

Effects of Water Quality and Habitat on Composition of Fish Communities in the Upper Colorado River Basin

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Natural and human factors in the Upper Colorado River Basin result in differences in water quality and fish habitat. Fish community composition is associated with differences in water temperature, concentrations of dissolved solids and suspended sediment, elevation, habitat, and land use.

Introduction

The sampling design of the National Water-Quality Assessment (NAWQA) program emphasizes a multidisciplinary approach using physical, chemical, and biological information to provide multiple lines of evidence to describe water-quality conditions. The composition of fish communities at stream sites representing selected environmental settings is one characteristic assessed as part of the NAWQA program (Meador and others, 1993a). The presence and abundance of fish species can be related to water chemistry, physical habitat, and land-use activities to provide a more complete picture of water quality across a river basin.

Although fish communities may have a high degree of natural variability, they can be useful indicators of ecosystem health (Moyle, 1994). Berkman and others (1986) recommended fish be given consideration in biological water-quality monitoring of streams because they generally are perceived by the public to be ecologically relevant, and they are directly related to legislative mandates because of human health and endangered species concerns. This fact sheet summarizes the results of an August 1996 fish survey and relates these results to natural and human factors that affect water quality and physical habitat in the Upper Colorado River Basin (UCOL) study unit in Colorado.



Brown trout (typical invertivore species present in the Southern Rocky Mountains province).



Typical stream setting in the Southern Rocky Mountains province.

Description of Study Unit

The UCOL study unit includes about 17,800 square miles (fig. 1), which varies greatly in climate, geology, topography, and hydrology. The primary river, the Colorado River, originates in the mountains of central Colorado and flows 230 miles southwest into Utah, dropping about 10,000 feet in elevation. The major tributaries include the Blue, Eagle, Roaring Fork, and Gunnison Rivers (Driver, 1994).

The UCOL study unit is divided almost equally into two physiographic provinces: the Southern Rocky Mountains in the eastern, high-elevation part and the Colorado Plateau in the western, low-elevation part (Apodaca and others, 1996). Stream habitats vary from cool, clear, and forested headwater streams that have crystalline bedrock with high gradients and coarse substrates in the Southern Rocky Mountains, to warm, sluggish, less vegetated, and saline streams that have low gradients and fine substrates in the Colorado Plateau. Stream habitat and water quality reflect the extreme differences in elevation, climate, vegetation, and geology across the study unit, which have an associated effect on fish community composition.

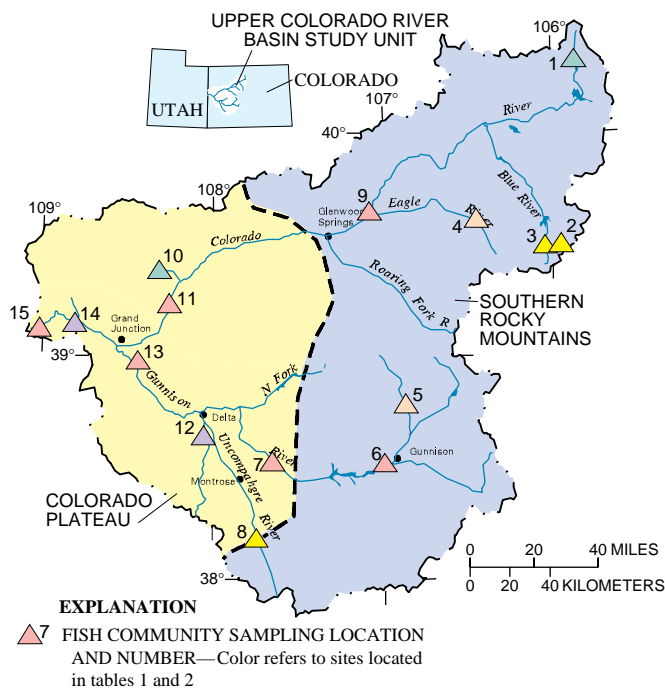


Figure 1. Location of Upper Colorado River Basin study unit, physiographic provinces, and fish community sampling sites.

Fish Communities in the Upper Colorado River Basin

A fish community is a group of fish that inhabit the same area of a stream and interact with each other. The structure of a fish community is determined by the species present, their relative abundances, their life stages and size distributions, and their distributions in space and time (Meador and others, 1993a). Fish communities were assessed at 15 sites throughout the UCOL in August 1996 (fig. 1; table 1). Seven sites represent drainage basins with specific land uses, such as agriculture, mining, and urban/recreation, and six sites have drainage basins with multiple land uses (Spahr and others, 1996). Two sites represent background conditions and generally are unaffected by human activities. Personnel from the U.S. Fish and Wildlife Service assisted with fish collection. Collection was done by electroshocking a stream reach 450 to 650 feet in length at wadeable sites and 1,500 to 3,000 feet in length at nonwadeable sites. The nonwadeable sites were sampled using fish-shocking equipment from a boat. Fish were identified, measured, weighed, and released back to the stream. A single reach of stream was sampled at each site, except for three sites where multiple-reach sampling was conducted. Multiple-reach sampling consisted of electroshocking two additional reaches at a site that had similar geomorphic channel units (that is, riffles, pools, and runs) and were adjacent to the primary reach. Multiple-reach sampling was done to determine variability of abundances and types of fish species within a stream segment 1 to 2 miles long. Type, trophic class, and relative abundance of native and nonnative fish species are listed in table 2.

Fish communities can have a high degree of variability because of geographic distribution of species, human modifications of streams and the surrounding landscape, presence or absence of nonnative species, and natural effects. Natural variability in fish communities can be attributed to differences in elevation, water temperature, physical habitat, water quality, and other important characteristics of the environmental setting.

Low abundances and types of fish species may be a result of water quality and habitat that can be affected by the surrounding land use. No fish were present at French Gulch (site 2) and Dry Fork (site 10) (fig. 1; tables 1 and 2). Site 2 is a mining site, and cutthroat trout are present upstream from the mined area (Jay Skinner, Colorado Division of Wildlife, oral commun., 1997); but fish are not present downstream from the mined area to the mouth of the stream. High dissolved-solids concentrations and low streamflow are associated with site 10, a background site. Absence of fish at site 10 might be attributed more to low streamflow and associated habitat than to water-quality conditions. The abundance and type of fish species at the Blue River site (site 3), a mining land-use site, were low compared to other sites in the Southern Rocky Mountains province. Lower abundances and fewer species were present at the Reed Wash site (site 14), an agricultural land-use site, compared to the other sites in the Colorado Plateau province. Eleven of the 13 sites with fish contained native and nonnative species. Only nonnative species were present at two sites, site 3 and the Gunnison River below Gunnison Tunnel (site 7). Site 3 is downstream from a mined area, and site 7 is downstream from a series of dams.

The multiple-reach sites are designated as sites A, B, and C for Baker (site 1), Gore (site 4), and Dry Creek (site 12) in table 2. The greatest difference in the number of fish species among the three sampled reaches occurred at site 12, where the number ranged from 6 to 9 among sampling reaches. The greatest difference in the total number of fish occurred at site 4, where abundances ranged from 115 to 371 among sampling reaches.

Table 1. Fish community sampling sites in the Upper Colorado River Basin

[Color represents land use; green = background; yellow = mining; orange = urban/recreational; red = multiple land use; purple = agriculture]

Site number ¹	Site name ²	USGS station number
1	Colorado River below Baker Gulch (Baker)	09010500
2	French Gulch at Breckenridge (French)	09046530
3	Blue River near Breckenridge (Blue)	392944106024400
4	Gore Creek at Dowd Junction near Minturn (Gore)	09066510
5	East River below Cement Creek (East)	09112200
6	Gunnison River at County Road 32 (Gunn 32)	383103106594200
7	Gunnison River below Gunnison Tunnel (Gunn Tun)	09128000
8	Uncompahgre River near Ridgway (Ridgway)	09146200
9	Colorado River at Dotsero (Dotsero)	09070500
10	Dry Fork at upper station, near De Beque (Dry Fork)	09095300
11	Colorado River near Cameo (Cameo)	09095500
12	Dry Creek at Begonia Road near Delta (Dry Creek)	09149480
13	Gunnison River near Grand Junction (Gunn GJ)	09152500
14	Reed Wash near Mack (Reed Wash)	09153290
15	Colorado River near Colorado-Utah State line (State line)	09163500

¹Site number refers to numbers in figure 1.
²Names in parentheses are site-name abbreviations.

Trophic class information can be useful in distinguishing differences among sites. Fish are categorized by trophic classes based on their type of diet. Data for this fact sheet were based on a generalized trophic classification for each species. Ninety-four percent of the total number of fish in the UCOL basin were classified as invertivores (I) or omnivores (O) (fig. 2; table 2). The remaining 6 percent were classified herbivores (H) or piscivores (P). Invertivores are fish that consume mostly invertebrates, whereas omnivores consume invertebrates, fish, and plants. Herbivores consume mostly plants, whereas piscivores consume mostly fish (Schrader, 1989).

Distinct fish communities are associated with the two physiographic provinces. Invertivore species are predominant at sites in the Southern Rocky Mountains province. Omnivore species are predominant at sites in the Colorado Plateau province. Herbivore and piscivore species were present only at sites in the Colorado Plateau province. Overlap of species is observed in a transition zone, which is located along the division line of the two physiographic provinces. The sites located closest to the transition zone are a Gunnison River site (site 7), the Uncompahgre site (site 8), and the Dotsero site (site 9). Overlap of trophic classes occurs at two of these sites (sites 8 and 9) as shown in figure 2. Site 7 is downstream from a large dam, and although physically located in the Colorado Plateau province, it is hydrologically represented as a Southern Rocky Mountains province site. Cold-water releases, low concentrations of dissolved solids and suspended sediment, and a suitable habitat at this site provide conditions for trout species that more typically occur at high-elevation sites in the Southern Rocky Mountains province.

The Gunnison River at County Road 32 (site 6) and site 9 have representation from both dominant trophic classes. The invertivore species are similar at these two sites; however, the composition of the omnivore species differs between sites. Site 6 has a high-elevation, cold-water sucker species, whereas site 9 supports primarily low-elevation, warm-water sucker species. Fish communities at site 6 may be affected by fishing pressure on trout and by increased pooled areas at the upper end of the downstream reservoir, which provides habitat conditions favorable to sucker species. Invertivore and omnivore

trophic classes are represented more evenly at site 12 than at other sites; however, 90 percent of the total number of invertivore fish species collected were minnows, which are characteristic of habitat conditions in the Colorado Plateau province. The herbivore and piscivore species also are characteristic of habitat conditions in the Colorado Plateau province.

Relation Between Water Quality and Fish Communities

Water temperature and concentrations of dissolved solids and suspended sediment generally are lower in the Southern Rocky Mountains province when compared to the Colorado Plateau province (figs. 3A, B, C). Elevation is considerably lower in the Colorado Plateau (fig. 3A). Median concentrations of dissolved solids and suspended sediment change noticeably near the transition zone between the two provinces. Changes in the geology from crystalline bedrock in the Southern Rocky Mountains province to sedimentary deposits in the Colorado Plateau province can be one factor for the changes in concentrations (Apodaca and others, 1996).

Water temperature is inversely related to elevation in the basin; as elevation decreases, water temperature increases (fig. 3A). Temperature is one major controlling factor in fish community composition in the UCOL study unit. Selected water-temperature conditions provide a favorable habitat for selected fish species (Coutant, 1977). The cold water of the Southern Rocky Mountains province is favorable to trout and sculpins, and the warm water of the Colorado Plateau province is favorable to suckers, minnows, and sunfish (table 2).

Dissolved solids is a measure of the concentration of cations (calcium, magnesium, sodium, and potassium,) and anions (bicarbonate, sulfate, and chloride) in water (Hem, 1992) and commonly is referred to as salinity. Dissolved-solids concentrations are higher at sites in the Colorado Plateau province than at sites in the Southern Rocky Mountains province (fig. 3B). Sucker species are more tolerant of the higher concentrations and, therefore, were more predominant in

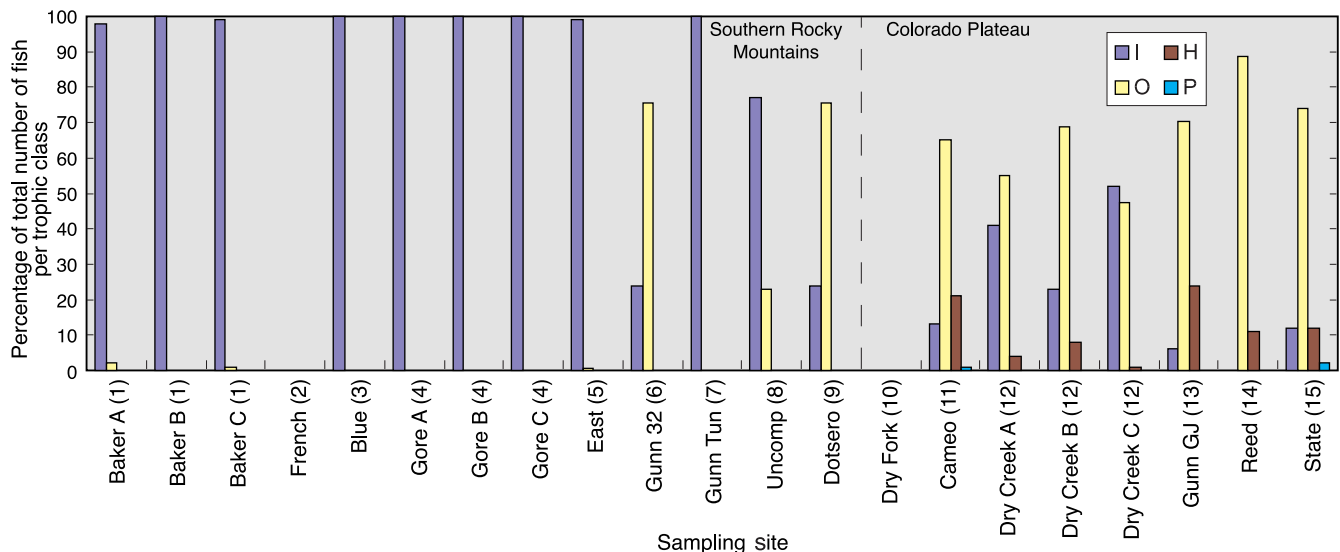


Figure 2. Percentage of total numbers of fish for the trophic classes represented at sampling sites in the Upper Colorado River Basin (I, invertivore; O, omnivore; H, herbivore; P, piscivore).

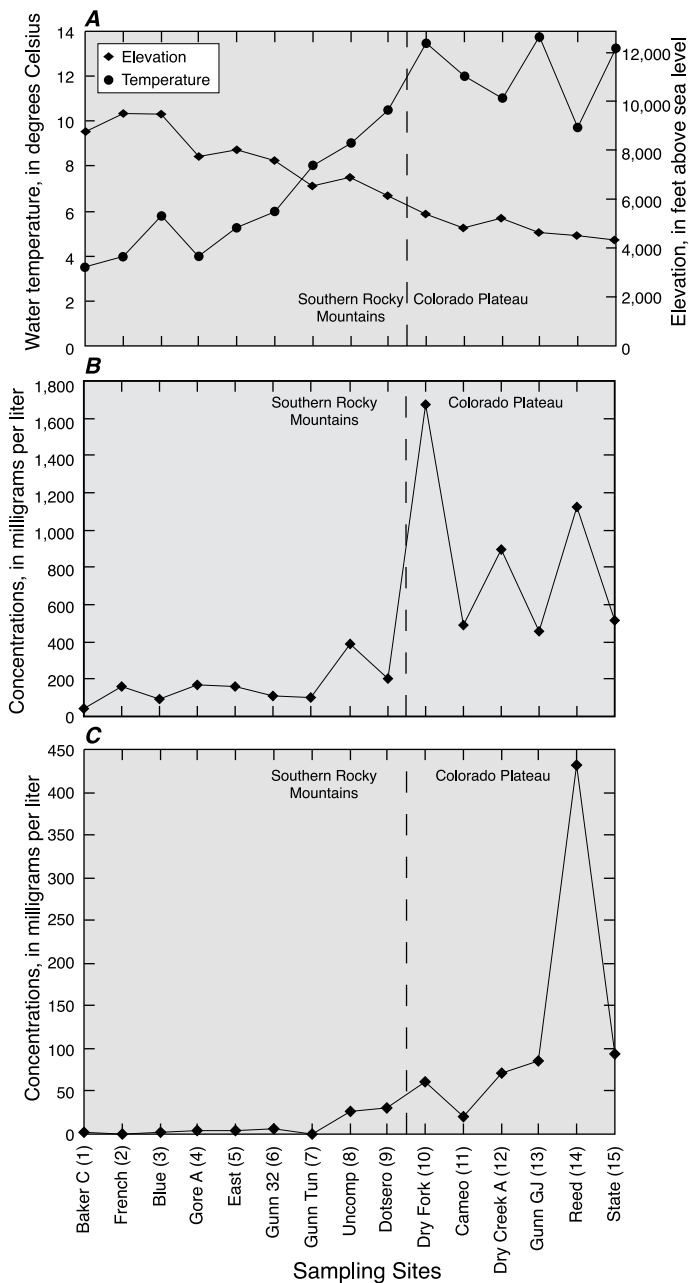


Figure 3. (A) Relation of water temperature and elevation; (B) dissolved-solids concentrations; and (C) suspended-sediment concentrations for fish community sampling sites in the Upper Colorado River Basin.

the Colorado Plateau province. Changes in species composition also were observed between sites in the Colorado Plateau province in comparison to sites in the Southern Rocky Mountains province.

Suspended sediment is the solid material transported in the streamflow, either in suspension or along the stream bottom. Many nutrients, trace elements, and pesticides adhere to these particles and are transported downstream. The omnivorous species, primarily present in the Colorado Plateau province, can tolerate high concentrations of suspended sediment. In general, as concentrations of suspended sediment increased (fig. 3C), numbers and types of omnivorous fish species also increased in a downstream direction in the Colorado Plateau province. Comparison of selected water-quality constituents and fish communities indicated a relation.

Relation Between Stream Habitat and Fish Communities

One important aspect of stream habitat is substrate type (Meador and others, 1993b). The relative abundances of coarse (boulder/cobble/gravel) and fine (sand/silt/clay/muck) bed materials at sites in the two physiographic provinces are shown in figure 4. These percentages are based on a qualitative habitat assessment using techniques designed for NAWQA (Meador and others, 1993b). Invertebrate species are more abundant in streams with cobble, gravel, and boulder substrates because these substrates provide space for invertebrates and, thus, provide food for fish. Most of the cold-water species need gravel and cobble to shelter their eggs during reproduction. As streams leave the headwater regions of the Southern Rocky Mountains province, where substrates consist mostly of coarse material, the substrate changes and includes finer materials mixed with some coarse materials. These finer materials account for most of the substrate in streams of the Colorado Plateau province. Sand, silt, clay, and muck are a natural part of the stream bottom, having been deposited mainly as a result of erosion and runoff from fields and streambank material. However, these finer materials can decrease available habitat for aquatic plants and



White sucker (typical omnivore species present in the Colorado Plateau province).



Typical stream setting in the Colorado Plateau province.

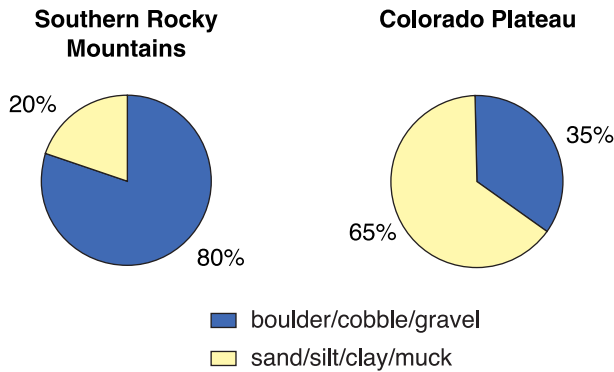


Figure 4. Percentages of types of bed substrate for fish community sampling sites in each physiographic province.

organisms by filling in spaces between rocks, which results in loss of cover for fish and their food sources and for spawning areas. Warm-water omnivorous species can tolerate the food-source and spawning areas that are present in streams in the Colorado Plateau province. Comparison of bed substrate and trophic classes (figs. 2 and 4) indicated a relation between fish communities and their habitat.

Summary

Differences in fish communities in the Upper Colorado River Basin study unit reflect the water quality and habitat that characterize the physiographic provinces. Fish communities are invertivores at high elevation, forested, high-gradient, cold-water sites in the Southern Rocky Mountains province and mostly omnivores at lower elevation, less vegetated, low-gradient, warm-water sites with high concentrations of dissolved solids and suspended sediment in the Colorado Plateau province. Invertivore species, such as trout, more commonly are present in the swift, clear, cold-water streams with boulder/cobble/gravel substrates in the Southern Rocky Mountains province. Omnivore, herbivore, and piscivore species, such as suckers, minnows, and sunfish, tolerate slow, turbid, warm-water streams with sand/silt substrates in the Colorado Plateau province.

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Fish collection on the Uncompahgre River near Ridgway (site 8).

Information on technical reports and hydrologic data related to the NAWQA program can be obtained from:

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