MICROHABITAT OF TROUT IN TAILWATERS BELOW WESTERN DAMS

Volume I
Narrative Report

by

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DISCLAIMER

The opinions, findings, conclusions, and recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the U.S. Bureau of Reclamation.

TABLE OF CONTENTS

TABLE OF CONTENTS (con't)

TABLE OF CONTENTS (con't)

LIST OF TABLES

LIST OF TABLES (con't)

LIST OF FIGURES

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ABSTRACT

This study was designed to obtain microhabitat data for trout species observed in the tailwaters below four dams operated by the U.S. Bureau of Reclamation. The rivers studied were the: Colorado River, Arizona; San Juan River, New Mexico; Gunnison River, Colorado, and the Green River, Wyoming. Data collected during this study were also compared to data collected previously in the Green River, Utah.

Data were collected for two seasons: winter (December to March) and summer (May to September). Data were collected during winter and summer 1984 and winter 1985.

Observations of fish were made by a diver using a modified scuba technique. Microhabitat variables were measured as nearly as possible to each fish's precise location. The four variables which were most pertinent in describing trout microhabitat were: fish velocity, mean velocity, fish depth, and water depth. Substrate was important during spawning.

Observations of fish were classified and analyzed according to the physical activity of the fish. The three primary activities observed were stationary swimming, random swimming, and spawning. Fish were separated into three groups using length frequency data which approximated age 0, juvenile, and adult trout.

The upper Colorado River drainage area experienced record winter snowfalls beginning in the winter of 1983 and continuing

throughout the course of the study. Heavy runoffs caused by these record snowfalls prevented sampling at the Green River, Wyoming and Gunnison River, Colorado sites during summer 1984. When diving could be conducted at these two sites, few or no trout were observed. Winter emigration appeared to be occurring from the Gunnison site. Winter emigration or very low trout densities appeared to cause the lack of observations in the Green River site.

In the Colorado River, trout used only limited portions of the total habitat and were not equally distributed along the course of the river. Seasonal differences in microhabitat choices were not observed in this river. Annual microhabitat choices in the Colorado River were essentially the same when comparisons were made between the winters of 1984 and 1985. The high flows that occurred throughout the study did not appear to be excessive for the trout.

The density of trout observed in the San Juan River was extremely high. It appears that the restrictive fishing regulations applied in this section of the river were a major reason for the high densities. Trout were utilizing lower water depths and velocities in the San Juan than were observed in other rivers.

When microhabitat data were compared among rivers, important differences were observed. Microhabitat differences observed during summer were reflective of physical differences among the rivers. Differences observed among rivers during winter were more diverse and appeared to be strongly influenced by tempera-

ture. The differences observed among rivers indicated that indiscriminate application of microhabitat data collected on one river to other rivers has a high probability of producing erroneous results. But it also seems probable that, with an adequate data base, microhabitat variations among rivers can eventually be predicted and data could be accurately applied to other rivers.

The relative size of an age group was found to be important when making comparisons of microhabitat choices within the same life stage. Microhabitat requirements for age 0 trout change sufficiently that they need to be separated into at least two sub-groups based on size.

INTRODUCTION

Study Objectives

A basic objective of this study was to obtain microhabitat data for all trout species observed in four different tailwaters below dams which are operated by the U.S. Bureau of Reclamation (USBR). Fish microhabitat data obtained in this study were intended to be utilized in the IFG-4 hydraulic simulation and fish habitat model (Bovee and Cochnauer 1977, Bovee and Milhous 1978). The rivers to be studied were the: Colorado River, Arizona; San Juan River, New Mexico; Gunnison River, Colorado; and the Green River, Wyoming (Figure 1). The trout species found in these rivers were: rainbow trout (Salmo gairdneri), brook trout (Salvelinus fontinalis), brown trout (Salmo trutta), and cutthroat trout (Salmo clarki).

Comparisons were to be made for the same species among rivers and between seasons for appropriate activities. The objective of comparing data among rivers was to determine whether microhabitat data collected on one group of rivers could be accurately applied to other rivers, or if variations in microhabitat choices occurred among rivers for a given species. The USBR currently has microhabitat data on brown trout from the Provo River (Gosse and Helm 1979), and rainbow and cutthroat trout from the Green River (Gosse 1982), that were collected using the same technique that was used in this study. If microhabitat data can be accurately applied among rivers, a great deal of effort and

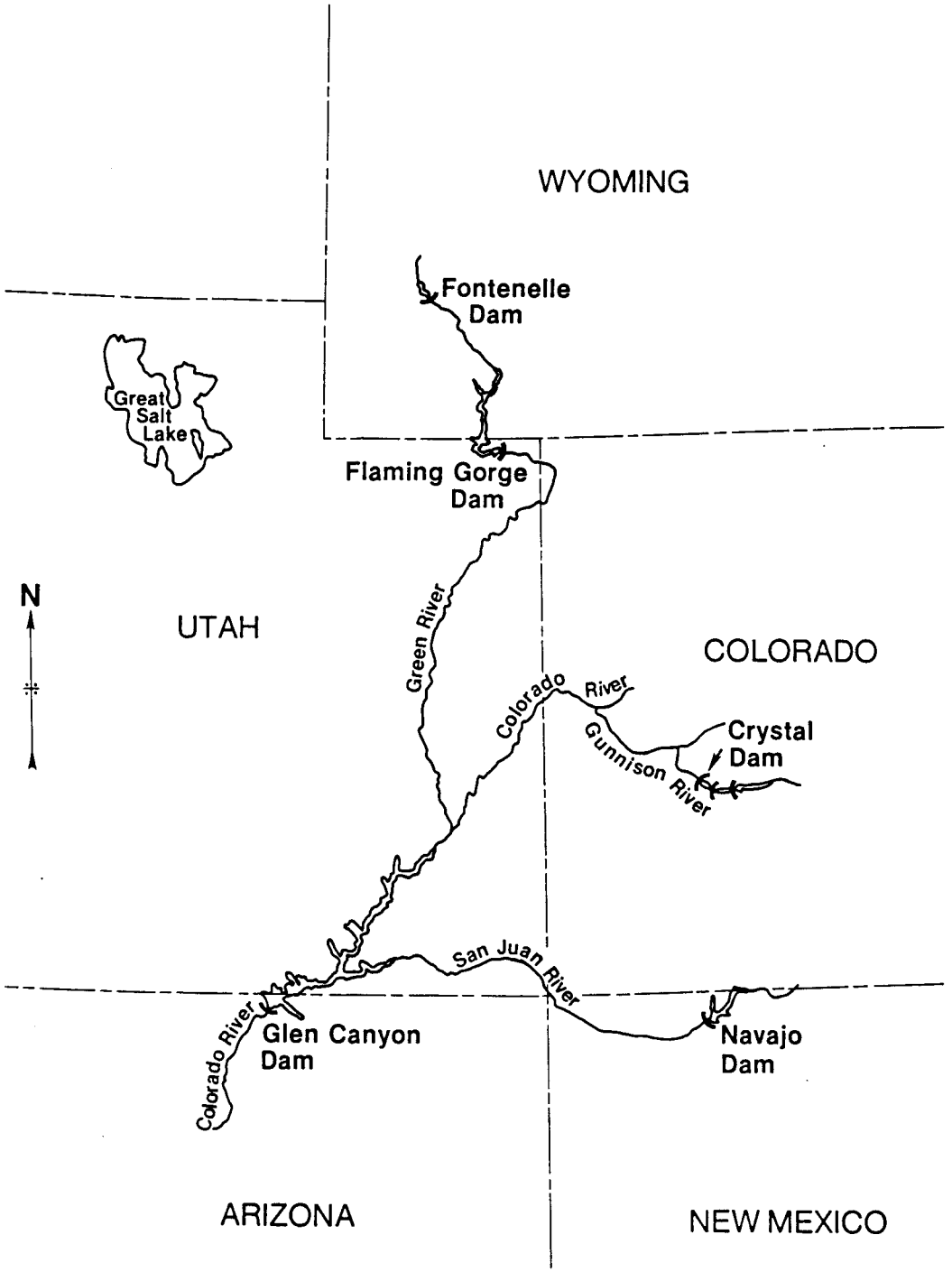


Figure 1. Upper Colorado River drainage area and USBR reservoirs.

expense could be spared. If microhabitat data cannot be indiscriminately applied across river systems, it might be possible to determine which microhabitat variables are most likely to change and how.

Another objective of the study was to determine if major changes in habitat preference or activity occur between winter and summer seasons in any of the rivers. Rainbow and cutthroat trout were observed to make major shifts in activity and habitat choices between winter and summer in the Green River, Utah (Gosse 1982). These shifts required that different data sets be used to accurately predict habitat preference between winter and summer. At the beginning of this study, it was unknown whether such seasonal shifts occurred in the rivers to be studied.

Data were collected by species, approximate life stage (age 0, juvenile, and adult), and physical activity of the fish for two seasons: winter (December to March) and summer (May to September). Data were collected during two successive winters: December, 1983 to March, 1984 and December, 1984 to March, 1985 which are referred to as winters 1984 and 1985, respectively. Summer data was collected only during summer 1984. Data were further stratified by flow releases, when necessary, for a particular river.

Site Descriptions

The upper Colorado River drainage area experienced extreme weather conditions beginning in the winter of 1983 and continuing throughout the course of the study. Record snowfalls oc-

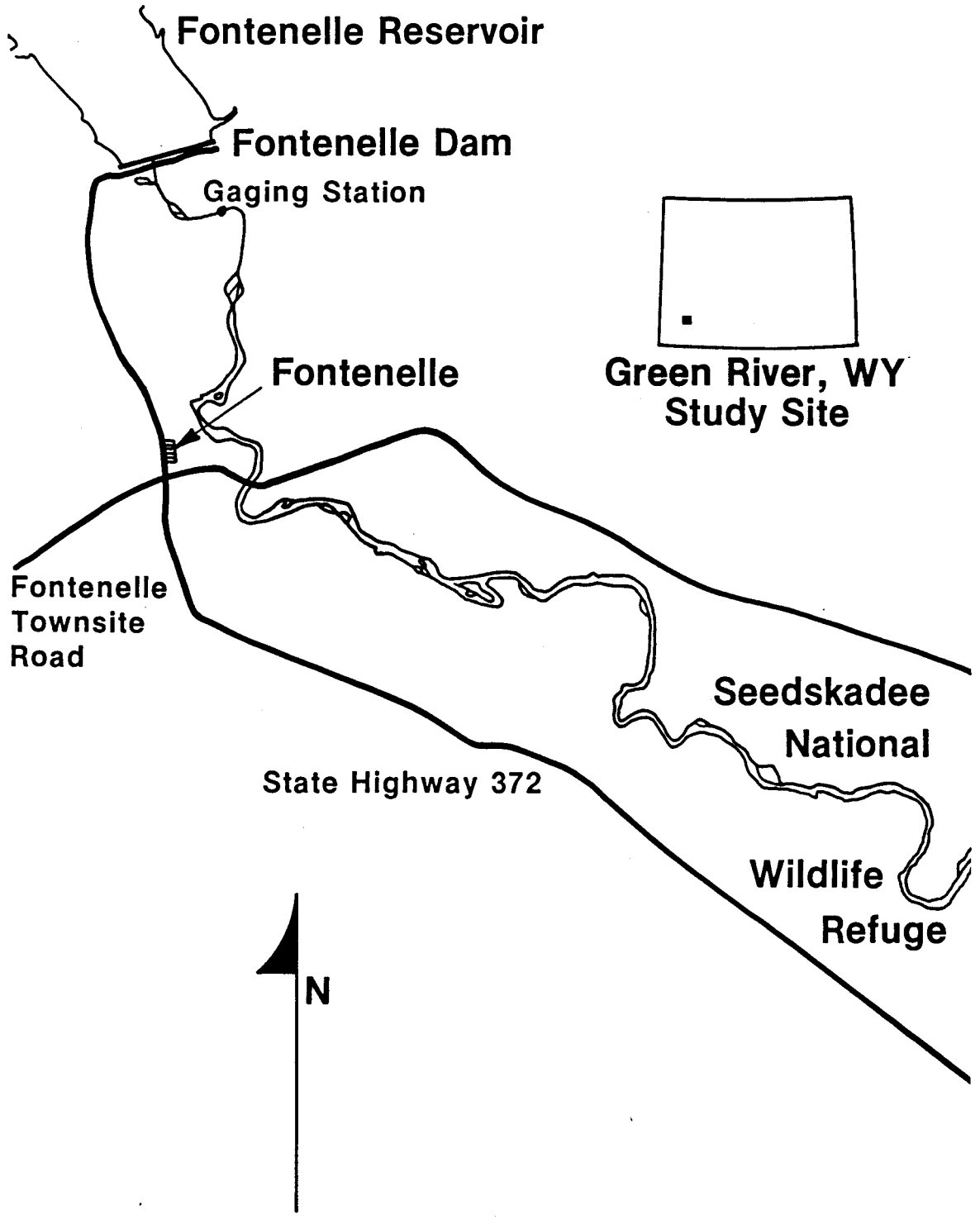


Figure 2. Green River, Wyoming study site.

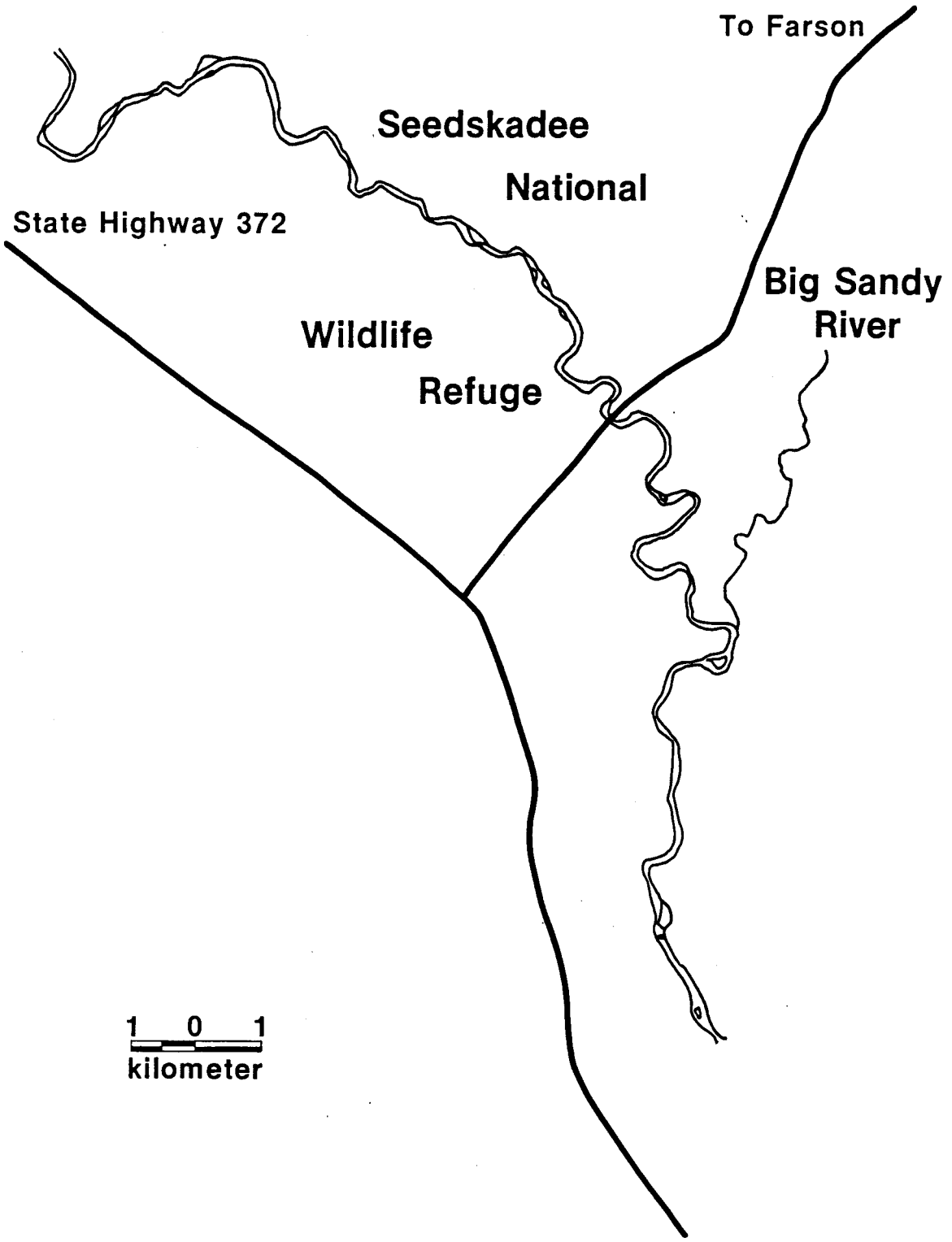


Figure 2. Continued.

curred during winters 1983, 1984, and 1985 throughout the region. These snowfalls caused heavy flooding during each subsequent spring which, in many cases, extended well into the summer.

Problems from the record snowfalls were further compounded by limited storage capacity in many of the reservoirs. In April, 1983 the water level at Fontenelle Reservoir, Wyoming was restricted to 43% of normal storage capacity because of structural problems with the dam (L. Morrison, USBR, personal communication). In addition, many of the reservoirs in the Colorado drainage filled to capacity in spring 1983. This forced operations at the various dams to bypass all additional flood water downstream which further compounded flooding problems at downstream reservoirs. Therefore, high flows and flooding were common during this study and, as a result, the study rivers were often too turbid for successful observations.

Green River, WY

The study site on the Green River, Wyoming extended from Fontenelle Dam downstream to the confluence with the Big Sandy River, a river distance of approximately 46 km (Figure 2). Fontenelle Dam is located approximately 56 km northeast of Kemmerer, Wyoming.

This is a relatively low gradient section of the river consisting primarily of glides with some riffles and pools but no rapids. Water temperatures vary widely between winter and summer, ranging between 0-25 C, respectively (Banks et al. 1974). Since the dam was constructed, mean releases have been 1600 cfs with a mean annual range from 500-5,000 cfs (Banks et. al. 1974).

Rainbow and brown trout have been found in the river along with spawning populations of kokanee (Oncorhynchus nerka). There were extremely high standing crops of mountain whitefish (Prosopium williamsoni) and suckers (Catostomus sp.) in this area. Common carp (Cyprinus carpio) and sculpin (Cottus sp.) were observed infrequently.

Gunnison River, CO

The study site on the Gunnison River, Colorado extended from Crystal Dam downstream approximately 43 km to the confluence with the North Fork of the Gunnison. Most of this area is located in the Black Canyon of the Gunnison and was inaccessible by boat. Only two areas were accessible for study: from the confluence with the North Fork upstream approximately 6.5 km; and from Crystal Dam downstream approximately 3 km to the Gunnison Tunnel diversion (Figure 3). Crystal Dam is the lowest dam in the Wayne Aspinal Unit, which also includes Morrow Point and Blue Mesa Dams.

In the upper study section, the river is quite restricted by the surrounding canyon and consists primarily of deep glides with some small riffles. In the lower study section, approximately the first 4.5 km of river upstream from the North Fork confluence is unrestricted by the broad canyon through which it flows. The river is relatively broad and shallow here and consists primarily of a series of shallow fast glides and riffles. Midstream depths often range between 1 to 2 m, depending on flows. Some side stream pools and back eddies are found, but depths are still usually less than 3 m. The upper 2 km of the lower study section

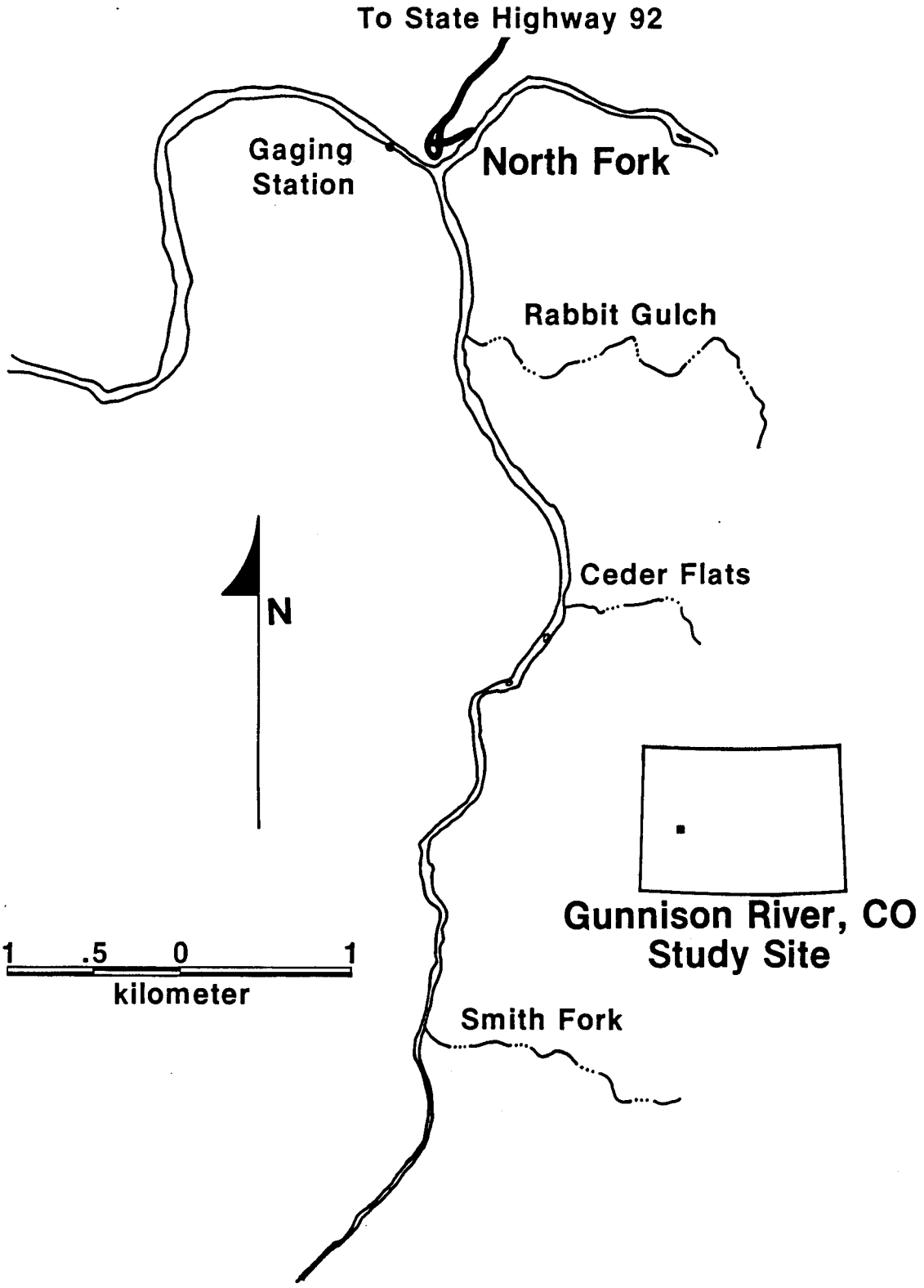


Figure 3. Gunnison River, Colorado study site. (These two maps are not continuous. The 33 km of river running through Black Canyon National Monument are not shown.)

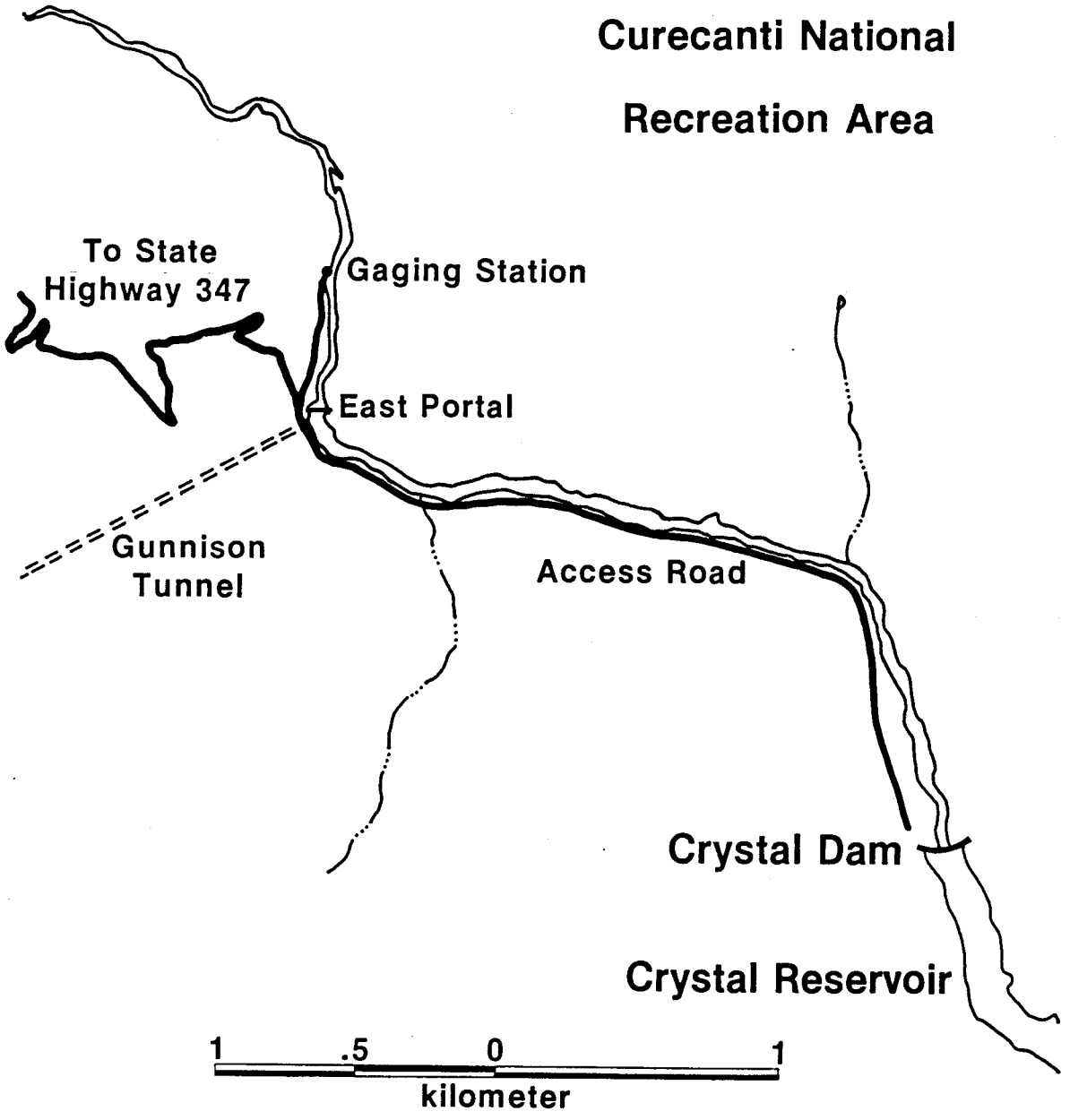


Figure 3. Continued.

flows through a very narrow gorge, with sheer rock cliffs along much of the shore. This part of the river consists primarily of deep glides with occasional rapids and back eddies.

Flows in the upper study section are determined by releases from Crystal Dam. Flows in the lower study section are also effected by irrigational diversions from the river through the Gunnison Tunnel. Maximum capacity of the dam's turbine is 1,770 cfs, with normally about 1,000 cfs diverted through the Gunnison Tunnel during the summer. The USBR currently maintains a minimum flow of 200 cfs in the river below the tunnel.

The extreme snowpack and resulting runoff in 1983 required bypassing additional water around the turbine from May to September resulting in an average total release during this time of 4,000 cfs and a maximum release of 10,000 cfs. These were the highest flows released down the river since the first dam, Blue Mesa, was closed in 1965.

Again in 1984, water was bypassed from January to September with a mean release during this time of 3,600 cfs and a maximum release of 10,000 cfs. Water temperatures normally range between 2-11 C at the tunnel diversion (Wiltzius 1978).

Brown and rainbow trout have been found in the study area with both species having some natural reproduction in the river (Nehring and Anderson 1983). Common carp were also observed during this study. Wiltzius (1978) provides a thorough description of the other species found in the Gunnison drainage, as well as a history of the diversion and dam development on the river.

Colorado River, AZ

The study site on the Colorado River extended from Glen Canyon Dam near Page, Arizona downstream to the confluence with the Paria River (Figure 4). The total river distance is approximately 25 km. The USBR established an IFG-4 site between river kilometers 14-18. This area was heavily sampled during this study, especially for adult and spawning microhabitat.

During the time of this study, the upper normal release from the dam was 27,000 cfs. This upper level reflected the fact that one turbine at a time was constantly inoperative for rewinding purposes. The current upper capacity through the turbines is approximately 32,000 cfs (L. Morrison, USBR, personal communication). Minimum releases from the dam are normally 3,000 cfs from April to September and 1,000 cfs during the remainder of the year. In 1983 and 1984, the excess runoff caused by the heavy winter snowfalls at upstream sites cumulated in Lake Powell. The reservoir filled during spring 1983 and continued filling to several meters above design capacity. Excess releases were bypassed around the turbines from June to August 1983 with a maximum total daily release of 90,000 cfs. Releases were bypassed again in 1984 from May to August with an approximate average release during this time of 40,000 cfs (J. Gough, USBR, personal communication).

Throughout 1984 and 1985, whenever water wasn't being bypassed, releases from Glen Canyon Dam were usually at the current maximum capacity of the turbines as a result of the high water situation. The flows encountered throughout this study

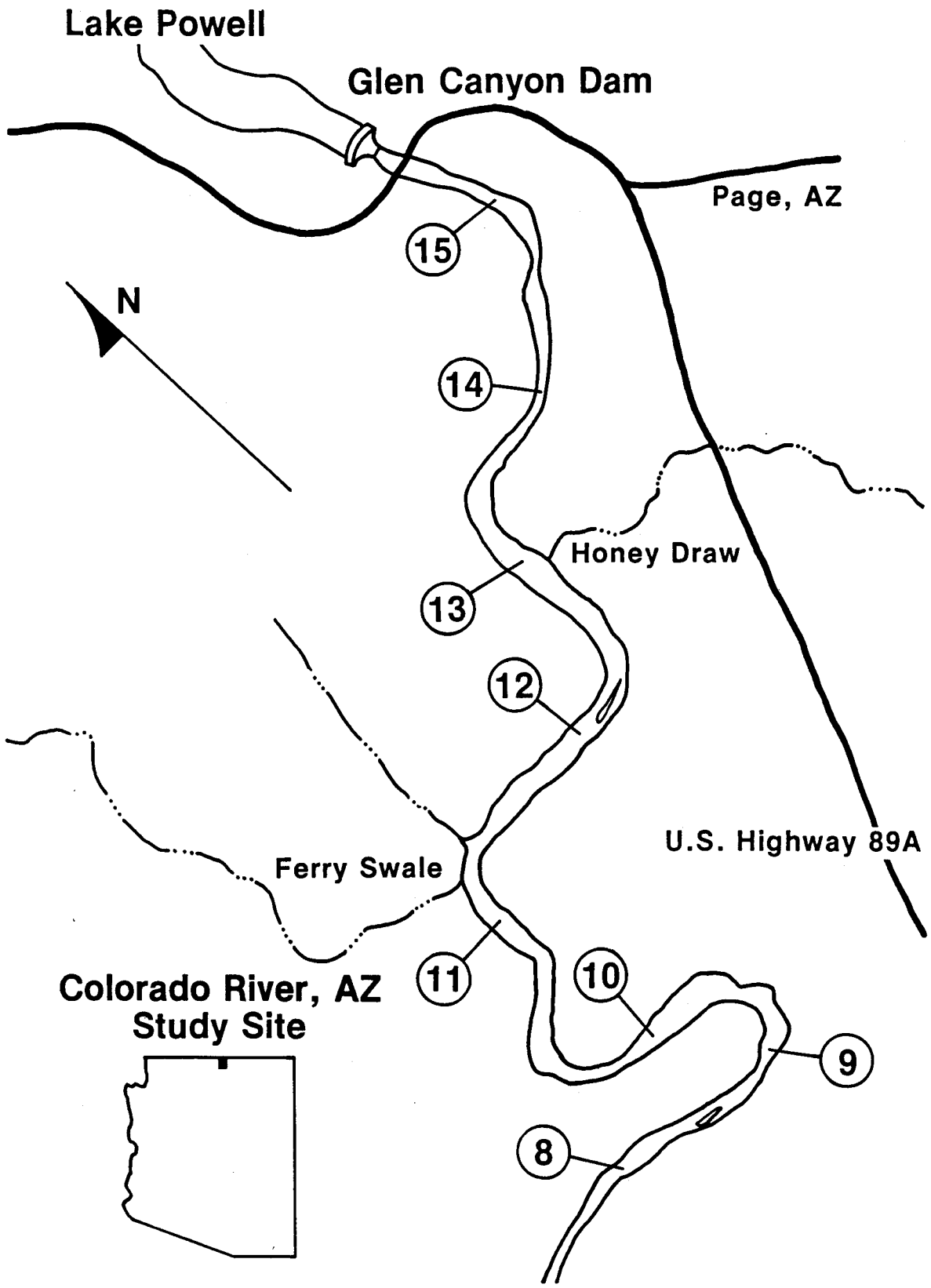
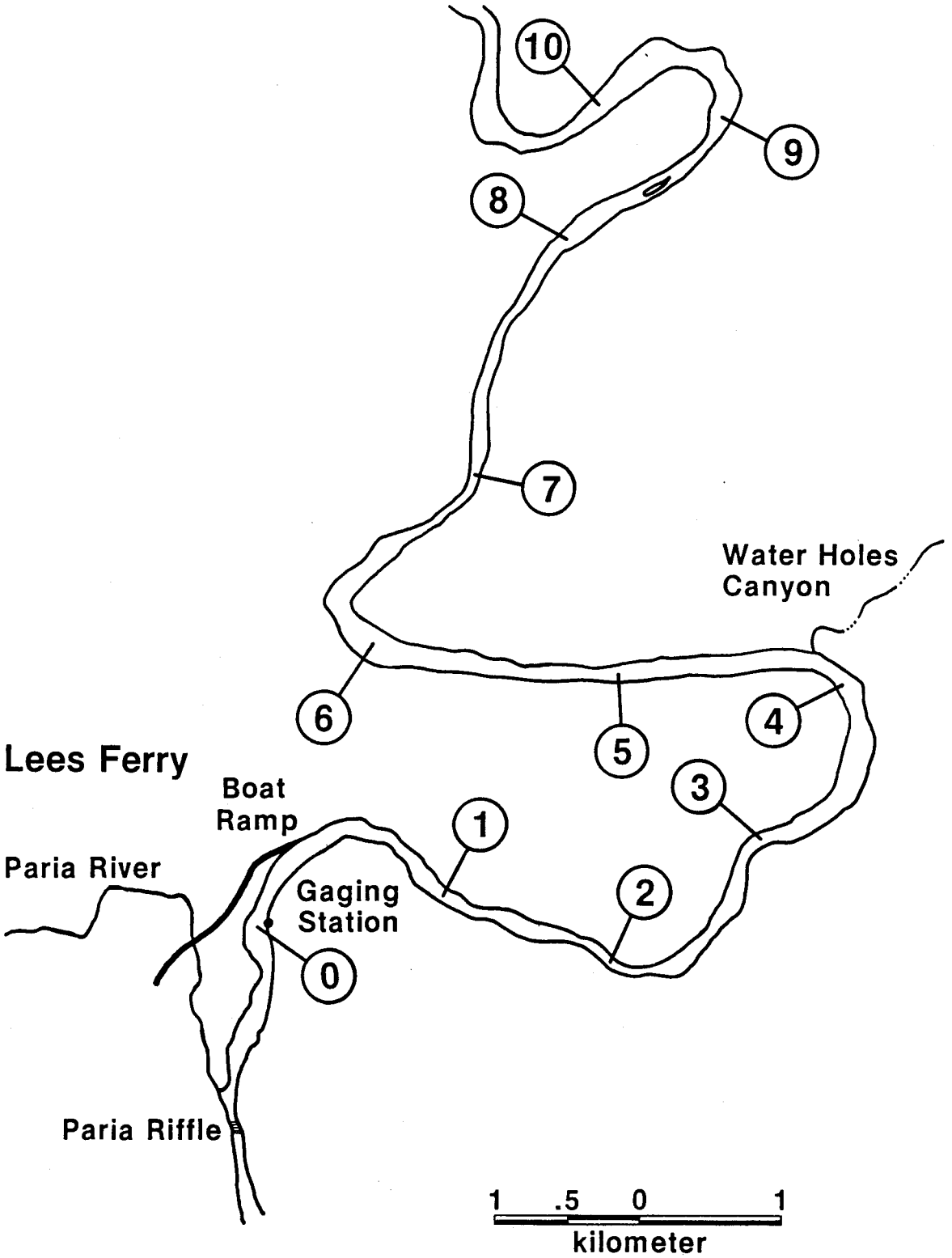


Figure 4. Colorado River, Arizona study site.



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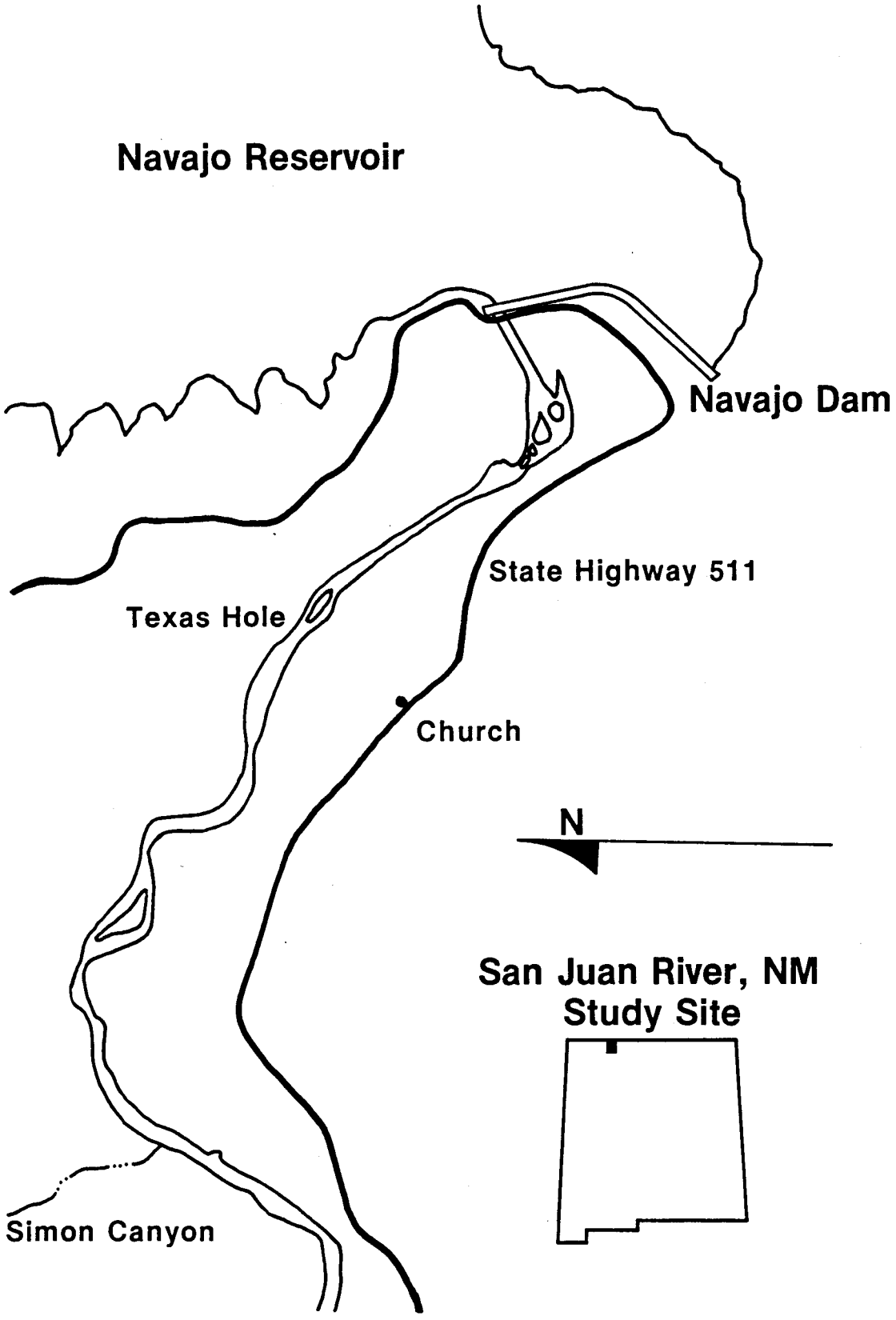
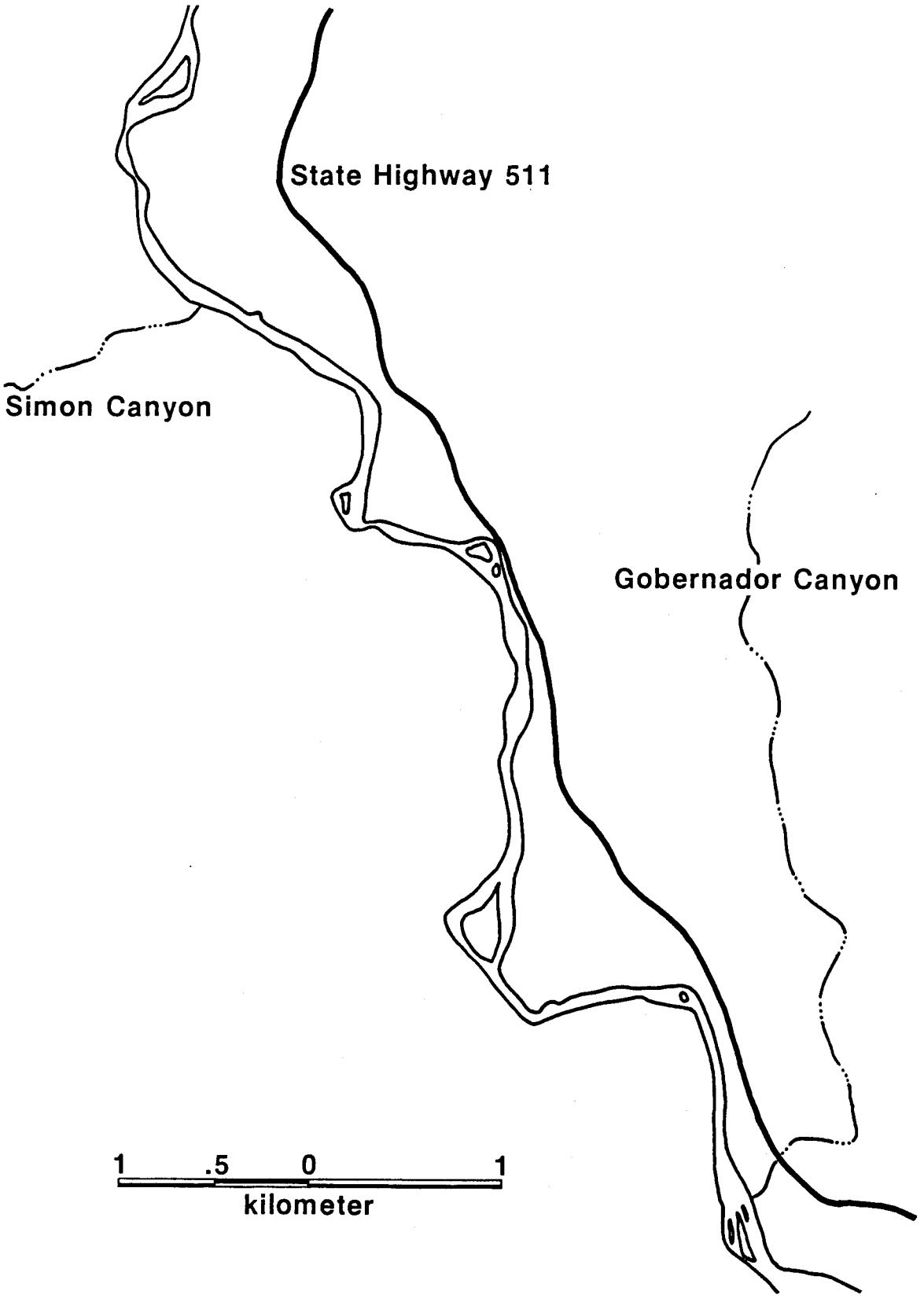


Figure 5. San Juan River, New Mexico study site.



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were therefore abnormal in that they were consistently at, or above, the normal release range. Releases were also steady for months at a time, as opposed to the normal operations at Glen Canyon which often produce large daily or weekly fluctuations, depending on electrical demand.

Water temperatures in the Colorado remain relatively constant throughout the year, ranging between 8-11 C. Most of the river in this section is comprised of glides. There are some deep areas and back eddies, but few distinct pools. There are no rapids in this section and there are only a few areas which become riffles during low flows.

The only species of trout observed while diving were rainbow and brook. Cutthroat trout were occasionally observed in creels, but were never detected while diving. Suckers (Catostomus sp.) were regularly observed while diving, and common carp were occasionally observed.

San Juan River, NM

The study site on the San Juan River extended from Navajo Dam, New Mexico downstream to Gobernador Wash, a river distance of approximately 11 km (Figure 5). Navajo Dam is located approximately 32 km northeast of Bloomfield, New Mexico. Releases from the dam normally range between 500-1500 cfs. The dam currently has no hydroelectric turbine and releases are controlled by irrigation demand and reservoir levels. For this reason, releases are usually fairly steady within a season.

The San Juan has a low gradient with low average velocities at the flow release observed during this study. It varies be-

tween wide, shallow, and often braided riffles with intermittent pools; and relatively deep, slow glides. Much of the riparian land in the upper section is a marsh which serves as a flood plain for the river.

Water clarity was poor at this site much of the time, probably resulting from a combination of high flow releases and the fact that Navajo Reservoir filled and inundated shore area which was usually dry. When data were collected, it was only in the upper 3 km of the study site because turbidity increased as one progressed downstream. With the exception of one brown trout, rainbow trout were the only trout observed while diving in this section of the river. Rainbow and cutthroat trout are both stocked in the river. Brown and cutthroat trout were reportedly more common in lower parts of the river.

Special angling regulations were in effect on the upper portion of this site from Navajo Dam downstream 5 km to Simon Canyon. The upper 1 km of this area was a catch and release only section, while the remaining 4 km had restricted catch and size limits. Both sections were restricted to artificial lure use only.

METHODS

Microhabitat Variables

Fish microhabitat has been defined previously (Gosse 1982) as being ". . . those physical (and occasionally chemical or biological) variables which define the precise location occupied by a fish, and which would or could change with small changes in a fish's location." "Microhabitat" or "microhabitat variables" will be used in this paper to refer to those physical variables which appear to be used by the fish to select their location.

Seven physical variables were measured for each microhabitat observation and are presented in the summary tables in Volume II. These seven variables are: fish velocity, mean velocity, fish depth, water depth, distance to the nearest thigmotactic surface, overhead light, and substrate type. Fish velocity, mean velocity, fish depth, water depth, and substrate were the most pertinent variables for describing microhabitat of trout observed during this study and are the only variables discussed in this report.

Fish velocity is defined as the water velocity measured at the exact location where the fish was observed. Mean column velocity was measured at four-tenths of the water column height, measured from the river bottom, occupied by the fish. Both velocity measurements were made to the nearest 3 cm/sec using an electronic current meter.

Water depth was normally measured using a diving depth gauge which could be corrected for altitude. Normally the diver carried two depth gauges which were checked against each other to insure accurate readings. In some cases where observations occurred in less than 1 m, a calibrated rod was used to provide greater accuracy. Water depth was measured in the exact vertical column occupied by the fish.

Fish depth, defined as the distance of the fish from the river bottom, was estimated by the diver to the nearest 5 cm. When fish depth was greater than 1 m, the diver used a depth gauge to assist in estimating fish depth.

Thigmotaxis is defined as a taxis in which contact with a solid body is the orienting factor. Fish are often not in contact with any solid body but they may remain in close proximity to one. The nearest thigmotactic surface was defined as the closest solid object or objects to the fish, which included the stream bottom, attached vegetation, submerged roots, and boulders.

Substrate type was recorded as rock (>30 cm), rubble (8-30 cm), gravel (0.3-8 cm), sand or silt (<0.3 cm), or other. The presence of plants growing on the original substrate was also recorded.

The level of overhead light reaching the fish was measured in foot-candles, but is presented in the summary tables as a percentage of full sunlight (1.076×10^5 lx). Measurements were made by the diver using an illuminance meter encased in a waterproof housing. Because obtaining light interfered with other

study objectives and since it was unimportant in defining microhabitat for the trout species observed in this study, it was not recorded during either winter.

Fish Subgroups

Observations of fish were classified according to the physical activity of the fish. Fish which maintained a stationary position by actively swimming against a current were classified as stationary swimming. Swimming without orientation toward a current (observed only in low velocity water) that did not produce a net change in location was defined as random swimming. Fish that remained stationary with no swimming motion (often by lying on the river bottom) were regarded as resting. Resting activity was observed only rarely in this study, usually for emergent fry, and is not presented in the summary tables in this report. Spawning activity was defined as fish actively engaged in spawning, redd excavation, fanning, and redd defense.

Fish were separated into three groups using a combination of size frequency data and habitat choices for all observations made on a particular river for each season. These groups were intended to approximate age 0, juvenile, and adult trout and are referred to as such in the text of this report. They are not exact in that no independent determinations such as scale readings were made to determine age. Additionally, considering that the populations studied were usually a combination of naturally reproduced and hatchery stocked fish, no division would be completely accurate. Although these divisions may not be perfectly

accurate chronologically, each group displays a cohesiveness in terms of habitat choices and activity. Trout do choose distinctly different microhabitat with increasing body size, and the three age groups reflect these different choices quite well. The summary tables in Volume II use the size categories for each group rather than the terms age 0, juvenile, or adult.

Observations of Fish

A modified scuba method was used to observe fish (Gosse 1981a, Gosse and Helm 1982). The diver wore an exorbitant amount of weight to facilitate remaining stationary on the stream bottom in the strong currents. The diver moved in an upstream direction to approach the fish from below and behind. An exhaust system vented air bubbles away and downstream from the diver to avoid frightening the fish. A surface to diver sonic transceiver allowed the diver to communicate with the surface personnel. The diver measured each microhabitat variable and relayed the data to the surface personnel for recording. During the first year of the study, velocity readings were made by the surface personnel after the diver had placed the underwater probe in the proper location. A fully submersible velocity meter which the diver could operate unassisted was used during the second year of the study.

A modified dry suit and full face mask protected the diver from cold water. The risks posed from the modified diving procedures were reduced with special safety training and equipment including: special weight release systems, multiple buoyancy

systems, a separate emergency air supply, and surface tenders in radio communication with the diver.

Travel within the study sites was done by boat. During most of the study, a 7 m aluminum hulled boat with an inboard motor and a jet drive was used. A 4 m inflatable raft with an outboard motor and jet boot was also used during the second winter to provide more and safer access in the smaller rivers. The surface personnel would perform their duties during the dive from the boats in order to be immediately ready for emergency rescue. Whenever possible, the boats would be beached with the engines turned off to reduce static to the sonic transceivers.

Under normal circumstances, fish were not frightened by the diver. However, when water clarity became marginal fish would become frightened before the diver could approach closely enough for species identification. Occasionally, fish were attracted to the diver when he had dislodged invertebrates from the substrate. Data were not taken for fish that were disturbed (either attracted or frightened). Fish that were traveling through the area observed by the diver were also not used for data, since they were not truly choosing microhabitat locations while being observed. Fish can, and will, travel through nearly all portions of the rivers studied, but they will occupy only certain areas; i.e., their microhabitat.

Variables were measured as nearly as possible to each fish's precise location. In situations where conditions changed over small distances, the fish's head or snout was used to define its location. For example, cover seeking fish may have their head in

shadow while the rest of their body is in bright light. Or, a large fish may place its head in low velocity water immediately behind a small rock with higher velocities occurring all around including the area where its tail is located. When several fish were observed in the same microhabitat (i.e., an area with steady conditions), measurements were made in a location representative of the entire area, usually near the middle of the group.

Snorkeling was used occasionally as a technique to cover large sections of river in an effort to find areas where trout were located. This was done when diving proved consistently unproductive. If trout were found, dives were then conducted to collect microhabitat data. Snorkeling was used for scouting purposes only and microhabitat data was not collected using this technique.

Sampling effort was distributed throughout whatever portion of each study site was accessible and had adequate visibility. All major types of habitat were sampled within the accessible portion of each site. This would include categories such as pools, glides, riffles, near-shore and midstream habitat. Sometimes a pattern would develop in which trout were likely to be found in certain habitat types and to be absent from others. Since microhabitat data could be collected only where trout were present, there was a propensity to make more dives in areas where trout were expected to be found rather than in areas where trout were consistently absent. Thus, in terms of macrohabitat, sampling effort was more representative of population distribution than of total habitat availability. However, because a certain

proportion of divers were always made in each habitat type, those containing few trout were probably sampled in greater proportion than their actual use by the population. When trout could not be found in a study site, sampling efforts were broadened to search all possible locations and often large sections of the study sites were snorkeled.

Depending upon the number of trout encountered, each dive often covered several macrohabitat types and would always encompass a wide range of microhabitat variables. For example, a diver might start in a glide, move from shore towards midstream, continue upstream through a back eddy with lateral movements to check both quiet and high velocity areas, and finally travel back to shore at the top of the back eddy. Within these several macrohabitat areas, a wide range of velocities, water depths, and substrates would be encountered. Thus, whatever biases occurred in choosing macrohabitat areas for diving were greatly dampened in terms of the actual microhabitat sampled. Often the total range of values encountered on even a single dive was broader than the range utilized by the trout for the different microhabitat variables. The profuse number of changes for each microhabitat variable which normally occurred during each dive precluded inadvertently selecting for specific microhabitat values.

Data Analysis

All data were collected as numerical codes on columnar data sheets from which they could be directly entered into computer files. Data input was verified a minimum of three times. Data

files were separated into subfiles by activity and flow for each season and river. A series of programs (one for each microhabitat variable) was then used to produce the summary tables in Volume II directly from the data in the subfiles.

Student's t test was used to test for differences between two means. Analysis of variance was used to test for differences among three or more means. In cases where the null hypothesis was rejected (F was significant), Fisher's least significant difference (Ott, 1977) was used to compare all possible pairs of sample means. The values necessary to perform these tests (variance, parameter sum of squares, etc.) were computed by the programs which produced the summary tables. The chi-square test of independence was used to determine whether the frequency of activities changed seasonally.

RESULTS

Summary Tables

Volume II contains all of the summary tables for the different microhabitat variables from which the text tables in this report were compiled. These summary tables are intended to be used in the construction of Habitat Suitability Indices necessary for the PHABSIM (Bovee 1982) model. The summary tables are organized by season, river, activity, and flow, as indicated in the Volume II Table of Contents. Within each of the appropriate subdivisions, summary tables of the different variables are presented along with pertinent statistics.

Green River, WY

Work was conducted on the Green River, Wyoming on three different occasions: October 1983, October 1984, and December 1984. Our primary objectives in October 1983 were initial training of the crew and to familiarize ourselves with the study area. Rainbow trout were observed on at least one occasion, but no data were taken. During this period, poor water clarity made data collection only marginally successful. By December 1983, temperatures were too low for diving. Extreme cold and heavy snowfall kept this study site unworkable throughout winter 1984.

Heavy snowfall produced continual flooding in the study site from late spring through summer 1984. This flooding caused severe turbidity which again made the river unworkable.

Structural problems with Fontenelle Dam necessitated reducing the reservoir level at this time, further augmenting the flood conditions in the river.

By October 1984, flow releases had returned to normal. Although October was outside of our definitions of winter and summer seasons, data collection was attempted at this time in the hope of obtaining some data from this site. However, a heavy algal bloom in the reservoir during October kept the water unworkably turbid.

When we returned to this site in early December, the water had cleared up and winter conditions were rapidly setting in. Most of the river was already ice-covered or totally blocked with ice flows. Approximately 14 km of river remained open to navigation and sampling. Water temperatures were at or near 0 C, while midday air temperatures were -11 C or lower.

Initial diving in December 1984 produced very few observations of trout and only one from which data could be collected, although many whitefish and suckers were observed. As a consequence, snorkeling was used to try to locate concentrations of trout. The entire section of river open to sampling was snorkeled, with less than ten trout observed along the entire distance although hundreds, if not thousands, of whitefish and suckers were observed. Two more dives were conducted in the stilling basin just below the dam. Two brown trout were observed during these dives. Both were well concealed deep within the crevices of the rock substrate. Considering that the water depth

was between 3-5 m here, this strong use of cover might be thought unusual.

The combination of logistical difficulties encountered at this site and the low trout densities observed precluded obtaining an adequate data base with a reasonable amount of effort. For this reason, no further diving was conducted at this site. Data analysis of three observations would be biologically and statistically meaningless, so this was not done.

Gunnison River, CO

Sampling was attempted on the Gunnison River four times during the study: November 1983, February 1984, March 1984, and February to March 1985. Many of the weather conditions that caused problems at the Green River site also caused problems at this site. Persistent rain produced turbid conditions in November 1983. Record snowfall during winter 1984 necessitated release of above normal flows from Crystal Dam in anticipation of heavy spring runoff. This caused turbid conditions to persist throughout the winter.

During each of the sampling periods in 1983 and 1984, dives were made extensively in the lower section of the study area, from the confluence with the North Fork upstream to about 2 km above Smith Fork. Visibility was usually adequate to see fish from 0.5-1.5 m away, although species identification was not always possible at these distances.

Over the course of these three sampling periods, dives were made in all of the pools and back eddies in this section at least

once, and usually several times. Dives were also extensively conducted in near-shore habitat. Midstream habitat was sampled to a lesser degree, since the above normal flows produced high velocities which made it unlikely that many trout would be found in this area. During the February 1984 sampling period, dives were made in two pools between the North Fork confluence and State Highway 92 (below the study area).

During the first three sampling periods, no trout were observed from which data could be obtained. Generally, few if any fish were observed per dive and most of the fish that were identified were common carp, which usually could be approached closely enough for observation. Although a trout was occasionally identified, it was always frightened away before it could be approached closely enough for species identification. Age 0 rainbow trout were observed at the head of an irrigation diversion approximately 1.5 km above the North Fork confluence; however, microhabitat data were not recorded for them, since they were not in the natural channel of the river.

The upper study section was not normally sampled in 1983 and 1984 because there were no boat launch sites there and the river was too deep for the surface crew to wade. This section provided better visibility than the lower study section because it was immediately below the dam. Because we were having difficulty locating trout in the lower section, this section was snorkeled in February 1984 by two divers from 100 m below the dam downstream to the Gunnison diversion, a distance of about 3 km. A total of three trout were observed in this entire section.

Heavy runoff from the 1984 winter snowpack caused flow releases to remain much above normal throughout the spring and summer; this made the water too turbid to sample. As a result, sampling wasn't attempted in summer 1984 on the Gunnison.

Poor water visibility persisted into winter 1985, but in late February and early March, sampling was again attempted on the Gunnison. By this time an inflatable raft had been made available that could be carried to the river and launched in the upper section of the study site. Water visibility was adequate at the beginning of this sampling period (2-3 m). Two dives were made in the upper section, but no trout were observed. Three dives were also made in the lower study section. No data were collected during these dives, but trout were briefly observed during one dive. Before more dives could be made, runoff from snowmelt reduced visibility to near zero.

Colorado River, AZ

Sampling schedule and flow releases

Winter 1984

Observations were made intermittently on the Colorado River from December 1983 to early March 1984. Releases from the dam were consistently high during this period in anticipation of a heavy spring runoff. Data presented for this season were collected during releases ranging from 25,000-25,800 cfs.

Much of the sampling effort for this season, especially during December and January, was directed toward observing spawning activity. A large percentage of the dives were conducted in

the upper half of the study section, which included the IFG-4 site, where most spawning was then occurring.

Summer 1984

Data were collected for summer from 20 May through 8 August on the Colorado River. During most of this period, abnormally high flows were being released as a result of heavy spring flooding. In addition to releasing the maximum amount of water possible through the generating turbines, additional water was also being released through the hollow jet tubes. The extra high flows occurred during most of the summer season, from May through 20 July. Flows ranged from 33,700-43,200 cfs with a median release during days of observation of 41,900 cfs. Observations made after 20 July were during flows ranging between 24,000-26,700 cfs.

Although sampling was conducted in all parts of the study site, it was more heavily concentrated in the lower half. Trout densities were much greater in the lower part of the study site and much more data per dive could be obtained by sampling there.

Winter 1985

Data were collected during the second winter season from January through March on the Colorado River. Releases from the dam were again consistently high because of expected high spring runoff, except during the last week in March when flows varied. All data presented for this season were collected during releases ranging from 24,000-27,000 cfs.

No data for spawning activity were taken during this season. The level of active spawning was quite low by the time sampling began in January; so effort was concentrated on collecting data for the other activities which had been given a lower priority the previous winter. Sampling efforts were again more concentrated in the lower half of the study site where trout densities were greatest.

Species composition and activity

Over the course of the study, rainbow trout were normally observed much more frequently than were brook trout (Table 1). However, age 0 brook trout were observed more frequently than age 0 rainbow during winter 1984. The age 0 brook trout had been stocked during the previous fall. Age 0 rainbow which had been stocked at the same time had grown enough that they were classified as juveniles by the winter season. The age 0 rainbow that were observed during winter 1984 resulted from natural reproduction. No age 0 trout of either species were observed during winter 1985. Juvenile rainbow trout were observed much more often than were brook. Adult brook trout were observed commonly during spawning, but in about a 1:7 ratio with rainbow trout.

Adults and juveniles of both species were observed stationary swimming more often than random swimming during both seasons on the Colorado River (Table 1). Usually 70-90% of the trout observed were engaged in stationary swimming. Age 0 brook trout during winter was the only group observed during random swimming more frequently than stationary swimming.

Table 1. The number of fish observed for different activities in the Colorado and San Juan Rivers by season.

Activity	Rainbow			Brook		
	Age 0	Juvenile	Adult	Age 0	Juvenile	Adult
Colorado River						
Winter 1984 and 1985						
Spawning	0	1	59	0	0	8
Stationary swimming	13	379	94	32	0	10
Random swimming	4	122	10	71	0	0
Summer (all flows)						
Stationary swimming	348	281	208	0	7	6
Random swimming	88	116	7	0	1	3
San Juan River						
Stationary swimming	0	132	433	--	--	--
Random swimming	58	59	153	--	--	--

Stocking efforts

Age 0 rainbow and brook trout were stocked in the Colorado River during fall 1983 in equal numbers but at different sizes (Table 2). This difference in size, possibly coupled with differential growth rates, resulted in the recently stocked rainbow trout being placed in the juvenile category and the brook trout in the age 0 category during winter 1984.

The next stocking occurred in June 1984 and consisted of rainbow trout only, as did all subsequent stockings (Table 2). Most of the age 0 rainbow trout observed in summer 1984 were from the June stocking, with a few observations of naturally reproduced rainbow trout. The naturally reproduced age 0 trout observed in summer chose habitat similar to the stocked trout.

Summer sampling on the Colorado had ceased before the August and September 1984 stockings occurred. The fish stocked at these times achieved adequate size to be considered juveniles by winter 1985. The trout stocked during February and March 1985 were also in the juvenile size range.

All of the stocked trout appeared to be in good condition and well adjusted to the river habitat whenever they were observed. This was true even for the trout stocked in June 1984 during the extra high flow period. Recently stocked trout were usually observed in groups and were normally located close to shore.

General distribution of trout

All of the trout stocked in 1983 and 1984 were released from the boat launch at Lees Ferry. They usually were found within

Table 2. Record of trout stocked at Lees Ferry, Colorado River, by Arizona Game and Fish* during the course of this study.

Season First Observed	Date Stocked	Number Stocked	Species Stocked	Average Length (cm)
Winter 1984	12 Oct 1983	10,000	rainbow	11
	12 Oct 1983	40,300	rainbow	11
	27 Oct 1983	30,000	brook	8
	27 Oct 1983	20,000	brook	8
Summer 1984	13 Jun 1984	25,000	rainbow	9
Winter 1985	24 Aug 1984	25,000	rainbow	8
	28 Aug 1984	28,000	rainbow	8
	4 Sep 1984	20,000	rainbow	8
	4 Sep 1984	30,000	rainbow	8
	14 Feb 1985	5,000	rainbow	18
	14 Mar 1985	10,400	rainbow	18

*Information provided by Dr. S. Reger, Arizona Game and Fish, Flagstaff, AZ.

approximately 0.8 km of the boat launch for at least the first seven months after they were stocked. During the June 1984 stocking, densities appeared somewhat higher below the boat launch than they were above. This may indicate a slight amount of downstream drift after planting. No observations were made below the Paria riffle to determine if stocked trout had drifted below that point.

Densities of juvenile trout were noticeably highest from the lower end of the study site to about 6.5 km above the boat launch, while the area within 2 km of the boat launch had the greatest concentration of juveniles.

The smaller adult trout also were more concentrated in the lower part of the study site during the non-spawning period, but to a much lesser degree than were juveniles or age 0 trout. Larger adults (40+ cm) appeared to be equally dispersed throughout the study site, with a possible numerical decrease in the immediate vicinity of the boat launch. Spawning trout were observed in the upper half of the study site more frequently than in the lower half.

Throughout the study site, and regardless of overall density, trout were usually found in relatively shallow water for all activities, with average water depth ranging between 1.5-4.0 m (Table 3). Considering that the central river channel is often 9-14 m deep and sometimes more, trout were selecting the shallower sections of the river. Trout were primarily located close to shore as opposed to utilizing midstream areas. To a lesser extent, trout were found in midstream sections of the

Table 3. Average water depth (cm) ±1 standard deviation ( ) for the activities of stationary and random swimming in the Colorado River during summer 1984, all flows combined, and winter 1984 and 1985 normal high flows.

		Rainbow			Brook		
Season	Activity	Age 0	Juvenile	Adult	Age 0	Juvenile	Adult
Winter	Stationary	14 (9-19)	416 (234-598)	439 (265-613)	129 (3-255)	--	258 (114-402)
	Random	--	331 (173-489)	391 (207-575)	151 (51-251)	--	--
Summer	Stationary	194 (52-336)	432 (308-556)	360 (241-479)	--	387 (285-489)	228 (114-342)
	Random	246 (160-332)	617 (579-655)	486 (448-524)	--	--	--

river when water depths remained uniformly shallow across the channel.

There was no indication of trout concentrating within pools or slow water habitat during either winter or summer. The only major change in trout distribution between winter and summer observations was the absence of spawning activity and the lack of large adults in the shallow spawning areas during the latter season.

Natural reproduction and spawning

Natural reproduction

Some age 0 trout resulting from natural reproduction were observed during winter 1984. A few of the naturally reproduced trout were collected for independent species identification by Bruce Bonebrake, Utah Division of Wildlife Resources. All of the trout collected were identified as rainbow trout. They represent the only age 0 rainbow trout observed during winter 1984.

These naturally reproduced trout could be differentiated from stocked trout because they were much smaller in size (3 cm) than the stocked trout (≈15 cm). The naturally reproduced age 0 trout were observed between 11-21 km upstream from the boat launch, while none of the recently stocked trout were observed more than 2 km above the boat launch. The naturally reproduced age 0 trout were generally found within several meters of the shore edge, usually in shallow (<0.3 m) and low velocity water. The type of habitat these newly emergent trout were selecting comprises a very small and limited part of the total river habitat.

What were believed to be naturally reproduced age 0 rainbow trout were also observed during the summer. They were smaller than the recently stocked age 0 rainbow and were found many kilometers upstream from any of the stocked age 0 trout.

Spawning

Spawning activity was observed throughout the season during winter 1984, from December to early March. Based on reports from professional river guides, spawning activity had probably begun as early as October that year. No actively spawning trout were observed during winter 1985, although redds which were old and beginning to silt over were found in January.

Most of the spawning was observed either near shore or in some of the small braided parts of the river that cross the two islands located at approximately river miles 8.5 and 12. Many of these areas are not inundated during lower flow releases. Reports from professional river guides indicated that much of the spawning which had occurred earlier in the year took place on mid-stream gravel bars. Flows and water depths were probably lower during this earlier period than when our observations were made.

Rainbow and brook trout were often observed using redds adjacent to each other and appeared to choose very similar spawning habitat. There was no significant difference ($P<0.05$) in fish depth between the two species (Table 4). For unoccupied redds, fish velocity was measured at a depth of 10 cm. There were no significant differences ($P<0.05$) among the three groups for fish velocity (Table 4). Water depth was significantly greatest

Table 4. Average values and sample number ( ) for four microhabitat variables in the Colorado River for the activity of spawning during winter 1984.

Species	Fish Depth (cm)	Fish Velocity (cm/s)	Mean Velocity (cm/s)	Water Depth (cm)
Rainbow	12 A* (59)	29 A (59)	49 A (59)	78 A (59)
Brook	11 A (8)	24 A (8)	33 B (8)	116 B (8)
Unoccupied Redds	--	27 A (78)	40 B (78)	61 C (78)

*Average values for a specific variable which do not share a common letter were significantly ($P<0.05$) different.

(P>0.05) for brook trout and significantly lowest (P>0.05) for unoccupied redds. But the differences among means were not great and rainbow trout were observed spawning in a greater range of water depths (50-400 cm) than were brook trout (50-200 cm). Spawning substrate was exclusively gravel for both species and for unoccupied redds.

Size differences within age groups

Comparisons will be made in the following sections to determine whether annual, seasonal, or flow level changes produced differences in microhabitat choices. Microhabitat choices for rainbow trout will also be compared among different rivers in subsequent sections. One of the difficulties in making such comparisons is that variables other than the one of concern will also be changing. Differences in species strain and origin, river size and flow release, temperature, diet, and relative size of a particular life stage could all potentially produce changes which might be attributed to the variable being compared.

Some of these potential differences can be held stable by making comparisons on the same population of fish within the same river. The first comparisons which will be made fall into this category. When comparisons are made among rivers, fewer variables can be controlled or even accounted for, and any difference among rivers can potentially result from numerous sources, including those mentioned above.

One variable which can at least be examined for differences, if not held constant, is average fish size within a life stage. It is important to consider whether such differences in fish size

occur, since a particular life stage, especially age 0 and juveniles, can choose different microhabitat as they increase in size.

Table 5 provides comparisons of mean fish length within life stages for different categories and will be referred to throughout this section on comparisons. Statistically significant ($P<0.05$) differences between means are indicated. The fact that a statistically significant size difference was found between groups does not necessarily imply that the two groups were choosing different microhabitat, especially when the differences were proportionally small. Rather, if statistically different choices in microhabitat were observed, a difference in size may be part of the reason.

Comparisons between years: winter 1984 and 1985

One of the purposes in having the study continue through two winter seasons was to determine whether yearly fluctuations in microhabitat choices would be observed. A second purpose in comparing data from the two winters is to see if they can be reasonably combined into one large data base. Winter flows during 1984 and 1985 in the Colorado River were essentially identical (25,000-26,000 cfs and 24,000-27,000 cfs, respectively), making comparisons easier. The following categories had an adequate number of observations for both years to enable valid comparisons: juvenile rainbow trout during random and stationary swimming, and adult rainbow trout during stationary swimming.

Table 5. Mean fish length (cm) and sample number ( ) by life stage and species between various seasons, flows, and rivers.

Comparison	Rainbow			Brook
	Age 0	Juvenile	Adult	Adult
		Colorado River		
Winter 1984	--	16 (131)*	35 (10)	--
Winter 1985	--	22 (469)*	34 (97)	--
Summer 1984 Extra High Flows	12 (369)	24 (374)*	32 (199)*	34 (3)
Summer 1984 Normal High Flows	11 (69)	17 (23)*	37 (17)*	32 (7)
Summer 1984	12 (436)*	24 (397)*	32 (216)	33 (10)
Winter 1984 and 1985	3 (22)*	20 (600)*	34 (107)	36 (10)
		Colorado River vs Green River		
Winter 1984 and 1985, Colorado	--	20 (600)*	34 (107)*	--
Winter 1981, Green River, Utah	--	23 (287)*	31 (961)*	--
		Colorado River vs Green River vs San Juan River		
Summer 1984, Colorado	12 (436)*	24 (397)*	32 (216)*	--
Summer 1984, San Juan	5 (58)*	26 (191)*	39 (586)*	--
Summer 1981, Green River, Utah	--	18 (463)*	32 (404)*	--

*Indicates a significant difference between means ($P<0.05$).

Juveniles

Juvenile rainbow trout had significantly ($P<0.05$) different mean lengths between the two winter seasons (Table 5). This difference in size was probably a result of later planting in the summer of 1983 than in 1984.

The difference in size for juveniles probably accounts for the differences observed in fish and water depth between the two years (Table 6). Generally, as fish become larger they choose both greater fish depth and water depth.

For the activity of random swimming, fish and mean velocities in 1985 were only 40-50% of the values observed in 1984 (Table 6). Remembering that juveniles were larger in 1985 than in 1984, this seems unusual, since larger fish generally are found in higher velocities.

For the activity of stationary swimming, mean velocities were not significantly ($P>0.05$) different. There was a significant difference ($P<0.05$) in fish velocity during stationary swimming. However, the small difference between the means (4 cm/s) probably has little biological meaning. In addition, this small difference is within the range of fluctuation normally found for currents flowing at the speed of the observed means.

Adults

Adult rainbow trout had no significant ($P>0.05$) differences for fish depth nor for fish and mean velocities between the two years (Table 6). Only water depth was significantly ($P<0.05$) different between the two years.

Table 6. Average values and sample number ( ) for four microhabitat variables during winter for 1984 and 1985 in the Colorado River.

Life Stage	Year	Fish Depth (cm)	Fish Velocity (cm/s)	Mean Velocity (cm/s)	Water Depth (cm)
			Stationary Swimming		
Juvenile Rainbow	1984	43 (83)*	34 (83)*	46 (83)	190 (83)*
	1985	91 (296)*	30 (276)*	44 (254)	479 (296)*
Adult Rainbow	1984	50 (10)	34 (10)	52 (8)	286 (10)*
	1985	59 (84)	35 (82)	52 (78)	487 (84)*
			Random Swimming		
Juvenile Rainbow	1984	74 (48)*	18 (48)*	21 (48)*	337 (48)
	1985	115 (74)*	9 (74)*	12 (74)*	327 (74)

*Indicates a significant difference between means ($P<0.05$).

Comparisons between flows: summer extra high and normal high

One of the major objectives in collecting microhabitat data in the tailwaters below dams was to be able to predict the effects of changes in release patterns from the dam upon the trout populations. Very few fluctuations in release patterns were observed because of the high water situation which persisted throughout this study. The one season when flow changes did occur was summer 1984, in the Colorado River. Extra high releases (33,000-43,000 cfs) occurred from spring until mid-August 1984 because water was bypassed around the turbines. Flows then went to normal high releases (24,000-27,000 cfs) for the rest of the summer. Only for the activity of stationary swimming were adequate numbers of observations made to make comparisons between flows.

Juvenile and adult rainbow trout both were significantly ($P<0.05$) different in size between flows (Table 5). The mean size of juveniles decreased during the later normal high flows because fish which had been classified as age 0 earlier had now grown enough to be in the juvenile classifications, thus skewing the mean size downward. The mean size of adults increased, reflecting the growth that occurred during the season. These changes in size within a life stage must be taken into consideration when making comparisons between the two flows.

For age 0 rainbow trout, mean values for all four microhabitat variables were significantly ($P<0.05$) different between flows (Table 7).

Table 7. Average values and sample number ( ) for four microhabitat variables for summer 1984 extra high flows and normal high flows in the Colorado River.

Life Stage	Flows	Fish Depth (cm)	Fish Velocity (cm/s)	Mean Velocity (cm/s)	Water Depth (cm)
			Stationary Swimming		
Age 0 Rainbow	Extra High	62 (285)*	19 (285)*	29 (285)*	169 (285)*
	Normal High	21 (63)	22 (63)	35 (63)	305 (63)
Juvenile Rainbow	Extra High	115 (258)*	29 (258)	39 (258)	436 (258)*
	Normal High	34 (23)	28 (23)	42 (23)	392 (23)
Adult Rainbow	Extra High	58 (192)*	31 (192)	47 (190)	365 (192)
	Normal High	31 (16)	28 (16)	46 (16)	295 (16)

*Indicates a significant difference between means ($P<0.05$).

Fish depth was significantly ($P<0.05$) less during normal flows than it was during extra high flows for all three life stages (Table 7). For juveniles and adults, there were no significant ($P<0.05$) differences for fish or mean velocity between the two flows. Water depth decreased slightly with the normal high flows for both juveniles and adults. This decrease was significant ($P<0.05$) for juveniles but not for adults.

Comparisons between seasons: summer and winter

An objective of this study was to determine if the pronounced seasonal changes in microhabitat choices observed in the Green River, Utah (Gosse 1982) would be observed in other river systems. The Colorado River was the only site in this study where both winter and summer data were collected.

For this comparison between seasons, data from both winter 1984 and 1985 were combined into one, as were the data from both flow levels during summer 1984. Both age 0 and juvenile rainbow trout had significantly ($P<0.05$) different mean lengths between winter and summer (Table 5). The size difference between the age 0 groups was probably biologically significant since the summer group was four times longer than the winter group. The size difference between juveniles was unlikely to have biological implications since there was only a 20% increase in size between groups.

Stationary swimming

Age 0 rainbow trout had significantly ($P<0.05$) lower mean values for winter than during summer for all stationary swimming

variables (Table 8). These differences are exactly what would be expected from the difference in size between the two groups, with little if any effect from seasonal differences. The age 0 trout observed in winter were newly emergent (from natural reproduction) and occupied shallow, low velocity, near-shore areas, which is typical habitat at this stage. The age 0 trout observed during summer were capable of occupying deeper and faster water. They were usually still close to shore, but not nearly as close as those observed in the winter.

Stationary swimming juvenile and adult rainbow trout exhibited some significant ($P<0.05$) differences in mean values for variables between winter and summer, but no clear trends (Table 8). For variables that did have a significant difference in means between seasons, examination of the total ranges and frequency distributions did not indicate any distinctive shifts in microhabitat choices between seasons. The low number of observations for adult brook trout during either season make it difficult to say whether any changes occurred and would help account for the lack of significant ($P>0.05$) differences found (Table 8).

Random swimming

For the activity of random swimming, adult rainbow trout exhibited no significant ($P>0.05$) differences between seasons (Table 8), but again low sample numbers make it difficult to say whether changes were occurring. Juvenile rainbow trout did have significant ($P<0.05$) and large differences for all variables except fish velocity during random swimming. Examination of the total ranges and frequency distributions for fish and water depth

Table 8. Average values and sample number ( ) for four microhabitat variables for summer 1984, all flows combined, and winter 1984 and 1985 normal high flows in the Colorado River.

Life Stage	Season	Fish Depth (cm)	Fish Velocity (cm/s)	Mean Velocity (cm/s)	Water Depth (cm)
			Stationary Swimming		
Age 0 Rainbow	Summer	55 (348)*	20 (348)*	30 (348)*	194 (348)*
	Winter	3 (13)	5 (13)	5 (13)	14 (13)
Juvenile Rainbow	Summer	108 (281)*	29 (281)	40 (281)*	432 (281)
	Winter	81 (379)	31 (359)	44 (337)	416 (379)
Adult Rainbow	Summer	56 (208)	31 (208)*	47 (206)	360 (208)*
	Winter	58 (94)	35 (92)	52 (86)	439 (94)
Adult Brook	Summer	34 (6)	19 (6)	29 (6)	228 (6)
	Winter	73 (10)	30 (10)	39 (10)	258 (10)
			Random Swimming		
Juvenile Rainbow	Summer	226 (116)*	11 (111)	9 (102)*	617 (116)*
	Winter	99 (122)	12 (122)	16 (122)	331 (122)
Adult Rainbow	Summer	145 (7)	9 (7)	8 (5)	486 (7)
	Winter	132 (10)	8 (10)	10 (10)	391 (10)

*Indicates a significant difference between means ($P<0.05$).

did indicate a major shift in microhabitat choice between seasons. Juvenile rainbow trout were choosing deeper quieter areas for random swimming during the summer than they used during winter.

Activity

Stationary swimming was consistently the dominant activity for rainbow trout during both seasons (Table 9). For age 0 and juveniles, there were no significant differences in the proportion of occurrence for the activities between seasons. The increased proportion of adults engaged in random swimming during winter over summer was statistically significant ($P<0.05$). Low sample size (Table 1) for random swimming adults may have accounted for this difference. In any case, random swimming was a minor activity for adult rainbow trout during either season.

San Juan River, NM

No data were collected from the San Juan during either winter season due to the poor visibility in the river. Although water clarity continued to be generally poor throughout the summer, it did improve in August and September. Data were collected from 21 August through 7 September during a constant release from the dam of 800 cfs. As mentioned previously, poor water clarity allowed for data collection only in the 3 km of river immediately below the dam.

The most dramatic aspect of microhabitat observations in this section of the river was the high numerical density of the trout. It was virtually impossible to go underwater without

Table 9. Percentages of rainbow trout engaged in stationary and random swimming during winter 1984 and 1985 and summer 1984 in the Colorado River.

Season	Activity	Life Stage		
		Age 0	Juvenile	Adult
Winter	Stationary	76	76	90
	Random	24	24	10 *
Summer	Stationary	80	71	97
	Random	20	29	3

*Indicates a significant ($P<0.05$) difference in frequency of activity between seasons.

being surrounded by trout. The majority of these fish appeared to have very good condition (K) factors. Despite their phenomenal density, there was no sign of stunting.

Trout were observed throughout this section of river in both the glide and pool areas. Considering that pools represented a smaller percentage of the total habitat area than glides, there may have been a slight preference by the trout for the pool habitat. Adult and juvenile trout were most often observed stationary swimming while age 0 trout were only observed random swimming (Table 1).

Age 0 trout were found predominantly in near-shore areas or in back eddies and side channel pools. The small average size (5 cm) of these age 0 trout (Table 5) indicates that they possibly resulted from natural reproduction, but very precise stocking records would be necessary to confirm this. The low mean water depth and mean fish velocity indicate that the age 0 trout were selecting very limited parts of the total river habitat (Table 10).

Both average water depth and fish velocity were low for juvenile and adult trout for both activities (Table 10) compared to other rivers. This is probably reflective of the overall habitat in the San Juan, which is a low gradient and relatively shallow river compared to the other intermountain rivers from which microhabitat data has been obtained. This idea will be examined more thoroughly in the next section.

Table 10. Average water depth (cm), fish velocity (cm/s), and sample number ( ) for rainbow trout during the activities of stationary and random swimming in the San Juan River during summer 1984.

Variable	Activity	Life Stage		
		Age 0	Juvenile	Adult
Water Depth	Stationary	--	195 (132)	207 (433)
	Random	73 (58)	204 (59)	228 (153)
Fish Velocity	Stationary	--	18 (132)	19 (430)
	Random	6 (58)	7 (59)	10 (153)

Comparisons Among Rivers

As mentioned in the Objectives section, an understanding of microhabitat variability among rivers can help determine how widely microhabitat data can be applied. With data collected in this study and previously in the Green River, Utah (Gosse 1982), comparisons can be made for rainbow trout between two rivers for winter and among three rivers for summer.

Winter: Green River, UT and Colorado River, AZ

A combined data set from both winter 1984 and 1985 on the Colorado River was used for this section. Data for the Green River, Utah was from winter 1981, with all flow levels combined (Gosse 1982).

The age 0 life stage was not available from the Green River, so only juvenile and adult rainbow were compared. Both life stages had significantly ($P<0.05$) different mean fish lengths between the two rivers (Table 5) although the biological implications may not be great because there was only a 3 cm difference between the means.

Stationary swimming

For the activity of stationary swimming, fish and mean velocities were significantly ($P<0.05$) higher in the Colorado River than in the Green for both life stages (Table 11). Water depth was significantly ($P<0.05$) greater in the Green River for juvenile rainbow trout but there was no significant ($P>0.05$) difference for adults between the two rivers. Fish depth for

Table 11. Average values and sample number ( ) for four microhabitat variables for the Colorado River, winter 1984 and 1985, and the Green River, winter 1981.

Life Stage	River	Fish Depth (cm)	Fish Velocity (cm/s)	Mean Velocity (cm/s)	Water Depth (cm)
			Stationary Swimming		
Juvenile Rainbow	Colorado	81 (379)	31 (359)*	44 (337)*	416 (379)*
	Green	82 (176)	23 (172)*	30 (154)*	621 (176)*
Adult Rainbow	Colorado	58 (94)	35 (92)*	52 (86)*	439 (94)
	Green	52 (653)	26 (640)*	42 (606)*	442 (653)
			Random Swimming		
Juvenile Rainbow	Colorado	99 (122)*	12 (122)*	16 (122)	331 (122)*
	Green	140 (111)*	15 (111)*	15 (111)	546 (111)*
Adult Rainbow	Colorado	132 (10)	8 (10)*	10 (10)*	391 (10)
	Green	110 (308)	17 (308)*	20 (308)*	483 (308)

*Indicates a significant difference betweens means ($P<0.05$).

both life stages was nearly identical between rivers, with no significant ($P>0.05$) differences.

Random swimming

For the activity of random swimming, both fish and water depth were significantly ($P<0.05$) higher in the Green River than in the Colorado for juvenile rainbow trout (Table 11). Fish velocity was also significantly ($P<0.05$) higher in the Green River for this group, but the difference was small.

There was no significant ($P>0.05$) difference in fish nor water depth for adults during random swimming. Both fish and mean velocities were significantly ($P<0.05$) lower in the Colorado River than in the Green, but this difference was most probably a result of small sample size in the Colorado River for this activity. The frequency distribution of adults in the Colorado River was similar to that found in the Green for both fish and mean velocities.

Summer: Green River, UT; Colorado River, AZ; and San Juan River, NM

Data compared in this section was collected in summer 1984 for the Colorado and San Juan Rivers during this study and in summer 1981 for the Green River, Utah (Gosse 1982). Both extra high and normal high flows were combined for the Colorado River. A combination of all flow releases was used for the Green River data base. The San Juan had a constant release for all data obtained from it.

There were significant ($P<0.05$) differences in mean fish length among all rivers and life stages except between adult

rainbow trout for the Colorado and Green Rivers (Table 5). The size differences among adults probably had little biological implications. The size difference between age 0 trout in the Colorado and San Juan Rivers was proportionally large enough to be biologically significant. Juveniles in the Green River had a smaller mean length primarily because somewhat different length categories had been used during this study and the juvenile category included some fish that were classified as age 0 in the other two rivers. This difference in size could have produced some differences in microhabitat choices.

Stationary swimming

For the activity of stationary swimming, there were generally more differences than similarities among the mean microhabitat variables for the three rivers (Table 12). These trends in variable choices were consistent, however, and reflected the differences in the three rivers.

For both juveniles and adults, fish velocity was significantly ($P<0.05$) lower in the San Juan than in either the Colorado or Green Rivers (Table 12). Fish velocities in the Colorado and Green Rivers were not significantly ($P>0.05$) different for either life stage.

Mean velocities were significantly ($P<0.05$) lowest in the San Juan River and significantly ($P<0.05$) highest in the Green for both life stages. Juveniles in the San Juan were the only group that had no significant ($P>0.05$) difference between fish and mean velocity during stationary swimming (Table 13). The difference between fish and mean velocities for adults in the San

Table 12. Average summer values and sample number ( ) for four microhabitat variables for three rivers during the activity of stationary swimming.

River	Fish Depth (cm)	Fish Velocity (cm/s)	Mean Velocity (cm/s)	Water Depth (cm)
		Juvenile Rainbow		
Colorado 1984	108 A* (281)	29 A (281)	40 A (281)	432 A (281)
San Juan 1984	88 B (132)	19 B (132)	19 B (132)	195 B (132)
Green 1981	28 C (291)	27 A (290)	46 C (290)	326 C (291)
		Adult Rainbow		
Colorado 1984	56 A (208)	31 A (208)	47 A (206)	360 A (208)
San Juan 1984	73 B (433)	19 B (430)	20 B (430)	207 B (433)
Green 1981	38 C (226)	30 A (224)	55 C (219)	369 A (226)

*Average values for a specific variable and life stage which do not share a common letter were significantly ($P<0.05$) different.

Table 13. Average summer fish velocity and mean velocity (cm/s) for three rivers during stationary swimming.

Variable	River: Colorado Summer 1984	River: San Juan Summer 1984	River: Green Summer 1981
		Juvenile Rainbow	
Fish Velocity	29*	18	27*
Mean Velocity	40	19	46
		Adult Rainbow	
Fish Velocity	31*	18*	30*
Mean Velocity	47	20	55

*Indicates a significant difference between means ($P<0.05$).

Juan was slight, but statistically significant ($P<0.05$).

Water depth was significantly ($P<0.05$) less in the San Juan than in the other two rivers (Table 12). Water depth for juveniles was significantly ($P<0.05$) greater in the Colorado than in the Green, but there was no significant ($P>0.05$) difference in water depth for adults.

For both life stages, fish depth in the Green was significantly ($P<0.05$) less than in the other two rivers (Table 12). When fish depth was expressed proportional to water depth, it was greatest in the San Juan and least in the Green River for both life stages (Table 14).

Random swimming

Proportional to water depth, fish depth was also greatest in the San Juan and least in the Green River for the activity of random swimming for juvenile and adult trout (Table 14). On an absolute basis, fish depth was significantly ($P<0.05$) greatest in the Colorado and significantly ($P<0.05$) least in the Green River for both life stages (Table 15).

Fish and mean velocity were significantly ($P<0.05$) less in the San Juan than in the Green River for juvenile and adult trout (Table 15). Values in the Colorado River for these two variables were not significantly ($P>0.05$) different from at least one of the other rivers. The low sample size of random swimming adults in the Colorado River may account for the lack of significant ($P>0.05$) differences.

For juveniles, water depth was significantly ($P<0.05$) less in the San Juan than in the other two rivers (Table 15) and

Table 14. Average summer fish depth of rainbow trout expressed as a percentage of average total water depth for two activities in three rivers.

Life Stage	River: Colorado Summer 1984	River: San Juan Summer 1984	River: Green Summer 1981
		Stationary Swimming	
Juvenile	25	45	9
Adult	16	35	10
		Random Swimming	
Age 0	68	63	--
Juvenile	37	56	19
Adult	30	46	7

Table 15. Average summer values and sample number ( ) for four microhabitat variables for three rivers during the activity of random swimming.

River	Fish Depth (cm)	Fish Velocity (cm/s)	Mean Velocity (cm/s)	Water Depth (cm)
		Age 0 Rainbow		
Colorado 1984	166 A* (88)	7 A (88)	17 A (88)	246 A (88)
San Juan 1984	46 B (58)	6 A (58)	6 B (58)	73 B (58)
		Juvenile Rainbow		
Colorado 1984	226 A (116)	11 A (111)	9 A (102)	617 A (116)
San Juan 1984	114 B (59)	7 B (59)	8 A (59)	204 B (59)
Green 1981	78 C (172)	11 A (172)	20 B (164)	416 C (172)
		Adult Rainbow		
Colorado 1984	145 A (7)	9 A,B (7)	8 A,B (5)	486 A,B (7)
San Juan 1984	104 B (153)	10 A (153)	11 A (153)	228 A (153)
Green 1981	71 C (178)	15 B (172)	19 B (171)	516 B (178)

*Average values for a specific variable and life stage which do not share a common letter were significantly ($P<0.05$) different.

greater in the Colorado than the other two rivers. For adults, water depth was significantly ($P<0.05$) less in the San Juan than in the Green. Water depth in the Colorado for adults was not significantly ($P<0.05$) different from either river; this was probably due to the small sample size.

Random swimming was the only activity for which age 0 trout were available for comparison, and then only between the Colorado and San Juan Rivers. Averages for all variables were significantly ($P<0.05$) different except for fish velocity (Table 15). These differences were what might be expected considering the difference in average size of the age 0 trout between the two rivers (Table 5). The larger age 0 trout in the Colorado occupied deeper, faster water and had a greater absolute fish depth than the smaller age 0 trout in the San Juan River. Proportional to total water depth, fish depth for the two groups was quite similar (Table 14). The lack of significant ($P>0.05$) difference between fish velocity for age 0 (Table 15) is probably a result of the narrow range of velocities utilized during random swimming.

DISCUSSION

Green River, WY

The lack of trout observed in the Green River, Wyoming in December 1984 indicates that either there were very low densities of trout or that they had emigrated from the approximately 14 km stretch of river that was accessible to sampling. Banks et. al. (1974) reported that over a twelve year period trout and whitefish standing crops were about equal in the Green River. They also indicated that suckers were not a major part of the fish biomass in the river. Their observations were totally different from ours. We found mountain whitefish and sucker biomass to be at an extraordinarily high level, while the biomass of trout observed during December represented less than one percent of the whitefish or sucker biomass.

The Wyoming Game and Fish Department actively samples this section of the river during non-winter months, but no recent reports of their findings were available to the author. Informal personal communications indicated that they also found low numbers of trout during their most recent sampling prior to December 1984.

Whether the lack of trout observations in December resulted from a very low population level or from seasonal migration, the information should be useful in management of the trout fisheries. If sampling during other seasons indicated adequate trout densities, a major seasonal migration is probably occurring.

Knowledge of where, and in what type of habitat, the trout are overwintering would be vital in defining and protecting the trout population during what is probably a very critical and vulnerable period in their annual cycle.

Gunnison River, CO

With the exception of the Colorado River, more effort was expended attempting to sample the Gunnison than any other river in the study. Despite repeated attempts, we were unable to collect microhabitat data or to even locate more than an occasional trout.

There appeared to be more to the lack of trout observations than just poor visibility. Although visibility in the San Juan was often as bad or worse as in the Gunnison, it could be determined that the San Juan contained a very high density of trout long before it became clear enough for data collection. When visibility was bad in the San Juan, the diver could still observe disturbed trout or observe silhouettes of unidentified trout. This was never the case in the Gunnison River. Any encounters with fish were rare. Visibility was adequate to good in the upper study section on several occasions, but trout were still observed very infrequently if at all.

Scuba and snorkeling are admittedly not infallible methods of locating fish, especially when visibility is marginal. However, these methods have been successful on most other rivers, especially when the intensity of sampling was as great as that on the Gunnison. Therefore, it appears that there were very low

numbers of trout in the Gunnison study site at the times it was sampled.

Population estimates and creel censuses conducted by the Colorado Division of Wildlife in 1981, 1982, and 1983 indicated that trout definitely occupied the lower study area and were being caught (Nehring 1983). The most probable explanation of the discrepancy between our observations and population estimates reported by Nehring is that seasonal migration was occurring. Trout may have been moving to areas outside of the lower study section during the winter. Creel censuses were conducted from May through September in 1982 and 1983. Population estimates were reported as occurring in "fall" of each year, with the 1981 estimate being made in August. All of our sampling was conducted from November through March, with visibility at its worst during the November sampling. Brown trout distribution would be different during the fall spawning season than during the rest of the year. Other studies have found winter distribution of rainbow trout different from the remainder of the year (Chapman and Bjornn 1969 and Gosse 1982).

If population estimates would be made in winter, the results should indicate whether major winter emigration is occurring from the lower study section. It would be valuable to know if seasonal redistribution is occurring. If it does occur, different microhabitat curves would need to be applied for each season.

No population estimates were conducted in the upper study section (Nehring 1983). However, creel census data by Nehring indicated that rainbow trout were present there in 1983 and were

being caught in large numbers. Nehring concluded that the reason for the large catch here in 1983 was that high flows were preventing anglers from using downstream access trails, and therefore, they were concentrating in this section. This heavy angling in 1983 could have caused a major reduction in the trout population by the time our first observations were made in winter 1984. Flow releases in 1984 were similar or greater than in 1983 and could have again placed heavy fishing pressure on this section. Winter emigration could also have reduced densities in this section.

Colorado River, AZ

Species composition and activity

One of the primary reasons that rainbow trout were observed in much greater numbers than brook trout was probably because rainbow trout were often stocked to the exclusion of brook. Brook and rainbow trout were stocked in equal numbers in fall 1983. These brook trout were observed frequently during the winter 1984 season, but did not continue to be observed during either of the seasons subsequent to winter 1984. This may be indicative that brook trout did not survive as well as the rainbow trout did or that brook trout had major emigration downstream from the study site.

The stocked age 0 brook trout observed in winter 1984 did appear to be in good condition and well acclimated to the river. However, age 0 brook trout was the only group observed random swimming more frequently than stationary swimming during winter

1984. In the Green River, the activity of random swimming was considered a behavioral form of energy conservation during periods of low food availability (Gosse 1982). This preference for random swimming age 0 brook trout may indicate a lack of adequate food availability or an inability to compete for the available food. The age 0 brook trout were stocked in the same area that larger rainbow trout had been stocked two weeks previously. This could potentially have given the brook trout a disadvantage in obtaining adequate habitat and food, which may have ultimately caused them to emigrate. It is difficult, however, to draw any solid conclusions based on only one stocking.

Other studies have found that brook trout populations suffered whenever they were sympatric with rainbow trout (King 1942, Larson and Moore 1985, Moore et al. 1983). King (1942) stated that, "Experience has repeatedly shown that very little benefit has been obtained from stocking fingerling brook trout . . . in water where rainbow trout occur."

The adult brook trout that were observed during this study generally appeared to be in excellent condition, normally with apparent condition (K) factors of two or more. Thus the brook trout that do survive to adulthood appear to do very well, but their survival may not be as good as the rainbow's.

With the exception of age 0 brook trout discussed above, there was a strong preference for the activity of stationary swimming for all groups. The very strong tendency for adult rainbow trout to engage in stationary swimming precludes developing adequate habitat indices for adults during the activity of

random swimming. Age 0 and juvenile rainbow trout engaged in random swimming approximately 25% of the time during both seasons. Although random swimming was never a major activity for age 0 nor juveniles, it occurred often enough that it should be considered for modeling purposes. Sample sizes for juvenile and adult brook trout were too small to really determine the importance of random swimming for this species.

It is important to include random swimming curves, whenever possible, in modeling efforts. Random swimming (in areas of low velocity) is often a method of energy conservation used by trout under adverse circumstances such as low food availability or low temperatures. Insuring that random swimming habitat is available would help protect the population during periods of adverse conditions, should they arise.

General distribution and densities of trout

General distribution

In a very general way, one could describe the distribution of trout in the Colorado River as two areas following along the course of the river and located on each side of the thalweg, or midstream section, of the river. These areas would be bounded by the lower and upper water depth limits for each life stage.

Normally, trout did not appear to utilize the central portion of the Colorado River. When they were observed in the central part of the river, it was usually in an area where the river was relatively shallow. There definitely appeared to be an upper limit to the water depth which trout in the Colorado would

utilize. However, the reasons that this area was seldom occupied were probably only indirectly related to water depth.

Naturally, light penetration decreased with increasing water depth. The density of rooted macrophytes began decreasing between 4-7 m, and almost totally disappeared by a depth of 10 m. Relative to its size, there is little allochthonous energy input into the Colorado River, and it is essentially an autotrophic system. Food availability would be closely related to areas where macrophyte production occurs. Thus, beyond a certain water depth, food availability would probably decrease dramatically except for downstream drift.

A second probable reason that few trout were observed in the midstream area was that water velocities tended to increase towards the center of the river. Thus food availability was decreasing as energy requirements increased, making this an undesirable location.

A third factor that could have reduced observations in deeper water was overall visibility. Fish could seldom be observed more than 3-4 m above the diver, who was on the river bottom. In the deeper areas, if trout were located high enough in the water column, they would have gone undetected. Normally, this would not have occurred because water velocities would have been too great for the trout, but it could potentially happen in the few deep, quiet sections of the river.

Densities

The greater numerical densities of age 0 and juvenile trout within the vicinity of Lees Ferry were undoubtedly a result of

limited dispersion of trout stocked at the Ferry. Our observations indicate that the majority of healthy, nonstressed trout probably do not move more than several kilometers from where they are stocked until they are mature enough to make their first spawning run. Although stressed trout have been observed to move downstream (Gresswell 1973), a great number of studies have found very limited movement in healthy trout populations as long as water temperatures do not become too low. Edmundson et. al. (1968) observed 88% of small steelhead trout moving less than 12 m in a two week period, while Whitworth and Strange (1983) found brook and rainbow trout moving an average of 13 and 25 m, respectively, over a year. Bjornn and Mallet (1964), Cargill (1980), Newell (1957), and Shetter (1937 and 1968) all found the majority of brook and rainbow trout having very limited movement, between none at all up to 3 km. The apparent lack of movement in the trout stocked in the Colorado is indicative that they are adapting well to the river habitat. Movement studies on the Colorado River are currently being conducted by the Arizona Game and Fish which may provide more information on this subject.

Densities declined progressively above the boat launch area. The upper half of the study area had low densities for all life stages, but especially for age 0. In the upper half of the study area, densities for all age groups were low enough that there was only about a 50% chance of observing trout on a given dive. Except during spawning, an average of about five trout per dive was normally observed in this area. Densities in the upper half

of the study area were much lower than were observed in any other river from which data could be collected.

The larger adult trout appeared to have redistributed themselves throughout the study area, either because they were more mobile than juveniles or because of migration associated with spawning activities. With the exception of spawning activities, large adults showed little tendency to congregate in groups and seemed to be well dispersed along the course of the river. There were locations where large adults were more likely to be observed than others, but these locations were scattered throughout the study site and did not contain major concentrations of large adults except during spawning.

Stocking effort

The result of releasing all fingerlings from the boat launch area has been to concentrate the majority of age 0 and juvenile trout in a small section of the river. The Lees Ferry area does provide good habitat, and a certain proportion of fingerlings should be released here. However, it would be beneficial if fingerlings were released throughout the entire study area, as had been done in the past and as is done on similar rivers such as the Green River, Utah (Larson et. al. 1981). This would allow the young fish to take maximum advantage of all the available resources in the river and would reduce competition among them.

Another problem with stocking exclusively at the Ferry is that this area is the only place available to the vast majority of shore fishermen. If a management objective is to maximize survival to adult size, exclusive stocking in this area would be

very counterproductive because the stocked trout are spending their first one or two years of life in the area with the highest fishing pressure.

Survival to adulthood could probably be greatly enhanced by stocking in similar habitat in other parts of the river. Whenever possible, subsequent stockings, especially of smaller size groups, should not be done in the same areas where other trout have recently been stocked. Stocking of small trout in areas already occupied by established and slightly larger trout can place them at a competitive disadvantage. The Lees Ferry area is probably near or even above its maximum carrying capacity, but the overall river between the dam and the Ferry appears to be far below its total carrying capacity. By stocking throughout this river section, more fish could be stocked and more should survive.

Natural reproduction and spawning

Natural reproduction

It is not possible, based on this study, to make any estimate of the percentage of trout resulting from natural reproduction. The observation of naturally reproduced trout in both winter and summer 1984 indicated that at least some of the spawning activity was successful. Current studies being conducted by Arizona Game and Fish will provide more information on the origin of trout in creels.

Spawning success was probably enhanced in winter 1984 by the steady flow releases. Many of the redds observed would have been dewatered by even moderate reductions in flow. Since the newly

emergent trout observed were closely associated with the shore line, they would also be greatly affected by changing flows. At the least, emergents would have to relocate with each flow change and would be more exposed and susceptible to predation as they changed locations. At the worst, they could become stranded and suffer direct mortalities as flows decreased.

Some changes could be made which would help to improve natural reproduction in the Colorado. The most obvious would be to provide steady or steadier flow releases during the peak of the spawning season. This would help protect adults spawning in shallow water from being stranded as flows decreased. But in order to insure successful reproduction, steady flows would have to be maintained until emergence. Although Reiser and White (1983) and Becker et. al. (1982) found that under certain conditions eggs in redds could withstand extensive dewatering, the latter study showed that this was true only during the early stages of egg development. Becker et. al. found that the last developmental stage prior to emergence sustained almost 100% mortality with less than 2 h/day of dewatering. Thus the steady flows would have to be maintained from spawning through emergence to be of much value. This would be considered extremely expensive in terms of lost generating potential.

It should be remembered that salmonids have evolved by reproducing in streams and tributaries that were much smaller than the Colorado River. The Colorado is certainly not an ideal spawning ground and trout are an exotic species in this system. The largest stream that Witzel and MacCrimmon (1983) observed

brook trout spawning in had a flow of 6.25 cfs while Lowry (1965) reported the most important reproduction tributary of one of his study streams had a flow of 0.6 cfs. In view of the available river habitat and the lack of any acceptable tributaries in this section, it seems unlikely that natural reproduction alone could sustain an adequate population density without major habitat modifications. Rather than attempting to enhance natural reproduction in a river as unsuitable as the Colorado, it would probably be more cost effective to continue or enhance current stocking efforts.

If stocking rather than natural reproduction is to be the major form of recruitment in the Colorado, or any other river, serious consideration should be given to the the idea of obtaining eggs from adults which have survived to maturity in the river. Brood stocks which have been domesticated for many generations have lost many of the adaptive advantages necessary for long-term survival in natural environments (Vincent 1960). Several studies have found that wild strains of salmonids survived better than domesticated strains when stocked in stream environments (Vincent 1960, Mason et al. 1967, Reisenbichler and McIntyre 1977). By using adults which have survived in the river as brood stock, many of the benefits of natural selection would be carried through to the stocked trout. Costs for such efforts might be offset by the savings achieved in not having to provide steady flows for extended periods.

Spawning

Based on the data from this study, there did not appear to be any biological differences in spawning choices between rainbow and brook trout. Witzel and MacCrimmon (1983) found that groundwater seepage, which was not measured during this study, was an important requirement for brook trout redds and was an important factor in separating them from brown trout redds.

A statistically significant difference was observed between brook and rainbow trout in their choice of water depth, but the sample size for the former was very small and the difference should be given little credit at this stage. Average water depth of unoccupied redds was lower because most of these were surface observations made in water of ≤ 1 m whereas observations by the diver were in depths up to 4 m.

The lack of observable differences in spawning choices has several implications. At this stage, one set of spawning habitat indices could possibly be developed for the Colorado using the combined data from both species and the unoccupied redds. Although this may produce some error by ignoring subtle differences between species, it has the advantage of reducing error resulting from limited sample size, which would be likely in the case of the brook trout.

The second implication of the overlapping spawning preferences is that the two species were directly competing for spawning microhabitat. Spawning habitat in the study area is probably limited and total spawning success is probably reduced by competition and successive spawning in the same areas. It is there-

fore probable that spawning success for brook trout will be hindered by the rainbow trout, which have a great numerical advantage over the brook trout. It is also quite probable that newly emergent age 0 of both species are competing for microhabitat. Only a minute portion of the total river provides the microhabitat they require. Everest and Chapman (1972) found that only different times of emergence prevented direct competition between newly emergent chinook salmon (Oncorhynchus tshawytscha) and steelhead trout.

Originally, there would have been a temporal as well as a geographical isolation in spawning for the two species. The broad spawning season observed for both species most probably resulted from the ultimate hatchery origin of trout in the Colorado, although the almost constant water temperatures may have also extended the seasons.

Most other studies have found spawning rainbow and brook trout using different fish velocities and depths than were observed during this study. Smith (1973) and Bovee (1978) listed spawning velocities for rainbow and steelhead trout higher than were observed during this study. Smith measured velocities 12 cm above "undisturbed gravel just above the upstream edge of the redd" while in this study measurements were made at the location of the trout, which was an average of 12 cm above the substrate, but within the redd. Velocities within the redd are lower than above undisturbed gravel, which accounts for part of the discrepancy between our findings and Smith's. It is not possible to

determine how measurements were made in the studies compiled by Bovee.

Smith (1973) and Witzel and MacCrimmon (1983) found average velocities for brook trout of 11 and 18 cm/s, respectively, compared to an average fish velocity of 24 cm/s observed during this study. Witzel and MacCrimmon were apparently measuring velocities using methods similar to those used in this study, but they were working in streams with flows 0.026% that of the Colorado River and the largest brook trout they observed were smaller than any adults observed in this study.

Average water depths for all of the studies cited above were less for both species than were observed during this study. In most cases the size of study streams wasn't presented, but it is highly probable that they were much smaller than the Colorado River. Hartman (1969) listed 2 m as the maximum stream depth of eight spawning tributaries used by rainbow trout.

The difference in size between the Colorado and traditional spawning streams probably accounted for the increased water depths observed during this study. It is possible that trout were using deeper than optimum water depths in the Colorado. Differences in methods probably accounted for some of the differences in velocities between this and other studies. Brook trout observed during this study were probably much larger than those observed during other studies, which probably also accounted for much of the differences observed in velocities between this and other studies.

Variable flows

The unusual flow regime which occurred throughout this study prevented observations of the fluctuating flow regime which normally occurs on the river. The high and extra high flows observed during this study did not appear stressful to the trout. It appears that aquatic plants could be adversely affected by a varied flow release. This would be important to the trout fisheries because there appears to be a strong link between the invertebrates upon which they feed and plant production. Limited sampling found Gammarus lacustris were highly associated with plant beds, with especially high densities in macrophytes located in low velocity water (Gosse 1981b).

As discussed in a previous section, plant density decreased with increasing water depth, and was essentially zero along much of the central portion of the river. High flows limit the depth to which plants can grow by limiting light. Extended periods of low flows cause desiccation of aquatic plants and limit the upper shore area that plants can grow in. Therefore, the greater the disparity between upper and lower flow releases, the narrower the phototrophic zone will become.

The concept of a broadening range of flow releases is a real threat below most dams. There is an ongoing effort to increase maximum generating capacities at many hydroelectric plants to satisfy peaking power demands. Since the amount of water flowing through a river system is relatively constant over time, increased releases would have to be offset either with longer periods of low flows, or with lower minimum releases. Thus there

would be a potential for broadening the range between upper and lower releases whenever generating capacities are increased.

It has been mentioned in previous sections that fluctuating flows could have an adverse impact on both spawning and newly emergent trout. Whether other groups of trout would be directly affected by fluctuating flows would be difficult to determine based on the flow regime we observed.

Comparisons between years: winter 1984 and 1985

Observations made during winter 1984 and 1985 on the Colorado River were compared to determine whether annual fluctuations were affecting microhabitat choices. Trout were using essentially the same microhabitat during both years. Most of the differences that were observed resulted from differences in size or the amount of spawning activity between the two winters.

The differences observed for juvenile rainbow trout for fish and water depth between winters were probably a result of the difference in size between the two years. The smaller juveniles in 1984 occupied lower fish and water depths than did the larger juveniles in 1985. Within a life stage, larger trout usually utilize deeper water than smaller ones.

The differences observed for fish velocity during stationary swimming, although statistically significant, were small in terms of absolute differences or biological meaning. For the activity of random swimming, the differences observed for fish and mean velocity between seasons were more dramatic and difficult to explain. The smaller juveniles in 1984 were occupying higher velocities than the larger juveniles in 1985 did. Within a life

stage, larger trout normally utilize higher velocities than do smaller ones. The somewhat small sample size in 1984 might account for part of the shift.

Adult rainbow trout exhibited no significant differences between the two years except in water depth utilized. One reason for the shift in water depths was that far more effort in 1984 was directed towards observing spawning activity, which means more dives were made in shallower water. Additionally, during the sampling periods in 1984, spawning was a more predominant activity than in 1985, which meant adults were more likely to be located in shallower water in 1984 even when not actively engaged in spawning.

Comparisons between flows: summer extra high and normal high

The flow regimes observed during summer 1984 in the Colorado River did not simulate normal operations, but they provided a unique opportunity to observe higher flows than could normally have been obtained. The extra high flows which were released during most of the summer allowed actual observations and data collection at or above release levels which would be produced if the generating capacity of the dam were increased. Normally, the effects of increased releases above normal operations can only be projected with the use of models which have not been thoroughly tested for accuracy.

In general, there were no indications that the extra high flows produced any worse conditions for the trout than were observed during normal high flows. It is probable, however, that

the trout relocated somewhat between flow levels in order to maintain desirable conditions.

Trout often move closer to the river bottom (decreased fish depth) to avoid high velocities during excessive flow releases. But for all three life stages, fish depth was significantly lower during normal flows than during extra high flows, the opposite of what would be expected if the extra high flows had been limiting. Thus, the trout were not being restricted to a narrow zone near the river bottom during the extra high flows. There was no obvious reason why fish depth should have so consistently decreased during normal high flows.

Although juveniles and adults did occupy higher fish velocities during extra high flows, the differences were neither significant nor great. Mean velocities for the fish were also not significantly different between the two flows.

There was no indication that the extra high flows produced stressful conditions for age 0 trout. If this had not been true, one might expect to have observed increased fish velocities during the extra high flows. Fish velocities for age 0 actually increased slightly as flows were reduced. This was probably a result of growth rather than flow changes.

Comparisons between seasons: summer and winter

In comparing between seasons, data from both winter 1984 and 1985 were combined as were data from both extra high and normal high flows during summer. Comparisons made in the previous two sections between the two winters and between the two flows had shown that in each case, they were essentially the same. Most of

the differences that were observed resulted from differences in size. The advantage in combining the data bases was to provide larger sample sizes and a more complete range of habitat choices.

In general, there were no consistent nor major shifts indicating major changes in microhabitat choices between seasons. Differences were observed in age 0 rainbow trout between winter and summer seasons in the Colorado River. These differences appeared to be the normal differences that would result from the changes in mean length that were found in this age group between the two seasons. Average values for a few variables were significantly different between the two seasons, but most were not significantly different. The one exception was for juvenile rainbow trout during the activity of random swimming. There was a shift toward deeper, quieter areas during the summer than were occupied during the winter. There was no apparent reason for this shift toward deeper water among juveniles.

There was no indication of a shift in activity preference between seasons. Stationary swimming was the predominant activity for all life stages during both seasons. Adult rainbow trout was the only group to exhibit a statistically significant difference in the proportion of activities between seasons. However, the percentage of adults engaged in random swimming was so low as to be of little biological importance during either season.

The lack of differences in parameter values between seasons in the Colorado River indicated that there were no major changes in location nor activities between seasons. Contrarily, observations in the Green River, Utah revealed dramatic changes in

microhabitat selection between winter and summer along with major shifts in activity (Gosse 1982). The importance and causes of seasonal changes in location and activity will be discussed more thoroughly in a subsequent section.

San Juan River, NM

Trout densities

Densities of rainbow trout in the upper section of the San Juan were the greatest that the author had ever observed for any trout species. Growth rates and productivity are usually very high in tailwaters below large impoundments but densities do not normally reach the level observed in the San Juan. Although they are probably not the only cause, the restrictive fishing regulations in this section of the San Juan appeared to be a major reason for the high densities observed.

Habitat in the San Juan is good, but it does not appear to be unique enough to account for the difference in densities between the San Juan and other rivers, especially since water depths and possibly velocities were below optimum. The more stable flows of the San Juan, compared to most other tailwaters, probably provide better habitat for naturally produced emergent trout and small stocked fry.

Precise comparisons of stocking densities among the San Juan, Colorado, and Green River, Utah were not possible because different size fish were stocked, available data were from different years, and stocking densities for individual rivers usually varied over time. However, based upon stocking records for

the Colorado River (Table 3), the Green River, Utah (Larson et al. 1981, Larson and Bonebrake 1982, and Bonebrake 1983) and the San Juan River (M. Hatch, New Mexico Department of Game and Fish [NMDGF], unpublished data provided to the USBR Upper Colorado Region) it appears that stocking densities in the San Juan were approximately twice as great as in the Green River and at least three times as great as in the Colorado River.

The differences in habitat, flow release patterns, and stocking densities observed between the San Juan and the Colorado and Green River, Utah could account for some of the higher trout densities observed in the San Juan. But if these were the major reasons for the high densities in the San Juan, densities should have been high throughout the study area since these factors were fairly constant throughout this reach of the river. Trout densities were not, however, constant throughout the study area and densities appeared to be very low below the special regulations section.

The one factor that did change within the San Juan and was also different between it and the other rivers was the restrictive fishing regulations. The fact that densities decreased noticeably and progressively in each subsequent area where regulations became more liberal supports the idea that the regulations were affecting densities. Additionally, length frequency histograms of trout in the restricted catch section show a large peak in numbers just below the legal keeping limit (NMDGF, unpublished memoranda, personal communication). This peak has continued to move upward as the minimum size limit of trout has

increased over the years (G. Thorne, NMDGF, personal communication).

The large number of anglers, especially out-of-staters from throughout the Southwest, observed on this relatively small, remote river indicated that the type of fishing provided here was very popular. Similar regulations might provide improved recreation in sections of other river systems.

Age 0 trout

The age 0 trout observed appeared to be the result of natural reproduction. Since poor visibility prevented data collection during spawning seasons, no data was obtained on spawning habitat or intensity in the San Juan. These age 0 trout were utilizing a very limited amount of the total river habitat. This is indicative that even a river the size of the San Juan, which is small compared to the Colorado, still does not provide much habitat for young age 0 trout.

One of the apparent requirements of age 0 microhabitat is physical isolation from adult trout. In both the Logan River system and the Provo River, age 0 brown trout were isolated from adults (Gosse and Helm 1982). Saunders and Smith (1962) found age 0 brook trout primarily in areas not occupied by older brook trout, while other authors found an inverse correlation between the number of adults and age 0 in different stream sections (Boussu 1954, Larson and Moore 1985, Sheppard and Johnson 1985).

The San Juan provides more microhabitat, especially in the upper part of the study area, for age 0 trout than do most western rivers below large impoundments. The extensive braiding

of the river, riparian vegetation, and shallow depths all provide physical isolation from adults. The steadier flows of the San Juan would also be beneficial to emergent trout. Natural reproduction potentially could sustain a larger proportion of the population in the San Juan than is possible in the Green River, Utah or in the Colorado River. However, in all of these rivers stocking will probably have to remain the primary source of recruitment for the fisheries to be maintained at current levels.

Varied flow releases

It is difficult to make any definitive statements regarding the effects of varied flow releases since data were collected at only one flow level. At the observed release of 500 cfs, rainbow trout were utilizing significantly lower water depths than they did in other rivers. It seems probable that water depth was already limiting at these releases, and any further reduction in releases could severely limit microhabitat in terms of water depth. An increase in flows above 500 cfs should not immediately produce a negative effect in terms of fish velocities, since average fish velocities for juveniles and adults were lower in the San Juan than in other rivers. It is possible that some increase in flow would provide more desirable water depths with little detriment in terms of velocities. Since the San Juan has a large flood plain, increased releases probably have less influence on velocities than in a more restricted river.

To the extent that natural reproduction contributes to the population, fluctuating flows would probably be detrimental to emergent trout. Also, fluctuating flows would probably be detri-

mental to trout stocked at a small size (approximately 6 cm or less). The projected range between upper and lower releases would be very important in determining the full effect of any projected flow fluctuations.

Comparisons Among Rivers

Winter: Green River, UT and Colorado River, AZ

Major differences were observed in winter microhabitat choices between the Colorado River and the 1982 study conducted in the Green River, Utah. Most of these differences reflected the seasonal changes in microhabitat which occurred in the Green River but which did not occur in the Colorado River.

Stationary swimming

In the winter, fish and mean velocities were significantly higher for both juveniles and adult rainbow trout in the Colorado than in the Green River, Utah during stationary swimming. There had been no significant differences in fish velocity during the summer between these rivers during stationary swimming. Mean velocity was higher in the Green than in the Colorado during the summer. The lower velocities observed in the Green River during the winter indicate that the fish were moving to lower velocity water than they would normally occupy during stationary swimming. In the Colorado River, even when velocities were significantly different between seasons, the change was small. This is indicative of the seasonal shift in microhabitat which occurs in the Green River but not in the Colorado.

The shift to deeper, slower water during winter in the Green River was further illustrated by water depth data. Juvenile rainbow trout in the Green River were in deeper water than was used by juveniles in the Colorado, yet the latter river has a far greater average and total depth. Juveniles in the Green River were concentrated in the deep pools, which is reflected by the greater water depth they occupied. Adult rainbow trout in the Green didn't exhibit as strong a tendency to utilize pools as did juveniles, and there was no difference in water depth between adults in the two rivers. The overall effect of these shifts in microhabitat in the Green River was felt to be a conservation of energy expenditure (Gosse 1982).

Random swimming

Water depth and fish depth were greater in the Green than in the Colorado River for juvenile rainbow trout during the activity of random swimming. This is indicative of juveniles concentrating into pools during the winter. Adult rainbow trout in the Green River did not have significantly different water or fish depth from adults in the Colorado. This again indicates that adults in the Green River were not concentrating into pools during the winter to the extent that juveniles were.

During random swimming, fish velocity was significantly higher in the Green than in the Colorado River for both juveniles and adults. Examination of frequency distributions indicated the major change appeared to be a slight increase in the Green River of the upper range of velocities utilized during this activity.

Summer: Green River, UT; Colorado River, AZ; and San Juan River, NM

Although many of the average values compared among the Colorado, San Juan, and Green River, Utah were significantly different, most of the differences were either explainable because of inherent differences among the rivers or were small enough to have little biological importance. The differences that were observed appear to be consistent with the differences among the rivers.

Differences were observed in both fish and mean velocities among the rivers. These differences were consistent in reflecting the differences in gradient among the rivers. Mean water depths were lower in the San Juan, the shallowest river, than in the Green or Colorado River. Fish depths varied among the rivers, but were reflective of the water depths and velocities found in each river.

The microhabitat choices measured for each river were, in Hutchinson's (1957) terms, the "realized" niche of the species for that particular river. The differences in microhabitat choices observed among these three rivers consistently reflect the different types of habitat available for the trout to choose from. The observed differences do not imply random choices among different populations but rather they reflect a compromise between Hutchinson's "fundamental" niche and what was available. The differences do imply that data obtained from one river cannot be indiscriminately applied to other rivers without regard to such factors as size, gradient, and climate. The consistency of the observed shifts with the physical differences among the

rivers leads to the expectation that, with an adequate data base, potential shifts in microhabitat choices should be predictable and that data could then be applied from one river to another.

Stationary swimming

Fish velocities in the Colorado and Green Rivers were not significantly different for either juvenile or adult rainbow trout during the activity of stationary swimming. Fish velocities in the San Juan for both life stages were about 40% less than in the other two rivers. Since a lower range of velocities was available in the San Juan, rainbow trout were possibly selecting velocities which were within their "acceptable" range but which were probably below their "optimum" velocity.

The lower fish velocities observed in the San Juan River may have also been partially due to the shallow water depths found in this river. Water depths utilized by trout in the San Juan were significantly less than in the other two rivers for both life stages. However, many of the trout observed in the San Juan were found concentrated in the deeper and slower sections of the river. Since much of the San Juan is shallower than adult rainbow trout normally prefer, the trout may have moved to deep, slow areas to find increased water depth although velocities were further reduced from optimum.

The lower mean column velocities observed in the San Juan reflect the physical difference between it and the other two rivers. The San Juan has a lower gradient than either the Green or Colorado River. Differences in gradient among the rivers account for the differences in mean velocities observed for fish

among the three rivers. The Green River, which has the highest gradient of the three rivers, had the highest observed mean velocities for both life stages during stationary swimming. Conversely, the San Juan, which has the lowest gradient, also had the lowest observed mean velocities for both life stages.

Differences in mean column velocities are more reflective of differences among rivers than of any differences in microhabitat choices by the trout, since mean velocities are not measured at the same depth the trout occupy. Differences in microhabitat choices by trout would be reflected by differences in fish velocity and these differences are normally much less than differences among mean velocities.

The similarity in occupied water depths between the Colorado and Green Rivers indicates that there is an upper as well as a lower limit on water depth for rainbow trout in lotic environments. If microhabitat choices were strictly a reflection of available habitat, water depth chosen by the trout in the Colorado would be expected to be greater than in the Green River. However, there was no significant difference between water depths occupied by adults in the two rivers. Juvenile rainbow trout did utilize significantly deeper water in the Colorado than in the Green River, but the 1 m difference was hardly reflective of the overall difference in depths between the two rivers.

Water depth for juvenile rainbow trout was greater in the Colorado than in the other two rivers and also greater than that occupied by adults in the Colorado River.

The differences in fish depth observed among the three rivers also appears to reflect physical differences among the rivers. The fact that the Green River had the lowest proportional fish depth (compared to the total water depth occupied) while the San Juan had the highest is indicative of the relative velocities. As velocities increase, trout tend to reduce their fish depth (move closer to the river bottom) in order to maintain preferred velocities. Thus, in the higher velocity Green River, trout had to locate proportionally lower in the water column to maintain preferred velocities than they did in the Colorado or in the much slower San Juan River.

Random swimming

The differences observed for age 0 rainbow trout between the Colorado and San Juan Rivers for mean velocity and for fish and water depth appear to result from the significant differences in fish size between the two rivers. This type of difference was also observed when comparisons were made between different size age 0 rainbow trout between winter and summer in the Colorado River.

For juvenile and adult rainbow trout, when fish depth was expressed proportional to total water depth, it produced the same pattern as was found for the activity of stationary swimming. Trout were proportionally highest in the water column in the slowest river, the San Juan, and deepest in the fastest river, the Green.

Fish and mean velocities for juveniles and adults were significantly lower in the San Juan than in the Green River, as

was found with stationary swimming. The range of velocities utilized during random swimming is smaller than with stationary swimming. Thus the absolute differences in velocities observed among the rivers was lower for random swimming. Similarly, velocities in the Colorado River, which has an intermediate gradient, were no longer significantly different from at least one of the other rivers during random swimming.

As with stationary swimming, juvenile rainbow trout in the Colorado River utilized greater water depths than were occupied in the other rivers or by adults in the Colorado. There does appear to be a tendency for juveniles in the Colorado to concentrate in deeper than normal water during summer, resembling the distribution found in the Green River for juvenile rainbow trout during winter (Gosse 1982).

The lower water depths occupied by trout in the San Juan again reflects the lower average depth of that river compared to the other two. At the same time, trout were occupying greater water depths than the average depth in this section of the river, probably indicating that they preferred greater water depths than were available.

Size Differences Within Age Groups

The relative age and size of a life stage was often important in defining microhabitat. Differences in size were especially important for age 0 trout and progressively less important for juveniles and adults.

Two comparisons were made where there were significant differences in size for age 0: in the Colorado River between summer and winters; and during summer between the Colorado and San Juan Rivers. In both cases, there were large and significant differences in microhabitat choices which were probably the result of differences in size. In this study and in previous studies by the author, age 0 trout were observed to move into faster, deeper water as they grew (Gosse 1982, Gosse and Helm 1979). Everest and Chapman (1972) found a linear relationship when length for age 0 steelhead trout was plotted against fish velocity or water depth. Larson and Moore (1985) found both age 0 rainbow and brook trout in faster and deeper water over time.

From this and other studies, it is becoming increasingly apparent that microhabitat requirements for age 0 need to be separated into two or more subgroups based on size. The many studies cited above all found a shift in microhabitat choices during the first year of life. Chapman and Bjornn (1969) stated in regard to salmonids: "Newly-emerged fish prefer or indeed can tolerate only nearly-still water. As growth proceeds the young fish shift toward faster and, to a degree, deeper water." Gosse and Helm (1982) stated that: "It is probable that microhabitat should be determined for a fourth life stage: emergents." Sheppard and Johnson (1985) felt that in view of changing microhabitat choices by age 0 steelhead, the probability-of-use curves should be seasonally adjusted.

There is probably no single correct method for subdividing the age 0 class, but there is adequate data to indicate that

microhabitat requirements for this age class must be divided into at least two groups. As clearly indicated by Everest and Chapman (1972), these changes are continuous with increasing size, and discreet subdivisions are a convenient, although somewhat erroneous, simplification which can readily be incorporated into current habitat models. In this study, an appropriate size range for the smallest or emergent group would have been approximately 0-6 cm, inclusive.

Juveniles had significantly different average lengths for every comparison that was made, although in many cases the actual difference between average lengths was less than 6 cm. The differences in average length were attributed to growth, different times of and size at stocking, and to different size categories between studies. The differences in size appeared to have little effect on juvenile microhabitat choices in all cases but one.

Adults had significantly different average lengths for four different comparisons, although the actual differences were 7 cm or less. These differences never produced any observable changes in microhabitat choices among adults observed in this study. However, it is conceivable that differences in size can produce different microhabitat choices between adults when the size differences become great enough, as in the following case. Differences were found in spawning choices between brook trout in the Colorado and brook trout observed by Witzel and MacCrimmon (1983). The latter study was conducted in streams with flows 0.026% that of the Colorado River and with adults which were much

smaller (8-29 cm FL) than those observed in the Colorado. The differences found between the two studies probably resulted from a combination of differences in both size of the rivers and the size of mature adults.

Until more complete data is available, it will be important to consider relative sizes when making comparisons between two groups within the same life stage or when defining microhabitat requirements for the younger life stages. This would be especially important in fisheries where much or all of the population is sustained by stocking of fingerlings. Since the size and time of stocking can vary greatly, the supposed "same" life stage could have substantially different microhabitat needs for successive years or among rivers. Conversely, measuring microhabitat of age 0 or juvenile fish in such a system for only one year could produce biased data curves if fish had widely varying sizes in subsequent years.

Seasonal Effects of Temperature

It seems probable that in rivers which experience major temperature changes there will be seasonal shifts in microhabitat choices. In the Colorado River, microhabitat choices between winter and summer seasons were very similar except for those differences which appeared to be caused from changes in size rather than from seasonal choices. The section of the Colorado River included in the study site has a very uniform temperature throughout the year. In the Green River, Utah, major changes were observed between winter and summer microhabitat choices for

cutthroat trout and for juvenile rainbow trout (Gosse 1982). The section of the Green River included in the study site had major temperature fluctuations between seasons.

The findings of this study were similar to many other studies which found changes in distribution or habitat choices in rivers which have low winter temperatures. These seasonal differences can take several forms. In Michigan, Shetter (1937) felt that the majority of brook trout left a tributary and overwintered in the main branch of the Au Sable River. In Idaho, Chapman and Bjornn (1969) reported similar movement of steelhead trout into larger systems prior to winter. This is the type of behavior that was suspected to be occurring during this study in the Gunnison River and the Green River below Fontenelle Dam.

Another type of behavior observed in some rivers with low winter temperatures was trout hiding within the interstitial substrate. Edmundson et. al. (1968) found juvenile steelhead trout primarily within the substrate during winter. Chapman and Bjornn (1969) reported that in experimental tanks steelhead were observed to enter the substrate as the water temperature went below 4.5 C and they came back up as the water was warmed to 5.5 C. Trout were observed in the Green River below Fontenelle to use interstitial substrate and some juvenile rainbow trout were observed doing this in the Green River below Flaming Gorge (Gosse 1982).

A third type of behavior observed during the winter in many rivers is the movement of salmonids from fast water into deeper, slower areas. Bustard and Narver (1975) observed this type of

behavior for young coho salmon and steelhead trout. In the Green River, Utah juvenile trout were observed to concentrate in pools during winter (Gosse 1982). Chapman (1962) and Pettit and Wallace (1975) observed similar behavior for coho salmon and whitefish, respectively. Trout in the Provo River, Utah (Gosse and Helm 1979) and the Logan River system (Gosse 1981a) used pools more in the winter than during summer.

The seasonal changes in microhabitat selection observed in the rivers mentioned above were probably either directly or indirectly a function of temperature changes. In the Colorado, where temperatures do not fluctuate seasonally, there were essentially no seasonal differences in microhabitat. Although low temperatures may be the driving factor in winter changes, there must be other factors which cause the wide diversity of behavioral reactions observed. During winter, age 0 steelhead were observed in substrate interstices during low flows and to actively feed during higher flows when drift would be greater (Bustard and Narver 1975). Reimers (1963) found stocked hatchery trout losing weight during winter while concomitant wild trout actively fed and maintained condition. Thus, the effects of low temperatures on food availability within a river, coupled with physiological or behavioral differences among strains, and the overall habitat availability probably account for the different reactions observed during winter.

The microhabitat choices and activities observed during the non-winter periods, and throughout the year in some rivers, could be considered optimum growth activities. The microhabitat

choices observed in many rivers during winters could be considered energy conservation activities (Chapman and Bjornn 1969, Gosse 1982). This correlates to observations where growth and production in lotic salmonid populations become negative during late fall or winter (Hunt 1966, Gosse 1978). Rimmer (1985) found that production was near zero at the same time that pool occupancy of rainbow trout was greatest. Hunt (1969) found fat content of brook trout during winter to be one-third that found during mid-spring. Oliver et al. (1979) concluded that overwinter mortality was, "a result of exhaustion of energy substrates."

In rivers where low or negative production is observed, winters are periods of stress for the population. Reimers (1957) and Bustard and Narver (1975) felt that winters were periods of high mortality. In summary, winter microhabitat requirements are critical to the survival of a population.

It therefore becomes imperative to determine exactly what the winter microhabitat requirements are for a particular population. At the present time, this has to be done by making winter observations on a stream by stream basis. It was found above that microhabitat utilized during other times of the year can be very different from winter choices. To further complicate matters, trout apparently choose from among at least three major forms of winter behavior each requiring different microhabitat. Until more is known about these different winter choices, it would be almost impossible to apply winter microhabitat data from one stream to another.

SUMMARY AND CONCLUSIONS

Green River, WY and Gunnison River, CO

Microhabitat data could not be collected at either the Green River, Wyoming or the Gunnison River, Colorado. In both rivers high flows and poor visibility prevented sampling during the summer season. The extremely low density of trout observed in the Green River during winter indicated either a very small trout population existed in this river or that extensive winter emigration was occurring from the area sampled. Although marginal visibility in the Gunnison River often made sampling difficult, there appeared to be very few trout in either the upper or lower sections of the study area during the winter seasons. Since data from other studies conducted in the lower section indicated an adequate to good trout population during summer and fall, it appears that winter emigration was occurring.

Colorado River, AZ

Stationary swimming was the primary activity in the Colorado River during both seasons and for all age groups, with one exception.

In the Colorado River, trout used only limited portions of the total river. The midstream section was often unused, as were the deeper sections of the river.

Differences in trout densities throughout the study site in the Colorado River reflect original stocking patterns. Survival

can probably be improved by dispersing the stocked trout throughout the length of the study site.

Spawning was observed during the first winter of study and evidence was found of successful reproduction. No major differences were found between redd sites chosen by rainbow and brook trout. Steady flows from the beginning of spawning through emergence would probably increase natural reproduction. However, in view of the unsuitability of the Colorado as a spawning river, it would probably be more cost effective to continue or enhance current stocking efforts.

Trout were observed to use essentially the same habitat when comparisons were made between winter 1984 and 1985. Most of the differences observed resulted from differences in size or activity between the two years.

There were no indications that the extra high flows observed during summer 1984 were more stressful to trout than were the normal high flows observed during summer 1984. Although high or extra high flow conditions were observed throughout the study on the Colorado, there were no indications that the flows were excessive.

When comparisons were made between winter and summer seasons on the Colorado River, there were no consistent nor major shifts indicating major changes in microhabitat choices between seasons. Many of the differences that were observed appeared to result from differences in size between seasons.

San Juan River, NM

The density, size, and condition of rainbow trout in the upper section of the San Juan study site was extraordinary. Although habitat and stocking rates may account for part of the high densities, the restrictive fishing regulations applied in this section appear to be a major reason for this phenomena.

Evidence was found that some natural reproduction was probably occurring in this river. A larger proportion of the population can probably be sustained by natural reproduction in the San Juan than could be in rivers such as the Colorado.

At the observed flows, trout were utilizing lower water depths in the San Juan than they did in other rivers. Fish velocities were also lower in the San Juan than in other rivers. An increase in flow would possibly provide more desirable water depths without producing adverse velocities.

Comparisons Among Rivers

When comparisons were made between winter microhabitat choices in the Colorado River and the 1982 study on the Green River, Utah, major differences were observed. The majority of these differences were reflective of the fact that seasonal changes in microhabitat occurred in the Green River but not in the Colorado.

Comparisons were made for summer microhabitat among the Colorado, San Juan, and Green River, Utah. Significant differences were observed for many of the values compared. Most of

these differences were reflective of the physical differences that exist among the three rivers.

The differences observed among rivers during both seasons were great enough to indicate that indiscriminate application of data obtained on one river to other rivers has a high probability of producing erroneous results. Most of the differences observed among rivers appeared to be correlated to physical differences in the rivers. It is probable that with more knowledge of microhabitat variations among river systems, potential changes in microhabitat choices among rivers could be predicted, and data could be accurately applied to rivers other than the one it originated from.

Size Differences

When comparisons were made within the same life stage between two groups that had significantly different mean lengths, the two groups sometimes chose significantly different microhabitat. This was especially true for age 0 trout and progressively less important for juveniles and adults. Based on findings from this and other studies, it has become apparent that microhabitat requirements for age 0 need to be separated into at least two subgroups based on size. Juveniles and adults may not need to be further subdivided, but it will be important to consider relative size when comparing between two groups within the same life stage.

Seasonal Differences

Populations inhabiting rivers which experience major temperature changes will probably exhibit seasonal shifts in microhabitat choices. Although temperature appears to be an underlying cause of these changes, other factors are involved. Three types of responses to low winter temperatures have been observed among different salmonid populations: migration, movement into pools, movement into interstitial substrate. These cold periods appear to be very stressful to the population, which implies the winter microhabitat used during these periods are critical to the survival of the population. Because winter microhabitat is so different from other seasons, and because there can be so much variation in winter microhabitat choices among rivers, winter microhabitat will have to be determined for each river.

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APPENDIX

HIGH FLOW TESTS IN THE COLORADO RIVER, AZ

APPENDIX TABLE OF CONTENTS

INTRODUCTION

Aqua-Tech was assigned the task of making underwater observations of the trout population during and after the August spillway tests conducted at Glen Canyon Dam. Our objective was to observe whether there were any indications of stress, disorientation, or outright mortalities in the population. This paper will be concerned primarily with these observations and a discussion of the possible implications of the test upon the trout population.

The need to release excess flows at Glen Canyon Dam during the flooding which occurred in June and July, 1983 required the use of both the north and south spillways. Both of these spillways were damaged during this period. Repairs were made to the spillways during the remainder of 1983 and into August 1984. The U.S. Bureau of Reclamation (USBR) decided to test the south spillway before terminating the repair contract. Originally, this test was scheduled to have been conducted earlier in the summer before Lake Powell had become thermally stratified. Because of delays, the test was rescheduled for August 11 to 15, 1984 when the epilimnetic water released down the spillway would be much warmer than the metalimnetic water which normally is released downriver through the turbines.

The fact that the proposed test would cause temperature increases in the river produced concern that it had the potential

of causing adverse effects to the trout population in the river. These concerns were expressed to the USBR by biologists from both their own and other agencies. As a result, the original test was modified to produce smaller temperature changes in a series of steps to facilitate acclimation by the trout population.

Wegner (1984) provides a thorough description of the chemical and thermal profiles existing in Lake Powell during the test and which layers of water were released to minimize the thermal effects of the test. Personnel from the USBR and Arizona Game and Fish were responsible for monitoring thermal and water quality conditions on the river during the test period. Wegner (1984) describes these efforts in detail and they will not be repeated here.

Wegner (1984) also provides a complete description of the original proposed tests and the tests as they were finally conducted. Briefly, the tests consisted of three releases of 20,000 cfs down the south spillway. Each of these releases lasted for approximately 24 h with 5 to 15 h intervals between tests. The first 20,000 release was done in a series of three steps to allow for thermal acclimation by the trout. Just prior to the conclusion of the first 20,000 release, a 1 h test release of 50,000 cfs down the spillway was also made.

There was also a base release of 26,000 cfs through the dam before, during, and after all test releases down the spillway. This base release was a combination of cool water passing through the generating turbines and colder hypolimnetic water released

through the jet valves. The thermal increases caused by the warm epilimnetic water passing down the spillway were minimized by varying the proportion of water released through the turbines and jet valves.

The trout observations conducted during and after these tests were made using essentially the same scuba technique as has been described in the main report to collect microhabitat data. In addition to the standard equipment, the diver also wore a diving thermometer to make comparisons between surface and bottom temperatures. No attempt was made to measure microhabitat during the test period since our interest at this time was in observing the overall activity and behavior of the trout.

Elliot (1981) provides a description of the behavioral changes which he observed in thermally stressed brown trout. He described the first of three phases as, "The first external indications of abnormal behavior are a reluctance to feed [underlining mine], sudden bursts of activity . . . , rolling and pitching, defecation and rapid ventilatory movements." During the second phase fish swim only intermittently and have difficulty maintaining proper orientation. During the third phase, swimming has ceased and only movements of the opercula and pectoral fins occur, with death normally resulting.

OBSERVATIONS

Test Phase

August 11

The first 20,000 cfs test release began on August 11, 1984 with a series of three steps which released 5,000; 10,000; and 20,000 cfs along with the base release of 26,000 cfs. The first observation dive during the tests was made off the north shore at approximately river mile nine. The dive commenced when the water first began to rise in the early evening during the 5,000 cfs step. A number of trout were observed during the dive. The only change that was observed in trout activity was an increase in feeding rate which correlated with higher drift rates as flows increased. The dive lasted for approximately one hour with no other changes being observed.

During the dive, the water temperature decreased 0.5 C, possibly from overcompensation with jet valve water. No temperature increase was observed before nightfall, so a second dive was not made.

August 12

The first dive on August 12 was made across from the Lees Ferry boat launch. It was made in the morning when releases through the spillway were 20,000 cfs with a total flow release of 46,000 cfs (Wegner 1984). Because of the high flow releases,

visibility during the dive was restricted to about 1 m. Approximately 25 rainbow trout, ranging in size from 14 to 32 cm, were observed during the duration of the dive.

All of the trout observed were feeding actively and exhibited normal behavior. This site had relatively fast water, and all of the trout observed were engaged in stationary swimming and were maintaining fixed positions.

The second dive was made during the one hour 50,000 cfs test release through the spillway with a total flow release of 76,000 cfs. This dive was again made at river mile nine at the same location as the previous day. Flows from the 50,000 cfs step had just reached this site when the dive began. The flows peaked and had begun to recede slightly during the dive. Visibility at the beginning of the dive was approximately 0.7 m and decreased to essentially 0 m by the end of the dive. Water temperatures at this site varied between 16.5 to 17 C during the dive.

Several adult and age 0 rainbow trout were observed during the course of the dive. All of the trout were feeding actively and behaving normally. All of the trout were positioned in moderate current as opposed to utilizing quiet water which was located nearby.

August 13

The second sustained 20,000 cfs release continued through most of August 13, having begun during the previous evening. The first dive on this date was conducted approximately 0.5 km downstream from the Lees Ferry boat launch off the north shore.

Approximately 35 or more rainbow trout were observed during the course of the dive representing age 0, juvenile, and adults. All of the trout observed were behaving normally and most were actively feeding, especially the age 0 trout. Feeding rates varied from moderate to quite active.

It appeared that the 50,000 cfs test release from the previous day had caused substantial relocation and disturbance to the substrate. Much of the gravel substrate was barren of plants and was loose and fluffy compared to its normal compacted consistency. A deep hole that had previously existed at this site was now completely filled.

The second dive was conducted several hundred meters upstream from the Lees Ferry boat launch. Between 75 to 100 trout were observed on this dive, the majority being age 0. With one exception, all appeared normal and a great many were actively feeding. One very dark colored juvenile rainbow trout was observed that appeared to be unable to detect the diver nor the side of an underwater sand bank, which it repeatedly swam into. It appeared that this fish was blind, which is not an uncommon observation, especially in populations with heavy angling pressure. It is also common for blind fish to have very dark pigmentation.

Post-test Observations

The two dives conducted on August 14 were made at a base flow of 26,000 cfs between the second and third 20,000 cfs test

releases. The third sustained 20,000 cfs test produced a high degree of turbidity and no dives were conducted while it occurred on August 15. The remaining dives were conducted on August 16 and 17. The objective of the dives on the 14th, 16th, and 17th was to search slack water areas in the river where fish injured or killed by the tests were likely to be found. Dives were conducted in the upper portion of the study area because it was felt that any adverse conditions would have been most pronounced there.

August 14

The first dive was conducted in a large back eddy above the island near river mile twelve. In the deepest (8 m) and quietest part of the back eddy, a large amount of particulate matter and debris was settling out. A large unquantified number of deceased threadfin shad (Dorosoma petenense) approximately 6 cm in length were observed. No trout, alive or dead, were observed during the dive. Threadfin shad are not normally found in the river and these undoubtedly came down the spillway during the tests.

The second dive was conducted in a back eddy above the "no boating" buoys upstream from river mile fifteen. During the dive, two lethargic walleye (Stizostedion vitreum vitreum) and three catfish (Ictalurus sp.) were observed. All of these fish were alive and had probably come through the spillway during the tests. Approximately seven deceased threadfin shad about 4 cm long were also observed. No trout in any condition were observed during the dive.

August 16

August 16 was the first day of observations after the completion of the spillway tests. The first dive was in a large back eddy immediately downstream from the "no boating" buoys above river mile fifteen. No fish, living or deceased, were observed on the dive.

A shallow pool was snorkeled between dives on this day. This pool is approximately 0.5 km below the dam and is the first quiet water downstream from the dam. No deceased fish were observed in this pool.

The second dive was conducted in a back eddy downstream from Honey Draw. Two living and apparently healthy rainbow trout were observed along with one deceased threadfin shad. Approximately twenty more threadfin shad had washed up on shore at this site.

August 17

Before any dives were made on August 17, a pool below the island at river mile twelve and the shallow ($\simeq$1.5 m) bay behind the island were checked from the surface. The pool was checked by snorkeling and the bay was checked from the boat. A large number of living trout were observed in the bay, but no dead or injured fish were found in either area.

The first dive was conducted in a small back eddy shore at river mile nine. The second dive was made in a very large and deep (18 m) back eddy at approximately river mile eight. No dead or deceased fish were observed during either dive.

DISCUSSION

The original concern of involved biologists that the spillway tests could have adverse impacts upon the downstream trout population were justified. Initial plans for the spillway test would have produced greater and more rapid changes in temperature than actually occurred.

The current knowledge of optimum, preferred, and stressful temperatures for trout is contradictory, to say the least. Coutant (1977) lists a series of studies which found preferred temperatures for rainbow trout ranging between 13 to 22 C while Spigarelli and Thommes (1979) cite studies finding preferred temperatures ranging from 11.6 to 19 C. The majority of these studies were conducted in laboratory situations, with the remainder conducted in lentic environments. There is very little knowledge of temperature preferences or tolerances of trout populations in river environments. Thus, in order to insure the safety of the trout population in the Colorado River, it was necessary for concerned biologists to take a conservative position.

Ultimately, the spillway test was conducted in such a manner that river temperatures never increased more than 6 C from the pretest conditions of 11.2 C, and never changed more than 2 C per hour (Wegner 1984). The maximum temperature reached during the spillway tests (17.2 C) was below the avoidance level for both

rainbow and brook trout in any studies listed by Coutant (1977). Spigarelli and Thommes (1979) and Elliot (1981) felt that adverse reactions would be observed between 19 and 20 C.

Trout are generally considered to be capable of safely withstanding thermal changes up to 5.6 C without any acclimation. However, repeated instantaneous changes of this magnitude could reduce the fish's ability to handle such changes. Furthermore, very little is known of the cumulative effects of repeated thermal changes in fish. Thus, the steps which were built into the 50,000 cfs test were a reasonable and necessary safeguard in protecting the population from too radical a change.

Since the temperature changes and rates of change during the test were within what is considered to be safe limits, a major adverse impact upon the trout population should not have occurred. All of our observations during the tests indicated that the trout were exhibiting normal behavior and that they showed no signs of thermal stress. Elliot (1981) defines the "optimum temperature range" as the range of temperatures over which feeding occurs. For this reason, we were particularly concerned whether feeding was occurring while the tests were actually taking place. We were also particularly concerned with the behavior of age 0 trout, since Elliot (1981) and Spaas (1960) both felt that smaller fish had less resistance to thermal changes than did large ones.

No indications of behavioral changes, as described by Elliot (1981) and listed in the Introduction, were observed during the

spillway tests. Rather than observing a cessation of feeding, the different increasing steps of the test usually produced an increase in feeding. Normal or above normal feeding rates were observed throughout the tests. This is consistent with observations that flow increases occurring under constant temperature conditions normally produce increases in feeding rates (Gosse 1982).

Many age 0 trout were observed during the test phase. Like the adult trout, the age 0 trout exhibited high rates of feeding and showed no effect from temperature increases. Therefore, our observations throughout the test phase supported the expectations derived from the literature: that the temperature changes were small and gradual enough so as not to produce any observable behavioral changes in the population and that they probably had no adverse effects upon the trout population.

Our post-test observations support the observations made during the test phase. We found no indication that any trout had died or been injured during the test. The deceased and disoriented fish that were observed all were species that originated in the reservoir and probably came down the spillway during the test.

Post-test dives were conducted in quiet water areas in the upper section of the study area on the theory that the rate of thermal changes would be greatest closest to the dam (Wegner 1984) and therefore any adverse effects would have been greatest there. Many of the areas that injured fish were likely to have

drifted into were searched. The fact that deceased and injured fish originating from the reservoir were found indicated that the proper areas were being searched.

There were indications that plants and substrate were dislocated as a result of the high flows released. This probably had an adverse effect upon the invertebrate population, although the magnitude of this effect cannot be determined. Potentially, there could be some decrease in invertebrate drift until the population fully recovers. This could cause a decrease in trout growth, although whether the decrease could be quantified or detected is questionable.

SUMMARY

The spillway tests did not appear to adversely affect the trout population. All trout observed during the tests, including a large number of age 0 trout, appeared normal. There was no indication of any abnormal behavior nor of any decrease or cessation in feeding. These findings were consistent with the literature which indicated that the thermal changes occurring during the spillway tests should not have produced any adverse effect in a healthy trout population.

Post-test inspection of areas most likely to contain deceased or injured fish failed to detect a single injured trout. It is possible that some individual trout could have been injured by the test, particularly if they were in poor health or under stress from other causes. It seems highly unlikely that any significant proportion of the population could have been affected without our finding some sign of adverse effects.

The high flows which occurred during the test did cause some dislocation of plants and substrate. This probably reduced the standing crop of invertebrates in the study area. Whether this reduction was great enough to have any effect upon trout growth is unknown. The probable effect, if any, is slight.

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MICROHABITAT OF TROUT IN TAILWATERS BELOW WESTERN DAMS

Volume II
Summary Tables

by

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AUTHORS' DISCLAIMER

Since the concept of microhabitat first became popular about a decade ago, there has been a tendency to apply microhabitat data collected from one river to other rivers rather than to collect original data for each river. The savings in time and expense by such actions are obvious. Comparisons made among rivers in this study indicated, as had been suspected, that microhabitat choices sometimes shift among rivers depending on the available habitat choices.

The shifts that were observed appeared consistent with physical differences among the rivers, and it was concluded that with adequate data bases, such differences among rivers could probably be predicted and adjusted for. Until such predictive capabilities are developed and successfully tested, indiscriminate use of these data on rivers other than those from which they were collected will most probably produce erroneous results.

TABLE OF CONTENTS

*Variables are organized in the same order for each activity or flow.

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*Variables are organized in the same order for each activity or flow.

INTRODUCTION

The summary tables presented in this volume are designed to be used in conjunction with Volume I which contains the narrative report.

Tables presented in this volume are numbered independently of Volume I. The tables are subgrouped by river, season, activity, flow level, and physical variable. Within each table, fish are classified by species and life stage.

For all continuous variables, the number, mean, and variance for the variable are listed below each life stage. The number is simply the total number of fish observed for the particular variable. The mean is the true arithmetic average as computed from the original data. Therefore, a mean calculated from the summarized clumped data as presented in the tables will not agree with the true mean as listed. Similarly, the variance is calculated from the original data, and cannot be obtained by using the summarized data.

The four lines listed below the variance are partial calculations used in determining analysis of variance among groups. The line labeled "Par. sum" represents the sum of all observations: ΣX. The line labeled "Cor term" is equal to: $(\Sigma X)^2/n$

where: X is a single observation and

n is the total number of observations.

The line labeled "Par. SS" is equal to: ΣX^2. The line labeled "Error SS" is equal to:

(Par. SS) - (Cor term) or

$$\Sigma X^2 - [(\Sigma X)^2/n].$$

Since substrate is not a continuous variable, the mean and variance have not been calculated for it. The total number of fish observed for each life stage appears at the bottom as for other variables. Both the number of fish observed and the relative percentage of occurrence are presented for each substrate type. Each substrate category (rock, rubble, etc.) was subdivided as to whether it was nonvegetated or covered by attached plants. Plant coverage refers to both macrophytes and attached algae.

The variables of fish depth and distance to a thigmotactic surface were subdivided to provide detailed information and are not presented in a linear scale. Similarly, light was summarized on a logarithmic scale, to provide more precise information.

The meaning of the variable label for each row in a table changes among variables. For fish and mean velocity, the variable label represents the lower inclusive value for each increment. Thus the rows labeled 12 and 18 (cm/s) represent values of 12 to 17 and 18 to 23 (cm/s), respectively. For fish and water depth, light, and thigmotactic distance, the label represents the upper inclusive value for each increment. Thus rows labeled 150 and 200 (cm) represent values of 101 to 150 and 151 to 200 (cm), respectively.

Each summary table along with the accompanying statistical

information was generated by a computer program from a verified data file. A separate program was used for each variable and each program was repeatedly verified for accuracy. The same program produced the summary tables in the form presented here and stored them in a new file. From there the tables were printed on a typewriter quality printer by the computer. This process greatly reduced the potential for error in calculating or producing these tables.

WINTER 1984,

COLORADO RIVER

Table 1. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for fish velocity during stationary swimming.

Fish Vel. (cm/sec)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
0	7	0	0	0	0	1
6	5	5	1	0	0	0
12	1	3	1	28	0	0
18	0	4	1	0	0	3
24	0	5	0	0	0	0
30	0	34	0	4	0	1
36	0	14	4	0	0	0
42	0	6	2	0	0	1
48	0	1	0	0	0	1
54	0	10	1	0	0	0
60	0	0	0	0	0	0
66	0	1	0	0	0	1
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	13	83	10	32	0	8
Mean	4.69	33.71	33.53	17.15	0.00	31.24
Variance	11.8	169.6	216.8	26.2	0.0	442.6
Par. sum	61.0	2798.1	335.3	548.6	0.0	249.9
Cor term	.2859E+03	.9433E+05	.1124E+05	.9406E+04	.0000E+00	.7809E+04
Error SS	.1415E+03	.1390E+05	.1951E+04	.8129E+03	.0000E+00	.3098E+04
Par. SS	.4274E+03	.1082E+06	.1319E+05	.1022E+05	.0000E+00	.1091E+05

Table 2. The number of rainbow and brook trout observed in the Colorado River during normal high flows [25,000 - 26,000 cfs] in winter, 1984 for mean velocity during stationary swimming.

Mean Vel. (cm/sec)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	7	0	0	0	0	0
6	5	5	0	0	0	0
12	1	5	0	20	0	0
18	0	2	1	8	0	1
24	0	0	1	0	0	0
30	0	30	2	4	0	2
36	0	3	1	0	0	1
42	0	3	2	0	0	1
48	0	0	3	0	0	0
54	0	9	1	0	0	2
60	0	3	0	0	0	1
66	0	9	1	0	0	0
72	0	6	0	0	0	0
78	0	6	0	0	0	0
84	0	3	0	0	0	0
90	0	8	1	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	13	83	8	32	0	8
Mean	4.69	46.16	52.20	17.91	0.00	41.91
Variance	11.8	630.0	449.8	25.0	0.0	219.6
Par. sum	61.0	3831.3	417.6	573.0	0.0	335.3
Cor term	.2859E+03	.1769E+06	.2180E+05	.1026E+05	.0000E+00	.1405E+05
Error SS	.1415E+03	.5166E+05	.3148E+04	.7757E+03	.0000E+00	.1538E+04
Par. SS	.4274E+03	.2285E+06	.2494E+05	.1104E+05	.0000E+00	.1559E+05

Table 3. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for fish depth during stationary swimming.

Fish depth (cm)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
10	13	9	3	0	0	2
25	0	74	4	28	0	0
50	0	0	3	4	0	2
75	0	0	0	0	0	1
100	0	0	0	0	0	0
150	0	0	0	0	0	2
200	0	0	0	0	0	1
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	13	83	10	32	0	8
Mean	2.7	42.5	49.8	26.9	0.0	69.4
Variance	1.9	138.0	1376.0	83.5	0.0	3338.8
Par. sum	35.0	3530.0	498.0	860.0	0.0	555.0
Cor term	.9423E+02	.1501E+06	.2480E+05	.2311E+05	.0000E+00	.3850E+05
Error SS	.2277E+02	.1132E+05	.1238E+05	.2588E+04	.0000E+00	.2337E+05
Par. SS	.1170E+03	.1615E+06	.3718E+05	.2570E+05	.0000E+00	.6188E+05

Table 4. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for water depth during stationary swimming.

Water depth (cm)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
50	13	2	1	0	0	0
100	0	22	2	8	0	2
150	0	41	3	20	0	1
200	0	58	4	0	0	0
250	0	40	3	4	0	2
300	0	37	2	0	0	1
350	0	3	1	0	0	1
400	0	0	2	0	0	1
450	0	0	1	0	0	0
500	0	0	0	0	0	0
550	0	0	0	0	0	0
600	0	0	2	0	0	0
650	0	0	2	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	13	83	10	32	0	8
Mean	13.5	190.4	286.0	128.8	0.0	220.6
Variance	25.9	2606.0	27648.9	1585.5	0.0	13781.7
Par. sum	175.0	15800.0	2860.0	4120.0	0.0	1765.0
Cor term	.2356E+04	.3008E+07	.8180E+06	.5305E+06	.0000E+00	.3894E+06
Error SS	.3112E+03	.2137E+06	.2488E+06	.4915E+05	.0000E+00	.9647E+05
Par. SS	.2667E+04	.3221E+07	.1067E+07	.5796E+06	.0000E+00	.4859E+06

Table 5. The number of rainbow and brook trout observed in the Coloredo River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for substrate during stationary swimming.

Substrate type	Rainbow <12 cm		Rainbow 13-27 cm		Rainbow Adult		Brook <12 cm		Brook 13-27 cm		Brook Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	1	7	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	27	32	2	20	0	0	0	0	3	37
Rubble 8-30 cm												
barren	1	7	4	4	0	0	0	0	0	0	0	0
plant covered	3	23	8	9	3	30	0	0	0	0	1	12
Gravel .3-8 cm												
barren	0	0	2	2	1	10	0	0	0	0	0	0
plant covered	0	0	5	6	3	30	0	0	0	0	1	12
Silt <0.3 cm												
barren	6	46	0	0	0	0	8	25	0	0	1	12
plant covered	2	15	37	44	1	10	24	75	0	0	2	25
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	13		83		10		32		0		8	

Table 6. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for thigmotactic surface distance during stationary swimming.

Distance	Rainbow			Brook		
(cm)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	13	0	1	0	0	2
25	0	9	2	28	0	0
50	0	74	4	4	0	2
75	0	0	0	0	0	1
100	0	0	3	0	0	1
150	0	0	0	0	0	2
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	13	83	10	32	0	8
Mean	2.7	42.5	49.8	26.9	0.0	61.9
Variance	1.9	138.0	1378.0	83.5	0.0	2235.3
Par. sum	35.0	3530.0	498.0	880.0	0.0	495.0
Cor term	.9423E+02	.1501E+06	.2480E+05	.2311E+05	.0000E+00	.3063E+05
Error SS	.2277E+02	.1132E+05	.1238E+05	.2588E+04	.0000E+00	.1565E+05
Par. SS	.1170E+03	.1615E+06	.3718E+05	.2570E+05	.0000E+00	.4628E+05

What about life stage activity? Are results random?

Table 7. The number of rainbow and brook trout observed in the Colorado River during normal high flows [~~25,000~~ - 26,000 cfs] in winter, 1984 for fish velocity during random swimming.

Fish Vel.	Rainbow			Brook		
[cm/sec]	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	4	8	0	63	0	0
6	0	0	0	0	0	0
12	0	0	0	0	0	0
18	0	40	0	8	0	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	4	48	0	71	0	0
Mean	0.00	17.65	0.00	5.11	0.00	0.00
Variance	0.0	45.1	0.0	33.9	0.0	0.0
Par. sum	0.0	847.3	0.0	362.7	0.0	0.0
Cor term	.0000E+00	.1496E+05	.0000E+00	.1853E+04	.0000E+00	.0000E+00
Error SS	.0000E+00	.2117E+04	.0000E+00	.2374E+04	.0000E+00	.0000E+00
Par. SS	.0000E+00	.1708E+05	.0000E+00	.4227E+04	.0000E+00	.0000E+00

Table 8. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for mean velocity during random swimming.

Mean Vel. (cm/sec)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
0	4	8	0	63	0	0
6	0	0	0	0	0	0
12	0	15	0	0	0	0
18	0	0	0	0	0	0
24	0	10	0	0	0	0
30	0	25	0	8	0	0
36	0	15	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	4	48	0	71	0	0
Mean	0.00	20.83	0.00	6.48	0.00	0.00
Variance	0.0	117.9	0.0	94.2	0.0	0.0
Par. sum	0.0	999.7	0.0	460.2	0.0	0.0
Cor term	.0000E+00	.2082E+05	.0000E+00	.2983E+04	.0000E+00	.0000E+00
Error SS	.0000E+00	.5543E+04	.0000E+00	.6585E+04	.0000E+00	.0000E+00
Par. SS	.0000E+00	.2637E+05	.0000E+00	.9578E+04	.0000E+00	.0000E+00

Table 9. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for fish depth during random swimming.

Fish depth (cm)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
10	4	0	0	0	0	0
25	0	15	0	36	0	0
50	0	0	0	0	0	0
75	0	10	0	0	0	0
100	0	8	0	35	0	0
150	0	15	0	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	4	48	0	71	0	0
Mean	3.3	74.4	0.0	57.2	0.0	0.0
Variance	1.6	1794.5	0.0	1803.9	0.0	0.0
Par. sum	13.0	3570.0	0.0	4064.0	0.0	0.0
Cor term	.4225E+02	.2655E+06	.0000E+00	.2326E+06	.0000E+00	.0000E+00
Error SS	.4750E+01	.8434E+05	.0000E+00	.1263E+06	.0000E+00	.0000E+00
Par. SS	.4700E+02	.3498E+06	.0000E+00	.3589E+06	.0000E+00	.0000E+00

Table 10. The number of rainbow and brook trout observed in the Colorado River during normal high flows [25,000 - 26,0900 cfs] in winter, 1984 for water depth during random swimming.

Water depth [cm]	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
50	4	0	0	28	0	0
100	0	0	0	0	0	0
150	0	15	0	8	0	0
200	0	0	0	0	0	0
250	0	8	0	35	0	0
300	0	0	0	0	0	0
350	0	0	0	0	0	0
400	0	0	0	0	0	0
450	0	0	0	0	0	0
500	0	25	0	0	0	0
550	0	0	0	0	0	0
600	0	0	0	0	0	0
650	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	4	48	0	71	0	0
Mean	19.8	336.5	0.0	151.4	0.0	0.0
Variance	58.9	31865.9	0.0	10020.8	0.0	0.0
Par. sum	79.0	16150.0	0.0	10750.0	0.0	0.0
Cor term	.1560E+04	.5434E+07	.0000E+00	.1628E+07	.0000E+00	.0000E+00
Error SS	.1768E+03	.1498E+07	.0000E+00	.7015E+06	.0000E+00	.0000E+00
Par. SS	.1737E+04	.6932E+07	.0000E+00	.2329E+07	.0000E+00	.0000E+00

Table 11. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for substrate during random swimming.

Substrate type	Rainbow						Brook					
	<12 cm		13-27 cm		Adult		<12 cm		13-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	0	0	8	16	0	0	35	49	0	0	0	0
plant covered	0	0	25	52	0	0	0	0	0	0	0	0
Rubble 8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Gravel .3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Silt <0.3 cm												
barren	4	100	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	15	31	0	0	36	50	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	4		48		0		71		0		0	

Table 12. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for thigmotactic surface distance during random swimming.

Distance	Rainbow			Brook		
(cm)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	4	0	0	0	0	0
25	0	15	0	36	0	0
50	0	0	0	0	0	0
75	0	10	0	0	0	0
100	0	8	0	35	0	0
150	0	15	0	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	4	48	0	71	0	0
Mean	3.3	74.4	0.0	57.2	0.0	0.0
Variance	1.6	1794.5	0.0	1803.9	0.0	0.0
Par. sum	13.0	3570.0	0.0	4064.0	0.0	0.0
Cor term	.4225E+02	.2655E+06	.0000E+00	.2326E+06	.0000E+00	.0000E+00
Error SS	.4750E+01	.8434E+05	.0000E+00	.1263E+06	.0000E+00	.0000E+00
Par. SS	.4700E+02	.3498E+06	.0000E+00	.3589E+06	.0000E+00	.0000E+00

Table 13. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for fish velocity during spawning, including observations of unoccupied redds.

Fish Vel. (cm/sec)	Rainbow	Brook	Unoccupied
0	5	0	0
6	3	3	8
12	9	0	12
18	7	0	12
24	8	1	14
30	8	2	16
36	7	2	4
42	0	0	6
48	6	0	2
54	0	0	2
60	6	0	2
66	0	0	0
72	0	0	0
>78	0	0	0
Number	59	8	78
Mean	28.62	24.38	26.96
Variance	287.7	167.2	176.9
Par. sum	1688.6	195.1	2103.1
Cor term	.4833E+05	.4757E+04	.5671E+05
Error SS	.1668E+05	.1171E+04	.1362E+05
Par. SS	.6501E+05	.5827E+04	.7033E+05

Table 14. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for mean velocity during spawning, including observations of unoccupied redds.

Mean Vel. (cm/sec)	Rainbow	Brook	Unoccupied
0	0	0	0
6	0	0	2
12	0	0	4
18	4	0	4
24	5	4	14
30	8	2	14
36	9	0	8
42	6	0	10
48	3	2	2
54	8	0	4
60	5	0	4
66	4	0	8
72	4	0	0
78	0	0	4
84	0	0	0
90	2	0	0
96	0	0	0
102	1	0	0
108	0	0	0
114	0	0	0
120	0	0	0
126	0	0	0
132	0	0	0
138	0	0	0
144	0	0	0
150	0	0	0
156	0	0	0
162	0	0	0
>168	0	0	0
Number	59	8	78
Mean	48.87	32.77	40.41
Variance	376.7	145.3	343.0
Par. sum	2883.4	262.1	3151.6
Cor term	.1408E+06	.8589E+04	.1273E+06
Error SS	.2185E+05	.1017E+04	.2641E+05
Par. SS	.1628E+06	.9606E+04	.1538E+06

Table 15. The number of rainbow and brook trout observed in the Coloredo River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for fish depth during spawning.

Fish depth (cm)	Rainbow	Brook
10	34	3
25	22	5
50	3	0
75	0	0
100	0	0
150	0	0
200	0	0
250	0	0
300	0	0
400	0	0
500	0	0
600	0	0
700	0	0
800	0	0
900	0	0
>900	0	0
Number	59	8
Mean	12.4	11.4
Variance	68.8	64.6
Par. sum	729.0	91.0
Cor term	.9007E+04	.1035E+04
Error SS	.3876E+04	.4519E+03
Par. SS	.1288E+05	.1487E+04

Table 16. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for water depth during spawning, including observations of unoccupied redds.

Water depth (cm)	Rainbow	Brook	Unoccupied
50	52 [15 37] 15 41	3	46
100		1	26
150	5 [4 1] 2	0	6
200		4	0
250	1 [1 0] 0	0	0
300		0	0
350	1 [0 1] 1	0	0
400		0	0
450	0 [0 0] 0	0	0
500		0	0
550	0 [0 0]	0	0
600		0	0
650	0	0	0
700	0	0	0
750	0	0	0
800	0	0	0
850	0	0	0
900	0	0	0
950	0	0	0
1000	0	0	0
1050	0	0	0
1100	0	0	0
1150	0	0	0
1200	0	0	0
>1200	0	0	0
Number	59	8	78
Mean	77.6	115.6	61.1
Variance	2808.6	5438.8	900.6
Par. sum	4578.0	925.0	4762.0
Cor term	.3552E+06	.1070E+06	.2907E+06
Error SS	.1629E+06	.3807E+05	.6934E+05
Par. SS	.5181E+06	.1450E+06	.3601E+06

Table 17. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for substrate during spawning, including observations of unoccupied redds.

Substrate type	Rainbow		Brook		Unoccupied	
	N	%	N	%	N	%
Rock						
>30 cm						
barren	0	0	0	0	0	0
plant covered	0	0	0	0	0	0
Rubble						
8-30 cm						
barren	0	0	0	0	0	0
plant covered	0	0	0	0	0	0
Gravel						
.3-8 cm						
barren	59	100	8	100	78	100
plant covered	0	0	0	0	0	0
Silt						
<0.3 cm						
barren	0	0	0	0	0	0
plant covered	0	0	0	0	0	0
Other						
barren	0	0	0	0	0	0
plant covered	0	0	0	0	0	0
Total	59		8		78	

Table 18. The number of rainbow and brook trout observed in the Colorado River during normal high flows (25,000 - 26,000 cfs) in winter, 1984 for thigmotactic surface distance during spawning.

Distance (cm)	Rainbow	Brook
10	34	3
25	22	5
50	3	0
75	0	0
100	0	0
150	0	0
200	0	0
250	0	0
300	0	0
400	0	0
500	0	0
600	0	0
700	0	0
800	0	0
900	0	0
>900	0	0
Number	59	8
Mean	12.4	11.4
Variance	66.8	64.6
Par. sum	729.0	91.0
Cor term	.9007E+04	.1035E+04
Error SS	.3876E+04	.4519E+03
Par. SS	.1288E+05	.1487E+04

WINTER 1985,

COLORADO RIVER

Table 19. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for fish velocity during stationary swimming.

Fish Vel.	Rainbow			Brook		
(cm/sec)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	0	7	2	0	0	0
6	0	0	0	0	0	0
12	0	29	2	0	0	1
18	0	52	8	0	0	0
24	0	56	23	0	0	0
30	0	48	13	0	0	1
36	0	26	6	0	0	0
42	0	51	9	0	0	0
48	0	4	17	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	2	0	0	0	0
72	0	0	0	0	0	0
>78	0	1	2	0	0	0
Number	0	276	82	0	0	2
Mean	0.00	29.80	34.75	0.00	0.00	22.86
Variance	0.0	140.5	203.9	0.0	0.0	227.6
Par. sum	0.0	8223.5	2849.9	0.0	0.0	45.7
Cor term	.0000E+00	.2450E+06	.9905E+05	.0000E+00	.0000E+00	.1045E+04
Error SS	.0000E+00	.3863E+05	.1652E+05	.0000E+00	.0000E+00	.2276E+03
Par. SS	.0000E+00	.2837E+06	.1156E+06	.0000E+00	.0000E+00	.1273E+04

Table 20. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for mean velocity during stationary swimming.

Mean Vel.	Rainbow			Brook		
(cm/sec)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	0	0	0	0	0	0
6	0	0	0	0	0	0
12	0	48	8	0	0	1
18	0	4	3	0	0	0
24	0	19	7	0	0	0
30	0	28	4	0	0	0
36	0	18	3	0	0	0
42	0	24	11	0	0	1
48	0	33	4	0	0	0
54	0	18	13	0	0	0
60	0	12	3	0	0	0
66	0	14	12	0	0	0
72	0	5	0	0	0	0
78	0	28	6	0	0	0
84	0	2	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	4	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	0	254	78	0	0	2
Mean	0.00	43.52	51.66	0.00	0.00	27.43
Variance	0.0	469.3	687.0	0.0	0.0	464.5
Par. sum	0.0	11055.1	4029.5	0.0	0.0	54.9
Cor term	.0000E+00	.4812E+06	.2082E+06	.0000E+00	.0000E+00	.1505E+04
Error SS	.0000E+00	.1187E+06	.5290E+05	.0000E+00	.0000E+00	.4645E+03
Par. SS	.0000E+00	.5999E+06	.2611E+06	.0000E+00	.0000E+00	.1970E+04

Table 21. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for fish depth during stationary swimming.

Fish depth (cm)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
10	0	0	0	0	0	0
25	0	17	3	0	0	0
50	0	76	44	0	0	0
75	0	16	3	0	0	1
100	0	90	15	0	0	1
150	0	74	11	0	0	0
200	0	23	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	0	296	84	0	0	2
Mean	0.0	91.3	59.0	0.0	0.0	85.0
Variance	0.0	2200.5	1522.6	0.0	0.0	450.0
Par. sum	0.0	27014.0	4860.0	0.0	0.0	170.0
Cor term	.0000E+00	.2465E+07	.2929E+06	.0000E+00	.0000E+00	.1445E+05
Error SS	.0000E+00	.6492E+06	.1264E+06	.0000E+00	.0000E+00	.4500E+03
Par. SS	.0000E+00	.3115E+07	.4193E+06	.0000E+00	.0000E+00	.1480E+05

Table 22. The number of rainbow and brook trout observed in the Colorado River during normal high flows [24,000 - 27,000 cfs] in winter, 1985 for water depth during stationary swimming.

Water depth (cm)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
50	0	0	0	0	0	0
100	0	0	0	0	0	0
150	0	4	3	0	0	0
200	0	4	1	0	0	0
250	0	17	12	0	0	0
300	0	17	12	0	0	1
350	0	38	7	0	0	0
400	0	19	8	0	0	0
450	0	57	8	0	0	0
500	0	64	25	0	0	0
550	0	45	12	0	0	1
600	0	24	0	0	0	0
650	0	15	4	0	0	0
700	0	0	1	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	13	4	0	0	0
1050	0	13	4	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	0	296	84	0	0	2
Mean	0.0	478.8	456.8	0.0	0.0	405.0
Variance	0.0	23226.8	27906.4	0.0	0.0	36450.0
Par. sum	0.0	141730.0	38370.0	0.0	0.0	810.0
Cor term	.0000E+00	.6786E+08	.1753E+08	.0000E+00	.0000E+00	.3281E+06
Error SS	.0000E+00	.6852E+07	.2316E+07	.0000E+00	.0000E+00	.3645E+05
Par. SS	.0000E+00	.7471E+08	.1984E+08	.0000E+00	.0000E+00	.3645E+06

Table 23. The number of rainbow and brook trout observed in the Colorado River during normal high flows [24,000 - 27,000 cfs] in winter, 1985 for substrate during stationary swimming.

Substrate type	Rainbow						Brook					
	<12 cm		13-27 cm		Adult		<12 cm		13-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	0	0	45	15	8	9	0	0	0	0	1	50
plant covered	0	0	133	44	28	33	0	0	0	0	0	0
Rubble 8-30 cm												
barren	0	0	35	11	14	16	0	0	0	0	0	0
plant covered	0	0	13	4	13	15	0	0	0	0	0	0
Gravel .3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	1	1	0	0	0	0	0	0
Silt <0.3 cm												
barren	0	0	70	23	20	23	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	1	50
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	0		296		84		0		0		2	

Table 24. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for thigmotactic surface distance during stationary swimming.

Distance	Rainbow			Brook		
(cm)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	0	0	3	0	0	1
25	0	17	8	0	0	0
50	0	91	44	0	0	0
75	0	16	3	0	0	0
100	0	90	15	0	0	1
150	0	74	11	0	0	0
200	0	8	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	0	296	84	0	0	2
Mean	0.0	83.7	59.0	0.0	0.0	55.0
Variance	0.0	1627.9	1522.6	0.0	0.0	4050.0
Par. sum	0.0	24764.0	4960.0	0.0	0.0	110.0
Cor term	.0000E+00	.2072E+07	.2928E+06	.0000E+00	.0000E+00	.6050E+04
Error SS	.0000E+00	.4802E+06	.1264E+06	.0000E+00	.0000E+00	.4050E+04
Par. SS	.0000E+00	.2552E+07	.4193E+06	.0000E+00	.0000E+00	.1010E+05

Table 25. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for fish velocity during random swimming.

Fish Vel. (cm/sec)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
0	0	5	0	0	0	0
6	0	44	9	0	0	0
12	0	25	1	0	0	0
18	0	0	0	0	0	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	0	74	10	0	0	0
Mean	0.00	9.02	7.92	0.00	0.00	0.00
Variance	0.0	16.7	8.7	0.0	0.0	0.0
Par. sum	0.0	667.5	79.2	0.0	0.0	0.0
Cor term	.0000E+00	.6021E+04	.6280E+03	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.1216E+04	.7804E+02	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.7237E+04	.7061E+03	.0000E+00	.0000E+00	.0000E+00

Table 26. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for mean velocity during random swimming.

Mean Vel. (cm/sec)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	0	5	0	0	0	0
6	0	37	8	0	0	0
12	0	15	1	0	0	0
18	0	0	0	0	0	0
24	0	17	1	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	0	74	10	0	0	0
Mean	0.00	12.32	9.75	0.00	0.00	0.00
Variance	0.0	57.6	34.7	0.0	0.0	0.0
Par. sum	0.0	911.4	97.5	0.0	0.0	0.0
Cor term	.0000E+00	.1122E+05	.9513E+03	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.4207E+04	.3122E+03	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.1543E+05	.1263E+04	.0000E+00	.0000E+00	.0000E+00

Table 27. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for fish depth during random swimming.

Fish depth	Rainbow			Brook		
(cm)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	0	0	0	0	0	0
25	0	0	0	0	0	0
50	0	24	4	0	0	0
75	0	0	0	0	0	0
100	0	5	0	0	0	0
150	0	25	1	0	0	0
200	0	20	5	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	0	74	10	0	0	0
Mean	0.0	115.4	132.0	0.0	0.0	0.0
Variance	0.0	2701.9	5573.3	0.0	0.0	0.0
Par. sum	0.0	8540.0	1320.0	0.0	0.0	0.0
Cor term	.0000E+00	.9856E+06	.1742E+06	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.1972E+06	.5016E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.1183E+07	.2244E+06	.0000E+00	.0000E+00	.0000E+00

Table 28. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for water depth during random swimming.

Water depth (cm)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
50	0	0	0	0	0	0
100	0	0	0	0	0	0
150	0	14	3	0	0	0
200	0	0	0	0	0	0
250	0	20	0	0	0	0
300	0	0	0	0	0	0
350	0	0	0	0	0	0
400	0	32	2	0	0	0
450	0	0	2	0	0	0
500	0	8	0	0	0	0
550	0	0	5	0	0	0
600	0	0	0	0	0	0
650	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	0	74	10	0	0	0
Mean	0.0	327.2	391.0	0.0	0.0	0.0
Variance	0.0	21009.6	33921.1	0.0	0.0	0.0
Par. sum	0.0	24210.0	3910.0	0.0	0.0	0.0
Cor term	.0000E+00	.7921E+07	.1529E+07	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.1534E+07	.3053E+06	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.9454E+07	.1834E+07	.0000E+00	.0000E+00	.0000E+00

Table 29. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for substrate during random swimming.

Substrate type	Rainbow						Brook					
	<12 cm		13-27 cm		Adult		<12 cm		13-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock												
>30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Rubble												
8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	17	22	1	10	0	0	0	0	0	0
Gravel												
3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Silt												
<0.3 cm												
barren	0	0	15	20	1	10	0	0	0	0	0	0
plant covered	0	0	42	56	8	80	0	0	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	0		74		10		0		0		0	

Table 30. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1985 for thigmotactic surface distance during random swimming.

Distance	Rainbow			Brook		
(cm)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	0	0	0	0	0	0
25	0	0	0	0	0	0
50	0	24	4	0	0	0
75	0	0	0	0	0	0
100	0	5	0	0	0	0
150	0	25	1	0	0	0
200	0	20	5	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	0	74	10	0	0	0
Mean	0.0	115.4	132.0	0.0	0.0	0.0
Variance	0.0	2701.9	5573.3	0.0	0.0	0.0
Par. sum	0.0	8540.0	1320.0	0.0	0.0	0.0
Cor term	.0000E+00	.9856E+06	.1742E+06	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.1972E+06	.5016E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.1183E+07	.2244E+06	.0000E+00	.0000E+00	.0000E+00

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Table 31. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for fish velocity during stationary swimming.

Fish Vel. (cm/sec)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	12	11	2	0	0	1
6	5	5	1	0	0	0
12	1	32	3	28	0	1
18	0	56	9	0	0	3
24	0	61	23	0	0	0
30	0	82	13	4	0	2
36	0	40	10	0	0	0
42	0	57	11	0	0	1
48	0	5	17	0	0	1
54	0	10	1	0	0	0
60	0	0	0	0	0	0
66	0	3	0	0	0	1
72	0	0	0	0	0	0
>78	0	1	2	0	0	0
Number	13	359	92	32	0	10
Mean	4.69	30.70	34.82	17.15	0.00	29.57
Variance	11.8	149.5	203.1	26.2	0.0	382.0
Par. sum	61.0	11021.6	3185.2	548.6	0.0	295.7
Cor term	.2859E+03	.3384E+06	.1103E+06	.9406E+04	.0000E+00	.8741E+04
Error SS	.1415E+03	.5351E+05	.1848E+05	.8129E+03	.0000E+00	.3438E+04
Par. SS	.4274E+03	.3919E+06	.1288E+06	.1022E+05	.0000E+00	.1218E+05

Table 32. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for mean velocity during stationary swimming.

Mean Vel. (cm/sec)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	7	0	0	0	0	0
6	5	5	0	0	0	0
12	1	53	8	20	0	1
18	0	6	3	8	0	1
24	0	19	8	0	0	0
30	0	58	5	4	0	2
36	0	22	4	0	0	1
42	0	27	11	1.0	0	2
48	0	33	6	0	0	0
54	0	27	14	1.0	0	2
60	0	15	3	0	0	1
66	0	20	13	0	0	0
72	0	11	0	0	0	0
78	0	31	6	0	0	0
84	0	2	0	0	0	0
90	0	8	1	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	4	0	0	0
120	0	0	4	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	13	337	86	32	0	10
Mean	4.69	44.17	51.71	17.91	0.00	39.01
Variance	11.8	508.4	659.4	25.0	0.0	259.7
Par. sum	61.0	14886.4	4447.0	573.0	0.0	390.1
Cor term	.2859E+03	.6576E+06	.2300E+06	.1026E+05	.0000E+00	.1522E+05
Error SS	.1415E+03	.1708E+06	.5605E+05	.7757E+03	.0000E+00	.2337E+04
Par. SS	.4274E+03	.8284E+06	.2860E+06	.1104E+05	.0000E+00	.1756E+05

Table 33. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for fish depth during stationary swimming.

Fish depth (cm)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	13	0	4	0	0	2
25	0	26	10	28	0	0
50	0	150	48	4	0	2
75	0	16	3	0	0	2
100	0	90	18	0	0	1
150	0	74	11	0	0	2
200	0	23	0	0	0	1
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	13	379	94	32	0	10
Mean	2.7	80.6	58.1	26.9	0.0	72.5
Variance	1.9	2154.6	1500.2	83.5	0.0	2690.3
Par. sum	35.0	30544.0	5458.0	860.0	0.0	725.0
Cor term	.9423E+02	.2462E+07	.3169E+06	.2311E+05	.0000E+00	.5256E+05
Error SS	.2277E+02	.8144E+06	.1395E+06	.2588E+04	.0000E+00	.2421E+05
Par. SS	.1170E+03	.3276E+07	.4564E+06	.2570E+05	.0000E+00	.7678E+05

Table 34. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for water depth during stationary swimming.

Water depth (cm)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
50	13	0	0	0	0	0
100	0	2	1	8	0	2
150	0	20	3	20	0	1
200	0	25	3	0	0	0
250	0	37	2	4	0	2
300	0	20	13	0	0	2
350	0	38	8	0	0	1
400	0	19	8	0	0	1
450	0	57	8	0	0	0
500	0	64	25	0	0	0
550	0	45	12	0	0	1
600	0	24	2	0	0	0
650	0	15	4	0	0	0
700	0	0	1	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	13	4	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	13	379	94	32	0	10
Mean	13.5	415.6	438.6	128.8	0.0	257.5
Variance	25.9	32981.2	30384.1	1585.5	0.0	20812.5
Par. sum	175.0	157530.0	41230.0	4120.0	0.0	2575.0
Cor term	.2356E+04	.6548E+08	.1808E+08	.5305E+06	.0000E+00	.6631E+06
Error SS	.3112E+03	.1246E+08	.2826E+07	.4915E+05	.0000E+00	.1873E+06
Par. SS	.2667E+04	.7794E+08	.2091E+08	.5796E+06	.0000E+00	.8504E+06

Table 35. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for substrate during stationary swimming.

Substrate type	Rainbow <12 cm		Rainbow 13-27 cm		Rainbow Adult		Brook <12 cm		Brook 13-27 cm		Brook Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	1	7	45	11	8	8	0	0	0	0	1	10
plant covered	0	0	160	42	30	31	0	0	0	0	3	30
Rubble 8-30 cm												
barren	1	7	39	10	14	14	0	0	0	0	0	0
plant covered	3	23	21	5	16	17	0	0	0	0	1	10
Gravel .3-8 cm												
barren	0	0	2	0	1	1	0	0	0	0	0	0
plant covered	0	0	5	1	4	4	0	0	0	0	1	10
Silt <0.3 cm												
barren	6	46	70	18	20	21	8	25	0	0	1	10
plant covered	2	15	37	9	1	1	24	75	0	0	3	30
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	13		379		94		32		0		10	

Table 36. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for thigmotactic surface distance during stationary swimming.

Distance	Rainbow			Brook		
(cm)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	13	0	4	0	0	3
25	0	26	10	28	0	0
50	0	165	48	4	0	2
75	0	16	3	0	0	1
100	0	90	18	0	0	2
150	0	74	11	0	0	2
200	0	8	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	13	379	94	32	0	10
Mean	2.7	74.7	58.1	26.9	0.0	60.5
Variance	1.9	1590.5	1500.2	83.5	0.0	2196.9
Par. sum	35.0	28294.0	5458.0	860.0	0.0	605.0
Cor term	.9423E+02	.2112E+07	.3169E+06	.2311E+05	.0000E+00	.3660E+05
Error SS	.2277E+02	.6012E+06	.1395E+06	.2588E+04	.0000E+00	.1977E+05
Par. SS	.1170E+03	.2713E+07	.4564E+06	.2570E+05	.0000E+00	.5638E+05

Table 37. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for fish velocity during random swimming.

Fish Vel.	Rainbow			Brook		
(cm/sec)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	4	13	0	63	0	0
6	0	44	9	0	0	0
12	0	25	1	0	0	0
18	0	40	0	8	0	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	4	122	10	71	0	0
Mean	0.00	12.42	7.92	5.11	0.00	0.00
Variance	0.0	45.5	8.7	33.9	0.0	0.0
Par. sum	0.0	1514.9	79.2	362.7	0.0	0.0
Cor term	.0000E+00	.1881E+05	.6280E+03	.1853E+04	.0000E+00	.0000E+00
Error SS	.0000E+00	.5503E+04	.7804E+02	.2374E+04	.0000E+00	.0000E+00
Par. SS	.0000E+00	.2431E+05	.7061E+03	.4227E+04	.0000E+00	.0000E+00

Table 38. The number of rainbow and brook trout observed in the Colorado river during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for mean velocity during random swimming.

Mean Vel. (cm/sec)	Rainbow			Brook		
	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
0	4	13	0	63	0	0
6	0	37	8	0	0	0
12	0	30	1	0	0	0
18	0	0	0	0	0	0
24	0	27	1	0	0	0
30	0	15	0	8	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	4	122	10	71	0	0
Mean	0.00	15.66	9.75	6.48	0.00	0.00
Variance	0.0	98.0	34.7	94.2	0.0	0.0
Par. sum	0.0	1911.1	97.5	460.2	0.0	0.0
Cor term	.0000E+00	.2994E+05	.9513E+03	.2983E+04	.0000E+00	.0000E+00
Error SS	.0000E+00	.1186E+05	.3122E+03	.6595E+04	.0000E+00	.0000E+00
Par. SS	.0000E+00	.4180E+05	.1263E+04	.9578E+04	.0000E+00	.0000E+00

Table 39. The number of rainbow and brook trout observed in the Colorado River during normal high flows [24,000 - 27,000 cfs] in winter, 1984 and 1985, for fish depth during random swimming.

Fish depth [cm]	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
10	4	0	0	0	0	0
25	0	15	0	36	0	0
50	0	24	4	0	0	0
75	0	10	0	0	0	0
100	0	13	0	35	0	0
150	0	40	1	0	0	0
200	0	20	5	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	4	122	10	71	0	0
Mean	3.3	99.3	132.0	57.2	0.0	0.0
Variance	1.6	2732.2	5573.3	1803.9	0.0	0.0
Par. sum	13.0	12110.0	1320.0	4064.0	0.0	0.0
Cor term	.4225E+02	.1202E+07	.1742E+06	.2326E+06	.0000E+00	.0000E+00
Error SS	.4750E+01	.3306E+06	.5016E+05	.1263E+06	.0000E+00	.0000E+00
Par. SS	.4700E+02	.1533E+07	.2244E+06	.3589E+06	.0000E+00	.0000E+00

Table 40. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for water depth during random swimming.

Water depth (cm)	Rainbow <12 cm	Rainbow 13-27 cm	Rainbow Adult	Brook <12 cm	Brook 13-27 cm	Brook Adult
50	4	0	0	28	0	0
100	0	0	0	0	0	0
150	0	29	3	8	0	0
200	0	0	0	0	0	0
250	0	28	0	35	0	0
300	0	0	0	0	0	0
350	0	0	0	0	0	0
400	0	0	0	0	0	0
450	0	32	2	0	0	0
500	0	25	0	0	0	0
550	0	8	5	0	0	0
600	0	0	0	0	0	0
650	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	4	122	10	71	0	0
Mean	19.8	330.8	391.0	151.4	0.0	0.0
Variance	58.9	25073.7	33921.1	10020.8	0.0	0.0
Par. sum	79.0	40360.0	3910.0	10750.0	0.0	0.0
Cor term	.1560E+04	.1335E+08	.1529E+07	.1628E+07	.0000E+00	.0000E+00
Error SS	.1768E+03	.3034E+07	.3053E+06	.7015E+06	.0000E+00	.0000E+00
Par. SS	.1737E+04	.1638E+08	.1834E+07	.2329E+07	.0000E+00	.0000E+00

Table 41. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for substrate during random swimming.

Substrate type	Rainbow						Brook					
	<12 cm		13-27 cm		Adult		<12 cm		13-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	0	0	8	6	0	0	35	49	0	0	0	0
plant covered	0	0	25	20	0	0	0	0	0	0	0	0
Rubble 8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	17	13	1	10	0	0	0	0	0	0
Gravel .3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Silt <0.3 cm												
barren	4	100	15	12	1	10	0	0	0	0	0	0
plant covered	0	0	57	46	8	80	36	50	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	4		122		10		71		0		0	

Table 42. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in winter, 1984 and 1985, for thigmotactic surface distance during random swimming.

Distance	Rainbow			Brook		
(cm)	<12 cm	13-27 cm	Adult	<12 cm	13-27 cm	Adult
10	4	0	0	0	0	0
25	0	15	0	36	0	0
50	0	24	4	0	0	0
75	0	10	0	0	0	0
100	0	13	0	35	0	0
150	0	40	1	0	0	0
200	0	20	5	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	4	122	10	71	0	0
Mean	3.3	99.3	132.0	57.2	0.0	0.0
Variance	1.6	2732.2	5573.3	1803.9	0.0	0.0
Par. sum	13.0	12110.0	1320.0	4064.0	0.0	0.0
Cor term	.4225E+02	.1202E+07	.1742E+06	.2326E+06	.0000E+00	.0000E+00
Error SS	.4750E+01	.3306E+06	.5016E+05	.1263E+06	.0000E+00	.0000E+00
Par. SS	.4700E+02	.1533E+07	.2244E+06	.3589E+06	.0000E+00	.0000E+00

SUMMER 1984,

COLORADO RIVER

Compare to Winter

1) Separate

2) Combined

Table 43. The number of rainbow and brook trout observed in the Colorado river during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for fish velocity during stationary swimming.

Fish Vel. (cm/sec)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
0	1	0	1	0	0	0
6	13	0	0	0	0	0
12	0	1	2	0	0	1
18	12	11	3	0	0	2
24	26	0	4	0	0	0
30	0	0	1	0	0	0
36	10	11	2	0	0	1
42	0	0	1	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	1	0	2	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	63	23	16	0	0	4
Mean	22.16	28.36	28.38	0.00	0.00	22.10
Variance	107.1	66.2	269.7	0.0	0.0	107.6
Par. sum	1396.0	652.3	454.2	0.0	0.0	88.4
Cor term	.3093E+05	.1850E+05	.1289E+05	.0000E+00	.0000E+00	.1953E+04
Error SS	.6637E+04	.1457E+04	.4045E+04	.0000E+00	.0000E+00	.3228E+03
Par. SS	.3757E+05	.1986E+05	.1694E+05	.0000E+00	.0000E+00	.2276E+04

Table 44. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for mean velocity during stationary swimming.

Mean Vel. (cm/sec)	Rainbow			Brook		
	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	0	0	0	0	0	1
6	13	1	1	0	0	0
12	1	0	1	0	0	0
18	0	0	1	0	0	0
24	22	0	4	0	0	0
30	16	11	1	0	0	1
36	0	0	2	0	0	1
42	0	9	4	0	0	0
48	10	2	0	0	0	0
54	0	0	1	0	0	1
60	10	0	1	0	0	0
66	0	0	0	0	0	0
72	0	0	1	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	1	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	63	23	16	0	0	4
Mean	35.37	42.41	46.10	0.00	0.00	35.81
Variance	308.8	106.3	562.2	0.0	0.0	658.8
Par. sum	2228.1	975.4	737.6	0.0	0.0	143.3
Cor term	.7880E+05	.4136E+05	.3400E+05	.0000E+00	.0000E+00	.5131E+04
Error SS	.1915E+05	.2340E+04	.8433E+04	.0000E+00	.0000E+00	.1977E+04
Par. SS	.9795E+05	.4370E+05	.4244E+05	.0000E+00	.0000E+00	.7107E+04

Table 45. The number of rainbow and brook trout observed in the Colorado river during normal high flows [24,000 - 27,000 cfs] in summer, 1984 for fish depth during stationary swimming.

Fish depth [cm]	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
10	24	0	2	0	0	2
25	18	0	3	0	0	2
50	21	23	10	0	0	0
75	0	0	0	0	0	0
100	0	0	1	0	0	0
150	0	0	0	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	63	23	16	0	0	4
Mean	20.6	33.7	31.1	0.0	0.0	13.3
Variance	217.3	11.9	319.4	0.0	0.0	68.9
Par. sum	1298.0	775.0	497.0	0.0	0.0	53.0
Cor term	.2674E+05	.2611E+05	.1544E+05	.0000E+00	.0000E+00	.7023E+03
Error SS	.1348E+05	.2609E+03	.4791E+04	.0000E+00	.0000E+00	.2068E+03
Par. SS	.4022E+05	.2638E+05	.2023E+05	.0000E+00	.0000E+00	.9090E+03

Table 46. The number of rainbow and brook trout observed in the Colorado river during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for water depth during stationary swimming.

Water depth (cm)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
50	6	0	2	0	0	0
100	24	0	2	0	0	0
150	27	1	1	0	0	2
200	3	1	7	0	0	1
250	0	0	6	0	0	1
300	0	0	0	0	0	0
350	0	0	0	0	0	0
400	0	20	3	0	0	0
450	36	2	4	0	0	0
500	0	0	0	0	0	0
550	0	0	0	0	0	0
600	0	0	0	0	0	0
650	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	63	23	16	0	0	4
Mean	304.6	392.2	295.0	0.0	0.0	165.0
Variance	21780.1	1763.2	17173.3	0.0	0.0	2968.7
Par. sum	19190.0	9020.0	4720.0	0.0	0.0	660.0
Cor term	.5845E+07	.3537E+07	.1392E+07	.0000E+00	.0000E+00	.1089E+06
Error SS	.1350E+07	.3879E+05	.2576E+06	.0000E+00	.0000E+00	.8900E+04
Par. SS	.7196E+07	.3576E+07	.1650E+07	.0000E+00	.0000E+00	.1178E+06

Table 47. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for substrate during stationary swimming.

Substrate type	Rainbow						Brook					
	<14 cm		15-27 cm		Adult		<14 cm		15-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	1	1	0	0	1	6	0	0	0	0	0	0
Rubble 8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	3	4	1	4	2	12	0	0	0	0	2	50
Gravel .3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	1	25
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Silt <0.3 cm												
barren	12	19	0	0	2	12	0	0	0	0	0	0
plant covered	47	74	22	95	11	68	0	0	0	0	1	25
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	63		23		16		0		0		4	

Table 48. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for thigmotactic surface distance during stationary swimming.

Distance	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	24	0	2	0	0	2
25	19	0	4	0	0	2
50	20	23	9	0	0	0
75	0	0	0	0	0	0
100	0	0	1	0	0	0
150	0	0	0	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	63	23	16	0	0	4
Mean	20.4	33.7	30.3	0.0	0.0	13.3
Variance	214.3	11.9	331.1	0.0	0.0	68.9
Par. sum	1288.0	775.0	484.0	0.0	0.0	53.0
Cor term	.2633E+05	.2611E+05	.1464E+05	.0000E+00	.0000E+00	.7023E+03
Error SS	.1329E+05	.2609E+03	.4967E+04	.0000E+00	.0000E+00	.2068E+03
Par. SS	.3962E+05	.2638E+05	.1961E+05	.0000E+00	.0000E+00	.9090E+03

Table 49. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for light reaching them during stationary swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
20	26	22	6	0	0	1
30	10	0	4	0	0	1
40	0	0	2	0	0	1
50	3	1	2	0	0	0
60	0	0	0	0	0	0
70	0	0	1	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	39	23	15	0	0	3
Mean	22.5	17.8	28.5	0.0	0.0	24.0
Variance	54.4	31.4	233.6	0.0	0.0	129.9
Par. sum	879.3	409.3	427.5	0.0	0.0	72.0
Cor term	.1983E+05	.7283E+04	.1218E+05	.0000E+00	.0000E+00	.1728E+04
Error SS	.2067E+04	.6898E+03	.3270E+04	.0000E+00	.0000E+00	.2589E+03
Par. SS	.2189E+05	.7972E+04	.1545E+05	.0000E+00	.0000E+00	.1988E+04

EXTRA High Flows

Table 50. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for fish velocity during stationary swimming.

Fish Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	4	0	2	0	0	0
6	77	5	2	0	0	1
12	44	44	22	0	3	1
18	66	48	20	0	3	0
24	56	76	39	0	0	0
30	18	10	43	0	1	0
36	20	23	24	0	0	0
42	0	20	16	0	0	0
48	0	5	6	0	0	0
54	0	26	16	0	0	0
60	0	1	2	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	285	258	192	0	7	2
Mean	18.91	28.16	31.34	0.00	18.29	12.19
Variance	76.1	174.7	164.6	0.0	58.8	18.6
Par. sum	5388.9	7522.5	6016.8	0.0	128.0	24.4
Cor term	.1019E+06	.2193E+06	.1885E+06	.0000E+00	.2341E+04	.2973E+03
Error SS	.2161E+05	.4490E+05	.3145E+05	.0000E+00	.3530E+03	.1858E+02
Par. SS	.1235E+06	.2642E+06	.2200E+06	.0000E+00	.2694E+04	.3159E+03

EXTRA

Table 51. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for mean velocity during stationary swimming.

Mean Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	40	14	5	0	0	0
6	53	36	12	0	0	1
12	4	39	10	0	3	0
18	35	25	8	0	0	1
24	59	4	7	0	3	0
30	51	22	21	0	0	0
36	15	45	46	0	0	0
42	0	9	18	0	0	0
48	25	11	18	0	1	0
54	0	7	13	0	0	0
60	3	20	20	0	0	0
66	0	17	1	0	0	0
72	0	1	1	0	0	0
78	0	1	5	0	0	0
84	0	0	1	0	0	0
90	0	7	4	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	285	258	190	0	7	2
Mean	29.03	39.31	47.07	0.00	23.95	13.72
Variance	209.1	502.3	385.5	0.0	230.5	41.8
Par. sum	8272.3	10140.7	8942.8	0.0	167.6	27.4
Cor term	.2401E+06	.3986E+06	.4209E+06	.0000E+00	.4015E+04	.3763E+03
Error SS	.5939E+05	.1291E+06	.7286E+05	.0000E+00	.1383E+04	.4181E+02
Par. SS	.2995E+06	.5277E+06	.4938E+06	.0000E+00	.5398E+04	.4181E+03

EXTRA

Table 52. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for fish depth during stationary swimming.

Fish depth (cm)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
10	133	13	74	0	0	0
25	120	11	46	0	1	0
50	101	48	46	0	2	1
75	0	22	15	0	0	0
100	4	27	18	0	0	1
150	5	98	29	0	1	0
200	0	34	7	0	3	0
250	42	12	3	0	0	0
300	0	4	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	285	258	192	0	7	2
Mean	62.0	114.5	58.1	0.0	110.0	75.0
Variance	6547.0	3420.6	2706.6	0.0	5225.0	1250.0
Par. sum	17671.0	29540.0	11164.0	0.0	770.0	150.0
Cor term	.1096E+07	.3382E+07	.6491E+06	.0000E+00	.8470E+05	.1125E+05
Error SS	.1859E+07	.8791E+06	.5170E+06	.0000E+00	.3135E+05	.1250E+04
Par. SS	.2955E+07	.4261E+07	.1166E+07	.0000E+00	.1161E+06	.1250E+05

EXTRAS

Table 53. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for water depth during stationary swimming.

Water depth (cm)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
50	0	0	0	0	0	0
100	118	0	2	0	0	0
150	87	0	1	0	0	0
200	27	2	9	0	0	0
250	2	7	20	0	0	0
300	0	16	45	0	2	1
350	22	72	14	0	1	0
400	0	25	32	0	0	0
450	0	18	26	0	1	1
500	25	42	22	0	3	0
550	0	27	12	0	0	0
600	4	17	2	0	0	0
650	0	15	5	0	0	0
700	0	10	1	0	0	0
750	0	7	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	285	258	192	0	7	2
Mean	168.9	435.7	364.9	0.0	387.1	355.0
Variance	16374.1	16332.0	13602.0	0.0	10423.8	8450.0
Par. sum	48145.0	112410.0	70065.0	0.0	2710.0	710.0
Cor term	.8133E+07	.4898E+08	.2557E+08	.0000E+00	.1049E+07	.2521E+06
Error SS	.4650E+07	.4197E+07	.2598E+07	.0000E+00	.6254E+05	.8450E+04
Par. SS	.1278E+08	.5317E+08	.2817E+08	.0000E+00	.1112E+07	.2605E+06

EXTRA

Table 54. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for substrate during stationary swimming.

Substrate type	Rainbow <14 cm		Rainbow 15-27 cm		Rainbow Adult		Brook <14 cm		Brook 15-27 cm		Brook Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	5	1	106	41	48	25	0	0	0	0	0	0
Rubble 8-30 cm												
barren	0	0	0	0	1	0	0	0	0	0	0	0
plant covered	1	0	9	3	10	5	0	0	0	0	0	0
Gravel .3-8 cm												
barren	25	8	10	3	9	4	0	0	0	0	0	0
plant covered	0	0	2	0	12	6	0	0	0	0	0	0
Silt <0.3 cm												
barren	0	0	70	27	44	22	0	0	1	14	0	0
plant covered	254	89	61	23	68	35	0	0	6	85	2	100
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	285		258		192		0		7		2	

EXTRAS - STATIONARY

Table 55. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for thigmotactic surface distance during stationary swimming.

Distance (cm)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
10	88	11	47	0	0	0
25	110	43	43	0	1	0
50	36	22	15	0	5	1
75	0	28	18	0	0	0
100	21	97	28	0	0	1
150	5	34	7	0	1	0
200	0	12	1	0	0	0
250	25	4	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	285	258	192	0	7	2
Mean	45.1	114.0	54.4	0.0	50.0	65.0
Variance	4871.9	3483.7	2439.0	0.0	1025.0	2450.0
Par. sum	12846.0	29420.0	10437.0	0.0	350.0	130.0
Cor term	.5790E+06	.3355E+07	.5673E+06	.0000E+00	.1750E+05	.8450E+04
Error SS	.1384E+07	.8953E+06	.4659E+06	.0000E+00	.6150E+04	.2450E+04
Par. SS	.1963E+07	.4250E+07	.1033E+07	.0000E+00	.2365E+05	.1090E+05

Table 56. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for light reaching them during stationary swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	4	1	0	0	0
5	4	0	1	0	0	0
6	0	0	0	0	0	0
7	0	1	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	73	29	0	0	0
30	0	53	58	0	3	1
40	32	16	44	0	2	0
50	26	40	29	0	2	1
60	126	1	8	0	0	0
70	35	0	2	0	0	0
80	40	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	263	188	172	0	7	2
Mean	55.5	25.6	31.0	0.0	33.7	38.3
Variance	153.8	146.6	133.4	0.0	68.4	244.0
Par. sum	14586.6	4811.5	5334.0	0.0	235.7	76.6
Cor term	.8101E+06	.1231E+06	.1654E+06	.0000E+00	.7935E+04	.2935E+04
Error SS	.4029E+05	.2742E+05	.2280E+05	.0000E+00	.4102E+03	.2440E+03
Par. SS	.8504E+06	.1506E+06	.1882E+06	.0000E+00	.8345E+04	.3179E+04

ALL - STATIONARY

Table 57. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for fish velocity during stationary swimming.

Fish Vel. (cm/sec)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
0	5	0	3	0	0	0
6	90	5	2	0	0	1
12	44	45	24	0	3	2
18	78	58	23	0	3	2
24	82	76	43	0	0	0
30	18	10	44	0	1	0
36	30	34	26	0	0	1
42	0	20	17	0	0	0
48	0	5	6	0	0	0
54	0	26	16	0	0	0
60	1	1	4	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	348	281	208	0	7	6
Mean	19.50	29.09	31.11	0.00	18.29	18.80
Variance	83.0	165.6	172.1	0.0	58.8	94.5
Par. sum	6784.8	8174.7	6470.9	0.0	128.0	112.8
Cor term	.1323E+06	.2378E+06	.2013E+06	.0000E+00	.2341E+04	.2120E+04
Error SS	.2879E+05	.4637E+05	.3562E+05	.0000E+00	.3530E+03	.4723E+03
Par. SS	.1611E+06	.2842E+06	.2369E+06	.0000E+00	.2694E+04	.2592E+04

Table 58. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for mean velocity during stationary swimming.

Mean Vel. (cm/sec)	Rainbow			Brook		
	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	40	14	5	0	0	1
6	106	51	12	0	0	1
12	71	76	13	0	3	0
18	40	39	10	0	0	1
24	116	29	9	0	3	0
30	81	4	11	0	0	0
36	198	37	22	0	0	1
42	82	78	48	0	0	1
48	15	63	22	0	0	0
54	25	29	18	0	1	0
60	35	18	14	0	0	1
66	13	29	20	0	0	0
72	3	20	2	0	0	0
78	0	18	1	0	0	0
84	0	2	5	0	0	0
90	0	1	1	0	0	0
96	0	0	4	0	0	0
102	0	7	0	0	0	0
108	0	0	0	0	0	0
114	1	0	1	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	348	281	206	0	7	6
Mean	30.17	39.56	46.99	0.00	23.95	28.45
Variance	232.3	470.2	396.6	0.0	230.5	533.9
Par. sum	10500.4	11116.1	9680.5	0.0	167.6	170.7
Cor term	.3168E+06	.4397E+06	.4549E+06	.0000E+00	.4015E+04	.4856E+04
Error SS	.8062E+05	.1316E+06	.8131E+05	.0000E+00	.1383E+04	.2669E+04
Par. SS	.3974E+06	.5714E+06	.5362E+06	.0000E+00	.5398E+04	.7525E+04

Table 59. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for fish depth during stationary swimming.

Fish depth (cm)	Rainbow			Brook		
	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	37	25	30	0	0	2
25	138	11	49	0	1	2
50	122	71	58	0	2	1
75	0	22	15	0	0	0
100	4	27	19	0	0	1
150	5	98	29	0	1	0
200	0	34	7	0	3	0
250	42	12	3	0	0	0
300	0	4	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	348	281	208	0	7	6
Mean	54.5	107.9	56.1	0.0	110.0	33.8
Variance	5652.0	3632.9	2572.9	0.0	5225.0	1308.2
Par. sum	18969.0	30315.0	11661.0	0.0	770.0	203.0
Cor term	.1034E+07	.3270E+07	.6537E+06	.0000E+00	.8470E+05	.6868E+04
Error SS	.1961E+07	.1017E+07	.5326E+06	.0000E+00	.3135E+05	.6541E+04
Par. SS	.2995E+07	.4288E+07	.1186E+07	.0000E+00	.1161E+06	.1341E+05

Table 60. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for water depth during stationary swimming.

Water depth	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
50	0	0	0	0	0	0
100	118	0	4	0	0	0
150	111	3	1	0	0	2
200	30	3	10	0	0	1
250	2	7	26	0	0	1
300	0	16	45	0	2	1
350	22	72	14	0	1	0
400	0	45	35	0	0	0
450	36	20	30	0	1	1
500	25	42	22	0	3	0
550	0	27	12	0	0	0
600	4	17	2	0	0	0
650	0	15	5	0	0	0
700	0	10	1	0	0	0
750	0	7	1	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	348	281	208	0	7	6
Mean	193.5	432.1	359.5	0.0	387.1	228.3
Variance	20029.8	15271.9	14143.9	0.0	10423.8	13096.7
Par. sum	67335.0	121430.0	74785.0	0.0	2710.0	1370.0
Cor term	.1303E+08	.5247E+08	.2689E+08	.0000E+00	.1049E+07	.3128E+06
Error SS	.6950E+07	.4276E+07	.2928E+07	.0000E+00	.6254E+05	.6548E+05
Par. SS	.1998E+08	.5675E+08	.2982E+08	.0000E+00	.1112E+07	.3783E+06

Table 61. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for substrate during stationary swimming.

Substrate type	Rainbow						Brook					
	<14 cm		15-27 cm		Adult		<14 cm		15-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock												
>30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	6	1	106	37	49	23	0	0	0	0	0	0
Rubble												
8-30 cm												
barren	0	0	0	0	1	0	0	0	0	0	0	0
plant covered	4	1	10	3	12	5	0	0	0	0	2	33
Gravel												
.3-8 cm												
barren	25	7	10	3	9	4	0	0	0	0	1	16
plant covered	0	0	2	0	12	5	0	0	0	0	0	0
Silt												
<0.3 cm												
barren	12	3	70	24	46	22	0	0	1	14	0	0
plant covered	301	86	83	29	79	37	0	0	6	85	3	50
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	348		281		208		0		7		6	

Table 62. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for thigmotactic surface distance during stationary swimming.

Distance	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	112	7	35	0	0	2
25	129	11	51	0	1	2
50	56	66	52	0	5	1
75	0	22	15	0	0	0
100	21	28	19	0	0	1
150	5	97	28	0	1	0
200	0	34	7	0	0	0
250	25	12	1	0	0	0
300	0	4	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	348	281	208	0	7	6
Mean	40.6	107.5	52.5	0.0	50.0	30.5
Variance	4115.8	3685.2	2316.0	0.0	1025.0	1245.5
Par. sum	14134.0	30195.0	10921.0	0.0	350.0	183.0
Cor term	.5741E+06	.3245E+07	.5734E+06	.0000E+00	.1750E+05	.5582E+04
Error SS	.1428E+07	.1032E+07	.4794E+06	.0000E+00	.6150E+04	.6228E+04
Par. SS	.2002E+07	.4276E+07	.1053E+07	.0000E+00	.2365E+05	.1181E+05

Table 63. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for light reaching them during stationary swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	1	0	0	0
4	4	4	1	0	0	0
5	4	0	1	0	0	0
6	0	1	0	0	0	0
7	0	1	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	26	95	35	0	0	0
20	26	95	35	0	0	1
30	10	53	62	0	3	2
40	32	16	46	0	2	1
50	29	41	31	0	2	1
60	126	1	8	0	0	0
70	35	0	3	0	0	0
80	40	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	302	211	187	0	7	5
Mean	51.2	24.7	30.8	0.0	33.7	29.7
Variance	263.3	139.8	140.6	0.0	68.4	187.4
Par. sum	15476.0	5220.8	5761.4	0.0	235.7	148.6
Cor term	.7931E+06	.1292E+06	.1775E+06	.0000E+00	.7935E+04	.4417E+04
Error SS	.7924E+05	.2936E+05	.2616E+05	.0000E+00	.4102E+03	.7494E+03
Par. SS	.8723E+06	.1585E+06	.2037E+06	.0000E+00	.8345E+04	.5166E+04

Table 64. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for fish velocity during random swimming.

Fish Vel.	Rainbow			Brook		
[cm/sec]	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	6	0	1	0	0	1
6	0	0	0	0	0	0
12	0	0	0	0	0	2
18	0	0	0	0	0	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	6	0	1	0	0	3
Mean	3.05	0.00	0.00	0.00	0.00	10.16
Variance	0.0	0.0	0.0	0.0	0.0	40.3
Par. sum	18.3	0.0	0.0	0.0	0.0	30.5
Cor term	.5574E+02	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.3097E+03
Error SS	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.8052E+02
Par. SS	.5574E+02	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.3902E+03

Table 65. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for mean velocity during random swimming.

Mean Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	6	0	1	0	0	0
6	0	0	0	0	0	2
12	0	0	0	0	0	0
18	0	0	0	0	0	0
24	0	0	0	0	0	1
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	6	0	1	0	0	3
Mean	0.00	0.00	0.00	0.00	0.00	13.21
Variance	0.0	0.0	0.0	0.0	0.0	96.0
Par. sum	0.0	0.0	0.0	0.0	0.0	39.6
Cor term	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.5234E+03
Error SS	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.1920E+03
Par. SS	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.7154E+03

Table 66. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for fish depth during random swimming.

Fish depth	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	6	0	0	0	0	0
25	0	0	0	0	0	2
50	0	0	0	0	0	1
75	0	0	0	0	0	0
100	0	0	0	0	0	0
150	0	0	1	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	6	0	1	0	0	3
Mean	5.0	0.0	120.0	0.0	0.0	25.0
Variance	0.0	0.0	0.0	0.0	0.0	75.0
Par. sum	30.0	0.0	120.0	0.0	0.0	75.0
Cor term	.1500E+03	.0000E+00	.1440E+05	.0000E+00	.0000E+00	.1875E+04
Error SS	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.1500E+03
Par. SS	.1500E+03	.0000E+00	.1440E+05	.0000E+00	.0000E+00	.2025E+04

Table 67. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for water depth during random swimming.

Water depth	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
50	0	0	0	0	0	0
100	0	0	0	0	0	0
150	6	0	0	0	0	1
200	0	0	0	0	0	2
250	0	0	0	0	0	0
300	0	0	0	0	0	0
350	0	0	1	0	0	0
400	0	0	0	0	0	0
450	0	0	0	0	0	0
500	0	0	0	0	0	0
550	0	0	0	0	0	0
600	0	0	0	0	0	0
650	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	6	0	1	0	0	3
Mean	110.0	0.0	310.0	0.0	0.0	170.0
Variance	0.0	0.0	0.0	0.0	0.0	400.0
Par. sum	660.0	0.0	310.0	0.0	0.0	510.0
Cor term	.7260E+05	.0000E+00	.9610E+05	.0000E+00	.0000E+00	.8670E+05
Error SS	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.8000E+03
Par. SS	.7260E+05	.0000E+00	.9610E+05	.0000E+00	.0000E+00	.8750E+05

Table 68. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for substrate during random swimming.

Substrate type	Rainbow						Brook					
	<14 cm		15-27 cm		Adult		<14 cm		15-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock												
>30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	1	100	0	0	0	0	2	66
Rubble												
8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	1	33
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Gravel												
.3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Silt												
<0.3 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	6	100	0	0	0	0	0	0	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	6		0		1		0		0		3	

Table 69. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984, for thigmotactic surface distance during random swimming.

Distance	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	6	0	0	0	0	1
25	0	0	0	0	0	2
50	0	0	0	0	0	0
75	0	0	0	0	0	0
100	0	0	0	0	0	0
150	0	0	1	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	6	0	1	0	0	3
Mean	5.0	0.0	120.0	0.0	0.0	16.7
Variance	0.0	0.0	0.0	0.0	0.0	108.3
Par. sum	30.0	0.0	120.0	0.0	0.0	50.0
Cor term	.1500E+03	.0000E+00	.1440E+05	.0000E+00	.0000E+00	.8333E+03
Error SS	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.2167E+03
Par. SS	.1500E+03	.0000E+00	.1440E+05	.0000E+00	.0000E+00	.1050E+04

Table 70. The number of rainbow and brook trout observed in the Colorado River during normal high flows (24,000 - 27,000 cfs) in summer, 1984 for light reaching them during random swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	0	0	0	0	0
30	0	0	1	0	0	1
40	0	0	0	0	0	0
50	0	0	0	0	0	2
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	0	0	1	0	0	3
Mean	0.0	0.0	26.0	0.0	0.0	37.9
Variance	0.0	0.0	0.0	0.0	0.0	97.8
Par. sum	0.0	0.0	26.0	0.0	0.0	113.7
Cor term	.0000E+00	.0000E+00	.6770E+03	.0000E+00	.0000E+00	.4310E+04
Error SS	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.0000E+00	.1955E+03
Par. SS	.0000E+00	.0000E+00	.6770E+03	.0000E+00	.0000E+00	.4506E+04

Table 71. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for fish velocity during random swimming.

Fish Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	50	20	0	0	0	0
6	7	42	4	0	0	0
12	25	28	1	0	0	0
18	0	21	1	0	1	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	82	111	6	0	1	0
Mean	7.29	11.07	10.16	0.00	18.29	0.00
Variance	30.9	37.7	43.4	0.0	0.0	0.0
Par. sum	597.4	1228.3	61.0	0.0	18.3	0.0
Cor term	.4352E+04	.1359E+05	.6194E+03	.0000E+00	.3345E+03	.0000E+00
Error SS	.2504E+04	.4142E+04	.2168E+03	.0000E+00	.0000E+00	.0000E+00
Par. SS	.6856E+04	.1774E+05	.8361E+03	.0000E+00	.3345E+03	.0000E+00

Table 72. The number of rainbow and brook trout observed in the Colorado River during extra high flows [33,000 - 43,000 cfs] in summer, 1984 for mean velocity during random swimming.

Mean Vel.	Rainbow			Brook		
[cm/sec]	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	0	23	0	0	0	0
6	0	50	3	0	0	0
12	32	23	0	0	0	0
18	50	6	1	0	1	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	82	102	4	0	1	0
Mean	18.70	8.90	9.91	0.00	18.29	0.00
Variance	11.6	20.9	58.1	0.0	0.0	0.0
Par. sum	1533.1	908.3	39.6	0.0	18.3	0.0
Cor term	.2867E+05	.8088E+04	.3925E+03	.0000E+00	.3345E+03	.0000E+00
Error SS	.9432E+03	.2112E+04	.1742E+03	.0000E+00	.0000E+00	.0000E+00
Par. SS	.2961E+05	.1020E+05	.5667E+03	.0000E+00	.3345E+03	.0000E+00

Table 73. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for fish depth during random swimming.

Fish depth (cm)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
10	7	2	1	0	0	0
25	0	0	0	0	0	0
50	0	0	0	0	0	0
75	25	3	0	0	0	0
100	0	24	1	0	0	0
150	0	15	4	0	1	0
200	50	39	0	0	0	0
250	0	23	0	0	0	0
300	0	10	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	82	116	6	0	1	0
Mean	178.1	226.4	149.2	0.0	180.0	0.0
Variance	6546.7	4892.4	5244.2	0.0	0.0	0.0
Par. sum	14605.0	26260.0	895.0	0.0	180.0	0.0
Cor term	.2601E+07	.5945E+07	.1335E+06	.0000E+00	.3240E+05	.0000E+00
Error SS	.5303E+06	.5626E+06	.2622E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.3132E+07	.6507E+07	.1597E+06	.0000E+00	.3240E+05	.0000E+00

Table 74. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for water depth during random swimming.

Water depth (cm)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
50	0	0	0	0	0	0
100	0	0	0	0	0	0
150	25	0	0	0	0	0
200	7	2	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
350	50	0	0	0	0	0
400	0	0	0	0	0	0
450	0	0	3	0	0	0
500	0	12	0	0	0	0
550	0	25	1	0	0	0
600	0	23	1	0	1	0
650	0	13	0	0	0	0
700	0	6	0	0	0	0
750	0	23	1	0	0	0
800	0	0	0	0	0	0
850	0	12	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	82	116	6	0	1	0
Mean	256.2	617.4	515.0	0.0	560.0	0.0
Variance	6495.4	14177.6	18550.0	0.0	0.0	0.0
Par. sum	21010.0	71620.0	3090.0	0.0	560.0	0.0
Cor term	.5383E+07	.4422E+08	.1591E+07	.0000E+00	.3136E+06	.0000E+00
Error SS	.5261E+06	.1630E+07	.9275E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.5909E+07	.4585E+08	.1684E+07	.0000E+00	.3136E+06	.0000E+00

Table 75. The number of rainbow and brook trout observed in the Colorado river during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for substrate during random swimming.

Substrate type	Rainbow						Brook					
	<14 cm		15-27 cm		Adult		<14 cm		15-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock >30 cm												
barren	0	0	53	45	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	1	100	0	0
Rubble 8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Gravel .3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Silt <0.3 cm												
barren	50	60	61	52	4	66	0	0	0	0	0	0
plant covered	32	39	2	1	2	33	0	0	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	82		116		6		0		1		0	

Table 76. The number of rainbow and brook trout observed in the Colorado River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for thigmotactic surface distance during random swimming.

Distance	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	0	0	1	0	0	0
25	7	2	0	0	0	0
50	50	0	0	0	0	0
75	0	0	0	0	0	0
100	25	3	0	0	0	0
150	0	24	1	0	0	0
200	0	15	4	0	1	0
250	0	44	0	0	0	0
300	0	18	0	0	0	0
400	0	10	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	82	116	6	0	1	0
Mean	62.3	224.2	149.2	0.0	180.0	0.0
Variance	725.4	4676.3	5244.2	0.0	0.0	0.0
Par. sum	5105.0	26010.0	895.0	0.0	180.0	0.0
Cor term	.3178E+06	.5832E+07	.1335E+06	.0000E+00	.3240E+05	.0000E+00
Error SS	.5876E+05	.5378E+06	.2622E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.3766E+06	.6370E+07	.1597E+06	.0000E+00	.3240E+05	.0000E+00

Table 77. The number of rainbow and brook trout observed in the Coloredo River during extra high flows (33,000 - 43,000 cfs) in summer, 1984 for light reaching them during random swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	1	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	8	1	0	0	0
30	0	4	0	0	0	0
40	25	0	3	0	0	0
50	50	0	0	0	0	0
60	7	2	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	82	14	4	0	1	0
Mean	45.2	25.6	26.6	0.0	4.0	0.0
Variance	23.3	171.3	82.4	0.0	0.0	0.0
Par. sum	3702.4	358.9	106.5	0.0	4.0	0.0
Cor term	.1672E+06	.9202E+04	.2834E+04	.0000E+00	.1608E+02	.0000E+00
Error SS	.1886E+04	.2227E+04	.2473E+03	.0000E+00	.0000E+00	.0000E+00
Par. SS	.1691E+06	.1143E+05	.3082E+04	.0000E+00	.1608E+02	.0000E+00

Table 78. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for fish velocity during random swimming.

Fish Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	56	20	1	0	0	1
6	7	42	4	0	0	0
12	25	28	1	0	0	2
18	0	21	1	0	1	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	88	111	7	0	1	3
Mean	7.00	11.07	8.71	0.00	18.29	10.16
Variance	29.9	37.7	50.9	0.0	0.0	40.3
Par. sum	615.7	1228.3	61.0	0.0	18.3	30.5
Cor term	.4308E+04	.1359E+05	.5309E+03	.0000E+00	.3345E+03	.3097E+03
Error SS	.2604E+04	.4142E+04	.3053E+03	.0000E+00	.0000E+00	.8052E+02
Par. SS	.6912E+04	.1774E+05	.8361E+03	.0000E+00	.3345E+03	.3902E+03

Table 79. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for mean velocity during random swimming.

Mean Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	6	23	1	0	0	0
6	0	50	3	0	0	2
12	32	23	0	0	0	0
18	50	6	1	0	1	0
24	0	0	0	0	0	1
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	88	102	5	0	1	3
Mean	17.42	8.90	7.92	0.00	18.29	13.21
Variance	33.3	20.9	63.2	0.0	0.0	96.0
Par. sum	1533.1	908.3	39.6	0.0	18.3	39.6
Cor term	.2671E+05	.8088E+04	.3140E+03	.0000E+00	.3345E+03	.5234E+03
Error SS	.2898E+04	.2112E+04	.2527E+03	.0000E+00	.0000E+00	.1920E+03
Par. SS	.2961E+05	.1020E+05	.5667E+03	.0000E+00	.3345E+03	.7154E+03

Table 80. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for fish depth during random swimming.

Fish depth	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	6	0	1	0	0	0
25	7	2	0	0	0	2
50	0	0	0	0	0	1
75	0	0	0	0	0	0
100	25	3	0	0	0	0
150	0	24	2	0	0	0
200	0	15	4	0	1	0
250	50	39	0	0	0	0
300	0	23	0	0	0	0
400	0	10	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	88	116	7	0	1	3
Mean	166.3	226.4	145.0	0.0	180.0	25.0
Variance	8021.0	4892.4	4491.7	0.0	0.0	75.0
Par. sum	14635.0	26260.0	1015.0	0.0	180.0	75.0
Cor term	.2434E+07	.5945E+07	.1472E+06	.0000E+00	.3240E+05	.1875E+04
Error SS	.6978E+06	.5626E+06	.2695E+05	.0000E+00	.0000E+00	.1500E+03
Par. SS	.3132E+07	.6507E+07	.1741E+06	.0000E+00	.3240E+05	.2025E+04

Table 81. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for water depth during random swimming.

Water depth (cm)	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
50	0	0	0	0	0	0
100	0	0	0	0	0	0
150	31	0	0	0	0	1
200	7	2	0	0	0	2
250	0	0	0	0	0	0
300	0	0	0	0	0	0
350	50	0	1	0	0	0
400	0	0	0	0	0	0
450	0	0	3	0	0	0
500	0	12	0	0	0	0
550	0	25	1	0	0	0
600	0	23	1	0	1	0
650	0	13	0	0	0	0
700	0	6	0	0	0	0
750	0	23	1	0	0	0
800	0	0	0	0	0	0
850	0	12	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	88	116	7	0	1	3
Mean	246.3	617.4	485.7	0.0	560.0	170.0
Variance	7421.4	14177.6	21461.9	0.0	0.0	400.0
Par. sum	21670.0	71620.0	3400.0	0.0	560.0	510.0
Cor term	.5336E+07	.4422E+08	.1651E+07	.0000E+00	.3136E+06	.8670E+05
Error SS	.6457E+06	.1630E+07	.1288E+06	.0000E+00	.0000E+00	.8000E+03
Par. SS	.5982E+07	.4585E+08	.1780E+07	.0000E+00	.3136E+06	.8750E+05

Table 82. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for substrate during random swimming.

Substrate type	Rainbow						Brook					
	<14 cm		15-27 cm		Adult		<14 cm		15-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock												
>30 cm												
barren	0	0	53	45	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	1	14	0	0	1	100	2	66
Rubble												
8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	1	33
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Gravel												
.3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Silt												
<0.3 cm												
barren	50	56	61	52	4	57	0	0	0	0	0	0
plant covered	38	43	2	1	2	28	0	0	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	88		116		7		0		1		3	

Table 83. The number of rainbow and brook trout observed in the Colorado river during all flows (24,000 - 43,000 cfs) in summer, 1984 for thigmotactic surface distance during random swimming.

Distance	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	6	0	1	0	0	1
25	7	2	0	0	0	2
50	50	0	0	0	0	0
75	0	0	0	0	0	0
100	25	3	0	0	0	0
150	0	24	2	0	0	0
200	0	15	4	0	1	0
250	0	44	0	0	0	0
300	0	18	0	0	0	0
400	0	10	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	88	116	7	0	1	3
Mean	58.4	224.2	145.0	0.0	180.0	16.7
Variance	886.0	4676.3	4491.7	0.0	0.0	108.3
Par. sum	5135.0	26010.0	1015.0	0.0	180.0	50.0
Cor term	.2996E+06	.5832E+07	.1472E+06	.0000E+00	.3240E+05	.8333E+03
Error SS	.7709E+05	.5378E+06	.2695E+05	.0000E+00	.0000E+00	.2167E+03
Par. SS	.3767E+06	.6370E+07	.1741E+06	.0000E+00	.3240E+05	.1050E+04

Table 84. The number of rainbow and brook trout observed in the Colorado River during all flows (24,000 - 43,000 cfs) in summer, 1984 for light reaching them during random swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	1	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	8	1	0	0	0
30	0	4	1	0	0	1
40	25	0	3	0	0	0
50	50	0	0	0	0	2
60	7	2	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	82	14	5	0	1	3
Mean	45.2	25.6	26.5	0.0	4.0	37.9
Variance	23.3	171.3	61.9	0.0	0.0	97.8
Par. sum	3702.4	358.9	132.5	0.0	4.0	113.7
Cor term	.1672E+06	.9202E+04	.3511E+04	.0000E+00	.1608E+02	.4310E+04
Error SS	.1886E+04	.2227E+04	.2476E+03	.0000E+00	.0000E+00	.1955E+03
Par. SS	.1691E+06	.1143E+05	.3759E+04	.0000E+00	.1608E+02	.4506E+04

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Table 85. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for fish velocity during stationary swimming.

Fish Vel.	Rainbow			Brook		
[cm/sec]	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	0	8	20	0	0	0
6	0	16	60	0	0	0
12	0	37	129	0	0	0
18	0	39	125	0	0	0
24	0	15	31	0	0	0
30	0	3	32	0	0	0
36	0	0	7	0	0	0
42	0	14	24	0	0	0
48	0	0	2	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	0	132	430	0	0	0
Mean	0.00	18.45	18.54	0.00	0.00	0.00
Variance	0.0	108.3	94.2	0.0	0.0	0.0
Par. sum	0.0	2435.4	7970.5	0.0	0.0	0.0
Cor term	.0000E+00	.4493E+05	.1477E+06	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.1418E+05	.4041E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.5911E+05	.1882E+06	.0000E+00	.0000E+00	.0000E+00

Table 86. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for mean velocity during stationary swimming.

Mean Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	0	8	20	0	0	0
6	0	28	76	0	0	0
12	0	41	106	0	0	0
18	0	23	107	0	0	0
24	0	0	15	0	0	0
30	0	16	50	0	0	0
36	0	2	21	0	0	0
42	0	14	31	0	0	0
48	0	0	4	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	0	132	430	0	0	0
Mean	0.00	18.96	20.12	0.00	0.00	0.00
Variance	0.0	139.6	130.6	0.0	0.0	0.0
Par. sum	0.0	2502.4	8653.3	0.0	0.0	0.0
Cor term	.0000E+00	.4744E+05	.1741E+06	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.1829E+05	.5603E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.6573E+05	.2302E+06	.0000E+00	.0000E+00	.0000E+00

Table 87. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for fish depth during stationary swimming.

Fish depth	Rainbow			Brook		
[cm]	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	0	1	7	0	0	0
25	0	2	37	0	0	0
50	0	12	123	0	0	0
75	0	0	5	0	0	0
100	0	82	181	0	0	0
150	0	35	80	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	0	132	433	0	0	0
Mean	0.0	88.1	72.6	0.0	0.0	0.0
Variance	0.0	531.1	1172.7	0.0	0.0	0.0
Par. sum	0.0	11630.0	31420.0	0.0	0.0	0.0
Cor term	.0000E+00	.1025E+07	.2280E+07	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.6958E+05	.5066E+06	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.1094E+07	.2787E+07	.0000E+00	.0000E+00	.0000E+00

Table 88. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for water depth during stationary swimming.

Water depth	Rainbow			Brook		
[cm]	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
50	0	0	0	0	0	0
100	0	4	55	0	0	0
150	0	49	122	0	0	0
200	0	38	66	0	0	0
250	0	1	24	0	0	0
300	0	34	95	0	0	0
350	0	1	45	0	0	0
400	0	5	26	0	0	0
450	0	0	0	0	0	0
500	0	0	0	0	0	0
550	0	0	0	0	0	0
600	0	0	0	0	0	0
650	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	0	132	433	0	0	0
Mean	0.0	194.7	207.3	0.0	0.0	0.0
Variance	0.0	5312.0	8185.3	0.0	0.0	0.0
Par. sum	0.0	25705.0	89745.0	0.0	0.0	0.0
Cor term	.0000E+00	.5006E+07	.1860E+08	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.6959E+06	.3536E+07	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.5702E+07	.2214E+08	.0000E+00	.0000E+00	.0000E+00

Table 89. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for substrate during stationary swimming.

Substrate type	Rainbow						Brook					
	<14 cm		15–27 cm		Adult		<14 cm		15–27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock												
>30 cm												
barren	0	0	18	13	29	6	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Rubble												
8–30 cm												
barren	0	0	15	11	38	8	0	0	0	0	0	0
plant covered	0	0	11	8	138	31	0	0	0	0	0	0
Gravel												
.3–8 cm												
barren	0	0	73	55	154	35	0	0	0	0	0	0
plant covered	0	0	15	11	40	9	0	0	0	0	0	0
Silt												
<0.3 cm												
barren	0	0	0	0	4	0	0	0	0	0	0	0
plant covered	0	0	0	0	30	6	0	0	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	0		132		433		0		0		0	

Table 90. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for thigmotactic surface distance during stationary swimming.

Distance	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	0	1	19	0	0	0
25	0	2	48	0	0	0
50	0	12	101	0	0	0
75	0	0	4	0	0	0
100	0	82	181	0	0	0
150	0	35	80	0	0	0
200	0	0	0	0	0	0
250	0	0	0	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	0	132	433	0	0	0
Mean	0.0	88.0	71.3	0.0	0.0	0.0
Variance	0.0	547.3	1288.9	0.0	0.0	0.0
Par. sum	0.0	11610.0	30890.0	0.0	0.0	0.0
Cor term	.0000E+00	.1021E+07	.2204E+07	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.7170E+05	.5568E+06	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.1093E+07	.2761E+07	.0000E+00	.0000E+00	.0000E+00

Table 91. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for light reaching them during stationary swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15–27 cm	Rainbow Adult	Brook <14 cm	Brook 15–27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	3	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	23	41	0	0	0
30	0	20	74	0	0	0
40	0	0	21	0	0	0
50	0	0	0	0	0	0
60	0	0	2	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	0	43	141	0	0	0
Mean	0.0	20.7	24.0	0.0	0.0	0.0
Variance	0.0	46.2	73.2	0.0	0.0	0.0
Par. sum	0.0	890.7	3390.4	0.0	0.0	0.0
Cor term	.0000E+00	.1845E+05	.8152E+05	.0000E+00	.0000E+00	.0000E+00
Error SS	.0000E+00	.1939E+04	.1025E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.0000E+00	.2039E+05	.9177E+05	.0000E+00	.0000E+00	.0000E+00

Table 92. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for fish velocity during random swimming.

Fish Vel.	Rainbow			Brook		
[cm/sec]	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	21	40	24	0	0	0
6	37	5	97	0	0	0
12	0	0	7	0	0	0
18	0	8	11	0	0	0
24	0	6	14	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	0	0	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
>78	0	0	0	0	0	0
Number	58	59	153	0	0	0
Mean	5.83	6.56	9.88	0.00	0.00	0.00
Variance	11.8	85.8	49.5	0.0	0.0	0.0
Par. sum	338.3	387.1	1481.3	0.0	0.0	0.0
Cor term	.1974E+04	.2540E+04	.1434E+05	.0000E+00	.0000E+00	.0000E+00
Error SS	.6742E+03	.4976E+04	.7527E+04	.0000E+00	.0000E+00	.0000E+00
Par. SS	.2648E+04	.7516E+04	.2187E+05	.0000E+00	.0000E+00	.0000E+00

Table 93. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for mean velocity during random swimming.

Mean Vel.	Rainbow			Brook		
(cm/sec)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
0	21	40	24	0	0	0
6	37	5	97	0	0	0
12	0	0	7	0	0	0
18	0	8	11	0	0	0
24	0	0	0	0	0	0
30	0	0	0	0	0	0
36	0	0	0	0	0	0
42	0	6	14	0	0	0
48	0	0	0	0	0	0
54	0	0	0	0	0	0
60	0	0	0	0	0	0
66	0	0	0	0	0	0
72	0	0	0	0	0	0
78	0	0	0	0	0	0
84	0	0	0	0	0	0
90	0	0	0	0	0	0
96	0	0	0	0	0	0
102	0	0	0	0	0	0
108	0	0	0	0	0	0
114	0	0	0	0	0	0
120	0	0	0	0	0	0
126	0	0	0	0	0	0
132	0	0	0	0	0	0
138	0	0	0	0	0	0
144	0	0	0	0	0	0
150	0	0	0	0	0	0
156	0	0	0	0	0	0
162	0	0	0	0	0	0
>168	0	0	0	0	0	0
Number	58	59	153	0	0	0
Mean	5.83	8.42	11.49	0.00	0.00	0.00
Variance	11.8	195.8	137.9	0.0	0.0	0.0
Par. sum	338.3	496.8	1758.7	0.0	0.0	0.0
Cor term	.1974E+04	.4184E+04	.2022E+05	.0000E+00	.0000E+00	.0000E+00
Error SS	.6742E+03	.1136E+05	.2097E+05	.0000E+00	.0000E+00	.0000E+00
Par. SS	.2648E+04	.1554E+05	.4118E+05	.0000E+00	.0000E+00	.0000E+00

Table 94. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for fish depth during random swimming.

Fish depth	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	0	0	1	0	0	0
25	21	12	0	0	0	0
50	25	5	37	0	0	0
75	0	0	0	0	0	0
100	12	23	89	0	0	0
150	0	0	0	0	0	0
200	0	0	0	0	0	0
250	0	19	26	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	58	59	153	0	0	0
Mean	46.1	114.2	103.8	0.0	0.0	0.0
Variance	599.2	6267.1	3349.8	0.0	0.0	0.0
Par. sum	2675.0	6740.0	15875.0	0.0	0.0	0.0
Cor term	.1234E+06	.7700E+06	.1647E+07	.0000E+00	.0000E+00	.0000E+00
Error SS	.3415E+05	.3635E+06	.5092E+06	.0000E+00	.0000E+00	.0000E+00
Par. SS	.1575E+06	.1133E+07	.2156E+07	.0000E+00	.0000E+00	.0000E+00

Table 95. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for water depth during random swimming.

Water depth	Rainbow			Brook		
[cm]	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
50	9	6	0	0	0	0
100	49	6	3	0	0	0
150	0	5	34	0	0	0
200	0	15	45	0	0	0
250	0	0	0	0	0	0
300	0	21	57	0	0	0
350	0	0	0	0	0	0
400	0	6	14	0	0	0
450	0	0	0	0	0	0
500	0	0	0	0	0	0
550	0	0	0	0	0	0
600	0	0	0	0	0	0
650	0	0	0	0	0	0
700	0	0	0	0	0	0
750	0	0	0	0	0	0
800	0	0	0	0	0	0
850	0	0	0	0	0	0
900	0	0	0	0	0	0
950	0	0	0	0	0	0
1000	0	0	0	0	0	0
1050	0	0	0	0	0	0
1100	0	0	0	0	0	0
1150	0	0	0	0	0	0
1200	0	0	0	0	0	0
>1200	0	0	0	0	0	0
Number	58	59	153	0	0	0
Mean	72.8	204.4	228.2	0.0	0.0	0.0
Variance	205.3	10152.7	6377.5	0.0	0.0	0.0
Par. sum	4222.0	12060.0	34910.0	0.0	0.0	0.0
Cor term	.3073E+06	.2465E+07	.7965E+07	.0000E+00	.0000E+00	.0000E+00
Error SS	.1170E+05	.5889E+06	.9694E+06	.0000E+00	.0000E+00	.0000E+00
Par. SS	.3190E+06	.3054E+07	.8935E+07	.0000E+00	.0000E+00	.0000E+00

Table 96. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for substrate during random swimming.

Substrate type	Rainbow						Brook					
	<14 cm		15-27 cm		Adult		<14 cm		15-27 cm		Adult	
	N	%	N	%	N	%	N	%	N	%	N	%
Rock												
>30 cm												
barren	12	20	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	32	54	71	46	0	0	0	0	0	0
Rubble												
8-30 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	14	23	52	33	0	0	0	0	0	0
Gravel												
.3-8 cm												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	7	4	0	0	0	0	0	0
Silt												
<0.3 cm												
barren	46	79	6	10	1	0	0	0	0	0	0	0
plant covered	0	0	7	11	22	14	0	0	0	0	0	0
Other												
barren	0	0	0	0	0	0	0	0	0	0	0	0
plant covered	0	0	0	0	0	0	0	0	0	0	0	0
Total	58		59		153		0		0		0	

Table 97. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for thigmotactic surface distance during random swimming.

Distance	Rainbow			Brook		
(cm)	<14 cm	15-27 cm	Adult	<14 cm	15-27 cm	Adult
10	0	6	3	0	0	0
25	46	6	0	0	0	0
50	0	5	35	0	0	0
75	0	15	9	0	0	0
100	12	8	80	0	0	0
150	0	0	0	0	0	0
200	0	0	0	0	0	0
250	0	19	26	0	0	0
300	0	0	0	0	0	0
400	0	0	0	0	0	0
500	0	0	0	0	0	0
600	0	0	0	0	0	0
700	0	0	0	0	0	0
800	0	0	0	0	0	0
900	0	0	0	0	0	0
>900	0	0	0	0	0	0
Number	58	59	153	0	0	0
Mean	33.2	105.6	101.6	0.0	0.0	0.0
Variance	721.7	6850.1	3473.9	0.0	0.0	0.0
Par. sum	1925.0	6230.0	15545.0	0.0	0.0	0.0
Cor term	.6389E+05	.6578E+06	.1579E+07	.0000E+00	.0000E+00	.0000E+00
Error SS	.4113E+05	.3973E+06	.5280E+06	.0000E+00	.0000E+00	.0000E+00
Par. SS	.1050E+06	.1055E+07	.2107E+07	.0000E+00	.0000E+00	.0000E+00

Table 98. The number of rainbow and brook trout observed in the San Juan River during a constant flow of 800 cfs in summer, 1984 for light reaching them during random swimming.

Percent of full light	Rainbow <14 cm	Rainbow 15-27 cm	Rainbow Adult	Brook <14 cm	Brook 15-27 cm	Brook Adult
<.01	0	0	0	0	0	0
.05	0	0	0	0	0	0
.1	0	0	0	0	0	0
.5	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	25	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
20	0	0	0	0	0	0
30	0	8	11	0	0	0
40	0	0	0	0	0	0
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	12	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
Number	37	8	11	0	0	0
Mean	25.8	24.6	24.6	0.0	0.0	0.0
Variance	750.9	0.0	0.0	0.0	0.0	0.0
Par. sum	958.9	197.2	271.1	0.0	0.0	0.0
Cor term	.2485E+05	.4861E+04	.6684E+04	.0000E+00	.0000E+00	.0000E+00
Error SS	.2703E+05	.0000E+00	.4883E-03	.0000E+00	.0000E+00	.0000E+00
Par. SS	.5188E+05	.4861E+04	.6684E+04	.0000E+00	.0000E+00	.0000E+00