.
Little Willow Creek	Wasatch Mountain, Central Utah	Small stream with steep gradient; habitat similar to other streams mentioned with plunge-pool characteristics; average discharge .11 to .14 m³s (4 to 5 cfs).
Birch Creek	Beaver Mountains, Southcentral Utah	Very small, 16 km (10 miles) in length; discharge generally less than .028 m³s (1 cfs); certain stream segments subject to high temperatures.
Sam Stowe Canyon	Sevier River Drainage, Southcentral Utah	Small stream approximately 4.8 km (3 miles) long with stable water source from spring .028 m³s (≈1 cfs); introduced 1977.

Bonneville Basin. Current nomenclature includes all cutthroat trout as a single species (*Salmo clarki*) with subspecies being distinguished by major drainages or geographical areas. Hence, the name *S. c. utah* has been used to designate those native trout found in the Bonneville Basin.

Even more troublesome than differences in nomenclature is the lack of unique diagnostic characters upon which positive identification can be based (Behnke 1970; Behnke 1976a). A review of museum specimens collected from the Salt Lake and Utah Lake drainages (1872-1915) has provided certain taxonomic differences upon which to base classification. Behnke stressed that these differences are based on comparison of anticipated mean values of certain characters. Furthermore, it was also stressed that much overlap occurs in many taxonomic characters of interior forms of cutthroat trout.

Biochemical analysis, using electrophoretic patterns has also proven to be of little value in providing conclusive differences in several groups of cutthroat and rainbow trout (Stalnaker et al. 1975; Wydoski et al. 1976). These workers did locate an unusual variation in lactate dehydrogenase (LDH) in samples of Bonneville Basin cutthroat from the Deep Creek Mountains. This variation suggested that some unique event(s) caused a variant allele to occur in cutthroat trout of the Snake Valley area. Snake Valley cutthroat were also differentiated from other Bonneville Basin cutthroat populations by having more basibranchial teeth, a longer head, a deeper more compressed body and a longer dorsal fin positioned more posteriorly (Hickman 1977). Hickman further discussed taxonomy of existing Bonneville cutthroat populations through use of principal component, discriminate, and Wilks and Lambda analyses. From examination of 16 characters, Hickman determined that basibranchial teeth, pyloric caeca, scales in the lateral line series, cundal peduncle depth, and gillrakers provided the best discriminating power for differentiating between cutthroat populations (Table 3).

These findings indicated that cutthroat populations on the western boundary of the basin were most divergent from populations located in the northeastern area. In addition, there was considerably more overlap in populations from the central and southern portions of the Bonneville Basin (Hickman 1977). Graphical representation of Hickman's data provides a better comparison of character divergence in Bonneville cutthroat populations (Figures 2 and 3).

To summarize the diagnostic characteristics for *S. c. utah*, the following mean values should be used for comparison: Vertebrae, 61-62; gillrakers, 18-20; pyloric caeca, 30-40; scales above lateral line, 36-42; scales in lateral series, 155-179; and basibranchial teeth present in at least 90 percent of populations (Behnke 1976a). The spotting pattern is also slightly different from other subspecies of cutthroat trout; the spots are larger and fewer but more evenly distributed over the entire body in *S. c. utah*.

BIOLOGY AND LIFE HISTORY

Food Habits

Information on food habits of *S. c. utah* is very limited. Suckley (1874) briefly mentioned food found in cutthroat taken from the Weber River. All stomachs examined by Suckley contained terrestrial insects such as wasps, beetles and ants. Yarrow (1874) described food preferences of cutthroat trout in Utah Lake. Cutthroat in this large limnetic environment were very non-selective and consumed both terrestrial and aquatic food items such as invertebrates, snakes, frogs, and small fish. The piscivorous aspects of lake populations of Bonneville cutthroat were particularly interesting. Yarrow (1874) stated, "The trout is very voracious devouring other fish smaller than itself, particularly a species locally know as silver-sides, of from two to six inches in length; on dissection, I have found the stomach of the trout crammed with these little fish." Although the species was not identified, it is probable that the silver-sides mentioned by Yarrow were Utah chub (*Gila atraria*) or red-side shiner (*Richardsonius balteatus*), both of which cause problems in present fishery management programs. The Bonneville form of cutthroat trout could have provided a beneficial biological control of other native fish species. Goode (1884) briefly stated that mountain trout (*S. purpuratus*, now known as *S. c utah*) were opportunistic and fed on

Table 3.

Primary morphological characters of *S. c. utah* from different streams.[1] Range and mean ( ) of morphological characters.

Locality	Gillrakers	Pyloric Caeca	Scales Above Lateral Line	Scales in Lateral Line Series	Basibranchial Teeth
Trout Creek UT 1974, 1976 n=29	18-22 (19.7)	28-40 (34.3)	33-41 (37.3)	146-170 (153.5)	9-41 (23.3)
Pine Creek NV 1959, 1970, 1972 n=61	19-25 (21.8)	25-47 (33.9)	33-46 (38.8)	133-176 (146.9)	8-50 (27.3)
Goshute Creek NV (Pine Creek stock) 1972 n=20	17-22 (20.0)	31-45 (35.7)	35-45 (39.0)	128-162 (143.9)	8-46 (24.7)
Hendrys Creek NV Very Headwaters 1972 n=20	18-23 (20.9)	29-46 (36.1)	35-45 (39.1)	129-163 (149.9)	14-19 (24.5) 1 of 20 w/o teeth
Raymond Creek WY Wyoming 1974, 1976 n=30	16-21 (17.7)	39-54 (45.3)	36-44 (39.0)	148-183 (167.9)	1-22 (5.4) 1 of 30 w/o teeth
Reservoir Canyon and Water Canyon UT Virgin River Drainage 1959, 1973 n=30	17-21 (19.2)	29-40 (35.3)	38-45 (40.3)	139-169 (157.2)	6-19 (11.2)
Willow Creek UT Jordan River Drainage 1973, 1976 n=22	17-21 (18.7)	25-39 (34.0)	35-42 (37.5)	141-180 (162.9)	13-36 (20.1)
Birch Creek, Tributary Beaver River UT 1973 n=12	18-20 (19.1)	24-43 (36.3)	36-42 (38.4)	151-161 (156.3)	1-19 (11.2)
Museum Collections 1872-1915 Salt Lake-Utah Lake Drainages n=19	17-22 (19.7)	— —	32-43 (37.8)	150-186 (163.0)	3-20 (9.9)

[1]Data were summarized from Behnke 1976a and 1976b; Hickman 1977.

any living thing. Although the early studies of food preferences were somewhat limited in scope, they did provide a common conclusion. *S. c. utah*, found in both river and lake environments, were relatively non-selective in their feeding habits and other native fish were an integral part of the diets of lake populations.

Recent efforts to document food habits have been restricted to a few populations of *S. c. utah* found in small isolated streams. During June 1975, stomachs were examined from 39 cutthroat collected from Birch Creek, Beaver County, Utah. Specimens ranged from 58 to 200 mm (2-8 inches) in length and from 4 to 96 g (.140 to 3.4 oz.) in weight. Both terrestrial and aquatic invertebrates were

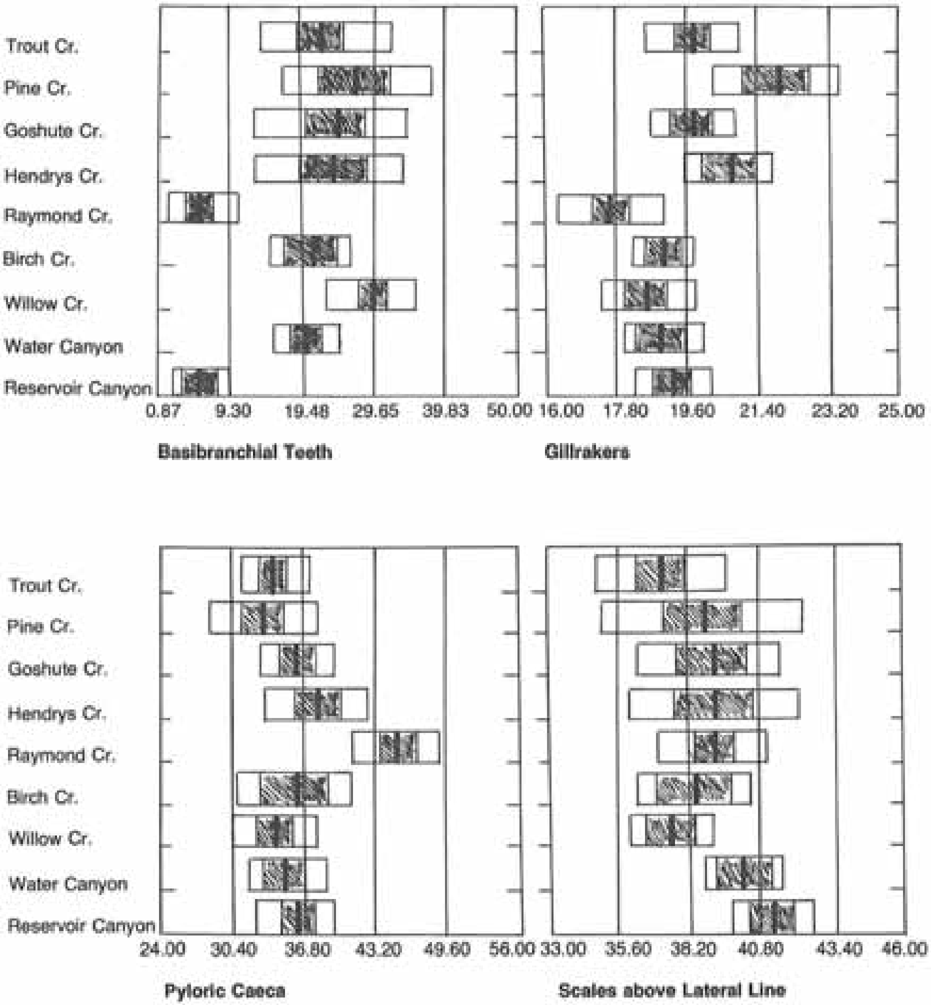

Figure 2. Meristic counts of basibranchial teeth, gillrakers, pyloric caecae, and scales above the lateral line for various populations of cutthroat trout from Utah and adjoining states. (The dark line indicates the population mean, the shaded area of each bar indicates one standard deviation, and the entire bar indicates the range for each fish population). (Data from Behnke 1976a, 1976b; Hickman 1977)

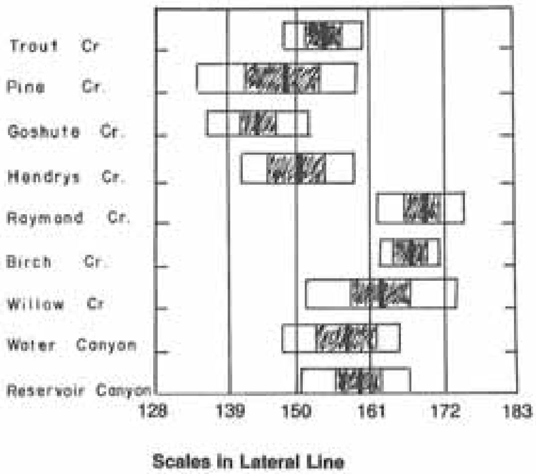

Figure 3. The number of scales in the lateral line for various populations of cutthroat trout from Utah and adjoining states. (The dark line indicates the population mean, the shaded area of each bar indicates the range for each fish population). (Data from Behnke 1976a, 1976b; and Hickman 1977)

the predominate food source during this early summer period (Table 4). All stomachs contained some food items and, in most cases, numerous food items were found in each stomach. The volume of food items eaten by both young and old Bonneville cutthroat was compared with the benthic communities in Birch Creek, Beaver County, Utah (Figure 4). Seasonal changes in consumption of certain food items would be expected because of seasonal changes in the abundance of macroinvertebrates. A review of macrobenthic communities occurring in Birch Creek indicated that macroinvertebrates were more evenly distributed in the stream during early summer and that some benthic forms became highly localized during late summer and early fall (Winget and Reichert 1976). This clustering of certain invertebrates may be associated with lower stream flows thus reducing suitable habitats for invertebrates and considerably altering the natural drift. A change from a highly diversified diet during early summer months to a more restricted diet during late summer and early fall would result from fluctuation in numbers and species of invertebrates. Information on winter food habits was not collected; it is likely that feeding would be drastically reduced because of lower temperatures, and confinement of aquatic invertebrates found in close proximity to individual fish.

Examination of cutthroat stomachs sampled in the fall of 1975 from Trout Creek, Juab County, Utah, contained primarily terrestrial invertebrates (Charles Thompson, personal communication).[3] Hickman (1977) also examined Bonneville cutthroat trout from Trout Creek for food preferences. He found that terrestrial insects (primarily ants) comprised 50 percent by volume of the diet but aquatic forms such as Trichoptera, Ephemeroptera, Diptera, Plecoptera, Coleoptera, Hemiptera, Araneida, and Lepidoptera were also eaten.

These recent observations substantiate the opportunistic feeding nature of Bonneville cutthroat trout. Unfortunately lake populations of *S. c. utah* were not available for comparison with earlier reports. It can be speculated that

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Table 4.

Food of 39 cutthroat trout (*S. c. utah*) from Birch Creek, Utah (June 1975). Expressed as percent volume and percent of occurrence.

Food Items	Immature 58-100 mm n=22		Mature Females 104-195 mm n=9		Mature Males 112-220 mm n=8	
	Volume (% of Total)	Frequency of Occurrence (% of Fish)	Volume (% of Total)	Frequency of Occurrence (% of Fish)	Volume (% of Total)	Frequency of Occurrence (% of Fish)
Terrestrial						
Orthoptera (Grasshoppers)	4.1	.9	——	——	5.6	25.0
Hymenoptera (Ants, Bees, wasps)	7.2	45.5	31.5	100.0	25.2	100.0
Spiders	——	——	1.0	11.1	2.3	37.5
Aquatic						
Diptera (midges)						
Chironomidae	29.1	95.5	3.2	77.8	4.7	100.0 Tr
blackfly	1.5	63.6	2.7	100.0	2.8	87.5 Tr
other diptera (march fly, tipulids, red color fly)	7.2	31.8	4.1	100.0	2.8	62.5
Plecoptera	26.5	81.8	21.5	100.0	16.4	87.5
Tricoptera	——	36.4	6.4	100.0	3.7	75.0
Coleoptera	1.0	45.5	8.2	88.8	12.2	87.5
Ephemeroptera	——	18.2 Tr	——	22.2	.5	100.0 Tr
Unidentifiable insects and partially digested insects	6.1	95.5	8.2	100.0	11.7	100.0
Debris and detritus	15.3	100.0	13.2	100.0	11.7	100.0
Other organisms	2.0	4.5	——	——	——	——

Gravel and parasites formed 0.5% of the total volume.
Tr = Trace

dietary preferences of stream populations have changed very little during the past 100 years and it would be reasonable to speculate that lake populations would have similar diets to those studied 100 years ago.

Age and Growth

Early workers did not study the age and growth of Bonneville cutthroat from either stream or lake populations. A maximum size of 425 to 450 mm (17 to 18 inches) with a mean of somewhat less that 300 mm (12 inches) was reported for Bonneville cutthroat taken near Ft. Bridger, Wyoming, from the Bear River drainage (Suckley 1874). Yarrow (1874) reported fish from 2.3 to 2.7 kg (5 to 6 lbs) and up to 650 mm (26 inches) in length were caught from the Timpanogos River (Provo River) in Utah. These larger rivers undoubtedly provided better habitat and more food for fish than the smaller headwater tributaries. Lake populations of Bonneville cutthroat in Utah Lake attained a size of 7 kg (15.5 lbs) and 762 mm (30 inches) in length.

Cutthroat sampled in Birch Creek, Beaver County, Utah, during 1974-75 had a mean length and weight of 126 mm (5 inches) and 27 g (0.06 lbs), respectively. The largest of 214 fish was 237 mm (9.3 inches) in total length and weighed 135 g (0.30 lbs). Sampling of Trout Creek, Deep Creek Mountains, by Utah Division of Wildlife Resources personnel revealed that *S. c. utah* had a slightly greater size in both length and weight. The mean total length of the 91 fish sampled in October 1975, was 146 mm (5.7 inches) with an average weight of 36 g (0.08 lbs). This difference in average size could be a reflection of better habitat in Trout Creek associated with a greater average stream flow (Figure 5).

Information pertaining to age of *S. c. utah* was lacking in historical surveys of the Bonneville Basin. Recent attempts to provide some age data was undertaken of *S. c. utah* collected from Birch Creek in September 1973[4] and in June 1975. Fish were preserved in 10 percent formalin. Scales, from preserved fish, were taken about halfway between the origin of the dorsal fin and the lateral line, mounted on numbered gummed paper, and impressed on cellulose acetate using heat and pressure. Age determination and measurements of scales were made on an Eberback projector. Back calculation of growth from scale impressions have been determined to be the same as from actual scales (Butler and Smith 1953).

Scales first form on cutthroat when they are 25 to 66 mm (1 to 2.5 inches) in total length (Carlander 1969). At high elevations or in cold streams and lakes, annuli may not be formed during the first year of life (Brown and Bailey 1952; Laasko 1955). In the Logan River, Utah, all cutthroat trout formed scales during their first year of life but not all formed annuli (Fleener 1952). Trout from Birch Creek appeared to form an annulus during the first year of life. In most trout, the annulus was obvious but in some it was faint. Annulus formation in trout from Birch Creek was not determined because fish were only available from two samples.

Various mathematical models (direct proportion, linear and curvilinear relationships) have been used to calculate the lengths of cutthroat trout at the end of each growing season. A linear relationship ($r = 0.87$) fit the data from Birch Creek cutthroat trout and was used as the mathematical relationship to back-calculate growth (Figure 6). The length-weight relationship for 55 cutthroat trout from Birch Creek, Utah, was $\log W = 5.047 - 3.053 \log TL$ with a correlation coefficient of 0.992 (Figure 7). Female grew faster than males for the first two years of life based on mean lengths (Figure 8) but differences were not statistically significant and the data were combined (Table 5).

[4]Samples taken by C.B. Stalnaker and G.T. Klar, Cooperative Fish Unit, Utah State University, Logan, Utah 84322

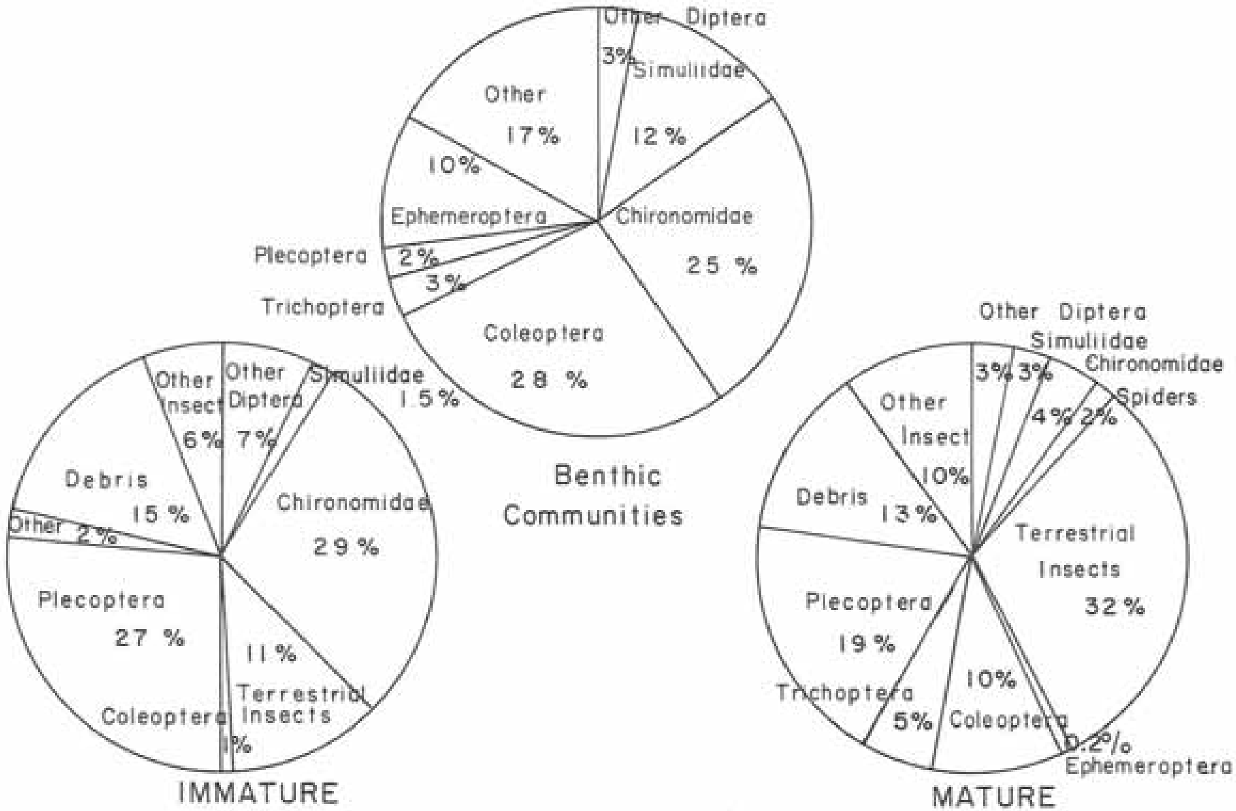

 Figure 4. Comparison of the food habits of Bonneville cutthroat trout and the benthic organisms from Birch Creek, Beaver County, Utah.

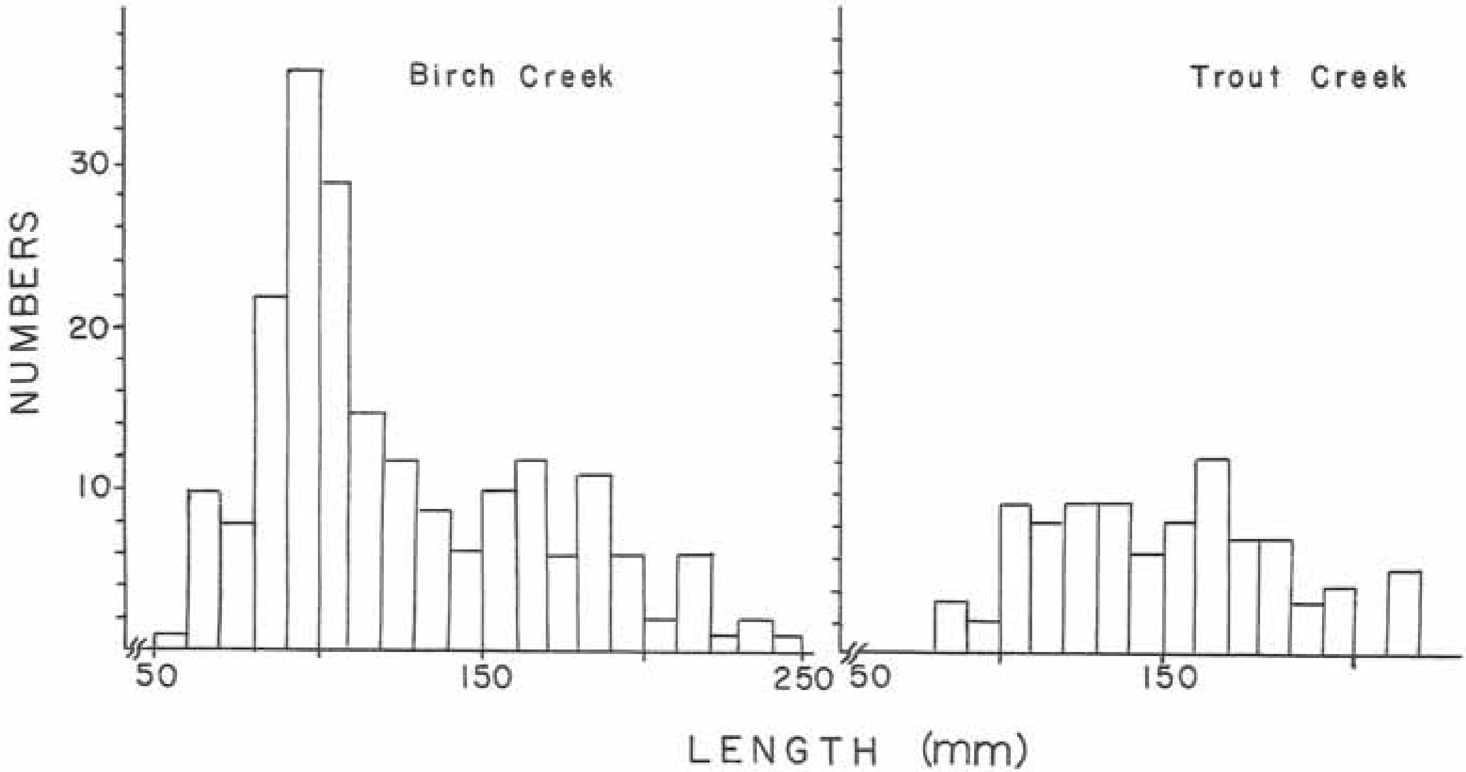

Figure 5. Length frequency distributions for samples of Bonneville cutthroat trout from Birch Creek, Beaver County, and Trout Creek, Juab County, Utah.

Growth of cutthroat trout has been shown to be variable depending upon size, temperature, and productivity of the water. In large rivers and lakes, this species grows rather rapidly. However, in smaller headwaters, stream growth was slower (Figure 9). Cutthroat trout in Birch Creek grew about the same or perhaps slightly slower than trout in the Strawberry River, Utah (Platts 1958), tributaries to Priest Lake, Idaho (Bjornn 1957), and Flint Creek, Montana (Spindler and Bailey 1955). Trout in these streams had completed four years of growth, except in tributaries of Priest Lake.

This limited age and small size of trout from smaller streams could be a function of stress placed on larger fish in limited habitat. All streams presently containing Bonneville cutthroat are very small with very limited pools that serve as deeper water habitat. Hickman (1977) reported that a cutthroat of 241 mm (9.5 inches) in length and 125 g (0.28 lbs) was collected in a pond with a depth of 62 cm (24 inches) and a width of 110 cm (43 inches). In Birch Creek, the deepest pool surveyed was approximately 33 cm (13 inches) with an average pool depth of less than 20 cm (7.8 inches) (Duff and Cooper 1976). Limited habitat could magnify stresses derived from lack of cover, space and adequate food. There could also be problems with accurate aging of fish using standard techniques. It is not uncommon for a fish to develop four distinguishable annuli and live for several more years without developing additional annuli. There would be considerably more overlapping of annuli as fish become older and growth was surpressed by limited environment. A combination of these factors

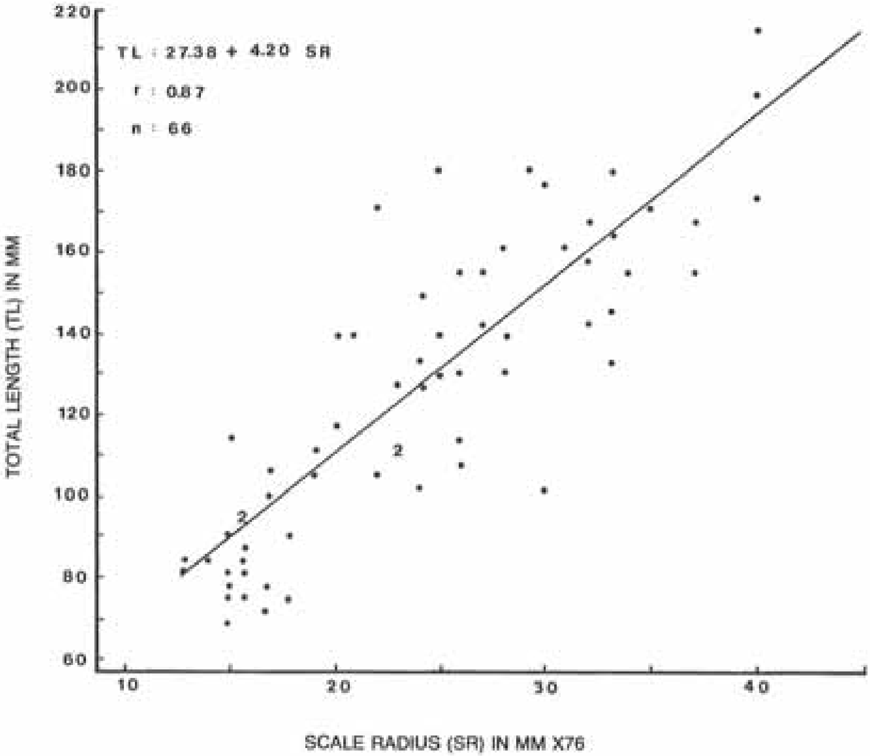

Figure 6. Body-scale relationship for Bonneville cutthroat trout from Birch Creek, Beaver County, Utah.

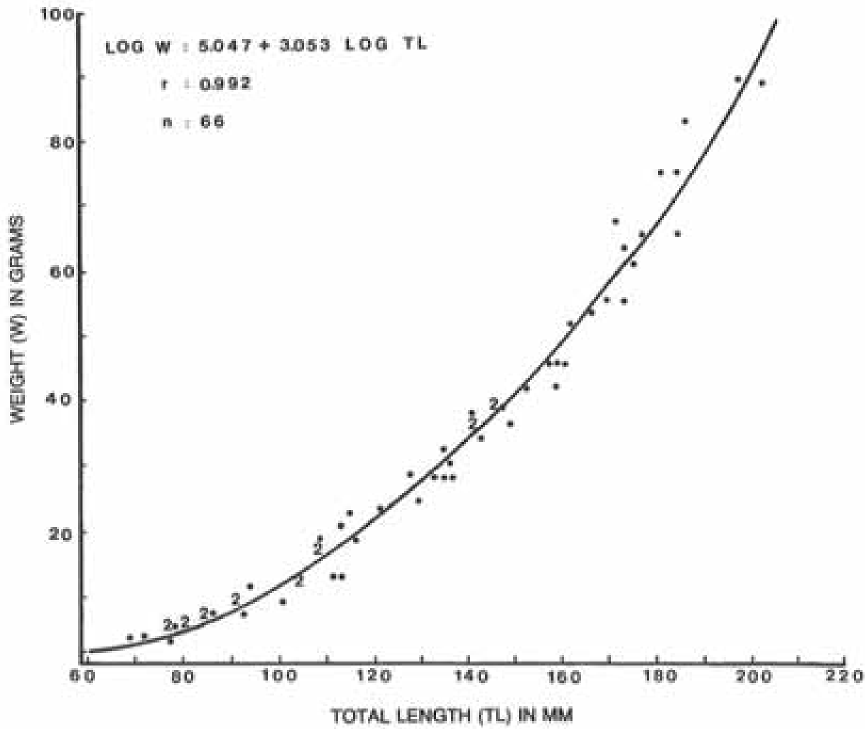

Figure 7. Length-weight relationship for Bonneville cutthroat trout from Birch Creek, Beaver County, Utah.

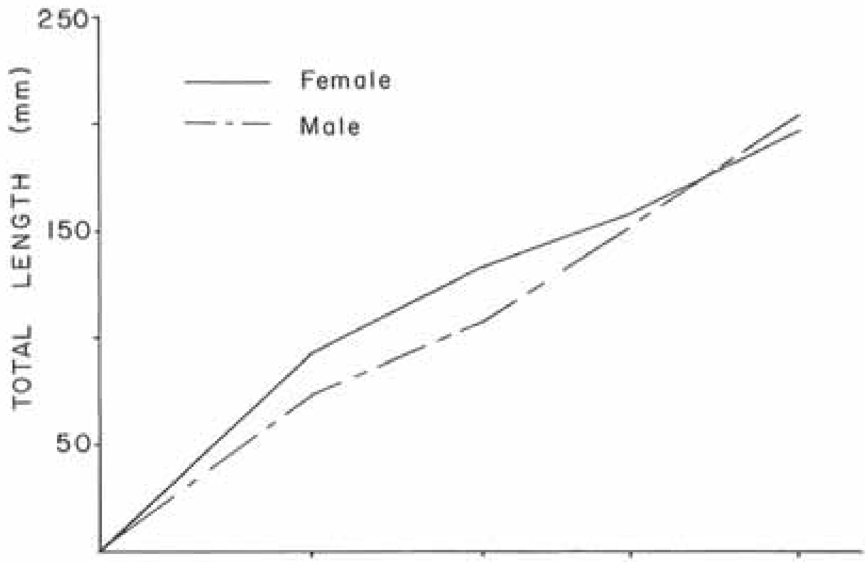

Figure 8. The total lengths of Bonneville cutthroat trout from Birch Creek, Beaver County, Utah, at the end of each growing season.

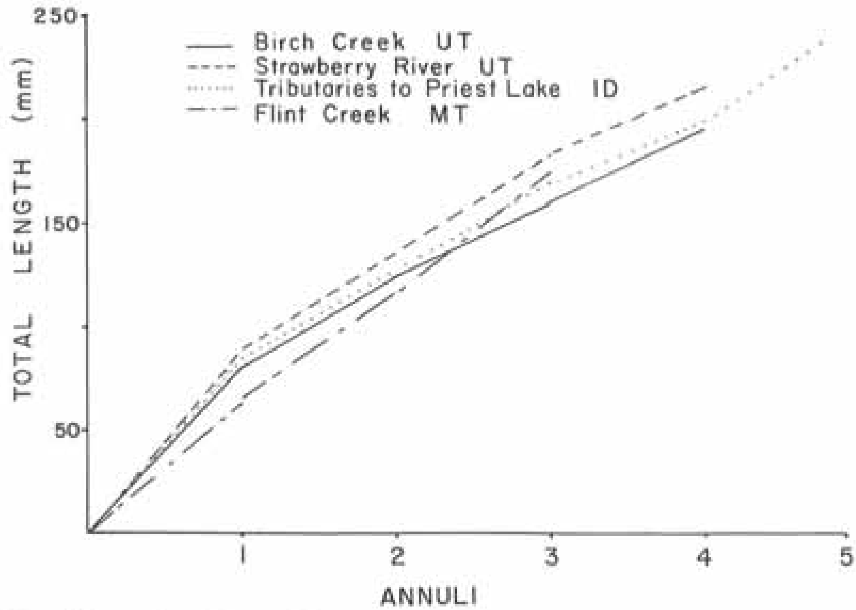

Figure 9. Comparison of the growth in various populations of cutthroat trout from streams in the Intermountain West.

Table 5.

Mean calculated total angth at the end of each growing season for cutthroat trout from Birch Creek, Utah.

Age Group	Number of Fish	Mean calculated total length at each annulus (mm) 1	2	3	4
Females					
I	1	96.4			
II	11	98.9	131.4		
III	16	92.2	133.9	158.1	
IV	1	83.0	136.6	173.4	200.2
Mean length		94.6	133.0	159.0	200.2
Increment of growth		94.6	38.5	25.0	26.8
Number of fish		29	28	17	1
Males					
I	25	80.0			
II	7	62.5	101.1		
III	4	70.2	112.2	141.5	
IV	2	82.9	141.5	182.2	205.1
Mean length		75.9	110.7	155.1	205.1
Increment of growth		75.9	42.7	33.1	22.9
Number of fish		38	13	6	2
Sexes combined					
I	26	83.9			
II	18	81.5	118.9		
III	20	79.9	128.6	157.8	
IV	3	80.6	135.2	173.0	196.8
Mean length		81.9	124.8	159.8	196.8
Increment of growth		81.9	44.2	30.3	23.8
Number of fish		67	41	23	3

was likely the case for the Bonneville cutthroat population in Birch Creek, Beaver County, Utah.

Population Dynamics

During recent studies on cutthroat trout in Birch and Trout creeks, population estimates were made to determine standing crops and biomass in these small streams. Sampling areas on Birch Creek consisted of four sections, each covering a distance of 161 m (528 ft). The sections were electro-fished using the two sample method (Ricker 1958) to estimate the population. A section on Trout Creek was also sampled and provided comparative data (Table 6).

Table 6.

Density of Bonneville cutthroat trout (*S. c. utah*) in Birch Creek, Beaver County, and Trout Creek, Juab County, Utah.[1]

	Birch Creek				Trout Creek			
	No./km	(No./mile)	No./ha	(No./acre)	No./km	(No./mile)	No./ha	(No./acre)
Section 1	——————[2]							
Section 2	96	(154)	702	(284)				
Section 3	378	(608)	2948	(1193)	752	(1210)	2135	(864)
Section 4	287	(461)	2234	(904)				
Total estimate			1962	(794)			2135	(864)

[1]Stream reach sampled was 161 m (528 ft.).
[2]Only one fish was sampled in this section.

The total estimated stream population for Birch Creek was calculated to be 4,190 fish based on a total area of 2.14 ha (5.28 acres) for the 16.1 km (10 miles) of stream inhabited by cutthroat trout. The biomass estimates for the Birch Creek stations were 25.2 kg/ha (22 lbs/ac), 46.5 kg/ha (41 lbs/ac), and 48.9 kg/ha (44 lbs/ac), respectively. Total estimated biomass in Birch Creek was 40.3 kg/ha (42.4 lbs/ac) or 86.2 kg (190 lbs) of fish. Total estimated biomass in Trout Creek was 379.3 kg (827 lbs). The larger biomass (standing crop) for the Trout Creek population habitat 3.5 ha (8.6 ac) versus 2.14 ha (5.3 ac). Population estimates were not available for other populations of Bonneville cutthroat found in Utah. It can be speculated that their numbers would also be limited because of restricted habitat where they are found.

The year 1977 was considered to be the driest on record and many smaller streams in Utah were severely affected. Birch Creek became dry in the lower 4.8 km (3 miles), thus reducing habitable area from 16.1 to 11.3 km (10 to 7 miles). It was estimated that approximately 0.32 ha (0.79 acres) of good habitat and 225 trout (5 percent of total population) were lost. The drought had a lesser effect on cutthroat trout in Trout Creek. Water conditions were not monitored in other streams containing Bonneville cutthroat trout but these populations were probably affected.

Old, partially functional log structures were credited for the survival of half the know population of Gila trout (*Salmo gilae*) during two consecutive drought years in New Mexico (Jester and McKirdy 1966). It is believed that stream habitat improvements can benefit trout populations in small streams in the Intermountain West (Wydoski and Duff 1978).

Reproduction

The sex of all fish used for growth evaluation was determined by macroscopic examination of the gonads. Males were judged to be mature if they had enlarged testes or testes with residual sperm pockets. Females were judged to be mature if they contained residual eggs from a previous spawning or had eggs that were developing. The majority of cutthroat trout (57.3 percent of 68) in these two collections were males; however, larger fish were selected during sampling in September 1973 for electrophoretic analysis. Therefore, the June 1975 sample was perhaps more representative of the sex ratio in which 43.6 percent of 39 trout were males.

Further reproductive analysis of the Birch Creek population was conducted during the spring of 1977 in conjunction with an on-going management program.[5] During that sampling, males comprised 50 percent of the fish observed. Sex ratios for cutthroat from Trout and Birch creeks, Juab County, were similar to Birch Creek, Beaver County (Hickman 1977).

No male cutthroat trout of Age Group I from Birch Creek were mature; however, seven of eight males from Age Group II were mature. All males longer than 134 mm (5.25 inches) in total length were mature. No females were mature in Age Groups I and II. Females were first mature in Age Group III (1 year later than males); the smallest mature female fish was 147 mm (5.7 inches) in total length.

Three females in the September 1973 collection contained developing eggs and were completing their third summer of life. These trout contained: Ninety-nine eggs (2 mm diameter) in a fish 147 mm (5.7 inches) total length and weighing 39 g (0.08 lbs.); 60 eggs (1.5 mm in diameter) in a fish 158 mm (6.25 inches) total length and weighing 45 g (0.09 lbs.); and 176 eggs (1.5 mm in diameter) in a fish 176 mm (7.0 inches) total length and weighing 75 g (0.17 lbs.).

Spawning in Birch Creek began during early May and continued until June. Water temperature was 6.7°C (44°F) during peak spawning activity. Spawning was first noted in the lower reaches of the stream and then progressed upstream. Water temperatures in the upper and lower stream reaches varied up to 2°C (5°F). Hickman (1977) observed ripe cutthroat trout during late May and reported that spawning was completed in Trout Creek mid- to late June.

MANAGEMENT IMPLICATIONS

When managing fish populations, biologists, administrators, and the public must be prepared to accept variation, dynamic populations, a largely uncontrollable environment, the need for compromises, the need to deal in optimum rather than maximum results, and conflicting desires of the angling public (Everhart et al. 1975). These variables would be the same in managing a fishery for large rainbow trout or managing small and little known endemic cutthroat fishery.

Past management efforts directed specifically toward Bonneville cutthroat have been largely non-existent. When white settlers first entered the Bonneville Basin, *S. c utah* abounded in all streams and lakes. Cutthroat trout

[5]Utah cutthroat trout management proposal for the Southern Region prepared January 1977; approved February 1977 as an integral part of Southern Region fishery management.

populations became established and evolved in these waters as a result of natural phenomena that occured over an extended period of time. Within a very short time following colonization of the Bonneville Basin, cutthroat populations began to decline drastically. As early as 1872, declines of the cutthroat trout in Utah lakes were observed (Yarrow 1874). Decline in lake populations was associated with similar reductions in stream populations. Losses of native trout were related to overharvest by commercial fishing and loss of habitat resulting from diversion and dewatering of area streams used for spawning and rearing. Another event which undoubtedly had a major impact on Bonneville cutthroat was introduction of non-native salmonids such as rainbow trout. Hybridization that resulted, virtually eliminated the genotypic characters of native cutthroat populations and replaced them with hybrids exhibiting cutthroat-rainbow characteristics. Influences on native cutthroat trout proceeded at a very rapid rate and by the early 1900's, *S. c. utah* was believed to be extinct. Under the assumption that the Bonneville cutthroat was extinct, state managers of sport fisheries utilized cutthroat trout from Yellowstone Lake. Management of Utah waters with the Yellowstone Lake strain still continues today.

Recently, several populations of what appear to be pure *S. c. utah* have been identified in small isolated streams in Utah, Nevada and Wyoming. These populations can be used for evaluating the potential role of native cutthroat trout in present and future sport fishery management. As indicated by Behnke (1976c), the idea of supporting angling for a rare or unique trout while trying to increase their abundance may appear contradictory to management goals. However, to increase abundance of a rare or unique trout, it will be necessary to re-establish the fish in waters within its native range. Such introductions would include public fishing waters. Behnke noted that no trout species has become rare or endangered through excessive sport fishing. There is, however, evidence that cutthroat trout populations can be suppressed, thus requiring special regulations for protection. Studies indicate increased abundance, size and angling rate for cutthroat following initiation of specialized regulations (Bjornn 1975; Bjornn and Thurow 1974; Hogander et al. 1974).

Bonneville cutthroat populations would increase numerically from specific programs and would provide a real benefit to sport fishery management. Present populations are confined to small isolated streams which are poor or marginal trout habitat. Although these fish are restricted to poor waters, Bonneville cutthroat appear to be in a healthy biological condition. Substitute fisheries perhaps can be established in other waters in Utah. An increase in fishable waters will be needed as the angling population increases and there is more competition for use of the aquatic resource.

A second benefit to sport fishery management could be the piscivorous food habits of native cutthroat. Historically, the Utah cutthroat and the Lahontan cutthroat trout were known to be piscivorous in their feeding habits. In documenting the effects of the Newlands Project on the Pyramid Lake fishery, Behnke (1974) stated that the official record of Lahontan cutthroat was 12.7 kg (41 lbs) but that other reliable statements revealed that a fish of 19.2 kg (62 lbs) was taken from Pyramid Lake, Nevada, in 1916. Behnke reported that the Lahontan cutthroat trout fed extensively on tui chub (*Gila bicolor*). The cutthroat from Utah Lake also reached large sizes. These fish were probably old since the fishery was unexploited at that time and were large because of their piscivorous feeding habits.

The present management of cutthroat trout fisheries utilize the Yellowstone Lake form which is not known to be piscivorous. Cutthroat trout in Yellowstone Lake occur together ecologically [summer water temperatures rarely get above 15.5°C (60°F)] with fish that could be used as forage such as red-side shiner and longnose sucker (*Catostomus catostomus*) but do not feed upon them. Yellowstone Lake cutthroat reached a length of about 477 mm (18 inches) at the end of their seventh growing season (Carlander 1969). In contrast, cutthroat trout in

Bear Lake, Utah-Idaho, weighed 5.6 kg (18 lbs) and were piscivorous (McConnell et al. 1957). A population of redbanded trout in southeast Oregon populated a stream system and a reservoir. The fish in the reservior utilized as forage tui chub and grew to a larger size than the fish in the stream (Clair Kunkel, personal communication).[6] Bonneville cutthroat trout may provide an effective biological control for certain undesirable and competitive fish species such as Utah chub, red-side shiner, suckers, etc., that are presently causing many problems to lake and reservior management.

In summary, a management program specifically designed to re-establish Bonneville cutthroat trout in Utah waters could insure the continued existence of these unique fish in the biological heritage of Utah. Of equal importance, this subspecies could be beneficial to fishery management in Utah. Its survival in marginal habitats and its potential for biological control of nongame fish species could prove very advantageous to future sport fishery management. Continued study will be needed to establish the role Bonneville cutthroat trout will have in the biota of Utah and the Bonneville Basin.

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Notes