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GRAB SAMPLERS FOR BENTHIC MACROINVERTEBRATES IN THE LOWER MISSI--ETC(U)
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The use of any one single type and size of existing grab sampler for gathering representative benthic macroinvertebrate samples from the various habitats within rivers is impractical, if not impossible. Adjusting one sampling gear (grab sampler) to the existing habitat and program objectives appears to be the best approach. Although macroinvertebrate relative catch efficiency (catch by area inscribed by cocked sampler) varies among sampler types, the

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20. ABSTRACT (Continued).

catch efficiency of a single type varies with substrate, current regime, and bottoms contours to a greater extent.

Data from 24 grab samples, eight each taken with the Standard Ponar, Petite Ponar, and Shipek grabs from a backwater habitat were statistically compared using one-way analysis of variance. Total grabs produced 5696 organisms and 24 distinct taxa. Results showed no difference in catch efficiency among grab samplers for distinct taxa, total densities, and densities of the dominant taxa: *Lirceus* sp., *Ilyodrilus templetoni*, *Hexagenia* sp., *Limnodrilus cervix*, *Limnodrilus hoffmeisteri*, *Sphaerium* sp., and immature *Iliodrilus*. The Petite Ponar grab captured significantly fewer immature *Limnodrilus*. This was attributed to clumped distribution of these worms rather than difference in gear type. Analysis of the cumulative percent composition of newly acquired species showed that second and additional replicates of each grab type accounted for 10 percent or less of the total standing crop, as also found by Ward (1976) in marine substrate types.

A single grab per station is sufficient to characterize the dominant benthic macroinvertebrate standing crop community and is, therefore, recommended for survey level studies.

The Shipek grab is the preferred grab in habitats with strong currents; rough bottom morphology; and sand, gravel, or firm clay substrate. Ponar-type grabs are preferred for softer substrates under lower current velocities. This includes most backwater-type habitats, e.g., river borders, abandoned channels, oxbow lakes, and dike fields under low-flow conditions.

The choice between Petite Ponar and the Standard Ponar grabs depends upon the project design, but should be made with the following facts in mind. A single Standard Ponar grab samples a larger surface area than a single Petite Ponar grab; therefore, it provides a better representation of the immediate (station) benthic macroinvertebrate community than does the Petite Ponar grab. However, almost twice as many Petite Ponar samples can be taken and processed as Standard Ponar samples with similar effort. Greater numbers of stations dispersed over an area gives a better areal representation. Greater number of replicates provide smaller experimental error and, therefore, better support data for statistical inferences.

# Preface

The work described herein is part of the Environmental and Water Quality Operational Studies (EWQOS) conducted by the U. S. Army Engineer Waterways Experiment Station (WES) for the Office, Chief of Engineers (OCE), U. S. Army.

This study was part of pilot investigations conducted within EWQOS Work Unit VIIB to develop and test sampling equipment, techniques, and methodologies specifically designed to assess the environmental impacts of Corps activities within large open-channel waterways.

This report was prepared by Messrs. C. Rex Bingham, David B. Mathis, Larry G. Sanders, and Ms. Eva McLemore, under the direction of Dr. Thomas D. Wright, Chief, Waterway Habitat and Monitoring Group, Environmental Systems Division (ESD), Environmental Laboratory (EL); Mr. Bob O. Benn, Chief, ESD, EL; and Dr. John Harrison, Chief, EL. Dr. Jerome L. Mahloch was Program Manager of EWQOS.

COL Nelson P. Conover, CE, was Commander and Director of WES during field conduct of this study. Mr. Fred R. Brown was Technical Director of WES.

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## Contents

## Conversion Factors, U. S. Customary to Metric (SI) Units of Measurement

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| feet | 0.3048 | metres |
| inches | 2.54 | centimetres |

# GRAB SAMPLERS FOR BENTHIC MACROINVERTEBRATES IN THE LOWER MISSISSIPPI RIVER

## Introduction

1. Habitats for benthic macroinvertebrates within the Lower Mississippi River (LMR) are extremely diverse and dynamic. These habitats vary from unconsolidated muds within abandoned channels and oxbow lakes to cohesive clays of eroding, steeply sloping natural riverbanks to shifting coarse sand and gravel of the main channel (U. S. Atomic Energy Commission 1973, Conner and Bryan et al. 1975, Mathis et al. 1981).

2. Within these habitats, substrate type, water depth, and current velocity may also vary as a result of fluctuating water levels. For example, conditions within many LMR dike fields and secondary channels may approach those of the main channel during high river stages (Cobb and Clark 1981), while at lower river stages these same habitats may be predominantly depositional and similar to abandoned channels in character. Additionally, within most lotic habitats, numerous small depositional zones are also frequently encountered due to eddy action. Substrates in these depositional zones may vary from unconsolidated muds to fine sand to mud/fine-sand mixtures overlying coarse sand and gravel.

3. The variable sampling efficiency (ability to capture macroinvertebrates within and beneath area delineated by the sampler mouth) of a particular grab sampler with changes in habitat conditions encountered within the LMR often prevents the standardization of sampling effort. A determination of the most efficient grab sampler for each specific point in time and habitat to be sampled is often required.

4. Weber (1973) discussed a number of factors that may affect the number and kinds of benthic macroinvertebrates collected with a particular grab, and thus, its sampling efficiency under a specific set of habitat conditions. These factors include:

a. Depth of penetration.

b. Angle of jaw closure.

c. Completeness of jaw closure and consequent loss of sample material during retrieval.

d. Creation of a "shock" wave and consequent "washout" of near-surface organisms.

e. Stability of sampler at the high-flow velocities often encountered in rivers.

While all these factors must be considered in the choice of an efficient sampler, considerable experience at sampling various habitats within both the Middle and Lower Mississippi River convinces the authors that stability can frequently be an overriding factor to the other factors in this system.

5. Of the most frequently utilized grab samplers for freshwater benthic macroinvertebrate studies, the Standard Ponar grab is generally accepted as capable of efficiently sampling the widest variety of substrates (American Public Health Association 1975). This device (Figure 1) weighs approximately 28 kg and obtains a sample of approximately 0.05 $m^2$ in surface area. Although quite versatile, the Standard Ponar grab has features which limit its usefulness for certain environments and sampling designs.

6. First, the Ponar will not function consistently within most high energy aquatic habitats of the LMR (e.g., main channel, steeply sloping natural riverbanks, secondary channels). This inconsistent operation is attributed primarily to:

a. Incomplete jaw closure when sampling coarse sand, gravel, or cohesive clay substrates and a resulting loss of sample material during retrieval.

b. Instability on steep inclines in swift water (such as encountered along natural riverbanks) due to a high center of gravity. This frequently results in tip-over and roll of the sampler as it contacts the substrate. The tendency to tip and roll is increased by adding additional weights.

c. High current velocities frequently create sufficient drag on the sampler lead-line to prevent the required line slack for releasing the gravity triggering device.

7. The Shipek grab offers an alternative to counter these function deficiencies. The Shipek grab (Figure 2) will consistently collect adequate grab samples within high energy habitats of the LMR. When this

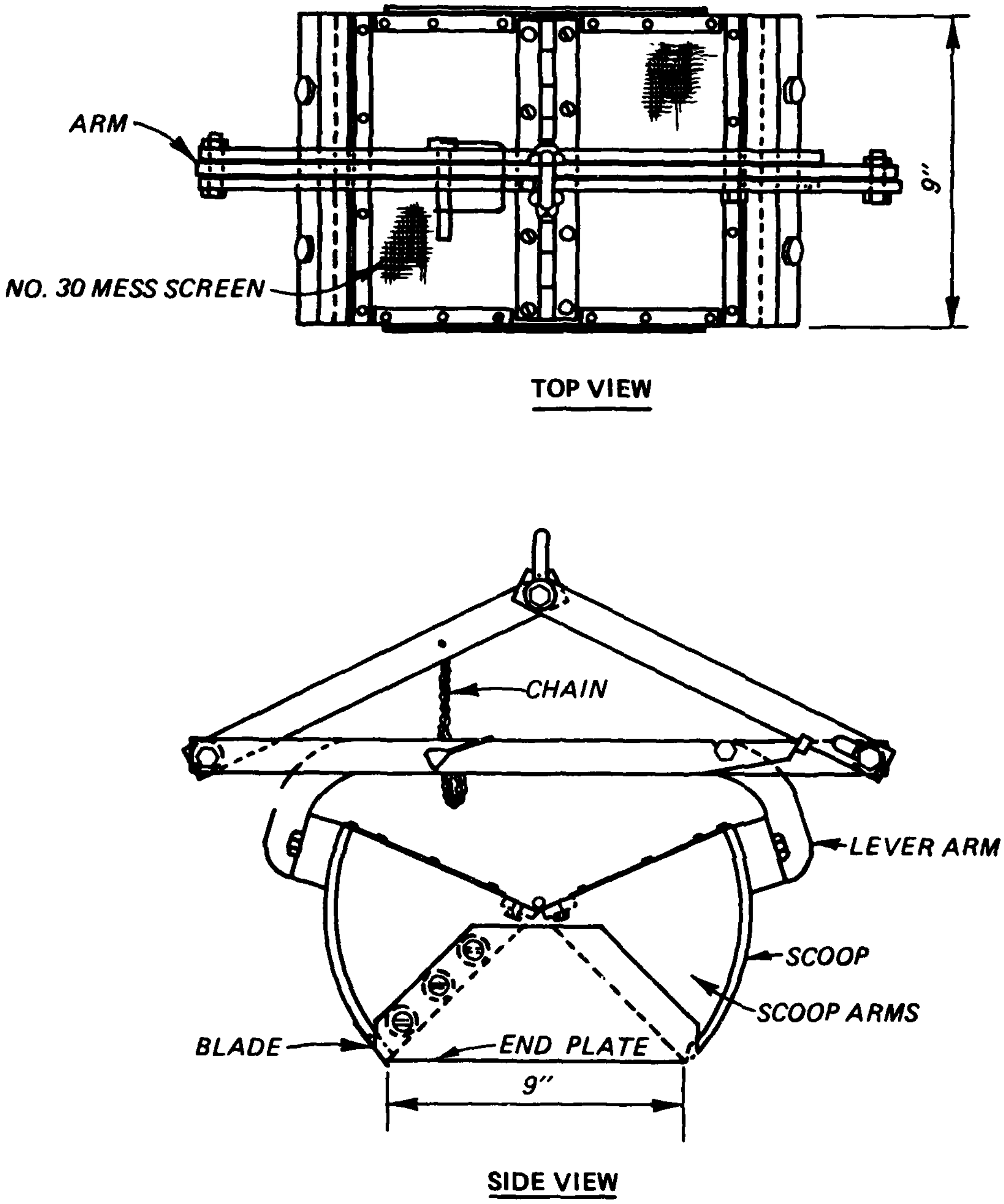
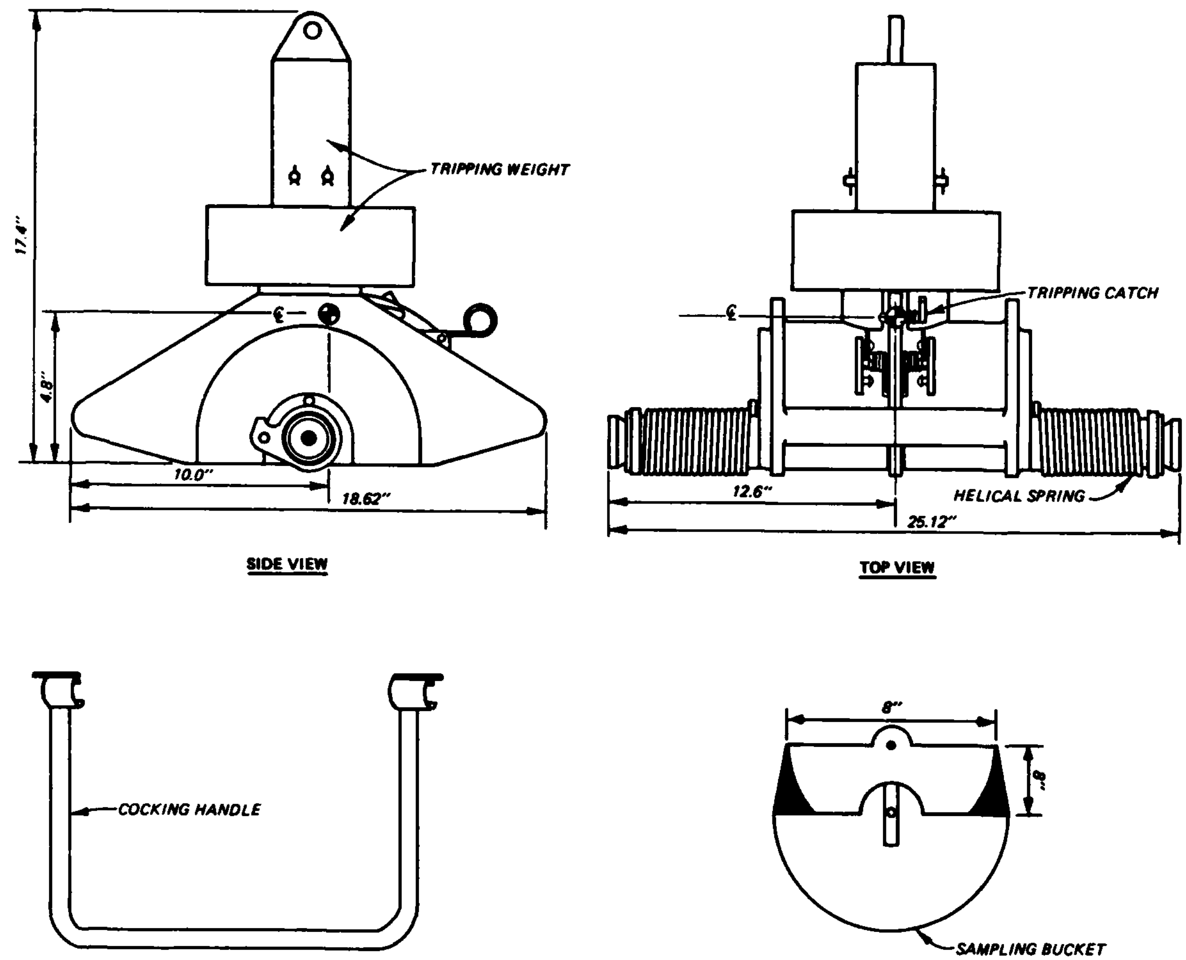


Figure 1. Ponar grab sampler




SHIPEK BOTTOM SAMPLER

Figure 2. Shipek grab sampler

grab contacts the bottom substrate, inertia from a self-contained weight releases a catch which activates strong helical springs, ensuring grab closure and retention of sample material, even in coarse sand and gravel. However, two basic criticisms of this device for benthic macroinvertebrate sampling purposes have been identified (Word 1976). These include: (a) poor depth of penetration and angle of closure which may result in significant underestimates of the deeper burrowing macroinvertebrate components such as the oligochaete, and (b) a significant "shock-wave" effect and consequent washout of surface-dwelling organisms. The latter criticism is of particular concern for studies within the LMR due to the frequent occurrence of thin layers of mud/fine-sand, overlying coarse sand and gravel within a number of LMR habitats.

8. The second limiting factor concerns adequate sample replication for comparative habitat investigations within the LMR. Mathis et al. (1981) found that for abandoned channels and other highly productive depositional macroinvertebrate habitats of the LMR, variability in assemblage estimates was generally as great as or greater than on a small scale (i.e., between replicate samples at a specific station within a habitat) as on a larger (station across a habitat) scale. They concluded that, for comparative studies across depositional habitats of the LMR, adequate sample replication was required both within and between habitat stations to effectively partition out these specific sources of data variability and, in turn, to provide for more effective hypothesis testing by statistical inference. Unfortunately, when using the Standard Ponar grab, the requirement for adequate sample replication often involves a substantial increase in both field and laboratory sample processing requirements, which are often primary limiting factors in benthic macroinvertebrate field studies.

9. The Petite Ponar grab, a recent addition to the field of aquatic ecology, offers the potential for providing the required sample replication for comparative off-channel habitat studies within the LMR, without undue requirements for laboratory processing of samples. This device (Figure 3) samples approximately one-half of the surface area sampled by the Standard Ponar grab and weighs considerably less than the

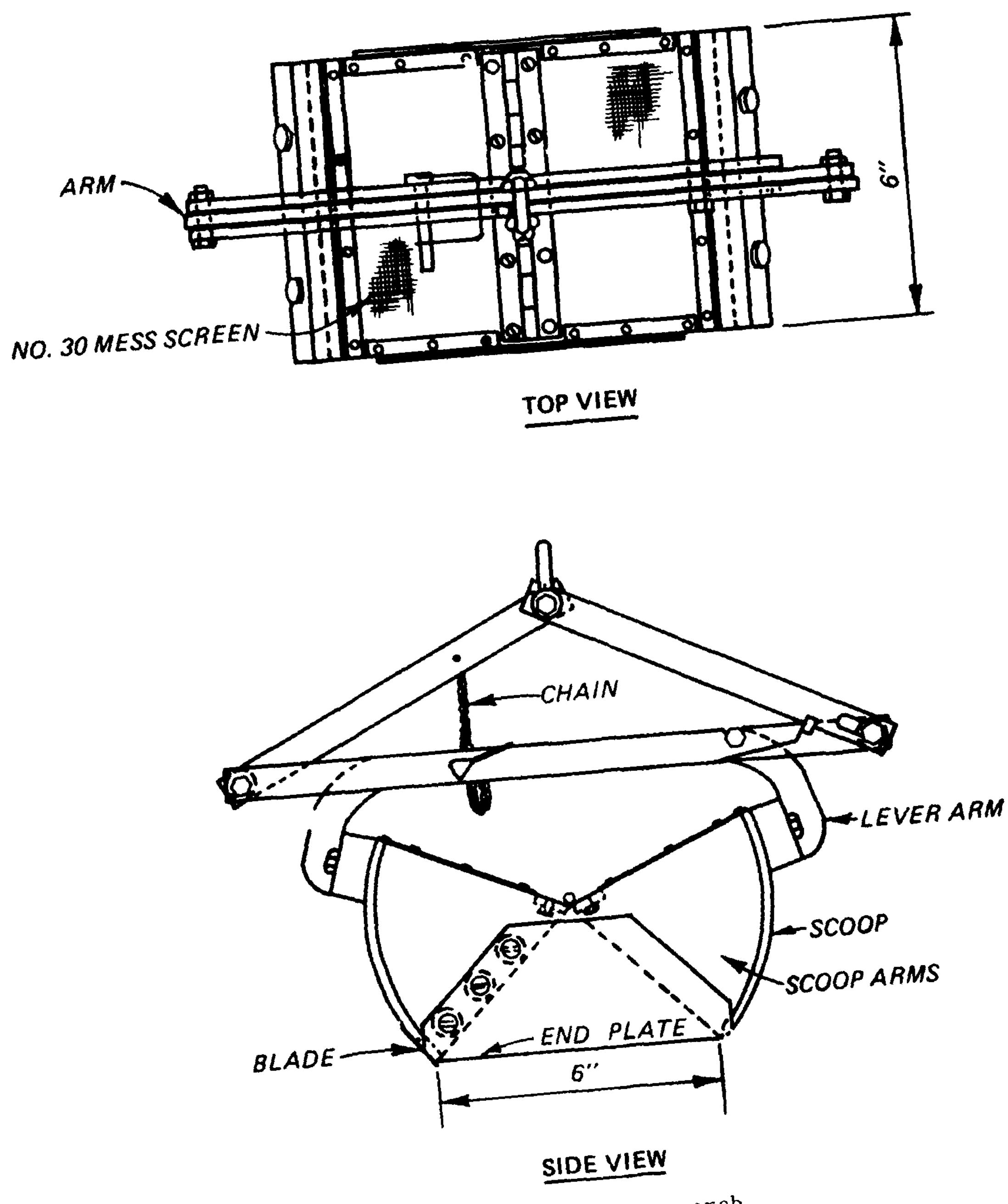



Figure 3. Petite Ponar grab

Standard Ponar grab. Otherwise, design features are identical, so it was expected that "per grab" sampling efficiency in similar habitats would be similar. If this proved true, then sampling with the Petite Ponar grab offered a means of approximately doubling sample replication, as compared to the Standard Ponar, and with little additional effort.

## Study Purpose and Scope

10. Although both the Petite Ponar and Shipek grabs offer potential for benthic macroinvertebrate sampling purposes within the LMR, the sampling efficiency of each within this system is untested. Therefore, the purpose of this study was to conduct a sampling gear efficiency evaluation to determine to what extent the Shipek and Petite Ponar grabs would be applicable for sampling purposes within this system. As previously discussed, the Standard Ponar grab is generally considered capable of efficiently sampling the widest variety of substrates (American Public Health Association 1975) and has been extensively evaluated (Flannagan 1970, Powers and Robertson 1967, etc.). Therefore, the Standard Ponar grab was used in this study as a reference from which to evaluate the relative sampling efficiency of both the Shipek and Petite Ponar grabs.

## Study Area

### Rationale for site selection

11. As mentioned in the introduction, the Standard Ponar grab has several deficiencies when attempting to sample under deep, swift water conditions and especially when the stream bottoms are firm and/or have a steep slope. The Shipek grab was suggested as capable of overcoming the deficiencies of the Ponar grab, but its catch efficiency was a factor of concern. Certain basic criticisms of the Shipek grab--shock wave washout of epifauna and reduction of catch due to shallow penetration--were mentioned. Therefore, these attributes of the Shipek required scrutiny. The experience of the authors has shown that the Standard Ponar grab

performs quite well in soft muds under low current conditions, and the Petite Ponar grab was expected to do likewise, since it has similar design features.

12. In order to allow the reduction of catch due to shock wave washout of epifauna and failure to reach deeper burrowing forms to be demonstrated, if severe, a test area that would allow these effects to manifest themselves was needed. A soft mud and silt substrate site known to contain relatively high numbers of both epifauna and deep burrowing oligochaetes was known to exist in Matthews Bend, an abandoned river channel in the Environmental and Water Quality Operational Studies (EWQOS) study area. A test site of this nature favors the Ponar type grabs over the Shipek grab, thus providing a stronger test of the catch efficiency of the Shipek grab.

Time of test

13. For best results, the test should be conducted during a season when macroinvertebrates would be active and well represented, and during that part of the diurnal cycle (daylight hours) that most benthic macroinvertebrate grab sampling is conducted. The spring season during daylight hours was determined as being an appropriate testing time as this would allow the results to be applied to the EWQOS LMR study. Test sample collection was conducted on 8 May 1979 during afternoon hours.

14. The concave bank of Matthews Bend, near its confluence with the main channel, was selected for testing purposes (Figure 4). Matthews Bend is classified as an abandoned river channel, a typical backwater of the LMR. It is characteristically lentic except at higher river stages and has a fairly uniform, unconsolidated mud substrate.

15. The selected sampling site is characteristic of most shoreline habitats of oxbow lakes and abandoned channels within this reach of the LMR. Previous data had shown this site to contain fairly high numbers of a variety of benthic macroinvertebrates characteristic of backwater habitats of the LMR (Mathis et al. 1981). During sampling efforts, there was no discernible current. Water depth over the sampling site was $4 \pm 0.5$ m.

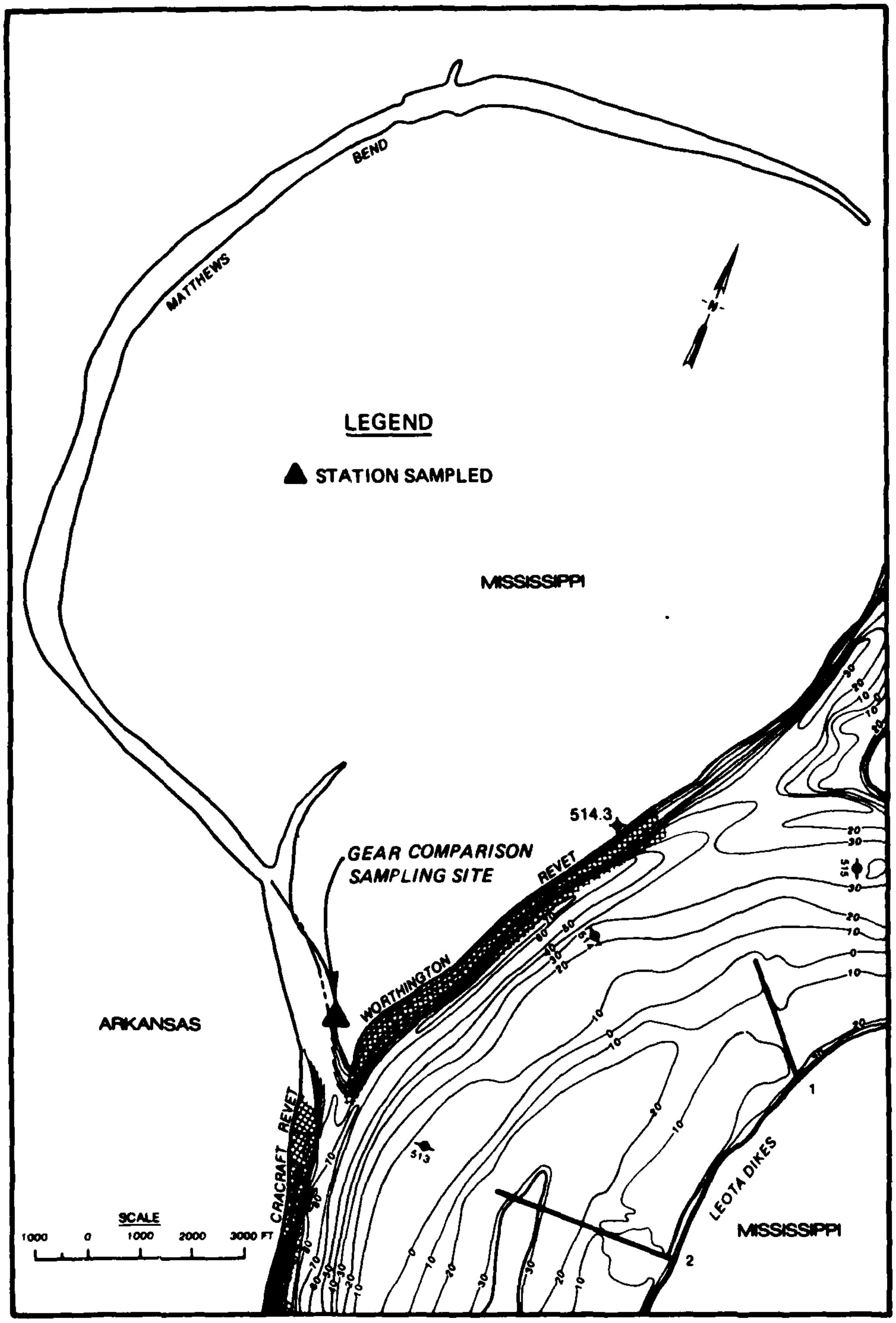



Figure 4. Matthews Bend study area

## Methods and Materials

16. Sampling was from the stern of a 40-ft* vessel. The vessel's bow was tied to a tree on the shoreline. Although the range of water depths during sampling was uniform (4 ± 0.5 m), the vessel's stern was allowed some movement during sampling efforts to minimize interaction between successive grab samples.

17. Drawings of the Standard Ponar grab, the Shipek grab, and the Petite Ponar grab with accompanying specifications are presented in Figures 1, 2, and 3, respectively. The top screens, employed to reduce shock wave propagation, are normally standard No. 30 mesh (600-micron openings) as factory-supplied on the Ponar-type grabs. These screens were replaced with standard No. 35 mesh (500-micron openings) to match sieve size openings desired for EWQOS testing, prior to sampling.

18. Twenty-four samples were taken, eight each with the Shipek grab, Standard Ponar grab, and Petite Ponar grab, consecutively. Each sample was sieved in the field and immediately placed in 5 percent formalin. In the laboratory each sample was removed to a 70 percent ethanol/Rose Bengal staining solution for a minimum of three days. Each sample was then sorted under 3X magnification and identified and enumerated at the lowest practical taxonomic level.

19. Prior to data analyses, counts per sample were standardized to counts per square metre. Spearman's Rank Correlation Coefficient (Spearman 1904) was used to test for the degree of association in assemblage structure estimates between samplers. The ranked estimated relative abundance of each distinct taxon collected by all three samplers was used for this test. *Limnodrilus hoffmeisteri* (variant) was treated as distinct from *L. hoffmeisteri* during analyses.

20. A one-way analysis of variance (ANOV) (Steel and Torrie 1960), using log-transformed data was used to test for significant ($\alpha \leq 0.05$) differences between samples for estimates of average sample standing

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

crop, average number of taxa per sample, and average counts per sample for *Hexagenia* sp., *Sphaerium* sp., *Lirceus* sp., *Ilydorilus templetoni*, *Ilyodrilus* immature, *Limnodrilus hoffmeisteri*, *L. cervix*, and *L.* immatures. Duncan's Multiple Range Test (Steel and Torrie 1960) ($\alpha = 0.05$) was used to locate differences between sampler means when so indicated by the ANOV.

## Results

21. A total of 5696 organisms, representing 24 distinct taxa of benthic macroinvertebrates were collected from 24 grab samples (Table 1). An average of 9.0 distinct taxa were collected per grab with an overall average sample density of 6518.1 organisms/m$^2$.

22. Seventeen distinct taxa were collected from the eight replicate Standard Ponar grabs. An average of 9.4 taxa (coefficient of variation (CV) = 17 percent) were collected per grab with a range of from 7 to 11 taxa per grab (Table 2). Three taxa were collected exclusively with the Standard Ponar. These included one specimen each of Gastropoda, Lepidoptera, and the oligochaete *Aulodrilus pluriseta*.

23. The average sample density obtained with the Standard Ponar was 5210.9 organisms/m$^2$ (CV = 32.8 percent). The most abundant taxon collected was the oligochaete *Ilydorilus templetoni*, representing 24.3 percent of the total sample density (Table 1). Next in order of total abundance were the oligochaete *Limnodrilus cervix*, the pelecypod *Sphaerium* sp., the isopod *Lirceus* sp. and the oligochaetes *Ilyodrilus* (immature), *Limnodrilus* (immature), and *L. hoffmeisteri*, these taxa representing 16.4, 14.0, 13.6, 13.5, 8.5, and 5.9 percent of the total sample density, respectively.

24. Sixteen distinct taxa were collected from the eight replicate Petite Ponar grabs (Tables 1 and 2). An average of 8.1 taxa (CV = 17 percent) were collected per grab with a range of from 6 to 10 taxa per grab. Three taxa were collected exclusively with the Petite Ponar. These included the oligochaete *Peloscolex superiorensis*, immature larvae of Tipulidae (Diptera) and the springtail Collembola.

25. The average sample density obtained with the Petite Ponar was 8473.0 organisms/$m^2$ (CV = 60.9 percent) (Table 2). The most abundant taxon collected was the oligochaete *I. templetoni* representing 22.6 percent of the total sample density. Next in order of total abundance were the oligochaetes *Limnodrilus cervix*, the isopod *Lirceus* sp., *Iyodrilus* (immature), *Limnodrilus* (immature), the pelecypod *Sphaerium* sp. and the oligochaete *L. hoffmeisteri*. Those taxa represented 16.9, 16.5, 13.8, 10.5, 8.2, and 5.6 percent of the total sample density, respectively.

26. Eighteen distinct taxa were collected from the eight replicate Shipek grabs (Tables 1 and 2). An average of 9.5 taxa (CV = 23.9 percent) were collected per grab with a range of from 6 to 14 taxa/grab. Two taxa were collected exclusively with the Shipek grab. These included one specimen each of the oligochaete *Tubifex newaensis* and Coleoptera.

27. The average sample density obtained with the Shipek grab was 5870.3 organisms/$m^2$ (CV = 52.9 percent) (Table 2). The most abundant taxon collected was *Ilydorilus templetoni*, representing 20.3 percent of the total sample density. Next in order of total abundance were the oligochaete *Limnodrilus cervix*, the pelecypod *Sphaerium* sp., the oligochaetes *L.* immature and *I.* immature, the ephemeropteran *Hexagenia* sp., the isopod *Lirceus* sp., and the oligochaete *L. hoffmeisteri*. These taxa represented 18.8, 17.1, 12.2, 11.4, 10.8, 8.7, and 7.3 percent of the total sample density, respectively.

28. The results of Spearman's Test of Association, comparing the ranked relative abundance of each of the 24 distinct taxa as estimated with each grab, are presented in Table 2. This test indicated a highly significant ($\alpha \leq 0.01$) positive association in relative abundance rankings among the three grabs. The highest degree of association was between the Shipek and Standard Ponar (R = 0.86) followed by the Shipek vs. Petite Ponar (R = 0.70) and Petite Ponar vs. the Standard Ponar (R = 0.68).

29. The results of the one-way ANOV are presented in Table 3. This test indicated no significant differences ($\alpha \leq 0.05$) between grabs for estimates of average total density, average number of taxa collected

per sample, or for average counts per taxon for any of the taxa tested except for *Limnodrilus* (immature). Average counts for this taxon were significantly higher for the Petite Ponar as compared to the Standard Ponar; no significant differences were found in estimates for this taxon between the Shipek and the Ponar nor between the Shipek and Petite Ponar.

## Discussion

30. As stated previously, data obtained with the Standard Ponar grab were used during this test as a reference from which to evaluate the effectiveness of the Shipek and Petite Ponar grabs for sampling purposes within the LMR.

31. Test results indicate fairly close agreement between each of the three grab samplers for estimates of assemblage composition and structure of the benthic community. No differences were found that could be directly attributed to differential efficiency of the individual grabs in sampling the deeper burrowing component of the assemblage. Additionally, no differences were found that could be directly attributed to variable sampler "shock-wave" effect, possibly due to the slow standardized rate of descent used for each grab during sampling efforts.

32. The differences between grabs in relative abundance estimates for several taxa are attributed primarily to the highly clumped distribution of these taxa as well as to differences in sampler dimensions (surface area enclosure) of the three grabs. Since the Shipek grab efficiency, as demonstrated in this backwater habitat, appears comparable to the Standard Ponar grab, it is reasonable to assume that its efficiency in the high energy systems where it consistently takes good substrate grabs is superior to that of the Standard Ponar grab which samples the substrate of such sites in a very inconsistent manner. Therefore, the Shipek grab appears to be the logical choice for sampling the high energy sites of the LMR. Also, since the Petite Ponar grab efficiency appeared comparable to that of the Standard Ponar in this backwater habitat, it is reasonable to assume that it will perform in a similar manner in other areas of this nature. Consequently, use of the Petite

Ponar grab in backwater habitats appears logical since it facilitates sampling and allows the taking of a greater number of replicate samples for comparable effort. However, when using the Shipek grab, it is suggested that a slow rate of sampler descent be maintained to minimize "shock-wave" effect, particularly when sampling depositional habitats.

33. Test results indicate that, for the three grab samplers tested, an inverse relationship existed between individual grab sampler dimensions (surface area sample) and data variability, particularly for estimates of assemblage standing crop. The Standard Ponar grab, which sampled the largest surface area of the three grabs tested, exhibited the least variability between replicate samples for estimates of assemblage standing crop. The Petite Ponar, the smallest of the samples tested, collected the fewest total number of distinct taxa, the lowest average number of taxa per sample, and exhibited the highest variability between replicate samples for estimates of assemblage standing crop. Additionally, the highest degree of association in ranked relative abundance estimates of individual taxa inhabiting the study site was found between the Shipek and Standard Ponar grabs (R = 0.86).

34. Word (1976) found that for certain marine substrate types, those new species acquired by collecting second and additional replicate samples at each station usually accounted for 10 percent or less of the total assemblage standing crop at each station. He concluded that useful descriptive information, such as for survey work to describe benthic assemblage composition and relative abundances of taxa comprising the assemblage for fish-food availability studies, could be obtained (at least for some substrate types) with a single grab sample at each station. As shown in Figure 5, this same trend was also evident from data obtained during this study. These test results also indicate, however, that for descriptive studies, data obtained with a single large (surface area) sampler are more representative of the assemblage, in terms of assemblage composition and structure, than data obtained with a single small sampler. Therefore, either the Standard Ponar or Shipek grab (depending on habitat conditions) is recommended over the Petite Ponar grab for descriptive oriented studies within the LMR when a limited number of grabs are required.

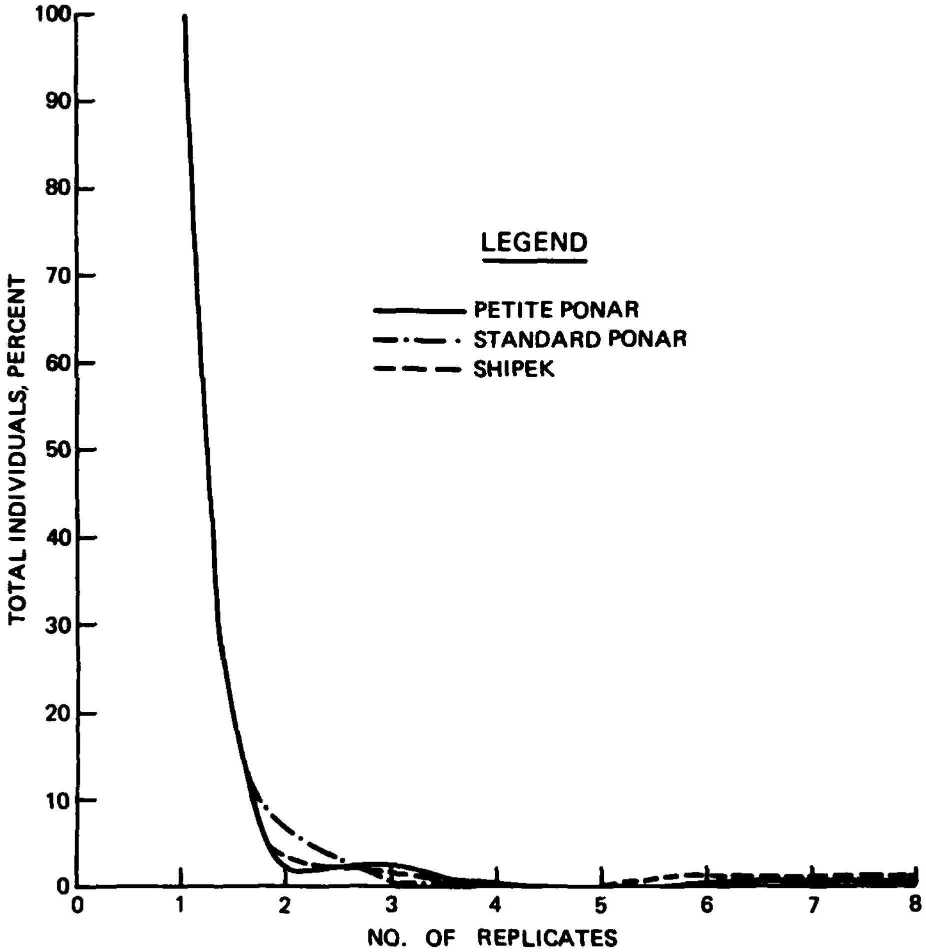


Figure 5. Percent composition
by newly acquired taxa

35. These test results support the findings of Mathis et al. (1981) that benthic assemblages of LMR backwater habitats generally exhibit a clumped pattern of distribution. Green (1979) as well as Elliot (1977) recommend that for comparative studies of these clumped assemblages, greater statistical precision is generally obtained by collecting smaller individual samples with increased sample replication. Elliot (1977) states that the advantages of such an approach include:

a. More small units can be collected and processed for the same amount of labor.

b. Reduced statistical error-of-assemblage estimates as a sample of many small units have more degrees of freedom than a sample of a few large units.

c. Since many small units cover a wider range of the habitat than a few large units, estimates of assemblage variation obtained from the small units are more representative.

Results of these tests indicate that the Petite Ponar obtained representative estimates of the study site benthic assemblage as referenced against data obtained with the Standard Ponar. Therefore, the Petite Ponar grab is recommended over the Standard Ponar for comparative (as opposed to descriptive) studies of LMR backwater habitats because greater replication is possible for hypothesis testing and laboratory processing requirements per sample are reduced. Although greater sampling efficiency (less data variability) is achieved from a given number of replicate samples with the Standard Ponar, the experience of the authors has shown that this is more than offset by the reduced processing and identification time (approximately one-half) for Petite Ponar samples as opposed to the Standard Ponar samples.

36. Given the various habitats listed by Cobb and Clark (1981), the dynamics of the system as discussed herein, and the results of this test, the experience of the authors with the various grab samplers on this river system suggests a matrix (Table 4) with habitat type versus flow condition for choosing a particular grab sampler suited to both river stage and habitat type.

## Conclusions

37. When lowered and seated gently, the Shipek grab can obtain freshwater benthic macroinvertebrate catches that are comparable to the Ponar-type sampler catches and in habitats considered more favorable to use of the Ponar-type grab.

38. The benthic macroinvertebrates catch efficiency of the Petite Ponar grab appears comparable to that of the Standard Ponar grab catch efficiency when sampling lentic soft-bottom habitats.

39. Second and additional sampler replicates accounted for

similarly low percent total assemblage standing crop for each type of grab sampler.

## Recommendations

40. The Shipek grab is recommended over Ponar-type grabs for sampling benthic macroinvertebrates in high-energy sites that are difficult to sample with Ponar-type grabs.

41. The Standard Ponar grab is recommended for survey-type benthic macroinvertebrate sampling on the LMR lentic backwater habitats when a limited number of samples per site are required.

42. The Petite Ponar grab is recommended for comparative benthic macroinvertebrate sampling of LMR lentic backwater habitats for survey-type sampling in these habitats when a larger number of samples per habitat are feasible.

43. One grab per station is recommended, regardless of the type of grab sampler, when sampling for survey purposes within the LMR system.

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Table 1

Distinct Taxa and Total Abundance of Each Collected with the Three Grab Samplers

| Taxon | Petite Ponar | | Standard Ponar | | Shipek | |
|---|---|---|---|---|---|---|
| | No. Collected | Percent of Total Collected | No. Collected | Percent of Total Collected | No. Collected | Percent of Total Collected |
| Arachnoidea | | | | | | |
| Arachnida | | | 2 | 0.092 | 2 | 0.103 |
| Crustacea | | | | | | |
| Isopoda | | | | | | |
| *Lirceus* sp. | 260 | 16.466 | 296 | 13.590 | 169 | 8.716 |
| Amphipoda | | | | | | |
| *Gammarus* sp. | 8 | 0.507 | 9 | 0.413 | 5 | 0.258 |
| Gastropoda | | | 1 | 0.046 | | |
| Insecta | | | | | | |
| Coleoptera | | | | | 1 | 0.052 |
| Diptera | | | | | | |
| *Chaoborus* sp. | | | 4 | 0.184 | 7 | 0.361 |
| *Pentaneura* sp. | 2 | 0.127 | 6 | 0.275 | 5 | 0.258 |
| Ceratopogonidae | 4 | 0.253 | 4 | 0.184 | 3 | 0.155 |
| Chironomidae | 2 | 0.127 | 5 | 0.230 | 6 | 0.309 |
| Tipulidae larva | 1 | 0.063 | | | | |
| Collembola | 1 | 0.063 | | | | |
| Ephemeroptera | | | | | | |
| *Hexagenia* sp. | 20 | 1.267 | 48 | 2.204 | 21 | 10.830 |
| Lepidoptera | | | 1 | 0.046 | | |
| Oligochaeta | | | | | | |
| Opisthopora | | | | | | |
| Lumbricidae | | | 5 | 0.230 | 3 | 0.155 |

(Continued)

Table 1 (Concluded)

| Taxon | Petite Ponar No. Collected | Petite Ponar Percent of Total Collected | Standard Ponar No. Collected | Standard Ponar Percent of Tctal Collected | Shipek No. Collected | Shipek Percent of Total Collected |
|---|---|---|---|---|---|---|
| Plesiopora | | | | | | |
| *Aulodrilus pluriseta* | | | 1 | 0.046 | | |
| *Dero* sp. | 1 | 0.063 | | | 6 | 0.309 |
| *Ilydorilus templetoni* | 357 | 22.609 | 530 | 24.334 | 394 | 20.320 |
| *Limnodrilus cervix* | 267 | 16.909 | 357 | 16.391 | 365 | 18.824 |
| *Limnodrilus hoffmeisteri* | 88 | 5.573 | 128 | 5.877 | 142 | 7.323 |
| *Limnodrilus hoffmeisteri* (variant) | 5 | 0.317 | 8 | 0.367 | 13 | 0.670 |
| *Peloscolex multisetosis* | 7 | 0.443 | | | 1 | 0.052 |
| *Peloscolex superiorensis* | 10 | 0.633 | | | | |
| *Tubifex newaensis* | | | | | 1 | 0.052 |
| *Ilyodrilus* (immature) | 208 | 13.802 | 280 | 13.480 | 222 | 11.449 |
| *Limnodrilus* (immature) | 158 | 10.484 | 185 | 8.494 | 241 | 12.243 |
| Pelecypoda | | | | | | |
| *Sphaerium* sp. | 129 | 8.170 | 305 | 14.004 | 332 | 17.122 |
| Total no. of organisms collected | 1579 | | 2178 | | 1939 | |
| Average no. of organisms | 197.38 | | 272.25 | | 242.38 | |

Table 2

Summary Statistics for Gear Evaluation Test

| | Ponar | Petite Ponar | Shipek |
|---|---|---|---|
| | Distinct Taxa | | |
| Mean, no. of taxa | 9.4 | 8.1 | 9.5 |
| Coefficient of variation, percent | 17.0 | 16.8 | 23.9 |
| Total collected, no. of taxa | 17 | 16 | 18 |
| | Standing Crop | | |
| Mean, no. of individuals (per square metre) | 5210.9 | 8473.0 | 5870.3 |
| Coefficient of variation, percent | 32.8 | 60.9 | 52.9 |

Spearman's Rank Test of Association

| Comparison | R Value (degrees of Freedom (df) = 22) |
|---|---|
| Ponar vs. Petite Ponar | 0.68 |
| Ponar vs. Shipek | 0.86 |
| Shipek vs. Petite Ponar | 0.70 |

Table 3

One-Way Analysis of Variance*

| No. of Taxa | Petite Ponar | Standard Ponar | Shipek |
|---|---|---|---|
| | | Distinct Taxa | |
| $\bar{X}$ | 8.1 | 9.4 | 9.5 |
| $S_x$ | 1.356 | 1.598 | 2.268 |
| $S_{\bar{x}}$ | 0.479 | 0.565 | 0.802 |
| | | | F** = 1.401 (N.S.) |
| | | Total Densities† | |
| $\bar{X}$ | 8473.0 | 5210.9 | 5870.3 |
| $S_x$ | 5161.24 | 1706.57 | 3104.83 |
| $S_{\bar{x}}$ | 1824.77 | 603.36 | 1097.72 |
| | | | F = 2.294 (N.S.) |
| | | *Lirceus* sp. Densities | |
| $\bar{X}$ | 1394.4 | 708.2 | 511.6 |
| $S_x$ | 1661.82 | 590.47 | 407.64 |
| $S_{\bar{x}}$ | 587.54 | 208.76 | 144.12 |
| | | | F = 2.123 (N.S.) |
| | | *Sphaerium* sp. Densities | |
| $\bar{X}$ | 694.3 | 729.7 | 1005.1 |
| $S_x$ | 269.83 | 305.63 | 562.5 |
| $S_{\bar{x}}$ | 95.40 | 108.06 | 198.8 |
| | | | F = 1.128 (N.S.) |
| | | *Ilyodrilus templetoni* Densities | |
| $\bar{X}$ | 854.1 | 1268.0 | 1192.8 |
| $S_x$ | 883.46 | 1011.85 | 1174.95 |
| $S_{\bar{x}}$ | 312.35 | 357.74 | 415.41 |
| | | | F = 2.420 (N.S.) |

(Continued)

* $\bar{X}$ = mean; $S_x$ = standard deviation; $S_{\bar{x}}$ = standard error; N.S. = not significant.

** F is the estimate of variance from the means divided by the estimate of variance from individuals.

† Densities are given in number/m$^2$.

Table 3 (Concluded)

| No. of Taxa | Petite Ponar | Standard Ponar | Shipek |
|---|---|---|---|
| | *Ilyodrilus* (immature) Densities | | |
| $\bar{X}$ | 1281.0 | 669.9 | 672.1 |
| $S_x$ | 1961.92 | 791.55 | 827.11 |
| $S_{\bar{x}}$ | 693.64 | 279.85 | 292.43 |
| | | | F = 0.882 (N.S.) |
| | *Hexagenia* sp. Densities | | |
| $\bar{X}$ | 107.6 | 114.8 | 63.58 |
| $S_x$ | 97.65 | 47.99 | 31.55 |
| $S_{\bar{x}}$ | 34.52 | 16.96 | 11.15 |
| | | | F = 0.938 (N.S.) |
| | *Limnodrilus cervix* Densities | | |
| $\bar{X}$ | 1437.1 | 854.1 | 1105.0 |
| $S_x$ | 849.40 | 512.64 | 751.54 |
| $S_{\bar{x}}$ | 300.31 | 181.25 | 265.71 |
| | | | F = 0.153 (N.S.) |
| | *Limnodrilus hoffmeisteri* Densities | | |
| $\bar{X}$ | 473.7 | 306.4 | 429.9 |
| $S_x$ | 369.70 | 202.60 | 117.05 |
| $S_{\bar{x}}$ | 130.71 | 71.63 | 41.38 |
| | | | F = 1.547 (N.S.) |
| | *Limnodrilus* (immature) Densities | | |
| $\bar{X}$ | 958.1 | 445.0 | 729.6 |
| $S_x$ | 194.96 | 491.90 | 525.47 |
| $S_{\bar{x}}$ | 68.93 | 173.91 | 185.78 |
| | | | F = 3.744 (Significant) |

Table 4

Preferred Grab Sampler* by Habitat Type and Flow Condition on LMR

| No. | Habitat Type | Low Flow | Moderate Flow | High Flow |
|---|---|---|---|---|
| 1 | Main Channel | SHK | SHK | SHK |
| 2 | Natural banks | SHK | SHK | SHK |
| 3 | Revetted banks | NA | NA | NA |
| 4a | Sandbar slack-water pools | PPON | PPON | NA |
| 4b | Natural sandbars | PPON | SHK | SHK |
| 5a | Dike field pool areas | PPON | SHK | SHK |
| 5b | Dike field sandbars | PPON | SHK | SHK |
| 6 | Permanent secondary channels | SHK | SHK | SHK |
| 7 | Temporary secondary channels | PPON | SHK | SHK |
| 8 | Abandoned channel Type I | PPON | PPON | PPON |
| 9 | Abandoned channel Type II | PPON | PPON | PPON |
| 10 | Oxbow lakes | PPON | PPON | PPON |
| 11 | Borrow pits | PPON | PPON | PPON |
| F | Inundated flood plain | NA | NA | NA |

* SHK = Shipek grab; PPON = Petite Ponar grab; NA = not applicable.

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Grab samplers for benthic macroinvertebrates in the Lower
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  Experiment Station). -- Vicksburg, Miss. : The Station ;
  Springfield, Va. : available from NTIS, 1982.
  21, 6 p. : ill. ; 27 cm. -- (Miscellaneous paper ; E-82-3)
  Cover title.
  "July 1982."
  Final report.
  "Prepared for Office, Chief of Engineers, U.S. Army under
EWQOS Work Unit VIIB."
  At head of title: Environmenta & Water Quality Operational
Studies.
  Bibliography: p. 21.

  1. Aquatic invertebrates. 2. Benthos. 3. Freshwater inver-
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  Mississippi River ... 1982.

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ways Experiment Station) ; E-82-3.
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