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MACROINVERTEBRATES IN THE SAVANNAH RIVER BELOW RICHARD B. RUSSELL LAKE GEORGIA AND SOUTH CAROLINA

by

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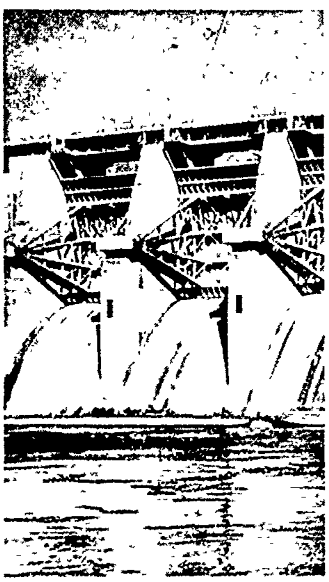

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A survey of the macroinvertebrate community in the Savannah River below Richard B. Russell Lake, Georgia and South Carolina, was conducted in October 1989. The purpose was to collect benthic data prior to maintenance dredging in the river immediately below the dam. The macroinvertebrate fauna in this reach of the Savannah River was dominated by oligochaete worms (64.8 percent) with lesser numbers of chironomid larvae (10.7 percent), the phantom midge *Chaoborus* sp. (8.1 percent), and bivalve molluscs (9.0 percent). Macroinvertebrates other than these groups were uncommon (3.8 percent) and consisted mainly of Trichopterans (*Crynellus fraternus* and *Oecetis* sp.), the Megalopteran *Sialis rotunda* and the burrowing mayfly, *Hexagenia* sp. Total macroinvertebrate density at six stations ranged from 237.3 ±41.4 to 2,480.0 ±247.7 (± SE) individuals/sq m. Sixteen species of chironomidae were identified; species diversity (2.05) and evenness (0.74) were moderate for this group. Fourteen species of oligochaetes were identified; species diversity (1.48) and evenness (0.56) were substantially less than for chironomidae. Three chironomids (*Ablabesmyia annulata*, *Cryptochironomus* sp., and *Procladius* sp.

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19. ABSTRACT (Continued).

Procladius sp.) comprised more than 68 percent of the chironomid assemblage. The oligochaete fauna was dominated by *Aulodrilus piqueiti* (60.4 percent) and *A. limnobius* (76.4 percent). Since macroinvertebrate density was substantially less at the station proposed for dredging, this action is likely to have little widespread negative effect on resident aquatic macroinvertebrates or higher trophic level organisms.

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PREFACE

In October 1989, the US Army Engineer Waterways Experiment Station (WES) initiated invertebrate studies in the Savannah River immediately below Richard B. Russell Lake, Georgia and South Carolina, for the the US Army Corps of Engineers, Savannah District (CESAS). The purpose was to collect baseline information on invertebrates to evaluate the effects of proposed dredging operations.

This report was prepared by Dr. Andrew C. Miller and Mr. C. Rex Bingham of the Aquatic Habitat Group (AHG), WES. Assistance in the field was provided by Mr. William Jabour at the WES laboratory near the site and by Mr. Mike Alexander from the CESAS project office. Assistance in the laboratory was provided by Ms. Sarah Wilkerson, WES.

Mr. Edwin Theriot was Chief, AHG, Dr. Conrad J. Kirby was Chief, Environmental Resources Division, and Dr. John Harrison was Chief, Environmental Laboratory at WES during preparation of this report. Mr. David Coleman, CESAS, monitored the study and reviewed an early draft of the report. The report was edited by Ms. Janean Shirley of the WES Information Management Division, Information Technology Laboratory.

Commander and Director of WES was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
gallons (US liquid)	3.785412	cubic decimetres
microns	0.001	millimetres
miles (US statute)	1.609347	kilometres

MACROINVERTEBRATES IN THE SAVANNAH RIVER BELOW RICHARD B. RUSSELL LAKE GEORGIA AND SOUTH CAROLINA

PART I: INTRODUCTION

Background

1. The US Army Engineer District, Savannah (CESAS), is planning to dredge the Savannah River immediately below Richard B. Russell (RBR) Lake, Georgia and South Carolina. Dredging will be conducted to convey the expected flows during capacity pumpback and capacity generation at the hydropower facility. Recently many aquatic habitats have been altered by channel diversion, modification, or construction of dams (Standford and Ward 1979). This demand on lotic habitats has brought about a concern in the effects of habitat manipulation on freshwater biota.

Purpose and Scope

2. The purpose was to obtain baseline data on sediment characteristics and benthic invertebrates in the Savannah River immediately below RBR Lake, Georgia and South Carolina. This information will be used by CESAS to evaluate the effects of proposed dredging on benthic biota.

PART II: STUDY AREA AND METHODS

Study Area

3. The Savannah River originates at the convergence of the Tugaloo and Seneca Rivers near Hartwell, in northeast Georgia. Both rivers have their headwaters on the southern slope of the Blue Ridge Mountains in North Carolina. From the 5,500-ft* altitude at the headwaters the river descends to approximately 1,000 ft in the Georgia-South Carolina Piedmont to about 200 ft at Augusta, GA. This 341-mile-long river flows predominantly southeast, and serves as the boundary between Georgia and South Carolina. The river enters the Atlantic Ocean near Savannah, GA (Bartlett 1984).

4. The drainage basin is located in the Piedmont Physiographic Province and is underlain by Precambrian age granite and metasedimentary gneiss and schist of the Little River series. Stratigraphic units consist of rocks of the Lower Little River series, recent alluvial soils consist of silty and poorly graded sands high in organic material, and residual soils composed of sand, silt, and clay. The rocks are of igneous or metamorphic origin and include granite, gneisses, schists, basic eruptives, and highly metamorphosed shales, sandstones, and limestone. Land use consists mainly of woodlands and pasture with lesser amounts of cultivated cropland. Recreational and urban areas comprise a minor component of the watershed. The waters of the Savannah River above Clarks Hill Dam (river kilometer 386) are relatively free of pollution (James et al. 1985).

5. The study area includes the upper reach of Clarks Hill Lake, immediately below RBR Lake (km 442) in McCormick County, South Carolina, and Elbert County, Georgia. In the study area the river is wide (approximately 0.5 mile), with a maximum depth of 20 to 30 ft. With the exception of the tailwaters of RBR Dam, water velocity in the study area was less than 0.1 ft/sec. Riparian areas are well vegetated, consisting mainly of pines and shrubs.

6. Samples were collected at six stations on 17-18 October 1989 (Figure 1). Samples were collected at stations 1-2 on 17 October; the remaining four stations were sampled on 18 October. The following is a brief description of the six stations:

a. ***Station 1.*** Station 1 was southwest of buoy 140, located just inside the mouth of a small embayment. The water depth was 21 ft.

b. ***Station 2.*** This station was approximately 350 ft upriver of buoy 149 in the main channel. The depth was 22 ft. This station was located in the area to be dredged.

c. ***Station 3.*** Station 3 was located downriver of the embayment approximately 10-20 ft off the right descending bank (RDB) of the river. The depth was approximately 20 ft.

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

d. ***Station 4***. This station was located east of station 3 and in the main channel. Samples were taken immediately downriver of buoy 140. The water was 21 ft deep.

e. ***Station 5***. Station 5 was located immediately upriver of buoy 140 and approximately 10-20 ft off the left descending bank (LDB) of the river. Water depth was approximately 30 feet.

f. ***Station 6***. This station was located in the mouth of Russell Creek in water approximately 25 ft deep. Station 6 was approximately 200 ft from the LDB.

Methods

7. At each station six sediment samples were collected with a Ponar Grab sampler (522.6 cm^2) operated from the bow of the boat with an electric winch. Five samples were separately sieved through a standard US Geological Survey No. 35 mesh sieve bucket. Detritus and organisms remaining on the sieve were placed in 1-L plastic bottles. These samples were preserved in the field with buffered 10-percent Formalin that was stained with rose bengal to facilitate locating and removing organisms. The sixth sediment sample was placed on ice and returned to the laboratory at the US Army Engineer Waterways Experiment Station (WES) for analysis of organic content. Organic content was determined by first drying the sample at 65^{o} C, weighing, then heating in a muffle furnace to 550^{o} C. The weight after firing at this latter temperature is termed "ash-free dry weight" and is the loss due to volatilization of organic material.

8. In the laboratory, benthic invertebrates were removed from sediments by an elutriation process. Sediment samples were agitated (swirled) in a 3-gal bucket and poured through a 500-μ mesh sieve. Lighter material (detritus and invertebrates) was poured out of the bucket, sand and gravel remained on the screen, and fine silt passed through the screen. Each sample was elutriated five times; lighter material was combined, and sand and gravel were discarded. Tests have indicated that this process retrieves 90 to 100 percent of the invertebrates on sand and gravel substrate.

9. Invertebrates were picked from the elutriated sample with the aid of a binocular microscope. Organisms were first sorted to major group (chironomids, oligochaetes, ephemeropterans, etc.) and counted. Following this initial analysis, chironomids, oligochaetes, and other invertebrates were identified to the lowest possible taxon with appropriate keys. Voucher specimens have been retained at WES.

10. Five individual rocks were picked from the riprap immediately below RBR dam on the right descending bank. Each rock was separately placed in a plastic zip-lock bag and preserved with 10-percent buffered Formalin. In the laboratory each rock was brushed to remove all detritus and attached organisms. Organisms were picked, counted, and identified.

PART III: RESULTS

Physical Conditions

11. Bottom sediments at stations surveyed in the Savannah River consisted almost entirely of fine-grained silt and sand. Little coarse-grained material (sand or gravel) was found at the stations surveyed, although larger particle sizes would be found near the tailwaters of RBR Lake. Percentage organic matter ranged from a minimum of 0.6 percent to 11.7 percent (Figure 2a). Percentage organic matter was similar at all sites, except at station 2, which consisted almost entirely of sand. This station was located in the area to be dredged.

12. Organic material consisted mainly of partially decayed twigs and leaves from evergreen trees within the watershed. This allocthonous material ranged from 1.2 to 21.1 g/sample at the six stations (Figure 2b). The lowest value was obtained at station 6 at the mouth of Russell Creek.

Biological Conditions

Macroinvertebrate community composition

13. The macroinvertebrate fauna in the Savannah River below RBR Lake was dominated by oligochaete worms (64.8 percent, Figure 3a). Immature chironomids, the phantom midge *Chaoborus*, and bivalve molluscs were subdominant and comprised 10.7, 8.1, and 9.0 percent of the assemblage, respectively. Bivalve molluscs consisted of two species, *Corbicula fluminea* and *Musculium transversum*. The only mayfly collected was the *Hexagenia* sp., a genus common in silt and mud in lentic habitats (Pennak 1978). Macroinvertebrates other than these groups were uncommon (3.8 percent) and consisted mainly of Trichopterans (*Crynellus fraternus* and *Oecetis* sp.) and the Megalopteran *Sialis rotunda* (Table 1).

14. There was considerable inter-site variability with respect to relative abundance of chironomids and oligochaetes (Figure 3b). Oligochaetes comprised 87.1 percent of these three groups at station 2 (where substrate consisted mainly of sand), and from 71.3 to 79.2 percent at stations 4, 5, and 6. At stations 1 and 3, relative numbers of oligochaetes were minimal, and comprised 32.5 and 20.8 percent of the assemblage, respectively. At these latter two stations, *C. fluminea*, *M. transversum*, *Chaoborus* sp., and *Hexagenia* sp. were comparatively more common than at the other four stations. Stations 1 and 3 were located immediately adjacent to Bobby Brown State Park (Figure 1), characterized by extensive unaltered riparian cover.

Macroinvertebrate density

15. Total macroinvertebrate density ranged from 237.3 ±41.4 to 2,480.0 ±247.7 (± SE) individuals/sq m at the six stations in the Savannah River (Table 2, Figure 4a). The highest variation in total macroinvertebrate density among the five replicate samples was at station 6 (ratio of range to density equaled 2.01); the lowest variation in

density estimates was at station 4 (ratio of range to density equaled 0.66). Lowest densities were found at station 2 (to be dredged) and at station 3. Total densities at stations 1, 4, 5, and 6 were similar. Based on the Kruskal-Wallis statistic (20.8), total density of macroinvertebrate populations was significantly different among the six stations ($p < 0.001$).

16. The highest densities of chironomidae were at station 1; oligochaete densities were greatest at station 4 (Figures 4b and 4c, respectively). Macroinvertebrates other than chironomids and oligochaetes were comparatively dense at station 1, moderately dense at stations 3 to 6, and in very low densities at station 2 (Figure 4d).

17. Correlations between percentage organic matter and density of macroinvertebrates, chironomidae, oligochaetes, and other invertebrates were positive but nonsignificant at the 0.05 level. Densities of all groups were lowest at station 2 where sand substrate predominated; however, densities at the other five stations were variable and not specifically related to organic content of sediment.

18. The relationship between cumulative species and cumulative individuals collected for the chironomidae and oligochaeta at all six stations (plotted consecutively) are displayed graphically in Figures 5a and 5b, respectively. A total of 16 species of chironomidae were identified (Table 3); the species-area curve depicted in Figure 5a indicates that new species were added to the list regularly. Although the curve shows a tendency to level after 110 individuals were identified, it is likely that this reach of the river supports more than 16 species of chironomidae. Species diversity for the chironomidae was moderately high (2.05, Table 3). Maximum possible diversity was 2.77 (species diversity assuming an equitable distribution among individuals of all species present). Evenness, which ranges from a theoretical low of near 0.0 to a high of near 1.0, can be considered moderately high at 0.74.

19. The species-area curve for oligochaeta became level more quickly than that of the chironomidae (Figure 5b). Fourteen species were identified after slightly more than 100 individuals had been identified. This number did not change after nearly 150 individuals had been identified (Table 4). In addition, oligochaete species composition was more similar among stations than the chironomidae. Oligochaete species diversity was less than the chironomidae (2.05). Oligochaete evenness was only 0.56, which was less than for the chironomidae (0.74).

20. Three taxa of chironomids (*Ablabesmyia annulata, Cryptochironomus* sp., and *Procladius* sp.) comprised more than 68 percent of the chironomid assemblage (Table 3). A graphical depiction of percentage abundance versus species rank (Figure 6a) for the chironomidae illustrates the comparatively even distribution of individuals among species. In contrast the curve for the oligochaeta reflects the extreme dominance of a single oligochaete, *Aulodrilus piqueiti*, which comprised more than 60 percent of this assemblage (Table 4, Figure 6b). This species plus *A. limnobius* totaled 76.4 percent of the oligochaete assemblage.

21. Relative abundance of major groups differed on the rock substrate of riprap versus that of benthic sediments in the Savannah River. Chironomids and oligochaetes

composed 42.4 percent and 56.6 percent, respectively, on the riprap as compared with 10.7 and 64.8 percent, respectively, in the benthic sediments (Figure 3a). Five species of chironomids (*A. mallochi*, *Dicrotendipes neomodestus*, *Endochironomus subtendis*, *Nanocladius minimus*, and *Tanytarsus querlus*) that were not found in benthic sediments were collected on the rock riprap (Table 5). These species are commonly found in coarse-grained substrates or sand and are relatively uncommon in mud or silt. The addition of five species to the list of chironomids from the riprap attests to the value of this material for increasing habitat and species diversity. The chironomids, as compared with the oligochaetes, benefited from the addition of riprap.

22. Mr. Mike Alexander, CESAS, collected shells of freshwater mussels (Unionidae) from an area immediately downriver of RBR Lake on the left descending bank of the river in the summer of 1989. The collection consisted of five species (*Elliptio complanata, E. lanceolata*, *Anodonta grandis*, *Anodonta imbecillis*, and *Alasmidonta undulata)*. The latter three are thin-shelled species indicative of soft substrate and lentic conditions (Parmalee 1967). The genus *Elliptio* is found in streams, rivers, and lakes in the Central and Eastern United States, and, like the other species of unionids collected during the survey, this species is not endangered and has no commercial value.

PART IV: DISCUSSION

Major Findings

23. The dominant taxa in this reach of Savannah River, tubificid worms, are typically found in slack-water habitats with silt or mud bottom. Many species of tubificids are considered to be tolerant of poor water quality, including low dissolved oxygen and high temperature (Brinkhurst and Cook 1974). *Branchiura sowerbyi* is a large, warmwater worm that is found in rivers and lakes although usually not in high densities except near thermal releases. *Ilyodrilus templetoni* is one of the most common tubificids in North America and usually achieves its highest densities in organically enriched substrate. Under optimal conditions, generation time for *I. templetoni* can be 6 weeks. Both species reproduce sexually but are capable of reproducing by fragmentation. *Aulodrilus piqueti* is a cosmopolitan oligochaete species that seems to prefer silt over sand and gravel substrate. Its primary mode of reproduction is asexual but it also reproduces sexually.

24. A comparatively uncommon oligochaete, *Piquetiella michiganensis* comprised approximately 1 percent of the assemblage in this reach of the Savannah River. This species has been reported in north-central North America only as far south as Virginia (Brinkhurst 1986). It has been collected in the Great Lakes and upper Mississippi River east to the Susquehanna and Chemung Rivers in New York (Hiltunen and Klemm 1980; Klemm 1985), and south to the Wabash River in southern Indiana.* This species has recently been found in Luxapalila Creek in Alabama (Bingham and Miller 1990). The apparent disjunct distribution of this species is likely the result of the lack of detailed taxonomic investigations of this group.

25. The chironomidae (immature midges) are common to abundant in rivers and lakes. *Chironomus* sp., *Ablabesmyia* sp., and *Procladius* sp. inhabit a wide range of lentic and lotic habitats often achieving high numbers in organically enriched substrates. The genus *Cryptochironomus* tolerates a wide range of water quality conditions but is usually not found in grossly polluted water.

26. Although the phantom midges (*Chaoborus* sp.) are found in bottom sediments, they exhibit pronounced daily vertical migratory movements. They remain in the mud near the substrate-water interface by day but in the night they move up to the surface and feed on crustaceans and insect larvae that they capture with their prehensile antennae.

27. Mayflies in the genus *Hexagenia* are borrowers, building U-shaped tubes through which they circulate water by movement of their gills (Pennak 1978; Hynes 1970). These invertebrates are typically found in the top 5-10 cm of mud or silt in lakes, ponds, and depositional zones in streams. Lotic caddisflies (trichopterans) of Southern streams are usually found attached to hard substrate such as rock or vegetation in

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* Personal communication, 1990, Dr. Michael S. Loden, Jefferson Parish Environmental Department, Jefferson, LA.

moderately fast to swift water. Many species spin nets and capture particulate organic matter and possibly small crustaceans or protozoans. Densities of this group are usually relatively low in sand or mud substrate in large rivers.

28. Typically, cumulative species is a linear function of the logarithm of the cumulative number of individuals (e.g., McNaughton and Wolf 1973). The lack of a semilogarithmic relationship between cumulative species and cumulative individuals for chironomidae (Figure 5a) was primarily because more species of this group probably occur in this reach of the Savannah River than were identified. The semilogarithmic nature of Figure 5b indicates that richness for the oligochaetes was low (and most species present were collected) in this reach of the river.

29. The dominance-diversity plots for chironomids (Figure 6a) illustrated the comparative even distribution of this group in the Savannah River. Conversely, the plot for oligochaetes (Figure 6b) shows the extreme dominance by two species and the relative uneven distribution of this assemblage. Typically, a range in species abundance of 3 to 5 orders of magnitude is associated with a rich assemblage of species (McNaughton and Wolf 1973).

Summary and Conclusions

30. The macroinvertebrate fauna of the Savannah River immediately below RBR Lake is dominated by oligochaetes and chironomids, with lesser numbers of burrowing mayflies and bivalve molluscs. The fauna is indicative of large, slow-moving rivers or reservoirs in the Southeast. Variability among stations with respect to species richness, total density, and density of major groups was notable although not extreme. Variation in biotic parameters was the result of differences in substrate composition, depth, distance to shore, and natural variability in macroinvertebrate distribution.

31. The dredging proposed by CESAS will take place in a reach of the river with moderate velocity and high sand content. Macroinvertebrate density was substantially less at this station than at the other stations surveyed. Therefore, the proposed dredging is unlikely to have a widespread negative effect on the aquatic macroinvertebrates or species in higher trophic levels that use these organisms for food.

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Table 1
Macroinvertebrates Other Than Chironomidae and Oligochaeta in the Savannah River, Georgia and South Carolina, Immediately Below Richard B. Russell Lake, October 1989

Class: Pelecypoda (clams, mussels)
  Corbiculidae
    Corbicula fluminea
  Sphaeriidae
    Musculium transversum
Order: Diptera (flies, mosquitoes, midges)
  Chaoboridae
    Chaoborus sp.
Order: Epemeroptera (mayflies)
  Ephemeridae
    Hexagenia sp.
Order: Megaloptera (fishflies)
  Sialidae
    Sialis rotunda
Order: Trichoptera (caddisflies)
  Polycetropodidae
    Cyrnellus fraternus
  Leptoceridae
    Oecetis sp.

Table 2
Summary Statistics for Total Macroinvertebrates at Six Stations in the Savannah River Below Richard B. Russel Dam, Georgia and South Carolina, October 1989

Station	Mean Density	Standard Error
1	1,496.4	269.3
2	237.3	41.4
3	642.9	81.8
4	2,480.0	247.7
5	1,890.6	444.5
6	1,106.1	332.1

Table 3
Distribution of Individuals Among Species of Chironomidae from Six Stations in the Savannah River, Georgia and South Carolina, October 1989*

Chironomidae	p
Ablabesmyia annulata	0.1313
Ablabesmyia peleenis	0.0303
Chironomus decorus gr.	0.0101
Chironomus plumosus	0.0101
Chironomus riparius	0.0303
Chironomus salinaris gr.	0.0101
Coelotanypus cocinnus	0.0505
Cryptochironomus sp.	0.3333
Endocchironomus nigricans	0.0101
Glyptotendipes sp.	0.0101
Microchironomus sp.	0.0202
Orthocladius sp.	0.0101
Paratendipes sp.	0.0101
Polypedilum nr. *scalaenum*	0.0606
Procladius sp.	0.2222
Tanytarsus querlus	0.0505

Total number of taxa	16
Total individuals	99
Diversity index (H′)	2.05
Maximum diversity	2.77
Evenness	0.74

Note: Shannon Weaver Diversity Index ($Log_{2.3026}$)
* p = relative abundance.

Table 4
Distribution of Individuals Among Species of Oligochaetes from Six Stations in the Savannah River, Georgia and South Carolina, October 1989*

Oligochaeta	p
Aulodrilus limnobius	0.1593
Aulodrilus piqueiti	0.6044
Branchiura sowerbyi	0.0330
Chaetogaster diaphane	0.0110
Dero digitata	0.0330
Dero nivea	0.0110
Dero obtusa	0.0055
Ilyodrilus tempeltoni	0.0330
Limnodrilus hoffmeisteri	0.0055
Nais elinquis	0.0110
Piquetiella michiganensis	0.0110
Prostoma rubrum	0.0275
Specaria josinae	0.0165
Uncinais uncinata	0.0385
Total number of taxa	14
Total individuals	182
Diversity index (H′)	1.48
Maximum diversity	2.64
Evenness	0.56

Note: Shannon Weaver Diversity Index ($Log_{2.3026}$)
* p = relative abundance.

Table 5
Distribution of Individuals Among Species of Chironomidae Collected from Individual Riprap in the Savannah River, Georgia and South Carolina, October 1989*

Chironomidae	p
Ablabesmyia mallochi	0.0370
Chironomus plumosus	0.1852
Cryptochironomus sp.	0.0370
Dicrotendipes neomodestus	0.0370
Dicrotendipes sp.	0.0370
Endocchironomus nigricans	0.1852
Endochironomus subtendis	0.0370
Nanocladius minimus	0.0370
Tanytarsus coffmani	0.0741
Tanytarsus querlus	0.3333

* p = relative abundance.

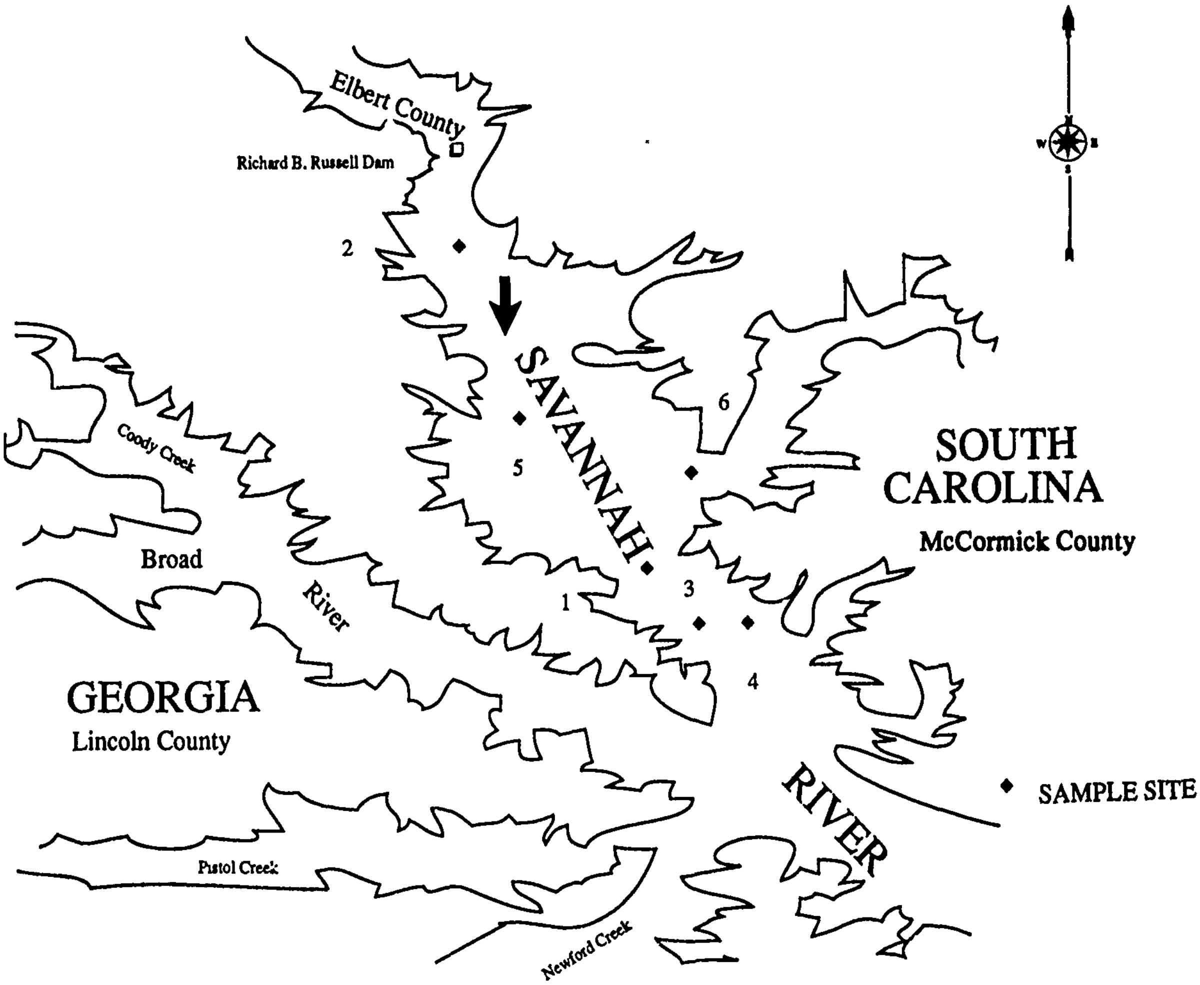
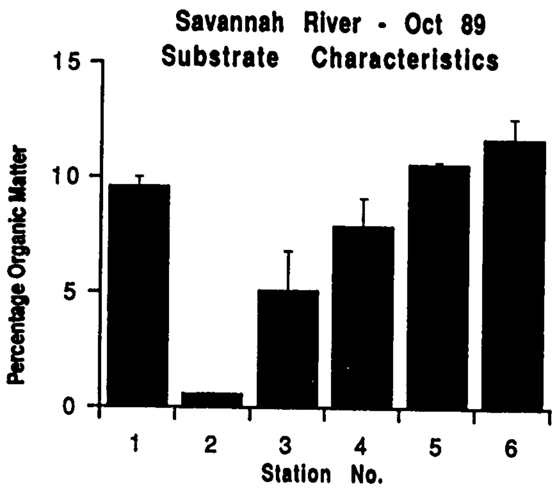
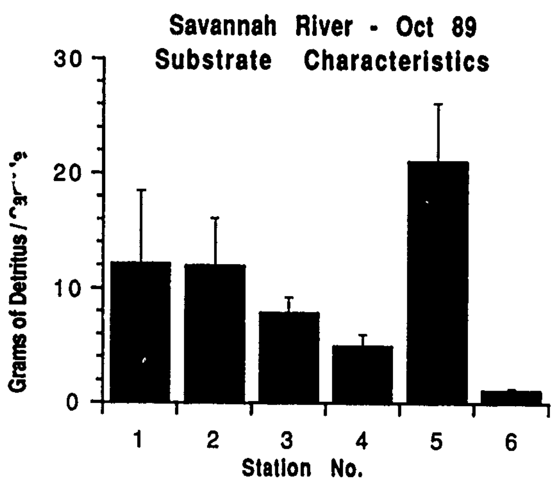


Figure 1. Map of the study area, showing location of the six sampling stations on the Savannah River, Georgia and South Carolina

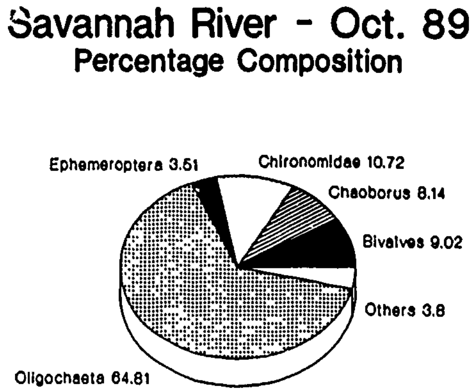


a. Percentage organic matter at six stations

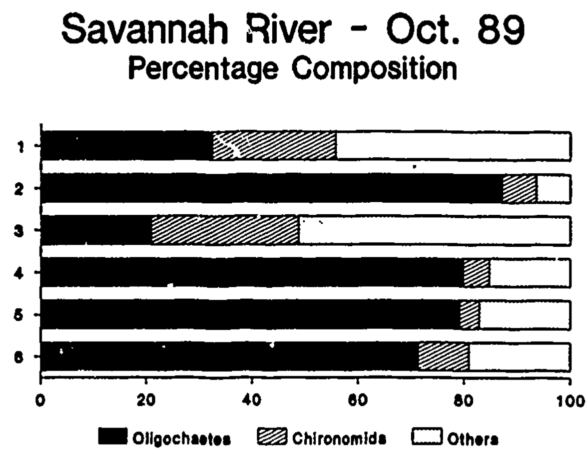


b. Grams of detritus per sample at six stations

Figure 2. Characteristics of substrate collected in the Savannah River, Georgia and South Carolina, October 1989

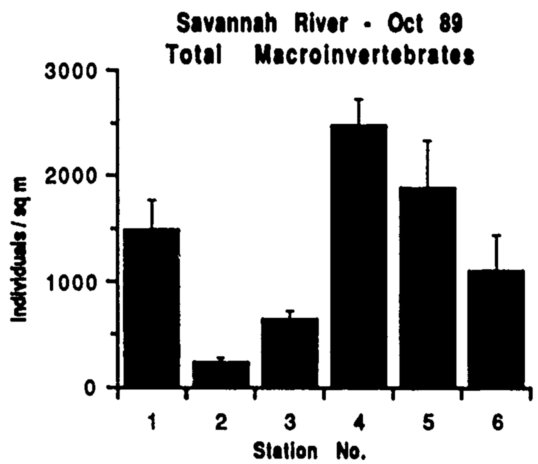


a. Percentage composition of major invertebrate groups

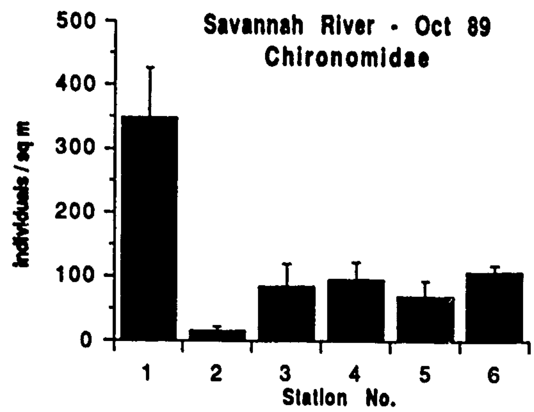


b. Percentage composition of oligochaetes, chironomids, and other invertebrates

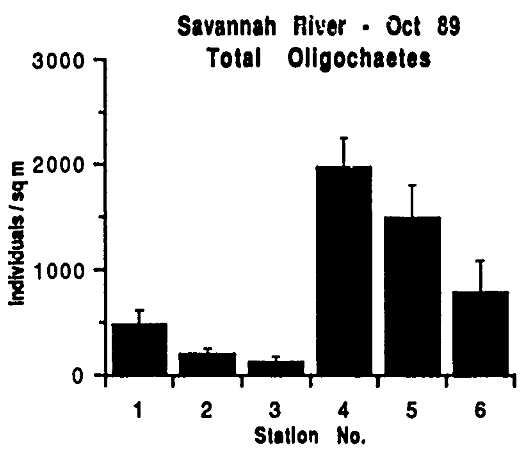
Figure 3. Characteristics of the macroinvertebrate community at six stations in the Savannah River, Georgia and South Carolina



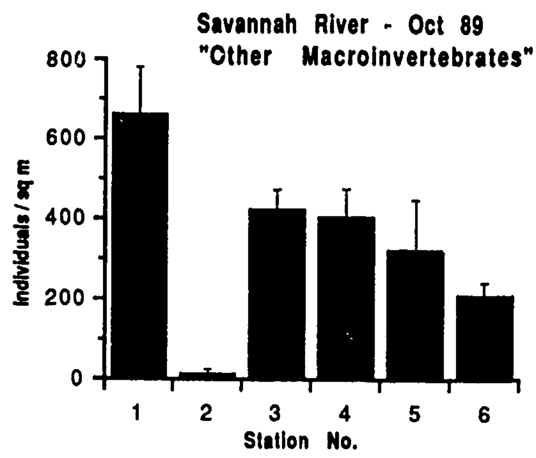
a. Total macroinvertebrates



b. Total chironomids

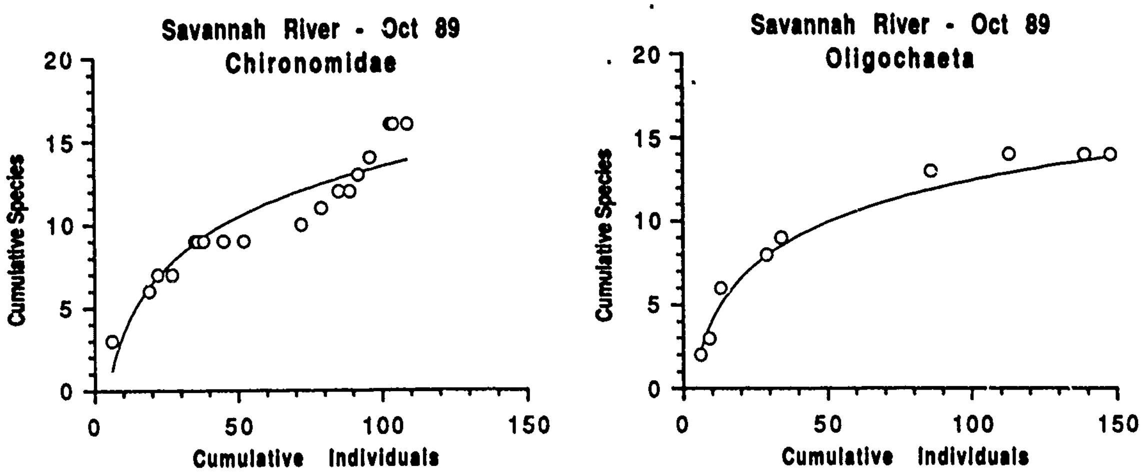


c. Total oligochaetes



d. Other macroinvertebrates

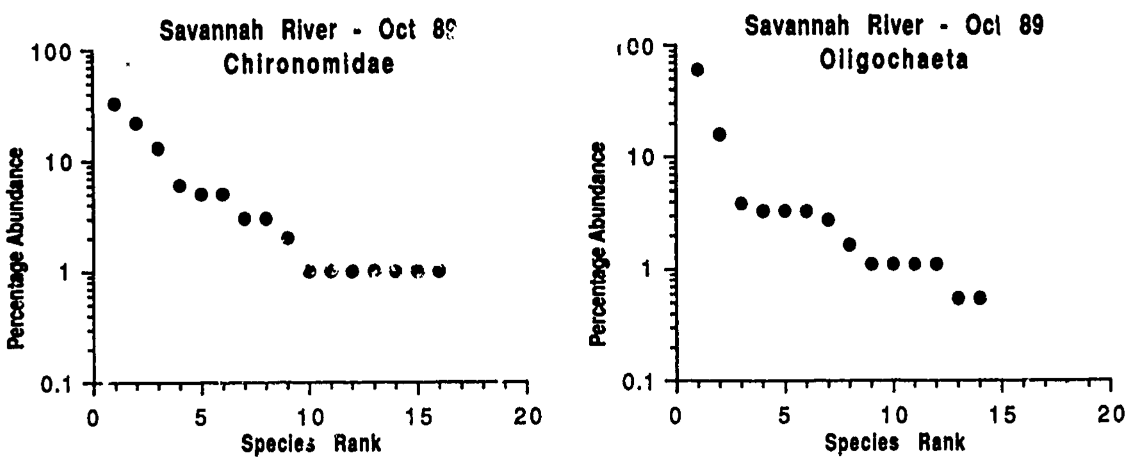
Figure 4. Density (individuals/m^2) of total macroinvertebrates and major groups from the Savannah River, Georgia and South Carolina, October 1989



a. Chironomidae

b. Oligochaetes

Figure 5. The relationship between cumulative species and cumulative individuals for macroinvertebrates collected in the Savannah River, Georgia and South Carolina, October 1989



a. Chironomidae

b. Oligochaetes

Figure 6. The relationship between percentage abundance and species rank for macroinvertebrates collected in the Savannah River, Georgia and South Carolina, October 1989