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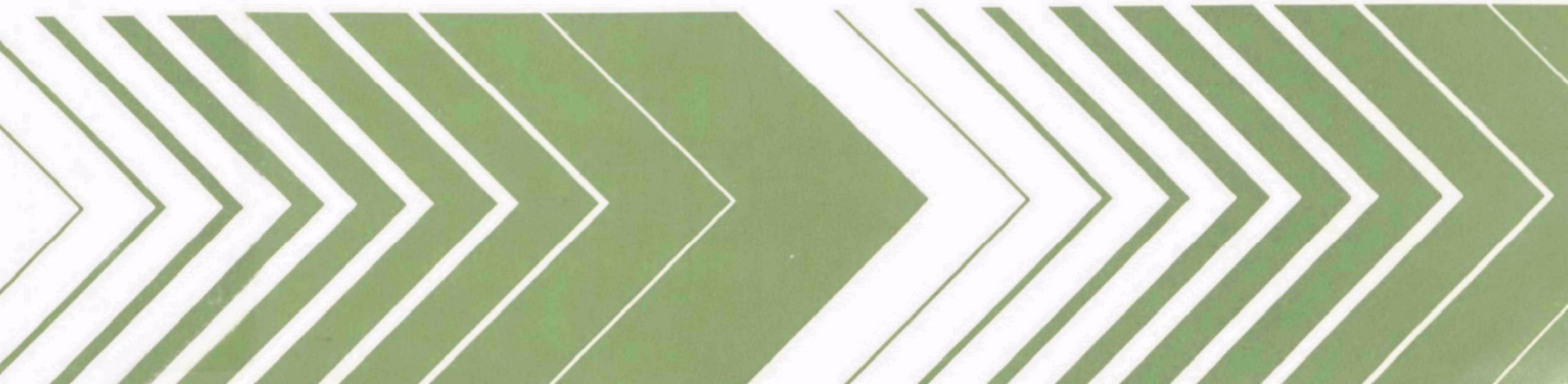
# Environmental Monitoring Series

# Macroinvertebrate Sampling Techniques for Streams in Semi-Arid Regions

## Comparison of the Surber Method and a Unit-Effort Traveling Kick Method



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# MACROINVERTEBRATE SAMPLING TECHNIQUES FOR STREAMS IN SEMI-ARID REGIONS

## Comparison of the Surber method and a unit-effort traveling kick method

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## FOREWORD

Protection of the environment requires effective regulatory actions which are based on sound technical and scientific information. This information must include the quantitative description and linking of pollutant sources, transport mechanisms, interactions, and resulting effects on man and his environment. Because of the complexities involved, assessment of specific pollutants in the environment requires a total systems approach which transcends the media of air, water, and land. The Environmental Monitoring and Support Laboratory-Las Vegas contributes to the formation and enhancement of a sound monitoring data base for exposure assessment through programs designed to:

- develop and optimize systems and strategies for monitoring pollutants and their impact on the environment
- demonstrate new monitoring systems and technologies by applying them to fulfill special monitoring needs of the Agency's operating programs

This report assesses the utility of two stream benthic macroinvertebrate collection methods for the purposes of water quality monitoring. Results presented herein can be used as a basis for developing water quality monitoring programs for streams of semi-arid western regions. Potential users of the information presented include federal, state, and local environmental and health agencies, as well as private organizations engaged in water quality monitoring and assessment. Further information is available from the Water and Land Quality Branch, Monitoring Operations Division.

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ABSTRACT

Streams of the arid and semi-arid regions of the western United States are characterized by irregular flow patterns resulting in highly unstable macroinvertebrate habitats and a sparse macrobenthic fauna. The use of a standard square-foot Surber stream-bottom sampler is of limited utility in these regions due to the combined effects of faunal paucity and patchiness. The efficiency of a unit-effort traveling kick method was compared with that of a standard Surber sampler in uniform fauna-poor riffles on the White River, Utah. Comparisons of 50 kick samples with 40 Surber samples revealed that kick samples provided more highly reproducible data than Surber samples in terms of counts of individuals and taxa, percentages of composition, and diversity indices (H). Visual preselection of the richest sites, however, improved the reliability of Surber sampler data. Some differences in organism selectivity of the two sampling methods were noted. The Surber method attributed greater relative importance to the more closely adherent and cryptic forms such as the simuliids, and the kick method was relatively biased towards easily dislodged organisms such as the baetid mayflies.

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# SECTION 1

# INTRODUCTION

Biological monitoring has long been recognized as an effective tool for evaluating the stability and environmental quality of ecosystems. Biological investigations are of particular significance in water quality monitoring programs since they offer a rapid and efficient means for evaluating the nature and extent of pollution related disturbances.

Biological monitoring should be an integral part of surface water quality monitoring programs. It should not, however, be viewed as an alternative to physical-chemical monitoring, but as a complementary tool for improving the efficacy and broadening the scope of water quality monitoring programs. Verification of cost-effective biological monitoring procedures is particularly important for the regions of the western United States which are rich in energy resources. These areas are expected to undergo considerable development in the near future, and many hundreds of miles of streams will require baseline and follow-up faunal surveys if biological monitoring is to be incorporated into comprehensive monitoring programs.

The relatively stationary bottom-dwelling macroinvertebrate communities are especially useful as natural monitors of water quality since they respond in a measurable and predictable manner to most types of pollutants. The recent history of water quality events can be detected through periodic sampling of the macrobenthos as the communities affected by the disturbance take weeks or months to recover. Periodic chemical sampling alone may "miss" short-term water quality fluctuations. In a sense, macrobenthic analysis provides a mechanism for integration of conditions between sampling periods.

Two attributes of macroinvertebrate communities which are particularly relevant to water quality investigations are faunal composition (distribution of the organisms among the species) and density. Accurate estimates of absolute values of these attributes require thorough and time-consuming ecological studies (Hynes 1970). However, estimates of these attributes taken from a standardized collection, although they may not accurately describe the entire benthic community, can be reliably compared with estimates of similar collections. Such comparative studies are relatively easy to conduct and are very effective for biological monitoring purposes because they can be used to detect and evaluate spatial and temporal changes in water quality.

Faunal composition of two or more collections can be reliably compared, provided the same sampling method is employed and the sample size is sufficient.

Methods of determining how sample size relates to the accuracy of faunal composition estimates are discussed in terms of species diversity by Pielou (1966), Wilhm (1970), Hurtubia (1973), and Fraser (1976) and in terms of number of taxa by Gaufin et al. (1956) and Stout and Vandermeer (1975).

The highly patchy or contagious distribution of macroinvertebrates necessitates that either very large numbers of replicates (>50) be collected in order to obtain precise standing-crop estimates (e.g., a 5 to 10 percent error of the mean), or rougher estimates (e.g., a 20 to 100 percent error of the mean) involving much fewer numbers of samples (<10) will have to be the object (Chutter 1972). However, natural variation in density is often so high that precise estimates have little meaning for purposes of water quality monitoring. In these cases, only when abundances change considerably can a man-made disturbance be suspected. This is particularly true in streams subject to intermittent flooding, where a single spate could reduce the density of organisms dramatically (Hynes 1970). Even through standing-crop estimates are relatively imprecise, they are valuable, as large changes in macroinvertebrate density will be detected.

Most stream macrobenthic samplers, such as the Surber (square-foot) sampler, are primarily designed for estimating standing crop. They are standardized by unit area and collect from relatively small areas of stream bottom. However, for purposes of estimating faunal composition, very large numbers of small-area replicates are often required to obtain reproducible data. This sampling problem is especially critical for streams of the semi-arid western regions where the bottom organisms may be relatively sparse due to the effects of intermittent spates accompanied by large sediment loads. There is a need to standardize and validate a sampling method for these streams which provides greater areal coverage with minimum effort and which provides more precise estimates of faunal composition than is generally achieved with area-standardized samplers such as the Surber sampler.

This report compares a standardized, unit-effort traveling kick method with the Surber method for obtaining macroinvertebrate data from fauna-poor areas of western United States streams characterized by episodic flow patterns.

## SECTION 2

## CONCLUSIONS AND RECOMMENDATIONS

Intensive macroinvertebrate sampling from a fauna-poor riffle area on the White River, Utah, utilizing two standardized techniques, demonstrated that the unit-effort traveling kick method was more efficient and cost-effective than the Surber sampling method for the purposes of biological monitoring. Replicate variability for the unit-effort traveling kick method was considerably lower than that for the Surber sampling method for kinds of taxa collected, percentage data of the more common taxa, and diversity index values. Under test conditions fewer kick net than Surber net samples were therefore required to obtain reproducible estimates of faunal composition. For purposes of detecting relative changes in the macrobenthic density, the kick net also provided reliable count data more efficiently (fewer replicates required) than did the Surber sampler. This increased efficiency is estimated to save as much as 75% sample collecting and sorting time to achieve a 50% level of precision for abundance estimates.

The unit-effort traveling kick method is much more versatile than the Surber sampling method. It can be used in riffles with water depths up to 1 meter, whereas the Surber sampler is of limited utility in waters over 30 cm deep. The increased efficiency and versatility of the kick method overcomes many of the sampling limitations associated with site suitability (particularly during periods of high discharge) and minimizes the numbers of replicate samples required. If Surber samples are to be collected from fauna-poor streams, the sample site selection should be limited to the fauna-rich areas of the riffle. Such site selection provides relatively large numbers of organisms per sample and low variability, thereby increasing water quality monitoring utility.

Although the present study only compares sampler performance in one riffle of one river, we are recommending intensive testing of the unit-effort traveling kick method for routine biological monitoring in larger fauna-poor western streams. A long fine-meshed (12 to 16 strands per cm) net is recommended for use with this method. In addition, selection of riffle habitats composed of medium-sized (approx. 10 cm) loose rocks with little or no vegetation and depths between 15 and 60 cm is recommended for the most effective employment of the unit-effort traveling kick method.

## SECTION 3

## MATERIALS AND METHODS

### STUDY AREA

The White River in Colorado and Utah (Figure 1) is representative of many rivers in the Colorado River Basin. Water quality in the upper reaches is excellent, supporting good trout populations and a rich, diversified invertebrate fauna. The river becomes increasingly turbid, progressing downstream, with chemical water quality undergoing a dramatic change characterized by an increase in dissolved solids. The downstream reaches of the river support a rather meager warm-water fishery and an unstable invertebrate fauna.

The study area was located at Southam Canyon, White River, Utah, near the Ua-Ub federally leased oil shale tracts (Figure 1). The mean annual discharge at Southam Canyon is 20 cubic meters per second and the stream's width is about 30 meters during periods of normal flow. The stream at the study area was bisected by a large stable island. Riffles with various water depths were located on both sides of the island. This was the only extensive riffle area within the mile stretch at Southam Canyon accessible by road. The substrate of the riffles was quite uniform and consisted of easily dislodged, flat shale stones (ranging in diameter from 5 to 20 cm) interspersed with fine and coarse gravel and underlain with gravel and sand. Except for a thin layer of periphyton (mainly diatoms), the substrate was quite free of attached vegetation, although it contained a considerable amount of trapped debris.

During the study period, September 5-6, 1976, the stream flow was relatively low and the water exceptionally clear in the lower White River due to the lack of any recent rains in the watershed.

### SAMPLING METHODS

#### Surber Method

A standard 0.093-$m^2$ (1 square foot) Surber sampler was modified as follows. The original net (68 cm long with 10 strands per cm), supplied by Wildco Supply Co., was replaced by a 90-cm-long, conical-shaped, 12-strand-per-cm (30 mesh) nylon net. It was assumed that the longer net would reduce backwash from the sampler, while the finer-meshed netting would allow entrapment of the smallest organisms defined as macroinvertebrates, i.e., those invertebrates retained by 30-mesh netting (U.S. EPA 1973). Surber samples were collected in accordance with prescribed methods (Needham and Needham 1962).

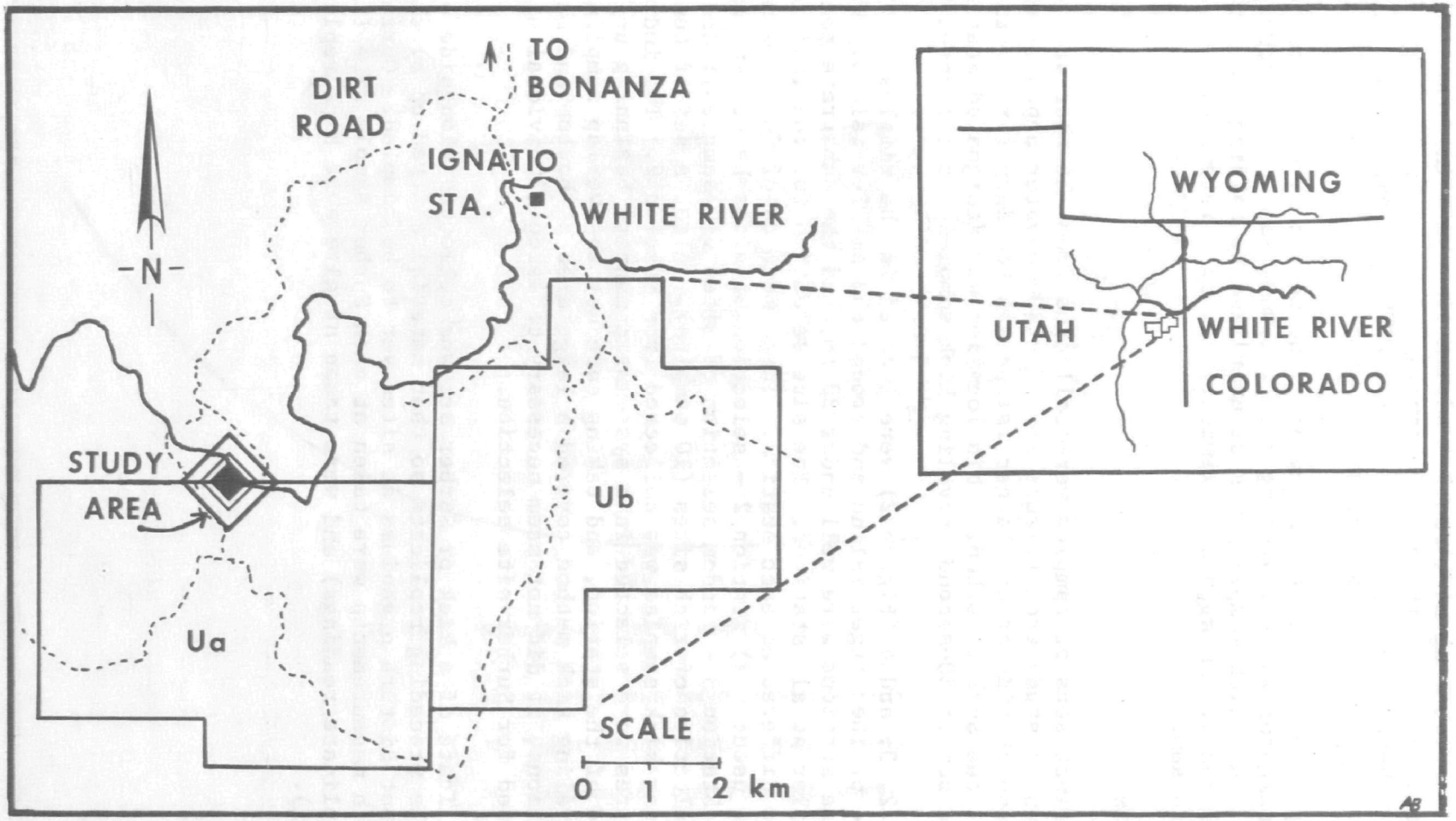


Figure 1. Location of the White River Southam Canyon study area near the Ua-Ub oil shale tracts in Utah.

Unit-Effort Traveling Kick Method

Unit-effort traveling kick samples were collected using a modified Turtox triangular dip net with a mouth opening of 28 cm by 28 cm by 34 cm. The 22-cm-long, 9-strand-per-cm net supplied with the sampler was replaced with a pyramid-shaped 76-cm long nylon net with 16 strands per cm (40 mesh).

Kick samples were collected by holding the net in front of and downstream from the investigator while traveling slowly downstream and vigorously kicking the substrate. All kick sampling was standardized by holding the net in the water for 30 seconds. An area approximately 3/4 by 4 meters (3 $m^2$) was disturbed for each sample.

SAMPLING DESIGN

Five distinct sets of samples were collected from the four stations at the Southam Canyon study area (Figure 2). The 40-cm water depth of the riffle on the south side of the larger island was too deep for practical application of the Surber method. This location was designated Station 1 and a 40-replicate set of 30-second traveling kick samples was collected here.

Stations 2, 3, and 4 (Figure 2) were located in the riffles on the northwest side of the larger island and around the smaller island. Water depths at these stations were well under 30 cm, and the substrate conditions were very similar at all stations. The site selection for the individual Surber samples differed at each station. Three methods of Surber sample site selection were used: (a) Station 2 - selection of sites by current speed (20 samples); (b) Station 3 - random selection of sites (10 samples); and (c) Station 4 - selection of rich sites (10 samples). Also, a set of ten 30-second traveling kick samples was collected from Station 2. The individual kick sample sites were selected in a systematic manner, beginning at the downstream end of the station, and taking care not to overlap sampling sites. Since the traveling kick method covered a large area of bottom and many habitat conditions, it did not seem necessary to select individual sites in the manners used for Surber site selection.

Each replicate of a kick or Surber set was collected alongside or upstream from the preceding replicate so that material stirred up by the sampling activity did not disturb organisms at sites yet to be sampled. Current-speed and water-depth measurements were taken at each Surber sample site (including occasional replicate readings) and were taken at alternate kick replicate sites (Table 1).

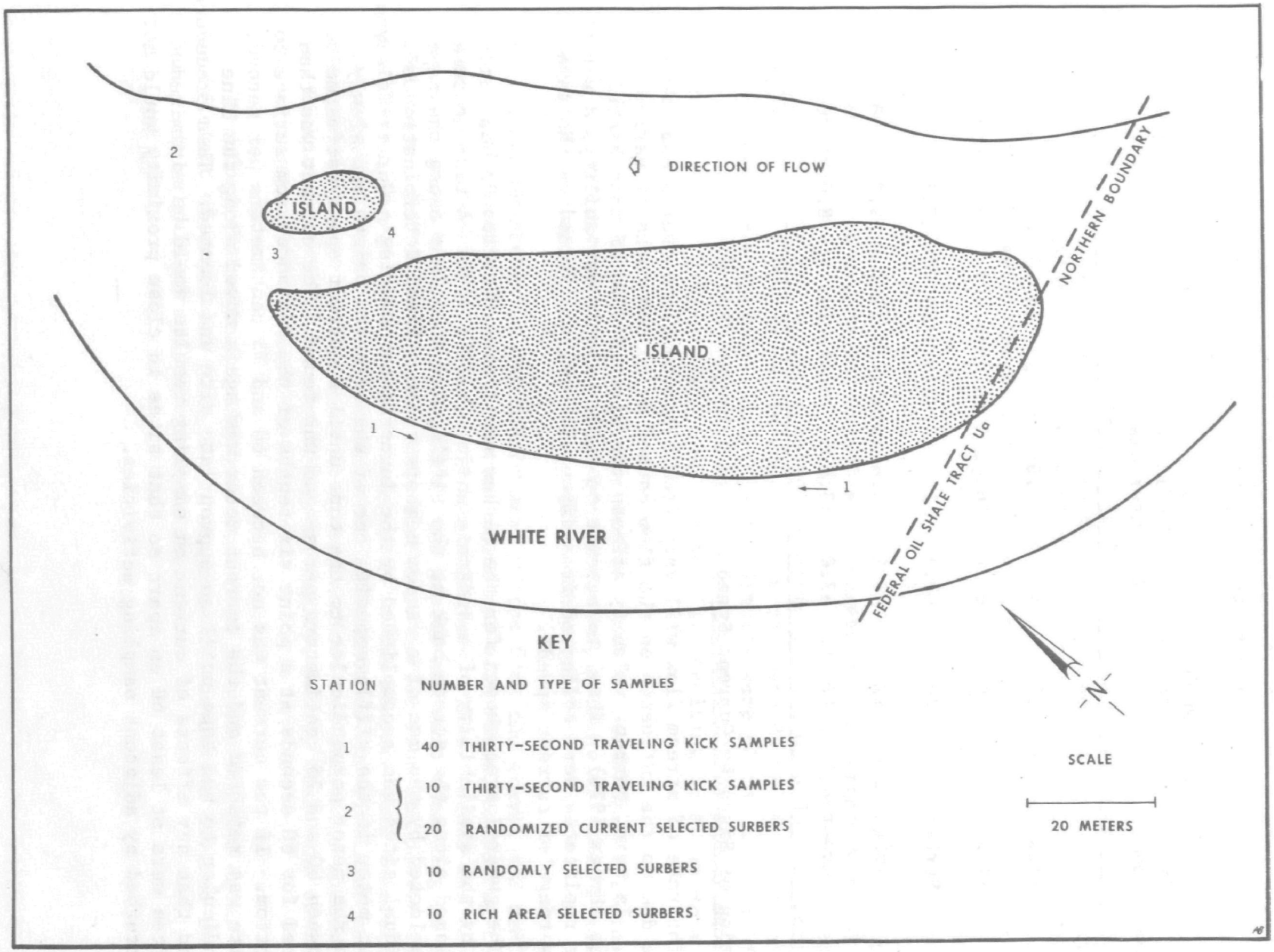


Figure 2. Location of sampling stations at the Southam Canyon study area, White River, Utah.

TABLE 1. MEANS ($\bar{X}$) AND 95% CONFIDENCE INTERVALS FOR CURRENT AND DEPTH MEASUREMENTS ASSOCIATED WITH MACROBENTHIC SAMPLES

| | | Current speed (cm/s) | | | Depth (cm) | | |
|---|---|---|---|---|---|---|---|
| Station | Type of Sample | Number of Measurements | $\bar{X}$ | 95% Confidence Intervals | Number of Measurements | $\bar{X}$ | 95% Confidence Intervals |
| 1 | Kick | 19 | 41.5 | ±1.6 | 14 | 40.0 | ±2.5 |
| 2 | Kick | 6 | 67.8 | ±6.8 | 6 | 17.0 | ±5.0 |
| 2 | Surber | 24 | 68.1 | ±1.1 | 20 | 12.1 | ±0.8 |
| 3 | Surber | 12 | 49.3 | ±3.6 | 10 | 9.3 | ±0.8 |
| 4 | Surber | 12 | 47.0 | ±3.7 | 10 | 8.0 | ±0.6 |

Selection of Sites by Current Speed

The rate of stream flow will vary from place to place over a shallow riffle due to the influence on the flow caused by bottom rocks of various sizes. In turn, current velocity affects the distribution of many benthic species (Hynes 1970). Thus, to attempt to reduce sample variability, a set of Surber replicates were collected from sites which were affected by the same narrow range of current speeds.

The general area chosen for the Surber replicates (Station 2) was determined by the availability of a suitable uniform riffle area. A tape measure was placed along the stream bank at the riffle, and 20 points along the tape were selected by the use of a random numbers table. Final determination of individual sites was accomplished by the investigator placing a Gurley-Teledyne current meter in the riffle opposite one of the selected points and slowly moving the meter perpendicular to the tape until a current speed estimated to be between 60 and 75 centimeters per second was found. The current was then measured for 60 seconds at a point six-tenths of the distance from surface to the bottom. If the current was not between 60 and 75 centimeters per second, the site was rejected and the current meter was again moved along the line perpendicular to the tape until an appropriate site was located. This procedure assured that any effects of current on sampling results would be minimized. All sites were at least 60 cm apart so that sites in close proximity would not be disturbed by adjacent sampling activities.

Random Selection of Sites

Randomly selected Surber sampling sites (Station 3) were selected by the establishment of a 3-meter-by-3-meter grid and the use of a two-digit random numbers table. If sites were closer than 60 cm to each other, another random number was chosen from the table.

Selection of Rich Sites

It was assumed that places in a riffle with piled-up rocks would provide more depth to the substrate and more trapped debris, and hence a larger surface area available for colonization. Portions of the bottom where rocks were visibly piled the highest were designated as rich sites (Station 4). Surber samplers were placed so that the pile of rocks chosen as a rich site was surrounded by the sampler frame.

SAMPLE HANDLING AND ANALYSIS

Samples were initially transferred from the Surber and kick nets to a bucket with a 12-strand-per-cm (30 mesh) screen on the bottom to avoid any accidental loss of organisms. Since 40-mesh and 30-mesh nets were used to collect the kick and Surber samples respectively, use of a 30-mesh screen for sample washing improved consistency between the methods in terms of minimum size of organisms included in the data. Samples were placed in mason jars and preserved with 100% Formalin solution in volumes approximately equivalent to the amount of organic debris in the sample, resulting in at least a 5% solution.

In the laboratory samples were washed clean of Formalin by placing them in a jar covered with a 12-strand-per-cm screen, pouring off the Formalin, and then rinsing the samples thoroughly with water.

Macroinvertebrates and debris were sorted from the gravel and sand by placing the sample in a round-bottom container with water, agitating the sample, and pouring off the debris and organisms. This process was repeated until no organisms could be found in the gravel and sand remaining in the container. Macroinvertebrates were then hand sorted from the debris in a shallow white pan. All macroinvertebrates in the samples were identified to species, when possible, and enumerated. (Chironomids and simuliids have been identified only to family; generic determinations are currently underway.) Dr. Richard Baumann of Brigham Young University, Provo, Utah, has confirmed the majority of identifications.

Standard statistical techniques were used in analyzing the data. The coefficient of variation (CV), i.e., the standard deviation divided by the mean, was calculated and expressed in percent.

The estimation of sample size required for a given level of precision was calculated according to the methods given by Steele and Torrie (1960):

$$n = \frac{t^2 \, CV^2}{p^2}$$

where $n$ = estimated number of samples required
$t$ = Student's t value for a given probability level and degrees of freedom based on the number of replicates
$CV$ = coefficient of variation
$p$ = acceptable percent error of the sample mean from the population mean

The average diversity per individual for these samples was estimated from the Shannon-Wiener formula (Shannon and Weaver 1963):

$$H = -\sum_{i=1}^{S} P_i \log_2 P_i$$

where $P$ = proportion of the ith taxon in the sample, which is calculated from $n_i/N$
$n_i$ = number of individuals of the ith taxon
$N$ = total number of individuals
$S$ = total number of taxa

The value H will increase with an increase in the number of taxa collected and/or with an increase in the evenness of the distribution of individuals among the taxa. Thus, H is a measure which takes into account both the number of species in a collection and their relative abundances.

## SECTION 4

## COMPARISON OF SAMPLING METHODS

### TOTAL COUNTS

The unit-effort traveling kick method collected higher counts of organisms per sample and yielded statistically more reproducible data than did the Surber method as expressed by lower coefficients of variation (Table 2)*. For example, at Station 2 the Surber method collected 21 organisms per sample, while the kick method collected more than 11 times as many organisms per sample (236) and yielded a coefficient of variation only about one-third that of the Surber method (29% vs. 83%). However, the Surber method collected many more organisms per unit area of bottom than did the traveling kick method. Each 30-second traveling kick sample was estimated to cover an approximate 3-$m^2$ area. Therefore, the area sampled is approximately 30 times as large as that covered by a Surber sample, and the number of organisms collected per unit bottom area is only 37% of the number collected per area by the Surber method. However, this lack of thoroughness in sampling by the kick method is more than compensated for by the 30-fold increase in the area sampled. The kick method results in a net increase of organisms collected and a net decrease in replicate variability.

Required sample size was estimated for acceptable percent errors of the sample mean from the population mean of 20% and 50%. Sampling efficiency as measured in these terms ranged from 2.5 to 7.5 times higher for the kick method than for the Surber method (Table 3).

The set of Surber replicates collected from the rich sites of a riffle (Station 4) yielded the most organisms and produced the least variable data of the three Surber collections (Table 2). The 48% coefficient of variation obtained for total counts is consistent with the findings of Hassler and Tebo (1958) who reported a CV of 50% with Surber samples taken from eastern streams. In addition, the 29 samples estimated to be required to obtain a mean within 20% of the population mean (Table 3) was comparable to results obtained by Chutter (1972) for randomized Surber sample data compiled by Needham and Usinger (1956) from a relatively productive western mountain stream. Chutter found 28 samples were required to obtain the same precision.

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* 'Quantitative' macroinvertebrate sampling techniques are often considered by benthic biologists as those which are standardized for unit area (Elliot 1971). However, this should not imply that data collected in any other standardized manner cannot be subjected to quantitative presentation, such as in Table 2.

TABLE 2. MEANS ($\bar{X}$) AND COEFFICIENTS OF VARIATION (CV) IN PERCENT FOR TOTAL NUMBER OF INDIVIDUALS, NUMBER OF TAXA, AND DIVERSITY INDEX FOR EACH SAMPLE SET

| Station | Type of Sample | Number of Samples | Total Counts | | Number of Taxa | | Diversity Index | |
|---|---|---|---|---|---|---|---|---|
| | | | $\bar{X}$ | CV | $\bar{X}$ | CV | $\bar{X}$ | CV |
| 1 | Kick | 40 | 118 | 30.6 | 11 | 15.4 | 2.79 | 7.2 |
| 2 | Kick | 10 | 236 | 29.2 | 13 | 19.9 | 2.61 | 3.8 |
| 2 | Surber | 20 | 21 | 83.3 | 6 | 34.3 | 2.02 | 19.8 |
| 3 | Surber | 10 | 16 | 67.5 | 6 | 52.5 | 2.02 | 44.6 |
| 4 | Surber | 10 | 69 | 48.0 | 9 | 20.2 | 2.47 | 12.2 |

TABLE 3. ESTIMATED NUMBER OF SAMPLES REQUIRED FOR EACH SAMPLING METHOD TO PROVIDE MEANS OF TOTAL COUNTS WITHIN 20% AND 50% OF THE POPULATION MEAN AT THE 95% LEVEL OF CONFIDENCE

| Station | Type of Sample | Number of Samples Required to Provide Sample Mean Values Within: | |
|---|---|---|---|
| | | 20% | 50% |
| 1 | Kick | 10 | 2 |
| 2 | Kick | 11 | 2 |
| 2 | Surber | 76 | 12 |
| 3 | Surber | 58 | 9 |
| 4 | Surber | 29 | 5 |

COUNTS PER TAXA

Analysis of count data for each of the nine most abundant taxa (representing at least 95% of all organisms collected) demonstrated that unit-effort traveling kick samples provided higher counts per sample and better statistical reproducibility than Surber samples for most of the common taxa (Table 4). The mean of the coefficients of variation for counts of individuals for all nine taxa were only 59% and 56% for the kick sets as compared to 138%, 120%, and 94% for the Surber sets. The Station 2 kick samples showed lower variation (CV value) for each of the nine taxa than the directly comparable Station 2 Surber sample set. The Surber samples collected from rich sites (Station 4) provided better reproducibility than did the other Surber sets.

TABLE 4. MEANS ($\bar{X}$) AND COEFFICIENTS OF VARIATION (CV) IN PERCENT FOR COUNTS OF ORGANISMS OF THE NINE MOST COMMON TAXA. (These taxa represent at least 95% of all organisms collected for any given set of samples.)

| Station: | 1 | | 2 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of Sample: | Kick | | Kick | | Surber | | Surber | | Surber | |
| Number of Samples: | 40 | | 10 | | 20 | | 10 | | 10 | |
| TAXON | $\bar{X}$ | CV | $\bar{X}$ | CV | $\bar{X}$ | CV | $\bar{X}$ | CV | $\bar{X}$ | CV |
| *Rithrogena undulata* | 10 | 53 | 75 | 31 | 2 | 98 | 3 | 62 | 7 | 38 |
| *Traverella albertana* | 7 | 51 | 42 | 34 | 6 | 89 | 3 | 89 | 12 | 40 |
| *Dactylobaetis cepheus* | 38 | 40 | 32 | 50 | 1 | 101 | 1 | 115 | 1 | 132 |
| *Pseudocleon sp.* | 11 | 65 | 48 | 49 | 2 | 100 | 4 | 64 | 11 | 58 |
| *Tricorythodes minutus* | 2 | 80 | 2 | 101 | 1 | 113 | 1 | 170 | 1 | 60 |
| *Isogenoides colubrinus* | 7 | 56 | 7 | 47 | 1 | 113 | 1 | 194 | 1 | 139 |
| Chironomidae | 19 | 83 | 8 | 48 | 1 | 248 | 1 | 129 | 5 | 91 |
| Simuliidae | 14 | 49 | 15 | 53 | 8 | 134 | 3 | 98 | 27 | 61 |
| *Hexatoma sp.* | 7 | 54 | 1 | 90 | 1 | 244 | 1 | 161 | 1 | 225 |
| Mean CV | | 59 | | 56 | | 138 | | 120 | | 94 |

RELATIVE ABUNDANCES

Analysis of the percentage composition data for the nine most abundant taxa again demonstrated that unit-effort traveling kick samples provided better statistical reproducibility than Surber samples in most cases (Table 5). The mean of the coefficient of variation values for percentage data for all nine taxa were 31% and 34% for the kick sets, as compared to 112%, 112%, and 65% for the Surber sets. The kick sample set collected from Station 2 showed lower variation for each of the nine taxa than the directly comparable Station 2 Surber sample set. However, the Surber sample set collected from the rich sites at Station 4 provided better reproducibility for five of the nine common taxa collected from the Station 1 kick sample set and for two of the nine taxa collected from the Station 2 kick sample set.

TABLE 5. MEANS ($\bar{X}$) AND COEFFICIENTS OF VARIATION (CV) IN PERCENT* FOR THE PERCENTAGE COMPOSITION OF THE NINE MOST COMMON TAXA. (These taxa represent at least 95% of all organisms collected for any given set of samples.)

| Station: | 1 | | 2 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of Sample: | Kick | | Kick | | Surber | | Surber | | Surber | |
| Number of Samples: | 40 | | 10 | | 20 | | 10 | | 10 | |
| TAXON | $\bar{X}$ | CV | $\bar{X}$ | CV | $\bar{X}$ | CV | $\bar{X}$ | CV | $\bar{X}$ | CV |
| *Rithrogena undulata* | 9 | 36 | 32 | 11 | 11 | 75 | 18 | 59 | 11 | 23 |
| *Traverella albertana* | 6 | 25 | 18 | 16 | 32 | 33 | 21 | 100 | 19 | 19 |
| *Dactylobaetis cepheus* | 32 | 12 | 13 | 22 | 4 | 86 | 4 | 108 | 2 | 112 |
| *Pseudocloen sp.* | 9 | 32 | 20 | 16 | 9 | 69 | 26 | 37 | 15 | 16 |
| *Tricorythodes minutus* | 2 | 54 | 1 | 91 | 3 | 120 | 2 | 168 | 2 | 42 |
| *Isogenoides colubrinus* | 6 | 31 | 3 | 18 | 4 | 106 | 2 | 167 | 2 | 89 |
| Chironomidae | 15 | 36 | 4 | 25 | 2 | 208 | 2 | 130 | 7 | 46 |
| Simuliidae | 12 | 27 | 7 | 34 | 29 | 56 | 20 | 72 | 38 | 14 |
| *Hexatoma sp.* | 6 | 28 | 1 | 76 | 1 | 256 | 2 | 166 | 1 | 220 |
| Mean CV | | 31 | | 34 | | 112 | | 112 | | 65 |

*The arc-sine transformation ($\sin^{-1}\sqrt{p}$, where p is the proportion of the taxon) was used to normalize percentage data before the CV was calculated.

Some relative differences in the selectivity of the two sampling techniques were evident in the data. For example, the unit-effort traveling kick method placed greater relative importance on the swimming baetid mayfly, *Dactylobaetis cepheus*, while Surber sampling attributed greater relative importance to the more closely adherent *Traverella albertana* and Simuliidae (Table 5). These differences in the relative representation of the organisms were primarily because the closely attached forms were more easily missed by the kick technique. In fact, the underrepresentation of these forms in the kick net collections was chiefly responsible for the lower total number of organisms collected per unit area by the kick method. As mentioned previously, when the counts of the Station 2 kick and Surber sets were corrected for unit area, the total count per area for the kick method was 37% of that for the Surber sampler. The great majority of this difference in total count (89%) could be accounted for by the differences in counts of the two common closely adherent taxa, Simuliidae and *Traverella albertana*. The other common forms collected from Station 2 showed very similar actual counts per area for both methods.

RICHNESS OF TAXA

Relative performance of the two methods with respect to number of taxa collected was particularly evident in the data from the directly comparable

kick and Surber sample sets taken at Station 2. The combined total of the 10 kick replicates and the 20 Surber replicates collected from the Station 2 riffle yielded 23 taxa. Nine of these taxa were found only in the set of 10 kick samples, while only a single taxon was found exclusively in the set of 20 Surber samples (Table 6). The difference between the taxa lists for these sample sets will likely increase when the highly diverse chironomids are identified. Only eight chironomids were found in the set of 20 Surber samplers while 81 were found in the set of 10 kick samples. (The 42 chironomids examined thus far from the Station 2 kick sample set have been tentatively separated into 16 different species.)

The unit-effort traveling kick method yielded a greater mean number of taxa per sample (11 and 13) than the Surber method (6 to 9) (Table 2). It also provided lower between-replicate variability (15%-20% CV vs. 20%-52% CV) for the number of taxa collected per sample (Table 2).

The Surber samples collected from rich sites (Station 4) gave the best results of the Surber sets (Tables 2 and 6). This sample set yielded the highest number of total taxa (16), the highest average number of taxa per sample (9), and the least variability for number of taxa (20% CV) of the Surber sample sets.

## DIVERSITY

Diversity indices, in themselves, are often difficult to interpret as indicators of water quality (Pinkham and Pearson 1976). The Shannon-Wiener diversity index (H), however, is a good measure of the representativeness of a particular collection of organisms, taking both species richness and distribution of individuals among the species into account (U.S. EPA 1973). The variability of diversity indices among replicates can thus be used as an overall measure of the reproducibility of the collection and, therefore, the reliability of the sampling methodology employed (Crossman and Cairns 1974). This fact is independent of the question of the applicability of the index to water quality determinations.

The mean diversity index values (H) calculated for each unit-effort traveling kick sample set was statistically more reproducible (4%-7% CV) than the diversity values for the Surber sample sets (12%-45% CV) (Table 2). The highest reproducibility for diversity values (12% CV) among the Surber sets was provided by the sample set collected from the rich sites at Station 4.

TABLE 6. NUMBER OF ORGANISMS PER SAMPLE, TOTAL NUMBER OF TAXA, AND DIVERSITY FOR EACH SAMPLE SET

| TAXON | Station: | 1 | 2 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| | Type of Sample: | Kick | Kick | Surber | Surber | Surber |
| | Number of Samples: | 40 | 10 | 20 | 10 | 10 |
| | | Mean Number of Organisms per Sample | | | | |
| EPHEMEROPTERA | | | | | | |
| *Rithrogena undulata* | | 10 | 75 | 2 | 3 | 7 |
| *Heptagenia elegantula* | | <1 | 1 | <1 | - | 1 |
| *Ephemerella inermis* | | <1 | 1 | - | <1 | - |
| *Traverella albertana* | | 7 | 42 | 6 | 3 | 12 |
| *Choroterpes albiannulata* | | <1 | - | - | <1 | - |
| *Centroptilum sp.* | | <1 | <1 | - | - | - |
| *Baetis sp.* | | <1 | 1 | - | - | <1 |
| *Dactylobaetis cepheus* | | 38 | 32 | 1 | 1 | 1 |
| *Pseudocloen sp.* | | 11 | 48 | 2 | 4 | 11 |
| *Callibaetis sp.* | | <1 | <1 | - | - | - |
| *Tricorythodes spp.* | | 3 | 2 | <1 | 1 | 2 |
| *Lachlania saskatchewanensis* | | <1 | <1 | - | - | - |
| PLECOPTERA | | | | | | |
| *Isogenoides colubrinus* | | 7 | 7 | 1 | 1 | 1 |
| *Acroneuria abnormis* | | - | <1 | - | - | - |
| ODONATA | | | | | | |
| *Ophiogamphus severus* | | <1 | <1 | - | <1 | <1 |
| *Hetaerina americana* | | - | - | <1 | - | - |
| TRICHOPTERA | | | | | | |
| *Hydropsyche sp. A* | | <1 | 2 | 1 | <1 | 1 |
| *Hydropsyche sp. B* | | <1 | <1 | <1 | - | <1 |
| *Brachycentrus sp.* | | <1 | - | - | - | <1 |
| *Hydroptila sp.* | | <1 | - | - | - | <1 |
| *Agraylea saltesea (?)* | | <1 | - | - | - | - |
| *Neotrichia sp.* | | <1 | - | - | - | - |
| DIPTERA | | | | | | |
| Chironomidae | | 19 | 8 | <1 | <1 | 5 |
| Simuliidae | | 14 | 15 | 8 | 3 | 27 |
| Empididae | | <1 | - | - | - | - |
| *Hexatoma sp.* | | 7 | 1 | <1 | <1 | <1 |
| *Tipula sp.* | | <1 | - | - | - | - |
| *Atherix variegata* | | <1 | 1 | <1 | - | - |
| COLEOPTERA | | | | | | |
| *Microcylloepus sp.* | | <1 | <1 | - | - | - |
| *Stenelmis sp.* | | <1 | <1 | - | - | - |
| ACARI | | | | | | |
| *Sperchon sp.* | | <1 | - | - | - | - |
| TOTAL | | 118 | 236 | 21 | 16 | 69 |
| | | Number of Taxa per Sample Set | | | | |
| | | 29 | 22 | 14 | 13 | 16 |
| | | Pooled Diversity (H)* per Sample Set | | | | |
| | | 2.98 | 2.71 | 2.58 | 2.86 | 2.64 |

*All organisms collected in a set of samples were pooled in order to estimate H.

## SECTION 5

## GENERAL DISCUSSION

Egglishaw (1964), Frost et al. (1971), and Crossman and Cairns (1974) investigated a kick method which disturbed small areas of substrate while the investigator remained relatively stationary. Data from these studies indicated they were performed in relatively rich habitats where small-area samples collected substantial numbers of organisms. The average coefficient of variation (41%) derived from Egglishaw's total count data was similar to that obtained in the present study using a unit-effort traveling kick method (30%). In addition, Egglishaw found that data resulting from differences between investigators' kicking techniques were "not large." Frost et al. (1971) evaluated the stationary kick method as an alternative to the Surber sampler, which they described as "cumbersome in rapid streams deeper than 30 cm." They found that although a large proportion of benthic organisms either bypassed the kick net or remained attached to the substrate, the reproducibility between samples was high enough to allow them to apply statistical tests for comparisons between sets of samples. Crossman and Cairns (1974) found the reproducibility of kick samples to be better than or comparable to that of artificial substrate samples in terms of community diversity. Results of the present study similarly indicate that unit-effort traveling kick samples provide reliable data for benthic investigations.

The unit-effort traveling kick method cannot be as precisely standardized as the more common methods which are standardized in terms of unit area. The kick method also is less thorough and misses a large proportion of the organisms living in the area being sampled. However, these disadvantages are outweighed in fauna-poor areas by the advantages of sampling an area approximately 30 times larger per replicate with no more time or effort expended. The larger the area sampled the more information (organisms) the sample contains. In addition, the relatively large sample variability resulting from the contagious faunal distribution found in stream benthos is minimized when a greater area is sampled.

The unit-effort traveling kick method yielded less variable data between replicates than the more conventional Surber sampler method for all parameters investigated, indicating that fewer replicates are required to provide a basis for comparative studies. For example, 12 Surber replicates, as opposed to 2 kick replicates, were required from Station 2 to reach a 50% level of precision for total count data (Table 3). Sample collection and handling takes approximately 15 minutes per kick or 30 minutes per Surber replicate. An additional 5-1/2 hours of field effort, then, were required to reach a 50% level of precision when the Surber method was employed rather than the kick method. In addition, the sorting and counting of organisms is a very time-consuming

procedure. In processing the Southam Canyon samples, it took approximately 8 hours to sort and count 2 kick replicates, while about 24 hours were required to sort and count 12 Surber replicates. All together, a minimum of 21-1/2 additional hours of effort (30 hours vs. 8-1/2 hours) were required to obtain even roughly reproducible total count data from a single fauna-poor station with Surber sampling. The difference in time expenditure would be even greater if a higher level of precision is required.

The unit-effort traveling kick method also showed lower replicate variability than the Surber method for the community composition parameters of richness of taxa, relative abundance, and community diversity. These results are particularly relevant to water quality determinations. A major objective of such studies is to make comparisons of the faunal composition (kinds of organisms and their relative abundances) of collections taken at different locations and times.

Ease of operation and flexibility of a sampling method should also be taken into account. The proper use of the Surber method requires manipulation by hand of substrate materials enclosed by the sampler frame. The required dexterity is very difficult to achieve in cold waters with either numb fingers or heavy gloves. (Thin gloves quickly tear against the rocky substrate.) The kick net is effective in water depths up to 1 meter, as compared to a 30-cm maximum depth for the practical use of the Surber sampler. This increased versatility of the kick net provides much additional sampling capability in areas and during seasons in which Surber sampling is impossible.

It is not surprising that the two methods demonstrated relative differences in their selectivity for some of the taxa. Hynes (1970) points out that all sampling methods tend to be selective. However, as stated in the introduction, a primary intent of biological water quality investigations is to make comparisons over time and space. It is only important, here, that inferences involving changes in the biota come from reproducible collections that are furnished by the same sampling methodology. If a more complete description of macroinvertebrate fauna is desired, kick net collections can be supplemented with collections and observations of the more securely attached forms through stone lifting.

In addition to comparing the unit-effort traveling kick method with the Surber method, this study compares methods of Surber site selection at a fauna-poor area. Selection of the "richest" sites (Station 4) of a riffle produced the least variable of the Surber method data for all parameters investigated. However, sample site selection is often a problem in streams such as the lower White River which are frequently too turbid for visual selection.

The Station 2 set of Surber samples collected from sites selected from a narrow range of current speed conditions showed little overall improvement in variability when compared to samples selected in a simple random manner (Station 3 sample set). However, the current speeds of the Station 3 sites were also quite similar to each other. Thus, little can be concluded from these data concerning the influence of current speed variability on sampling efficiency.

More detailed statistical analyses of these results and analyses of results from additional study areas (including variation caused by mesh size, sampling investigator and length of collection time) along with comparisons of artificial substrate samplers are in progress and will be included in subsequent reports.

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**16. ABSTRACT**

Streams of the arid and semi-arid regions of the western United States are characterized by irregular flow patterns resulting in highly unstable macroinvertebrate habitats and a sparse macrobenthic fauna. The use of a standard square-foot Surber stream-bottom sampler is of limited utility in these regions due to the combined effects of faunal paucity and patchiness. The efficiency of a unit-effort traveling kick method was compared with that of a standard Surber sampler in uniform fauna-poor riffles on the White River, Utah. Comparisons of 50 kick samples with 40 Surber samples revealed that kick samples provided more highly reproducible data than Surber samples in terms of counts of individuals and taxa, percentages of composition, and diversity indices. Visual preselection of the richest sites, however, improved the reliability of Surber sampler data. Some differences in organism selectivity of the two sampling methods were noted. The Surber method attributed greater relative importance to the more closely adherent and cryptic forms such as the simuliids, and the kick method was relatively biased towards easily dislodged organisms such as the baetid mayflies.

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|---|---|---|
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