Special Publication SJ2002-SP8

Aquatic Invertebrate Communities of Blue Cypress Lake: Spatial and Temporal Dynamics in the Context of Environmental Influences

Final Report for Contract No. 97B242

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ACKNOWLEDGMENTS

The authors wish to express their appreciation to Angela Byassee and Esmeralda Cardona for their dedicated work in the laboratory and invaluable contributions made toward completion of the Blue Cypress Lake aquatic invertebrate project.

We also wish to thank Don Fox and Steve Gornak for sampling the Blue Cypress Lake fish community, thereby providing relative abundance data and fish for our food habitats analyses. Much appreciation goes to Dale Jones for his efforts toward the completion of this report in his role as FWC liaison to the St. Johns River Water Management District. We also acknowledge Jim Estes for his administrative and personal support throughout this project.

EXECUTIVE SUMMARY

Blue Cypress Lake is the uppermost lake in the St. Johns River and is a principal lacustrine component of the 59,000 ha Upper St. Johns River Basin Project (USJRBP). The lake is distinguished by its pristine beauty and good black crappie and largemouth bass fisheries. It is considered to be among those components of the USJRBP least impacted by human activities.

Environmental goals of the USJRBP include restoration and preservation of the natural, native attributes of species diversity, community diversity, abundance, and biotic productivity. To realize these goals, baseline structures of resident biotic communities must be documented and monitored through time to provide a measure of project success and to detect environmental perturbation prior to large scale detrimental impacts. A proven tool for evaluating aquatic systems is the structure of invertebrate communities. These communities are sessile and environmentally sensitive, hence, they are sculpted by the conditions in which they develop. Invertebrates also serve as a fulcrum in aquatic food webs by converting the products of primary production into carbohydrates and protein for transport up the food chain. Consequently, environmental perturbation impacting aquatic invertebrate communities can have ecosystem-wide ramifications.

The structure of aquatic invertebrate communities inhabiting Blue Cypress Lake was examined for a one year period to evaluate the ecological condition and trophic status of what is considered one of the most pristine components of the St. Johns River ecosystem. A primary intent of the project was to evaluate the effects of possible future fluctuations in lake water level. Sampling was conducted at a minimum of nine locations during each of six sampling events occurring from May 1998 through April 1999. Standard, habitat specific, methods for detailed

ecological studies were employed. Results from a fish diet study conducted during 1995 were also analyzed to ascertain the relative importance of invertebrates in the food web.

Results showed that the bottom dwelling fauna of Blue Cypress Lake is numerically predominated by the Asian clam Corbicula fluminea and the burrowing mayfly Hexagenia orlando. These species were present in mean densities of 1,879 and 398 m^{-2}, respectively, and accounted for 40.8 percent and 8.6 percent of all invertebrate organisms collected. No other taxa accounted for more than 5 percent of the total organisms.

Primary determinants of community distribution were found to be habitat type, bottom depth, and sample month. With the exception of the presence of C. fluminea and H. orlando in every benthic habitat type sampled, each habitat supported an assemblage of distinct taxonomic composition. Sand sediments supported the most species rich and diverse community of the bottom habitats sampled. Peat and mud communities were substantially less species rich and diverse. Results of canonical correspondence analysis showed that 32 of the 35 dominant invertebrate taxa (91%) attained their greatest densities at less than the averaged measured bottom depth. Only taxa known for tolerance of poor habitat conditions (low dissolved oxygen, accumulated decaying organic matter) increased in abundance with increasing depth in mud sediments. Dissolved oxygen concentration, within the ranges measured throughout the course of the study, are not limiting to the Blue Cypress Lake invertebrate community.

Results of functional feeding group analysis reflect the dominance of the filter-feeding Asian clam Corbicula fluminea in benthic habitats and grazing larval Chironomidae (nonbiting midges) and Naididae (segmented worms) on Nuphar stems. All of these taxa are dependent upon algae as their primary food source, whether it be planktonic (as with C. fluminea) or attached to Nuphar stems (Chironomidae & Naididae). The high proportion of algae consuming invertebrate taxa relative to other functional groups is indicative of an adequate phytoplankton food supply, and of prevailing environmental conditions that are characterized by prolonged periods of low turbidity, good light penetration, and nutrient concentrations adequate for high levels of primary production.

Comparisons with Lake Okeechobee and other, smaller, central and south Florida lakes indicated that taxonomic composition, abundance, and diversity of the Blue Cypress Lake aquatic invertebrate community were comparable to the corresponding metrics from lakes considered to be biologically healthy. Relative to the other lakes examined, Blue Cypress Lake should be considered mesotrophic.

Analysis of gut contents of five sport fish species indicated that aquatic invertebrates constituted a very high proportion of diet items. Most prominent among these results was that black crappie were totally dependent upon invertebrates throughout the juvenile and adult stages. Crappie usually become piscivorus during the juvenile stage. However, almost no forage fish were present in the guts examined. Results of fish community sampling by otter trawl showed a correspondingly low abundance of forage fish. Invertebrate species most important in sport fish diets were H. orlando, the amphipod Hyalella azteca, and the grass shrimp Palaemonetes paludosus.

Given the proven negative response of Hexagenia mayflies to eutrophication effects, and the importance of H. orlando in the Blue Cypress Lake food web, we recommend that the species be considered, and monitored routinely as, the keystone indicator of the ecological health of the lake ecosystem. H. orlando has been identified as "one of the most ecologically limited species in Florida" (Berner and Pescador 1988), and, as such, its population dynamics can be a barometer of even subtle environmental change. A trend of decreasing H. orlando densities would signal a shift in trophic status that would have ramifications throughout the lake food web.

Water requirements of a growing Florida population, industry, and agriculture have prompted the state's water managers to operate entire watersheds as reservoirs rather than natural systems, often to the detriment of the resident biota. Although there currently are no plans to manage Blue Cypress Lake in such a manner, if water levels were to rise over the bank and into the surrounding marsh for prolonged periods of time, benthic habitat conditions would likely be altered to the extent that the structure of the bottom-dwelling invertebrate fauna would be altered substantially. These changes would likely be initiated by increases in allochthonous particulate organic matter input, nutrient levels, and turbidity. As a consequence, the lake would be forced from mesotrophic to eutrophic status. The resulting benthic invertebrate community would be species-poor and composed of tolerant taxa indicative of poor habitat conditions. Invertebrate species upon which sport fish depend as a food source would be negatively impacted by these conditions.

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Introduction

Blue Cypress Lake (Indian River Co., FL) is the uppermost lake in the St. Johns River watershed and is a principal lacustrine component of the 59,000 ha Upper St. Johns River Basin Project (USJRBP). The USJRBP encompasses the entire headwaters region of the St. Johns River, and, within this area, Blue Cypress Lake is distinguished by its pristine beauty, good water quality and highly regarded largemouth bass and black crappie fisheries (FDEP 1996, Fitzgerald et al. 1988). The lake and surrounding Blue Cypress Marsh Conservation Area are considered to be among those areas of the USJRBP that are least impacted by human activities (Miller et al. 1996).

The USJRBP was implemented to provide flood control, environmental enhancement, water supply, and recreation to an area extending from northeastern Okeechobee County to Lake Washington in Brevard County (Miller et al. 1996). Environmental goals of the USJRBP include restoration and preservation of the natural, native, attributes of species diversity, community diversity, abundance, and biotic productivity (Miller et al. 1998). These objectives are to be realized by managing water quality and implementing, both spatially and temporally, a natural hydrologic regime (Miller et al. 1998).

An initial step in addressing the environmental goals of the USJRBP is documentation of the baseline structures of biotic communities inhabiting the project area. Establishment of such a baseline provides a basis for evaluation of restoration and preservation success via comparisons with future data collections.

One proven and reliable tool for evaluating environmental status of aquatic ecosystems is the structure of aquatic invertebrate communities (Rosenberg and Resh 1993, Hauer and Lamberti 1996). Invertebrate communities are integral to the natural functioning of aquatic ecosystems because they provide a primary food source for higher trophic levels and their feeding and digestive activities are essential to decomposition and nutrient cycling. Therefore, any natural or anthropogenically induced alteration of invertebrate community structure can have ecosystem-wide ramifications.

Because they are environmentally sensitive, sessile, and relatively long-lived, invertebrate communities are sculpted by, and are products of, the environmental conditions in which they develop (Thorp and Covich 1991, Merritt and Cummins 1996). The structure of invertebrate communities, therefore, functions as an important indicator of aquatic ecosystem health. Specific invertebrate community configurations are indicative of specific habitat and water quality conditions. For the purpose of aquatic ecosystem assessment, invertebrate community evaluation possesses an advantage over traditional water chemistry analyses because the structure of aquatic invertebrate communities reflects not only present (instantaneous), but also past, environmental conditions.

The benefits of using invertebrate communities to evaluate aquatic ecosystem health were recognized in the early 1900s (Kolkwitz and Marsson 1908, 1909; Thienemann 1922). Since then, invertebrate community evaluation has been refined into a powerful analytical tool (Brundin 1949 and 1958, Cummins 1973, Brinkhurst 1974, Saether 1979, Wiederholm 1980, Hellawell 1986, Rosenberg and Resh 1992, Cummins and Merritt 1996). By using the taxonomic compositions, absolute abundances, and relative abundances of aquatic invertebrates as "early warning signals", water managers can respond to small scale problems and implement corrective measures prior to large-scale ecological perturbation.

Objectives

Given the need to establish a baseline useful for evaluation of restoration and preservation efforts, and also given the indicator capabilities of aquatic invertebrate communities, the present study was implemented with the following objectives:

1. Determine the current (baseline) structure of the aquatic invertebrate assemblages inhabiting Blue Cypress Lake. The elements of community structure to be examined and defined include taxonomic and functional composition, absolute and relative abundance, evenness of distribution, and diversity.
2. Determine the spatial and temporal distributions of the identified invertebrate assemblages.
3. Identify those invertebrate taxa most critical to the food chain and most valuable as indicators of ambient environmental conditions.
4. Compile a database structured to facilitate comparisons between the established baseline and future data collections.

5. Based upon the compositions, functional structures, and distributions of resident invertebrate communities, evaluate the current biological health of Blue Cypress Lake.

Study Area

Prior to human settlement and development, the USJRBP area was a mosaic of wetland and upland habitats that were sculpted, primarily, by rainfall and subtropical climate. Beginning in the early 1900s, large areas of the Upper St. Johns Basin were drained by construction of canals, levees, and road systems that were built in support of agriculture and a rapidly growing human population (Goolsby and McPherson 1978, Hand et al. 1994). By the mid 1980s, total floodplain acreage of the Upper St. Johns Basin had been reduced by more than 60 percent (Miller et al. 1996, Miller et al. 1998). Flows into the river from the Upper Basin were reduced to approximately 55 percent of pre-development levels (Tai and Rao 1982), surface water quality declined due to direct agricultural runoff (Lowe et al. 1984), and surface area of lakes decreased due to increased sedimentation. Ecological responses to the resulting altered hydroperiods and increased nutrient levels included reduced usage of the Upper Basin by wading birds and waterfowl, fish kills, and shifts in the areal coverage of wetland habitat types (Lowe et al. 1984).

However, because Blue Cypress Lake is located near the St. Johns headwaters and is surrounded by marshlands, it remained among the least impacted of water bodies within the Upper Basin. Average values measured for chlorophyll$_a$, total nitrogen, and total phosphorus (Fitzgerald et al. 1988) are low relative to other St. Johns River watershed lakes, but are indicative of mesotrophic to eutrophic conditions as measured using the precepts of Forsberg and Ryding (1980). The Florida Department of Environmental Protection has attributed chronically high NO_2 and NO_3 levels measured in the lake to agricultural runoff (Fitzgerald et al. 1988).

Results of a University of Florida study indicated that sediments have accumulated on the lake bottom at a steadily increasing rate since 1935 and that the rate of sediment phosphorus accumulation since 1970 is 2.3 times the 1920 rate (Brenner and Schelske 1995).

Results of bathymetry studies conducted by Coastal Planning and Engineering, Inc. (1992) showed the average depth of Blue Cypress Lake to be 2. 4 meters (7.8 feet); the deepest area, located near the center of the lake, was measured at approximately 3.0 meters (10 feet) (at a surface level of 23.0 NGVD; Coastal Planning and Engineering, Inc. 1992). Surface area of the lake was found to be approximately 26.5 square kilometers (6,555 acres), ranking Blue Cypress as the twenty-fourth largest lake in Florida. Three discrete bottom substrate zones were documented (Figure 1). The eastern one-third of the lake is underlain by sand, the bottom of the deeper, central lake region is composed of organic mud, and the northern, eastern and southern lake margins are underlain by peat ranging from coarse and unconsolidated in the north to hard and consolidated in the lake's southern area. Average sediment depth was determined to be 1.5 meters (4.9 feet) (Coastal Planning and Engineering 1992).

Rooted vegetation is not abundant in Blue Cypress Lake and is limited, primarily, to the extreme lake margins. Dominant macrophyte species include spatterdock (Nuphar luteum) and grasses (Panicum sp.).

Methods

Habitats and Location of Sampling Sites

To stratify the sampling design, Blue Cypress Lake was divided into three major habitat zones based upon bottom substrate characteristics identified during bathymetric studies (Coastal Planning and Engineering, Inc. 1992) and previous FWC sampling experience (Warren & Vogel

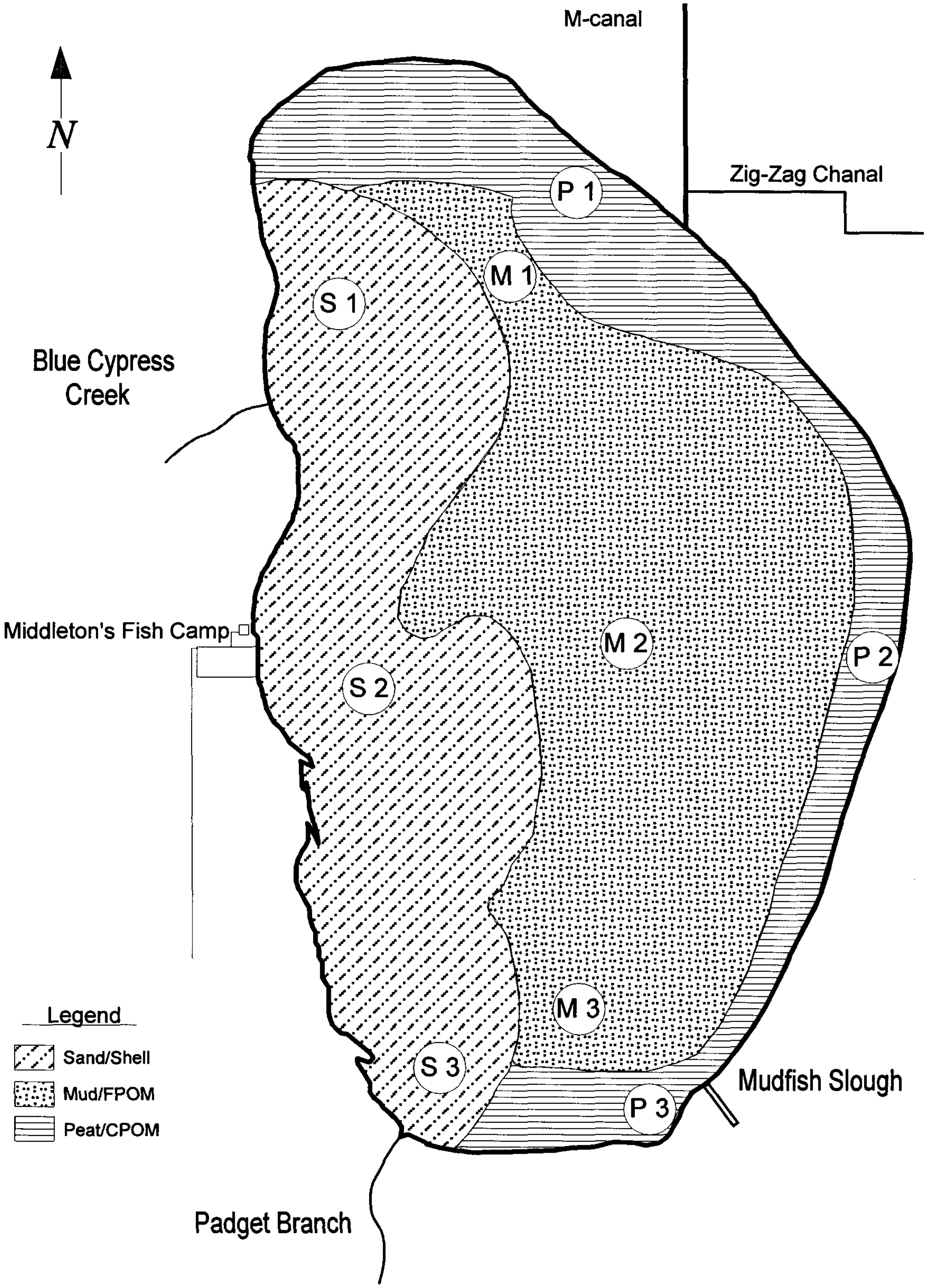

FIGURE 1. Map of Blue Cypress Lake, Indian River Co., FL, depicting locations of major bottom sediment types and relative locations of benthic invertebrate sampling sites. Latitudes and longitudes of sampling sites are presented in Table 1, page 8.

1991). The habitat zones established were: (1) sand zone, located along the western one-third of the lake; (2) mud zone, in the central area of the lake; and, (3) peat zone, along the north, east and south margins (Figure 1). Three fixed benthic invertebrate sampling sites were established in each of the three major sediment habitat zones (Figure 1; Table 1), yielding a total of nine benthic community sites. Sampling at fixed sites, rather than at sites selected randomly during each sampling event, facilitates future comparisons and tracking of invertebrate community structure and habitat coverages at stationary locations. To allow comparisons with previous FWC invertebrate collections, sampling sites were chosen to closely correspond with sites sampled during 1990-91.

Aquatic macrophytes typically support invertebrate communities of greater diversity, and with substantially different taxonomic compositions, than sediment-associated communities. Therefore, spatterdock (Nuphar luteum) was chosen as an additional habitat for sampling. Spatterdock was sampled at randomly selected locations during every sample period except December 1998, when high water levels precluded use of emergent macrophyte sampling gear. Random site selection was employed with the sampling of spatterdock to prevent bias caused by repeated sampling of a single, disturbed, site.

Timing of Sampling Events

Six sampling events were conducted during the one year duration of the field work component of the study. Sampling was conducted at approximately eight week intervals (Table 2) to ensure that those taxa with seasonally variable distributions (e.g. many aquatic insect species) would be sampled adequately.

TABLE 1. Site designation, habitat type, and location (decimal degree latitudes and longitudes) of FWC Blue Cypress Lake benthic invertebrate sampling sites, May 1998 through April 1999.

Site Designation	Habitat Type	Latitude/ Longitude
S-1	Sand	27 45.084 80 46.401
S-2	Sand	27 43.260 80 46.072
S-3	Sand	27 41.839 80 45.746
M-1	Mud	27 44.897 80 45.559
M-2	Mud	27 43.489 80 45.229
M-3	Mud	27 42.458 80 44.984
P-1	Peat	27 45.475 80 45.126
P-2	Peat	27 44.279 80 43.888
P-3	Peat	27 42.231 80 44.467

TABLE 2. Blue Cypress Lake aquatic invertebrate sampling periods, May 1998 through April 1999.

Sample Period	Dates
1	May 27 - 29, 1998
2	July 29 - 31, 1998
3	Oct. 21 - 28, 1998
4	Dec. 2 - 4, 1998
5	Feb. 10 - 11, 1999
6	April 21 - 22, 1999

Field Methods

During each of the six sampling periods, triplicate samples were obtained from each sampling site, yielding a total of 27 sediment-associated samples and three spatterdock-associated samples per sampling period.

A petite ponar dredge (surface area sampled = 224.96 cm^2) was used to sample benthic communities associated with sand, mud, and peat sediments. Sediment samples were hand-sieved in the field to remove excess water. The invertebrate community associated with spatterdock was sampled using a modified Hess stream sampler (Warren and Vogel 1991)(surface area sampled = 889.59 cm^2)(Figure 2). Upon collection, all samples were field-preserved with 95% ethanol. All sampling and rinsing devices used throughout the sampling process were fitted with 300 μm Nitex® mesh to ensure retention of smaller invertebrate taxa. Physico-chemical parameters measured concurrently to the sampling of each site included water depth and substrate type. Additionally, at each sampling site a dissolved oxygen and temperature profile was obtained with measurements taken at 0.5 meter intervals.

Laboratory Methods

In the laboratory, each sample was rinsed on a standard ASTM #50 sieve (300 μm) and processed separately using a stereo-dissecting microscope with magnification to 40X. Organisms were removed from samples using forceps and sorted to major taxonomic groups. A taxonomist enumerated and identified specimens to the lowest positive taxonomic level. Many smaller taxa, including Oligochaeta, Chironomidae, and Ceratopogonidae, were slide-mounted in CMC-10 to enable species level identification using phase-contrast microscopy (magnifications to 1000x). Immaturity, or damage to specimens, sometimes precluded identification to the species level.

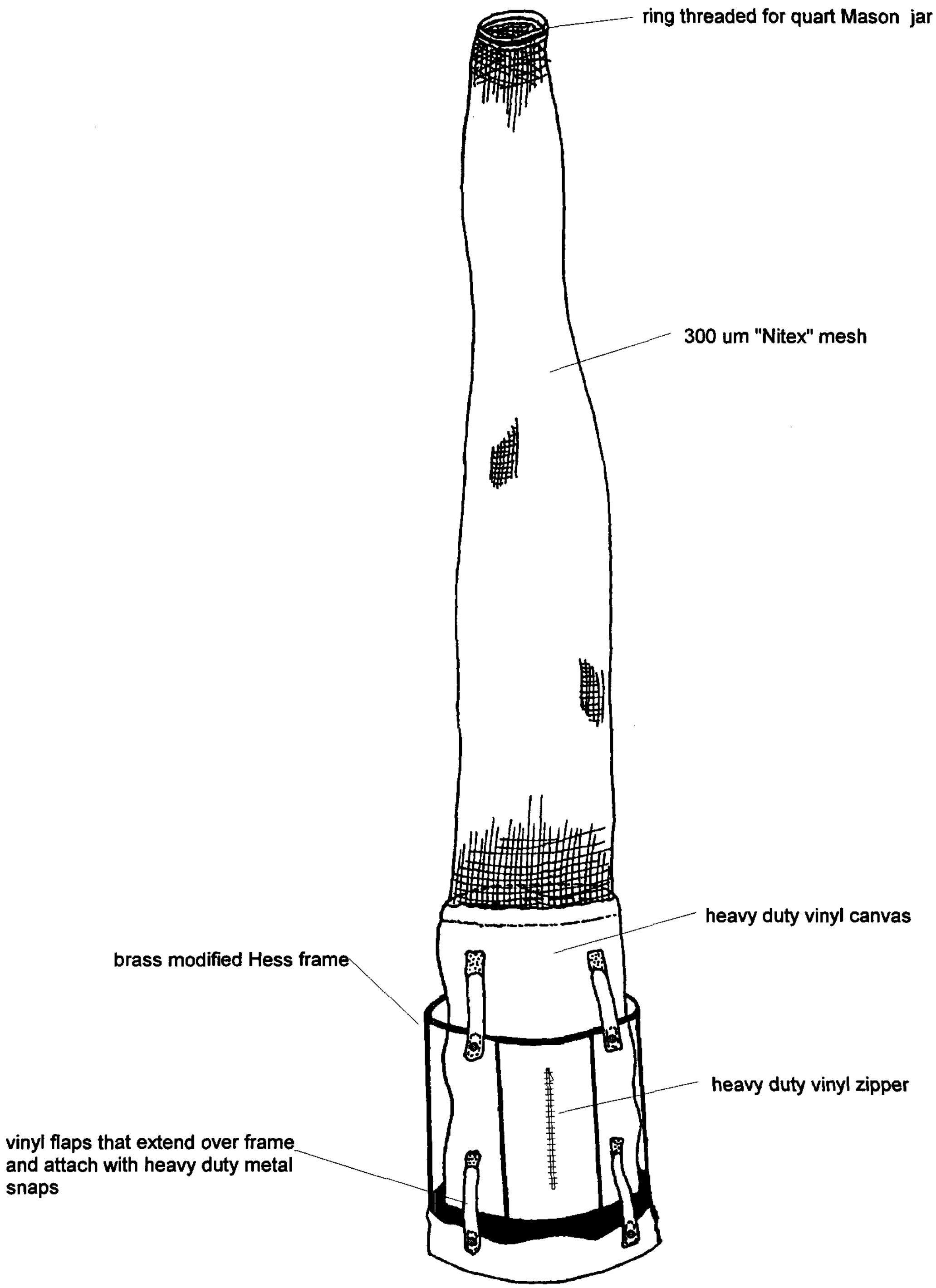

FIGURE 2. Depiction of modified Hess stream sampler used for sampling invertebrate communities associated with Nuphar luteum in Blue Cypress Lake. Sampler frame diameter = 34 cm; frame height = 36 cm; total height = 185 cm; mesh size = 300 microns.

Taxonomic literature used for species level identifications is listed in Appendix 1. Taxonomic identifications, counts, and ancillary measurement data from each sample were archived on individual laboratory sheets.

Fish Diet Methods

Although not a formal component of the project, Blue Cypress Lake fish diet analyses conducted prior to invertebrate community sampling are included in our discussion herein. During September 1995, bluegill (Lepomis macrochirus), redbreast sunfish (Lepomis auritus), redear sunfish (Lepomis microlophus), black crappie (Pomoxis nigromaculatus), and largemouth bass (Micropterus salmoides) were collected for diet analysis using an otter trawl. Upon collection, stomachs of the fish were removed and preserved in 10% buffered formalin. In the laboratory, the contents of each individual stomach were sorted and identified separately using stereo-dissecting microscopes with magnification to 40X.

Analytical Methods

Raw data were entered into a database constructed using dBase 5 (Borland International, Inc. 1994). Condescriptive statistical analyses were conducted using Systat version 7.0 (SPSS, Inc. 1997) or with analytical programs written by the authors. Multivariate analyses were conducted using PC-ORD version 4.0 (McCune and Mefford 1999).

Evenness (Pielou 1975)and Shannon's Index of diversity (Shannon and Weaver 1949) were computed for each sample. Evenness is a measure of the distribution of numbers among individual taxa. Evenness values range from 0 to 1 with a value of 1 being indicative of equal abundance of all taxa in a sample. Evenness values less than 0.40 are indicative of extreme dominance by one or a few taxa. Shannon's diversity index is a combined measure of evenness and species richness, with values ranging from 0 to over 4.0. Values over 3.0 are indicative of a community composed of many taxa that are present in nearly equivalent numbers. Values less than 2.0 are generally indicative of the presence of only a few species and numerical dominance by one or a few species.

Results and Discussion

Lakewide Invertebrate Community Overview

A total of 122 aquatic invertebrate taxa representing 27 major groups were collected from Blue Cypress Lake during the six sampling events conducted May 1998 through April 1999 (Table 3 and Appendix 2). Ninety-four taxa were collected from the three bottom sediment types sampled, while 70 taxa were collected from the lone aquatic macrophyte habitat sampled, Nuphar luteum. Forty-six of the 122 total taxa (37.7%) were larvae and pupae of the fly family Chironomidae (non-biting midges)(Appendix 2). Segmented worms of the family Naididae contributed 15 taxa (12.3%) to the total, while Gastropoda (snails) and Pelecypoda (clams and mussels) each contributed 7 taxa (5.7 % each). Anisoptera (dragonflies) and Ephemeroptera (mayflies) were each represented by 6 taxa (4.9% each) (Appendix 2).

Although several major groups such as Chironomidae and Naididae contributed relatively large numbers of taxa to the whole lake total taxa count, these same groups did not contribute large numbers of individuals to estimates of total organisms. Only five of the total of 94 taxa (5.3%) collected from sediments individually accounted for more than 2.8 percent of the total benthic organisms (Table 4). The Asian clam Corbicula fluminea was, by far, the single-most abundant benthic invertebrate collected (lakewide $\bar{x}$ density = 1,879 m^{-2}), accounting for 40.8

TABLE 3. Descriptors of aquatic invertebrate community quality in Blue Cypress Lake (Indian River Co.), May 1998 through April 1999. Means with the same letter superscript are statistically equivalent (ANOVA, $p = 0.05$, followed by Scheffe's multiple comparison; mean total organisms transformed by $\log(x + 1)$, other descriptors untransformed).

	Habitat				
Descriptor	All Sediments	Mud	Sand	Peat	Nuphar
	$\bar{x}$ (cv) n= 162	$\bar{x}$ (cv) n=54	$\bar{x}$ (cv) n=54	$\bar{x}$ (cv) n=54	$\bar{x}$ (cv) n=15
Mean Total Organisms m^{-2}	4,601 (1.02)	2,311 (0.54)[a]	5,287 (0.69)[b]	6,206 (1.06)[b]	2,713 (1.07)[a]
Total Species Richness	94	35	77	61	70
Mean Species Richness	12 (0.43)	9 (0.22)[a]	17 (0.20)[b]	9 (0.49)[a]	19 (0.38)[b]
Mean Diversity	2.37 (0.28)	2.17 (0.24)[a]	2.84 (0.17)[b]	2.09 (0.34)[a]	2.80 (0.21)[b]
Mean Evenness	0.69 (0.21)	0.70 (0.20)[a]	0.70 (0.16)[a]	0.68 (0.27)[a]	0.68 (0.20)[a]

TABLE 4. Rank, mean density (no. m^{-2}), coefficient of variation (cv), and percent composition of numerically dominant invertebrate taxa collected from Blue Cypress Lake habitats sampled from May 1998 through April 1999.

	Habitat				
	All Sediments	Mud	Sand	Peat	Nuphar
Rank	Taxon no. m^{-2} (cv) % n = 162	Taxon no. m^{-2} (cv) % n = 54	Taxon no. m^{-2} (cv) % n = 54	Taxon no. m^{-2} (cv) % n = 54	Taxon no. m^{-2} (cv) % n = 15
1.	C. fluminea 1,879 (1.53) 40.8%	C. fluminea 1,247 (0.86) 53.9%	C. fluminea 1,805 (1.58) 34.1%	C. fluminea 2,585 (1.50) 41.6%	Nematoda 1,042 (1.90) 38.4%
2.	H. orlando 398 (1.39) 8.6%	UIWOCS* 244 (0.62) 10.6%	H. orlando 782 (0.96) 14.8%	Hyalella azteca 459 (2.22) 7.4%	Thienemanniella sp. A 331 (0.98) 12.2%
3.	Hyalella azteca 173 (3.57) 3.8%	H. orlando 156 (0.61) 6.8%	Sphaeriidae 324 (1.62) 6.1%	Axarus sp. 389 (2.04) 6.3%	Tanytarsus sp. 143 (1.51) 5.3%
4.	UIWOCS* 171 (1.19) 3.7%	Coelotanypus sp. 111 (0.73) 4.8%	Nematoda 185 (1.31) 3.5%	H. orlando 254 (1.37) 4.1%	Thienemanniella sp. 124 (1.05) 4.6%
5.	Nematoda 130 (2.45) 2.8%	C. tricolor 72 (0.97) 3.1%	UIWOCS* 183 (1.49) 3.4%	Enchytraeidae 240 (2.10) 3.9%	Tanytarsus sp. C/D 115 (2.03) 4.2%
6.	Axarus sp. 130 (3.79) 2.8%	C. punctipennis 62 (1.37) 2.7%	P. nigrohalteralis 154 (0.88) 2.9%	Nematoda 192 (2.49) 3.1%	Dero pectinata 100 (1.86) 3.7%

* UIWOCS = Unidentifiable Immature Oligochaetes Without Capilliform Setae.

percent of all sediment-associated invertebrates collected during the study (Table 4, Appendix 2). C. fluminea is a nonindigenous species that was purposely introduced into North America in British Columbia during the 1920s (Counts 1991). Corbicula was first observed in northwestern Florida in 1960 (Schneider 1967) and spread rapidly throughout the entire state (Heard 1964, 1966, & 1979, Clench 1970, Bass and Hitt 1974). Corbicula often becomes very abundant in benthic habitats where the substrate is firm and consolidated, there is an abundance of phytoplankton and/or fine particulate organic matter (as a food source), and dissolved oxygen concentrations at the water column/sediment interface are sustained at levels greater than 4.0 ppm. Because Corbicula does not have a larval form (glochidia) that requires a fish host, as do most native North American unionid mussels, it is able to reproductively out-compete native species.

The burrowing mayfly Hexagenia orlando was the only other taxon to account for more than five percent of the total sediment-associated organisms (lakewide $\bar{x} = 398\ m^{-2}$; 8.6% of total)(Table 4). Like C. fluminea, H. orlando is dependent upon firm substrates (for establishment of burrows) and dissolved oxygen concentrations in excess of 4.0 ppm. According to Berner and Pescador (1988), H. orlando is one of the most ecologically limited species in Florida, being endemic to lakes with good water quality in central Florida. H. orlando becomes most abundant in sand substrates and thrives at depths ranging from 2.7 to 9.1 meters (9 to 30 feet) (Berner and Pescador 1988).

Other taxa among the five most abundant benthic invertebrates in Blue Cypress Lake included the amphipod Hyalella azteca ($\bar{x} = 187\ m^{-2}$; 3.8%), unidentifiable immature oligochaetes (segmented worms) without capilliform setae ($\bar{x} = 171\ m^{-2}$; 3.7%), Nematoda (roundworms)($\bar{x} = 130\ m^{-2}$; 2.8%), and organic sediment-inhabiting larvae of the nonbiting midge genus Axarus sp.

(Table 4 and Appendix 2). No other individual taxon accounted for more than three percent of the total benthic organisms collected over the duration of the study.

The taxonomic composition of the community inhabiting Nuphar differed substantially from that of sediment-associated communities. Nematoda were numerically dominant ($\bar{x}$ = 1,042 m^{-2}; 38.4 %)(Table 4, Appendix 2). The remaining four of the five most abundant taxa were larval Chironomidae, and included Thienemanniella sp. A (331 m^{-2}, 12.2%), Tanytarsus sp. (143 m^{-2}, 5.3 %), Thienemanniella sp. (124 m^{-2}, 4.6%), and Tanytarsus sp. C/D (115 m^{-2}, 4.2%)(Table 4). No other Nuphar-associated taxon accounted for more than 3.7% of the total.

Spatial and Temporal Influences Upon Distribution

Habitat type and season were important influences upon species richness, taxonomic composition, and distribution of Blue Cypress Lake invertebrate communities. Taxa richness in individual habitats ranged from 35 collected from mud to 77 collected from sand (Table 3). Taxa richness per sample was significantly greater in Nuphar and sand (19 and 17, respectively) than in mud and peat (9 and 9, respectively)(ANOVA, α=0.05)(Table 3). This pattern was repeated with mean diversity, where the Nuphar and sand values of 2.80 and 2.84 were significantly greater than 2.17 and 2.09 in mud and peat, respectively (ANOVA α=0.05)(Table 3). Mean values for evenness were statistically equivalent among all habitat types (range = 0.68 to 0.70; ANOVA α=0.05), and were indicative of dominance of all habitats by only a few species (Table 3 and Appendix 1).

Overall, within-habitat means of species richness, diversity, and evenness of distribution exhibited little seasonal variation and no pattern of higher or lower values in any one season (Figure 3). Diversity and evenness were especially homogenous, with most means of diversity ranging from 2.0 to 2.7 and evenness means ranging from 0.60 to 0.80 (Figure 3).

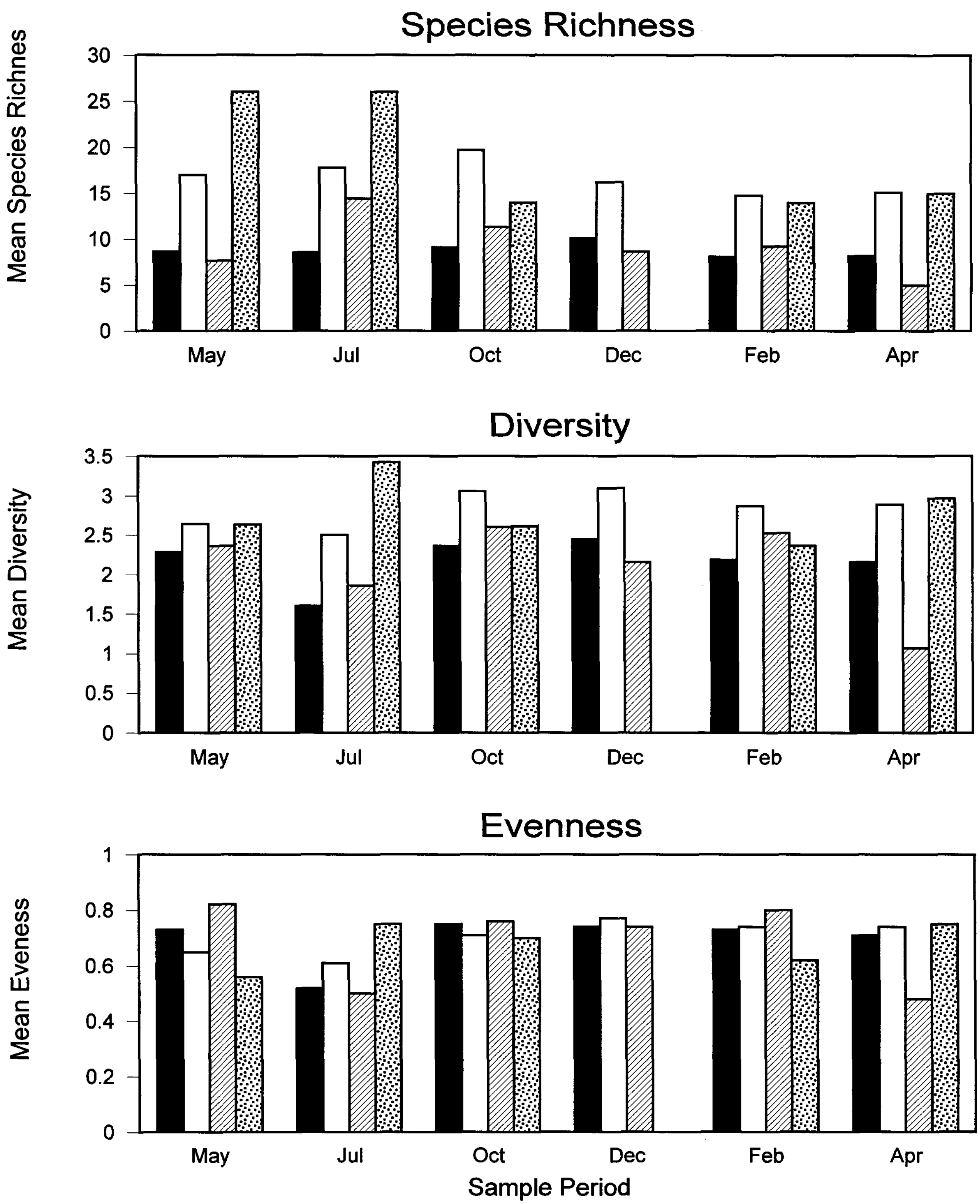

FIGURE 3. Habitat means of invertebrate community species richness, diversity, and evenness during the six Blue Cypress Lake (Indian River Co., FL) sampling periods from May 1998 through April 1999 (■ = Mud; □ = Sand; ▨ = Peat; ░ = Nuphar).

Monthly means of species richness in the Nuphar-associated community exhibited the greatest within-habitat variation, with values during the summer months of May and July being substantially greater (but not significantly greater; ANOVA α=0.05) than all other months (Figure 3).

Habitat means of total organisms per sample for the entire duration of the study were greatest in peat and sand substrates (6,206 and 5,287 organisms m^{-2}, respectively), and significantly less (ANOVA; α = 0.05) in Nuphar and mud (2,713 and 2,311 m^{-2}, respectively)(Table 3). Little variation in seasonal within-habitat means of total organisms was evident, with the exception of July, when high densities of immature Corbicula fluminea drove total organism densities to their highest values for the one year study period (Figure 4). Habitat mean densities of two major groups that typically dominate Florida lakes, Oligochaeta and Chironomidae, were also greatest during the summer months (Figure 4).

Aside from the ubiquitous presence of the Asian clam Corbicula fluminea and the burrowing mayfly Hexagenia orlando, the taxonomic compositions of the three sampled bottom habitats were quite dissimilar (Table 4). Unidentifiable immature oligochaetes (segmented worms) without capilliform setae, predaceous larvae of the midge (Chironomidae) genus Coelotanypus, and predaceous larvae of the phantom midge Chaoborus punctipennis were prominent among the dominant taxa in mud sediments. These taxa are all in some way dependent upon the soft, organic nature of mud bottoms. The oligochaetes burrow into, and feed upon, organic mud sediments; Coelotanypus and Chaoborus larvae prey upon microcrustacea while swimming in ooze at the mud surface.

Phytoplankton filtering Sphaeriidae (fingernail clams), immature oligochaetes, Nematodes, and organic deposit-feeding larvae of the tubicolous midge Paralauterborniella nigrohalteralis were

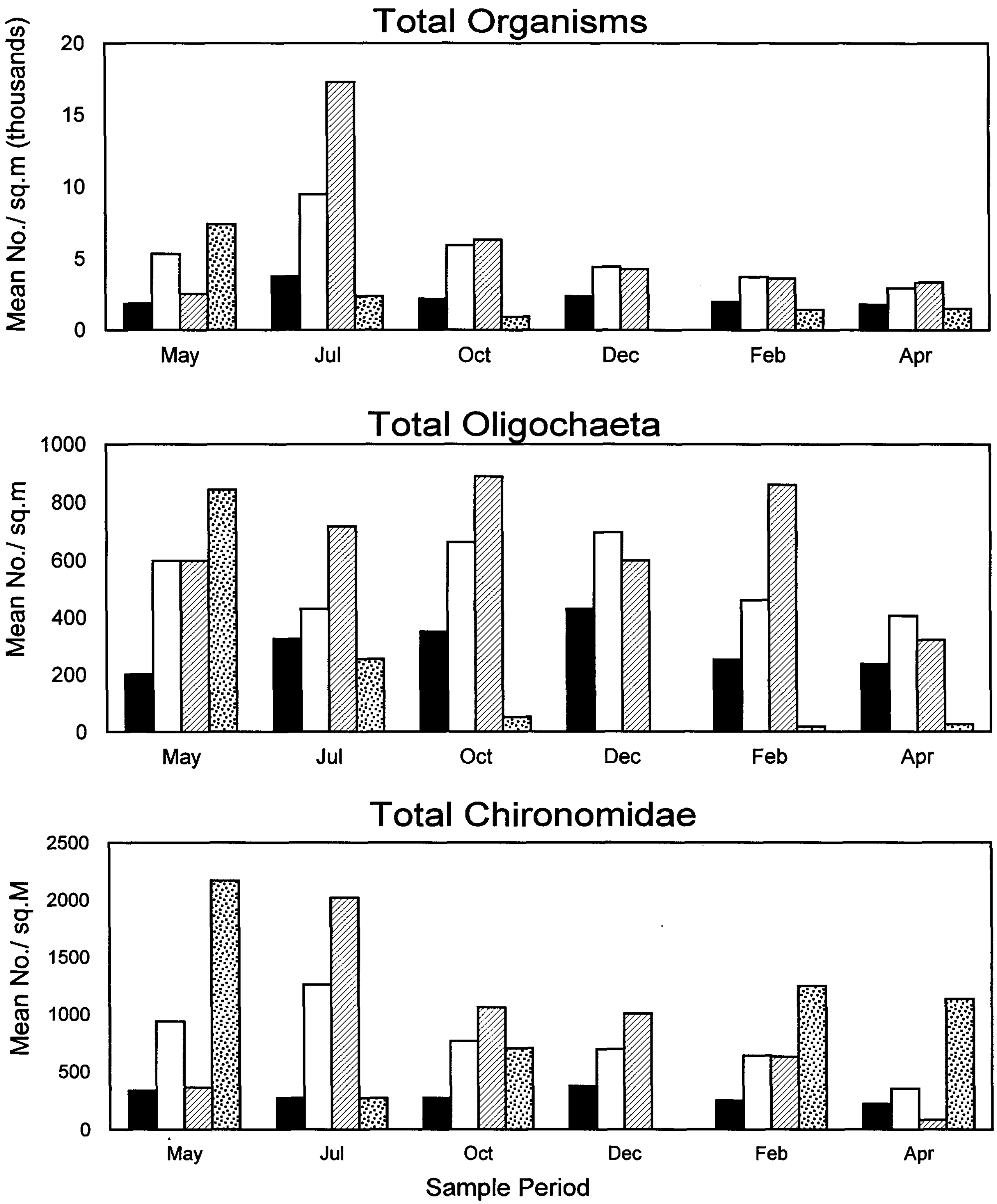

FIGURE 4. Habitat means of total organisms, total Oligochaeta, and total Chironomidae collected from Blue Cypress Lake (Indian River Co., FL) during the six sampling periods from May 1998 through April 1999 (■ = Mud; □ = Sand; ▨ = Peat; ░ = Nuphar).

the only taxa, other than C. fluminea and H. orlando, to account for 2.9 percent, or more, of the total organisms inhabiting sand (Table 4). Dominant taxa inhabiting peat sediments, other than C. fluminea and H. orlando (which together accounted for over 45 percent of the peat fauna), included attached algae grazing Hyalella azteca (7.4 %), larvae of the detritus collecting midge genus Axarus (6.3 %), and sediment consuming segmented worms of the family Enchytraeidae (3.9 %)(Table 4).

Little seasonal variation was apparent among means taxa richness, diversity, and evenness (Figure 3). However, substantial seasonal variation was evident in the abundance of dominant taxa (Figure 5). Densities of the single-most abundant species, Corbicula fluminea, were up to four times greater in benthic habitat types during the July sampling period than in any other period (Figure 5). Corbicula typically reproduce in large numbers during early spring, then experience high mortality (74 - 98 %) during initial month of life (McMahon 1991). Densities of the second-most abundant species, Hexagenia orlando, also exhibited a typical annual pattern, peaking during October (following the summer-long reproductive period), then declining, most likely due to predation, natural mortality, and emergence (Figure 5). The third-most abundant species, the amphipod Hyalella azteca, was present with a mean density exceeding 4,000 m^{-2} in peat sediments during July 1998, but was stable at less than 500 m^{-2} in all other habitats and seasons (Figure 5).

Influences of Dissolved Oxygen and Depth upon Abundance and Distribution

Canonical correspondence analysis (CCA)(ter Braak 1986, Johnson et al. 1993, Jongman et al. 1995) was used to evaluate influences of dissolved oxygen concentration, water depth, and bottom type upon abundance and distribution of dominant invertebrate taxa. CCA is a multivariate direct gradient analysis that constrains ordination with multiple regression. CCA is not restrained by multicollinearity in species abundances and is more appropriate than simple regression or

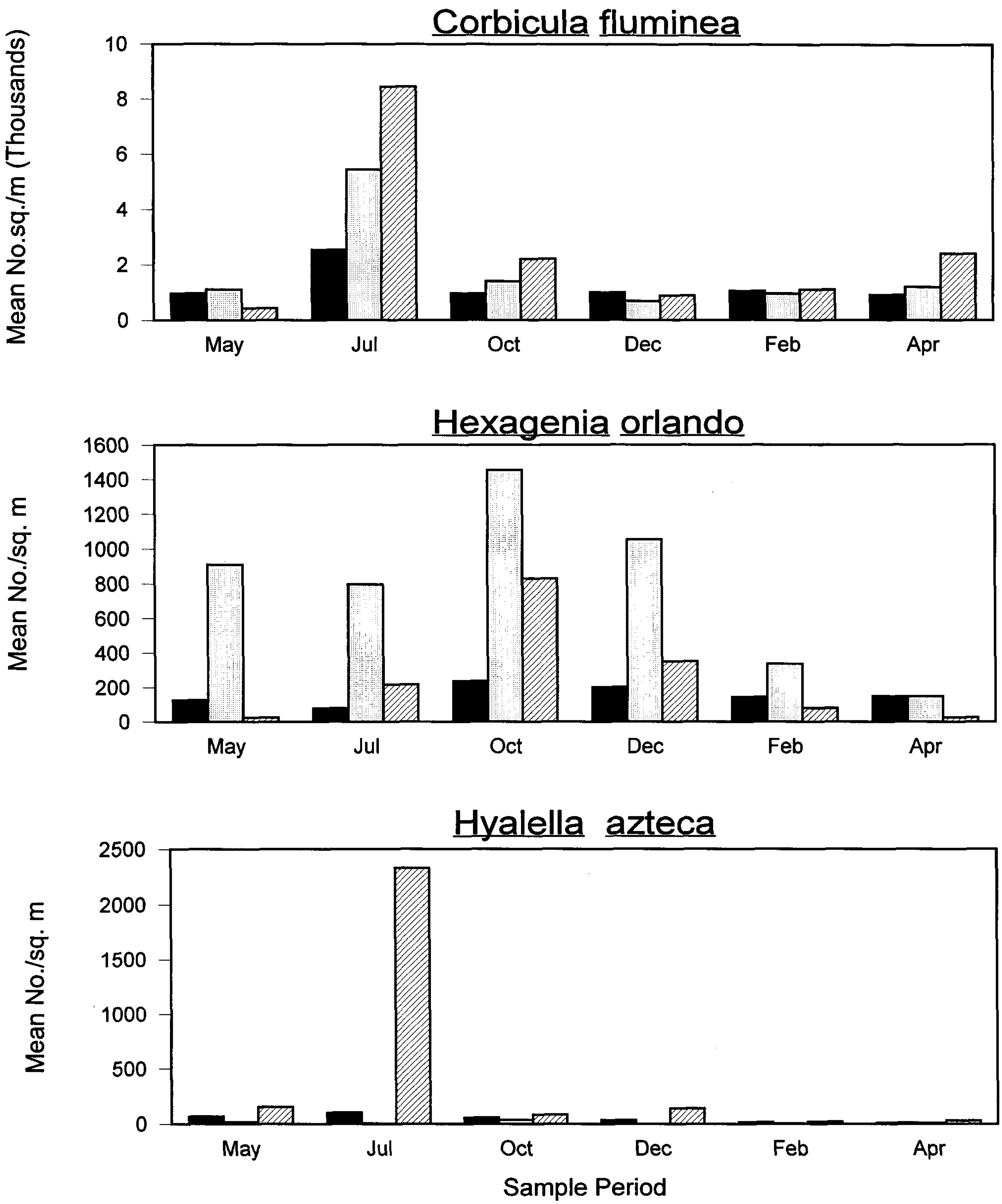

FIGURE 5. Habitat means of Corbicula fluminea, Hexagenia orlando, and Hyalella azteca collected from Blue Cypress Lake (Indian River Co., FL) during the six sampling periods from May 1998 through April 1999 (■ = Mud; ☐ = Sand; ▨ = Peat).

correlation techniques (for analysis of ecological data) because it assumes a unimodal (rather than linear), nonmonotonic, response to changes in environmental variables (ter Braak 1986).

CCA produces an ordination diagram (biplot) that summarizes a substantial amount of ecological information onto one page and aids in the visualization of relationships among taxa, and between taxa and measured environmental parameters (Figure 6). Arrows representing gradients of measured physicochemical parameters are plotted across the CCA axes. Values of an individual parameter decrease as distance increases, along the arrow shaft, away from the head of the arrow. The length of an individual arrow relative to the lengths of other arrows is a measure of the relative strength of the influence of the particular variable the arrow represents - the longer the arrow, the stronger the relationship and the more important the variable is in explaining the distributions and densities of dominant taxa. Points representing the optimum abundances of dominant invertebrate taxa are plotted in relation to points representing other dominant taxa and in relation to the environmental parameter and habitat arrows. Taxa ordinating near one another generally occur within the same habitats (e.g. mud, sand, or peat) in similar densities. Taxa ordinating on opposite sides of the diagram occur together rarely and in dissimilar abundances. Most importantly in the context of our analyses, a taxon's relationship to a variable is measured by the distance between the taxon's perpendicular relationship with the shaft of the particular parameter arrow and the head of that arrow. The distance between the two is directly related to the taxon's tolerance of the variable; therefore, a taxon located near the arrowhead of an environmental variable gradient is likely to be found in greatest densities at locations where the particular variable reaches its highest levels. A taxon whose perpendicular relationship with an environmental variable axis is relatively far from the arrowhead is likely to attain its highest densities in locations where the environmental variable is at

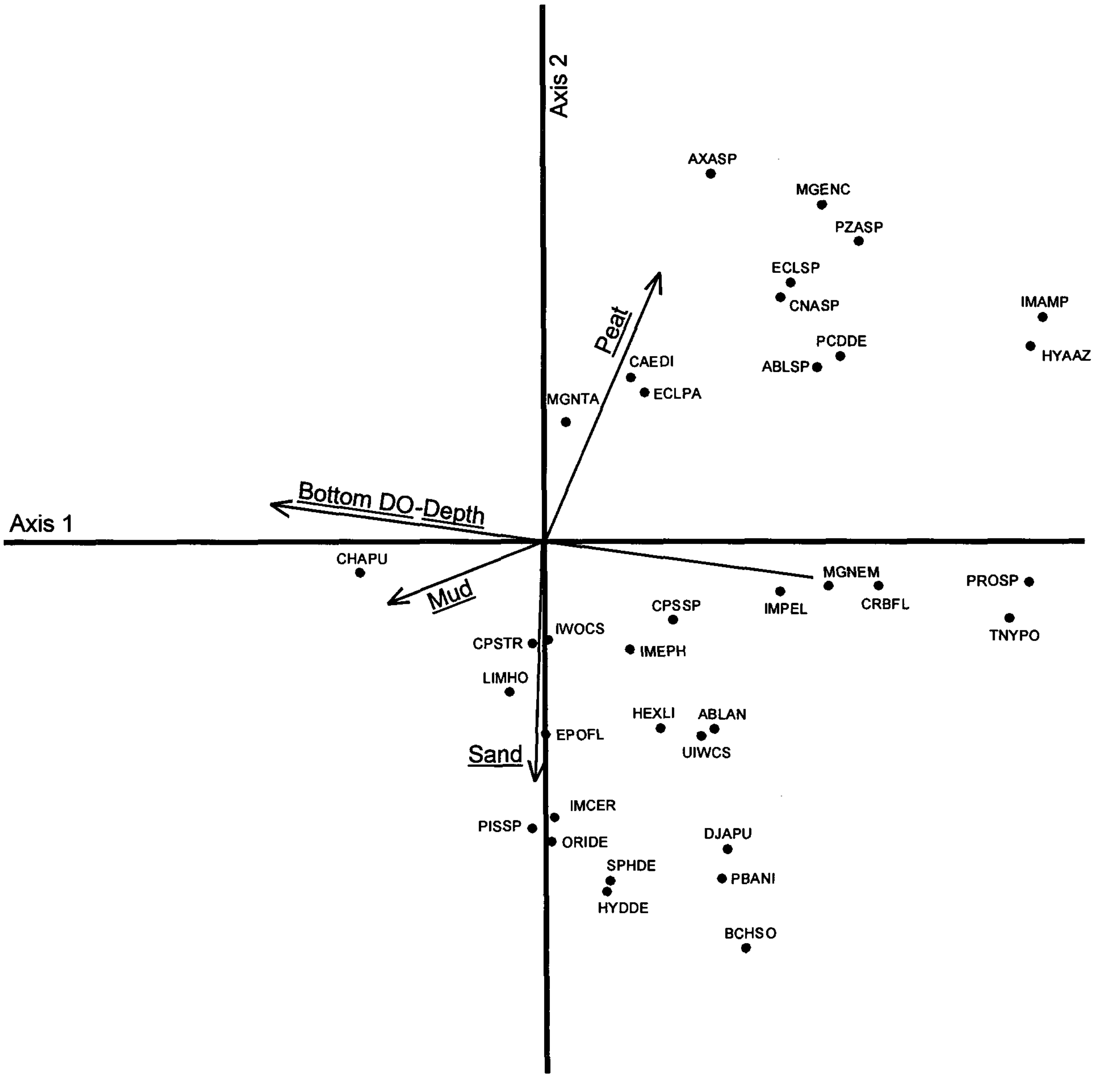

FIGURE 6. Biplot produced by canonical correspondence analysis of dominant (>5% relative abundance) aquatic invertebrate taxa inhabiting Blue Cypress Lake. Constraining environmental variables are water depth, bottom D.O. and sediment type. Species codes are translated in Appendix 3.

its lowest levels. A taxon located near the origin of the plot (which represents the average values of the environmental parameters) reaches its greatest abundance at moderate levels of the variable. In our CCA, the taxa that ordinate close to the bottom DO- depth arrowhead reach their greatest densities at deeper depths and/or higher dissolved oxygen levels. We complemented our CCA by overlaying the categorical variable bottom type (mud, sand, peat) onto the analysis. The resulting biplot (Figure 6) combined the independent variables depth and dissolved oxygen into one vector (the arrow labeled Bottom DO-Depth); the mud, sand, and peat habitat types are represented as separate arrows. Codes used for labeling the points representing dominant taxa in Figure 6 are translated in Appendix 3. Descriptive statistics for our analysis are contained in Table 5. Results of CCA indicated that, in Blue Cypress Lake, bottom type is more important than depth or dissolved oxygen concentration in determining invertebrate community distribution. Depth and dissolved oxygen, within the ranges measures during the study, were not limiting factors, but played secondary roles in structuring invertebrate assemblages.

Most sediment-associated dominant taxa reached their greatest densities in peat and sand sediments. Only three species, the phantom midge Chaoborus punctipennis (code CHAPU), the segmented worm Limnodrilus hoffmeisteri (LIMHO), and the larval midge Coelotanypus tricolor (CPSTR) reached their greatest densities in mud sediments at below average (2.3 m) depths (Figure 6). The remaining dominant taxa were separated into two fairly discrete clusters - one a peat-dwelling community and the second a sand-dwelling assemblage (Figure 6). The peat-associated assemblage (upper right quadrant of Figure 6) was a collection of predators (CNASP = Cernotina sp.,PZASP = Probezzia sp., ABLSP = Ablabesmyia sp.), detritus collectors (CAEDI = Caenis diminuta, ECLPA = Eclipidrilus palustris, MGENC = Enchytraeidae), and periphyton grazers

TABLE 5. Descriptive statistics resulting from canonical correspondence analysis of invertebrate communities associated with sediment habitats sampled in Blue Cypress Lake from May 1998 through April 1999.

Parameter	Axis 1	Axis 2
Eigenvalue	0.021	0.006
% of variance explained	15.7	4.3
Cumulative % explained	15.7	20.0
Pearson Correlation, Spp.-Envt.	0.691	0.676
Kendall (Rank) Corr., Spp.,-Envt.	0.539	0.629

Total variance in species data = 0.1341

(HYAAZ = Hyalella azteca)(Figure 6). The community associated with sand (lower right quadrant of Figure 6) was composed primarily of predaceous midge larvae (PROSP = Procladius sp., CPSSP = Coelotanypus sp., DJAPU = Djalmabatista pulchra)and phytoplankton filterers (CRBFL = Corbicula fluminea, SPHDE = Sphaeriidae)(Figure 6).

Given the overriding influence of substrate type, CCA results also showed that most invertebrate taxa attained their greatest densities in conditions of less than average measured values of bottom depth and dissolved oxygen. Near-bottom measurements of dissolved oxygen (DO) ranged from 3.4 ppm (Site S3, July 1998) to 8.6 ppm (Site S3, April 1999)(Appendix 4). Overall, DO concentrations were lowest in July; however, eight of the nine July open water measurements were above 4.0 ppm, despite the fact that near-bottom water temperatures were often in excess of 30° C (Appendix 4). The July 1998 S3 measurement was the lone case where bottom dissolved oxygen levels in open water areas were measured at below 4.0 ppm (Appendix 4). Based upon experience and published tolerance lists (e.g. Roback 1974), we consider 4.0 ppm a critical low threshold for the support of balanced benthic communities in south Florida lakes. Excluding the July sampling event, 91 percent of near-bottom oxygen measurements recorded from Blue Cypress Lake were 6.0 ppm or greater. We therefore consider dissolved oxygen concentration to be the least limiting of the three variables (substrate type, dissolved oxygen, depth) included in the CCA.

Depth, however, does play a major role in structuring Blue Cypress Lake benthic invertebrate communities. Of the 35 dominant invertebrate taxa included in the CCA, only three (Chaoborus punctipennis, Coelotanypus tricolor, and Limnodrilus hoffmeisteri) occurred in their greatest densities at greater than average bottom depth (2.4 meters)(Figure 6). C. punctipennis, C. tricolor, and L. hoffmeisteri are often among the most abundant benthic species in deeper areas of Florida lakes, and often dominate the profundal zones of lakes that thermally stratify. The remaining 32 taxa included in the Blue Cypress Lake CCA reached optimum densities in depths ranging from 1.7 to 2.4 meters.

Depth also affected descriptors of invertebrate community quality. Per sample counts of species richness and total organisms were negatively correlated with depth (correlation coefficients = -0.449 and -0.459, respectively; significant at $\alpha = 0.05$). Per sample diversity was slightly negatively correlated with depth (correlation coefficient = -0.080), but this correlation was not significant. Evenness was positively and significantly correlated with depth (correlation coefficient = 0.226; $\alpha = 0.05$), an indication that those organisms that dominate the community of deeper lake regions occur together in relatively similar abundances.

With most taxa reaching their greatest densities in shallower depths and sand substrates, a principal implication of our CCA results is that sustained periods of high water levels (over the bank) in Blue Cypress Lake would likely result in reductions in the areal distributions and densities of some taxa. The relative abundances of dominant taxa would shift, deeper water taxa (often less desirable) would become more abundant, and some taxa could be extirpated. Transport of allochthonous decaying organic matter from surrounding marshlands into the lake basin could exacerbate the depth problem by covering desirable sand habitat and creating higher sediment biochemical oxygen demand, thus decreasing the amount of oxygen available to fish and invertebrate communities.

Functional Feeding Group Analysis

A functional feeding group analysis was performed to gain a trophic perspective on aquatic invertebrate community structure. The functional feeding group concept was developed by aquatic ecologists as a tool to assess the degree to which the invertebrate biota of a given system is dependent upon a particular food resource, as a method to determine the primary source of a food resource (autochthonous, riparian, or allochthonous), and as a way to compare functional processes among different systems (Cummins 1973, Cummins & Merritt 1996). Functional group relative abundance has been shown to shift in response to environmental variables and food availability (Hawkins & Sedell 1991), and eutrophication (Carr & Hiltunen 1965).

To facilitate the analysis, each individual taxon was assigned to one of five major functional categories (Appendix 5). These assignments classify taxa with respect to their consumption of food resource types, the intent being to facilitate analyses using ecologically functioning groups rather than more artificial taxonomic classifications (Cummins and Merritt 1996). Categories used in our analysis were: Grazers (consumers of attached algae and microfauna), Gatherers (collectors of fine particulate organic detritus), Filterers (taxa which filter, either with spun nets or body parts, suspended particulate organic matter from the water column), Predators (consumers of live animal prey), and Piercers (consumers of fluids from living macrophytes) (Appendix 5).

High proportions of a single functional group within an invertebrate community are usually indicative of an abundance of its preferred food category (Hawkins and Sedell 1991). A high proportion of gatherers is indicative of extensive accumulations of decaying particulate organic matter (POM); a high proportion of filterers would infer large amounts of suspended organic matter, either plankton or POM. High percentages of grazers are usually indicative of low turbidities, moderate levels of nutrients, and an abundance of attached algae.

Results of functional feeding group analyses are presented in Figure 7. Filterers were the predominant functional group in all sediment types and commonly accounted for more than 40

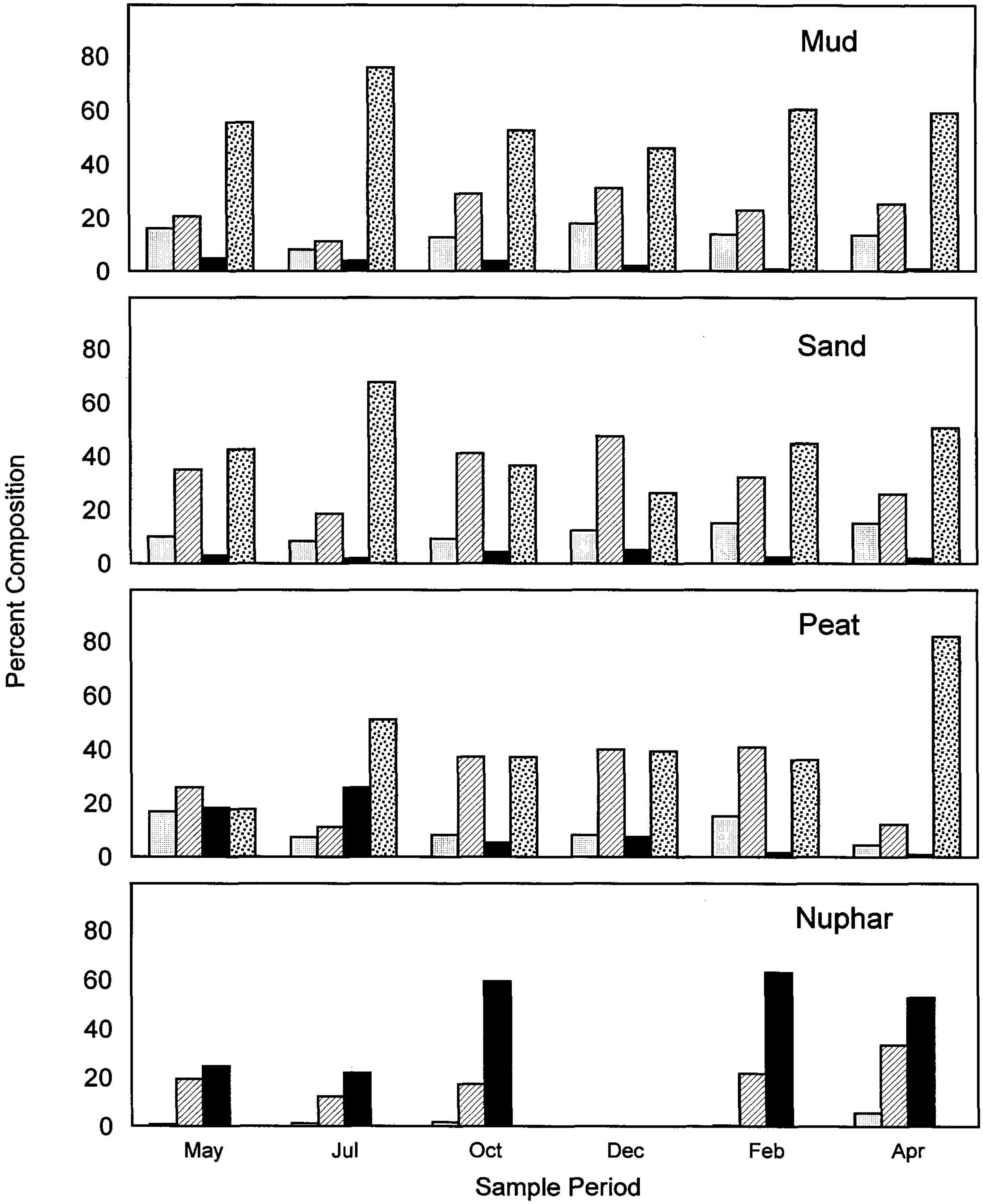

FIGURE 7. Seasonal and habitat variation of aquatic invertebrate functional group percent composition in Blue Cypress Lake (Indian River Co., FL) May 1998 through April 1999 (▢ = Predators; ▨ = Gatherers; ■ = Grazers; ▩ = Filterers).

percent of the total organisms in each habitat/sample period combination (Figure 7). POM gatherers were next most abundant, but rarely exceeded 40 percent of the total organisms. Only on three occasions (sand during 10/98 and peat during 12/98 & 2/99) did gatherers exceed filterers in relative abundance. Only in one habitat/sample period combination (peat during 7/98) did relative abundance of grazers exceed 20 percent. As is typical of invertebrate communities in lacustrine systems, predator taxa never exceeded 20 percent of the relative abundance and piercers were nonexistent (Figure 7).

Functional group structure on the Nuphar habitat differed substantially from that in benthic habitats. The most abundant taxon on Nuphar, Nematoda, was excluded from the functional group analysis because trophic characteristics of the group are species specific and species level nematode identifications were not within the scope of the project due to high costs. Consequently, attached algae grazers were the predominant known functional group identified from Nuphar stems during all sample periods. The relative abundance of POM gatherers on Nuphar exceeded 20 percent on only one occasion - April 1999 (Figure 7). No other functional group exceeded ten percent of the total organisms for any habitat/date combination throughout the duration of the study (Figure 7).

Overall, results of functional feeding group analysis reflect the dominance of the filter-feeding Asian clam Corbicula fluminea in benthic habitats and grazing larval Chironomidae (nonbiting midges) and Naididae (segmented worms) on Nuphar stems. All of these taxa are dependent upon algae as their primary food source, whether it be planktonic (as with C. fluminea) or attached to Nuphar stems (Chironomidae & Naididae). The high proportion of algae consuming invertebrate taxa relative to other functional groups is obviously indicative of an adequate phytoplankton food supply, and of prevailing environmental conditions that are characterized by prolonged periods of low turbidity, substantial light penetration, and nutrient concentrations adequate for high levels of primary production.

Comparisons With Other Florida Lakes

To enable comparison of the Blue Cypress Lake invertebrate community with the analogous communities inhabiting other central and south Florida lakes, we gathered quantitative data from reports compiled by the former Florida Game and Fresh Water Fish Commission (GFC; now Florida Fish and Wildlife Conservation Commission) and the Florida Department of Environmental Protection (FDEP). It is important to note that the following comparisons must be examined with the realization that differences in study design, field methods, level of taxonomic identification, and lake morphology prevent exacting comparisons.

Benthic invertebrate communities inhabiting Blue Cypress Lake and Lake Okeechobee were compared using results from collections obtained by GFC biologists during 1990-91 (Table 6, Appendix 6). Although a considerable size difference exists between the two lakes (Blue Cypress Lake = approximately 6,700 acres; Lake Okeechobee = approximately 450,000 acres), they are both shallow and characterized by three major bottom habitat types (fine mud, medium sand, coarse peat) in the sublittoral zone. To facilitate the comparisons, the two lakes were sampled twice (Nov. 1990 and June 1991), on consecutive days, using duplicate field methods (3 sites per sediment type, triplicate petite ponars at each site, 300 micron mesh). Laboratory methods and level of taxonomic identifications were also identical.

Results from the comparative collections showed that the Blue Cypress Lake invertebrate community was the more taxa rich and diverse of the two lakes. Blue Cypress Lake supported a greater number of taxa across all habitats and within each individual habitat. A total of 58 taxa were

TABLE 6. Benthic invertebrate community descriptor comparison in three bottom habitat types: Blue Cypress Lake vs. Lake Okeechobee, November 1990 and June 1991 sampling events combined.

	HABITAT TYPE					
	MUD		SAND		PEAT	
	Okeechobee	Blue Cypress	Okeechobee	Blue Cypress	Okeechobee	Blue Cypress
Parameter	$\bar{X}$ (cv) (n=18)	$\bar{X}$ (cv) (n=18)	$\bar{X}$ (cv) (n=18)	$\bar{X}$ (cv) (n=18)	$\bar{X}$ (cv) (n=18)	$\bar{X}$ (cv) (n=18)
Total Taxa Richness	16	19	10	34	37	51
Mean Taxa Richness	8 (0.20)	7 (0.13)	5 (0.38)	16 (0.21)	20 (0.25)	22 (0.46)
Mean Diversity	1.69 (0.16)	1.85 (0.42)	1.42 (0.19)	2.67 (0.19)	2.85 (0.23)	3.51 (0.08)
Mean Evenness	0.56 (0.19)	0.65 (0.39)	0.70 (0.23)	0.67 (0.14)	0.66 (0.16)	0.82 (0.09)
Mean Total Organisms	4,384 (0.44)	1,728 (0.59)	1,839 (0.71)	5,011 (0.17)	24,020 (0.23)	4,662 (0.88)

Total Taxa Lake Okeechobee= 40
Total Taxa Blue Cypress Lake = 58

collected from Blue Cypress Lake, whereas only 40 total taxa were collected from Lake Okeechobee (Table 6, Appendix 6). Within-habitat total taxa differences between the two lakes were particularly profound in sand (34 taxa from Blue Cypress; 10 taxa from Okeechobee) and peat (51 taxa from Blue Cypress; 37 taxa from Okeechobee) habitats (Table 6). When examined on a mean number of taxa per sample basis, the two lakes supported nearly equal numbers of taxa in mud (8 in Okeechobee vs. 7 in Blue Cypress) and peat sediments (22 in Blue Cypress vs. 20 in Okeechobee). However, Blue Cypress Lake supported a substantially greater number of taxa per sample in sand sediments (16 vs. 5 in Okeechobee)(Table 6).

Comparison of the taxonomic compositions of the benthic faunas of the two lakes (Appendix 6) indicated that Blue Cypress Lake was inhabited by more taxa regarded as intolerant of poor habitat conditions. This distinction was reflected especially in the mayfly (Ephemeroptera) and caddisfly (Trichoptera) faunas, where a total of seven taxa from the two taxonomic groups accounted for 38.3 percent of the Blue Cypress Lake mean total organism abundance. Only three mayfly and caddisfly taxa were collected from Lake Okeechobee; these three taxa together accounted for only 0.6 percent of the mean total organisms (Appendix 6).

Comparison of Shannon diversity values (Shannon and Weaver 1949) by habitat type showed that diversity of Blue Cypress Lake invertebrate communities consistently exceeded diversity of the corresponding communities in Lake Okeechobee. The relatively greater diversity of the Blue Cypress Lake community reflects the greater number of invertebrate taxa present in the lake and the more homogenous distribution of individuals among these taxa.

To provide a broad comparison of Blue Cypress Lake invertebrate communities with the analogous communities inhabiting other lakes in the region, we compiled data collected from 25

Florida lakes by FDEP from 1996 through 1999 (Rutter 1997, Rutter 1998, Rutter 1999, Rutter 2000). The FDEP-sampled lakes were mostly smaller (all but 1 < 1000 acres) and were located in the Lake Wales ridge or southwestern flatlands ecoregions. Sampling of these lakes occurred during the summer and winter seasons only. To validate our comparisons as much as possible, we used Blue Cypress Lake data from only the months of July (1998) and February (1999).

Our comparison of community descriptors (Table 7) showed that Blue Cypress Lake ranked first among the lakes in total taxa collected and Ephemeroptera/Trichoptera/Chironomidae (mayfly/caddisfly/non-biting midge) taxa collected. However, the greater Blue Cypress Lake totals for both descriptors are probably an artifact of a larger sample size. Blue Cypress Lake descriptor values were generated from 54 samples, whereas descriptor values from all other lakes included in Table 7 were computed from 24 samples per lake. More complete sample processing of FWC-collected samples also may have elevated taxa counts. FWC biologists removed all organisms from each sample; FDEP biologists removed only the first 100 organisms encountered. Perhaps the single best measure of the relative quality of the Blue Cypress Lake invertebrate community is a comparison of Shannon diversity values. To validate this comparison we computed a Blue Cypress Lake diversity value from a composite of all summer (July) and winter (February) samples, in a manner similar to FDEP's computation. The resulting value, 3.08, ranked 14th among values from the 26 lakes appearing in Table 7.

Based upon all of our comparisons, we conclude that the taxonomic composition, diversity, and abundance of the Blue Cypress Lake macroinvertebrate community is characteristic of healthy, relatively unimpacted lakes in central and south Florida . What makes the Blue Cypress Lake

TABLE 7. Aquatic invertebrate community descriptors from 25 central and south Florida lakes sampled 1997 - 2000, winter and summer collections combined. E/T/C = Ephemeroptera/Trichoptera/Chironomidae ratio. Organism densities are number/sq. meter.

Lake	Acres	Total Samples	Mean Total Organism Density	Total Taxa	E/T/C	Mean Density Hexagenia sp.	Shannon Diversity Value
Adelaide	96	24	5,640	46	2/4/25	0	4.42
Avalon	37	24	3,050	33	1/3/9	0	3.61
Blue Cypress Lake	**6,700**	**54**	**6,620**	**73**	**5/3/27**	**275**	**3.08**
Carrie	65	24	1,406	25	½/6	238	3.38
Clay	367	24	6,956	38	0/2/16	0	3.63
Crystal	22	24	2,303	11	0/0/6	0	1.23
Denton	66	24	1,841	27	2/2/10	0	2.64
Dinner	379	24	5,077	33	0/2/15	0	2.57
Huntley	680	24	1,028	35	1/3/17	301	3.38
Jackson-north basin	362	24	3,067	30	½/13	530	3.86
Jackson-south basin west	?	24	3,285	32	1/0/18	792	3.40
Jackson-south basin east	?	24	2,774	24	1/1/13	1,014	2.91

TABLE 7 (continued).

Lake	Acres	Total Samples	Mean Total Organism Density	Total Taxa	E/T/C	Mean Density Hexagenia sp.	Shannon Diversity Value
Josephine East	581	24	4,630	21	1/0/6	240	2.70
Josephine Middle	259	24	1,560	17	1/0/5	210	2.63
Josephine West	396	24	2,113	24	1/0/6	187	3.19
Little Bonnet	84	24	10,445	20	0/0/13	0	3.00
Persimmon	30	24	7,698	15	1/1/11	0	0.96
Rachard	15	24	4,177	25	1/0/16	0	2.20
Sebring	468	24	972	23	1/3/9	165	3.23
Sunshine	12	24	4,653	8	0/0/5	0	1.44
Trout	137	24	10,524	32	1/1/18	232	3.29
Tulane	89	24	5,883	28	2/2/13	0	2.93
Verona	35	24	13,412	33	0/3/17	0	3.40
Viola	73	24	2,950	36	1/3/18	0	3.31

invertebrate community unique, outstanding, and worthy of protection is the healthy population of the burrowing mayfly Hexagenia orlando.

The Significance of the Blue Cypress Lake Hexagenia orlando Population

The burrowing mayfly Hexagenia orlando should be regarded as the premier keystone indicator of the trophic status and overall biological health of Blue Cypress Lake. The indicator status of Hexagenia is well documented. Hexagenia were once abundant in lakes and large rivers throughout the eastern and midwestern United States, but, because nymphs (the immature aquatic form) are sensitive to habitat modifications caused by the accumulations of decaying organic material that accompany eutrophication, the genus has been extirpated from many aquatic systems (Fremling 1964, Carr and Hiltunen 1965, Mills et al.1966, Mills et al. 1978, Rasmussen 1988). Improved water quality and sediment conditions, however, can foster mayfly recolonization and recovery (Krieger 1996). Consequently, Hexagenia populations are useful not only as indicators of environmental perturbation, but also as indicators of recovery from perturbation. Berner and Pescador (1988) observed that H. orlando "is one of the most ecologically limited species in Florida", and, as such, its population dynamics can be a barometer of even subtle environmental change.

Among the different lake bottom habitat types in Blue Cypress Lake, the sand sediments comprising the eastern one-third of the lake supported the greatest densities of H. orlando. These densities ranged from 0 to 2578 individuals m^{-2} in individual samples, with seasonal means ranging from 148 m^{-2} in April, 1999, to 1452 m^{-2} in October 1998. The overall mean for sand sediments was 782 individuals m^{-2} (Figure 5, Appendix 2). Peat sediments supported intermediate densities, ranging from 0 to 1289 m^{-2} in individual samples, with seasonal means ranging from 25 m^{-2} in both

May, 1998, and April, 1999, to 830 m^{-2} during October, 1998 (Figure 5). The overall mean for H. orlando in peat sediments was 254 m^{-2} (Appendix 2). Mud sediments, which comprised the deepest bottom habitat type in the lake, supported far fewer H. orlando m^{-2} than the other bottom habitat types (Figure 5). Densities in individual samples ranged from 0 to 489 m-2. Seasonal means ranged from 79 in July, 1998, to 237 m^{-2} during October, 1998. The overall mean for H. orlando in mud sediments was 156 individuals m^{-2} (Appendix 2).

Blue Cypress Lake H. orlando density estimates computed for the present study are similar to recent H. orlando density estimates from lakes on Florida's central sand ridge. These lakes, located in Highlands and Charlotte Counties, are the center of H. orlando's distribution within the state (Berner and Pescador 1988). In studies of 23 lakes, Rutter (1997, 1998, 1999, 2000) found H. orlando in 9 lakes, with densities ranging from 55 to 439 individuals m^{-2} during winter collections and from 31 to 276 individuals m^{-2} during summer collection periods.

To document long-term trends in the abundance of H. orlando in Blue Cypress Lake, we obtained raw data from Florida Department of Environmental Regulation (FDER; now Florida Department of Environmental Protection) collections conducted from 1975 through 1983 (J. Hulbert, FDEP, personal communication). During this period, FDER routinely sampled at only one location - the center of the lake in mud sediments. Data from Florida Game and Fresh Water Fish Commission (now Florida Fish and Wildlife Conservation Commission) collections obtained at this same site in 1990, 1991, and during the present study (1998-99) were also used to construct a box-whisker plot of H. orlando densities for all sampling years (Figure 8). This plot must be examined with the consideration that the data are from one site only, and that the mud sediments at this site are not the habitat that harbors the greatest densities of H. orlando in Blue Cypress Lake. However, this mid-

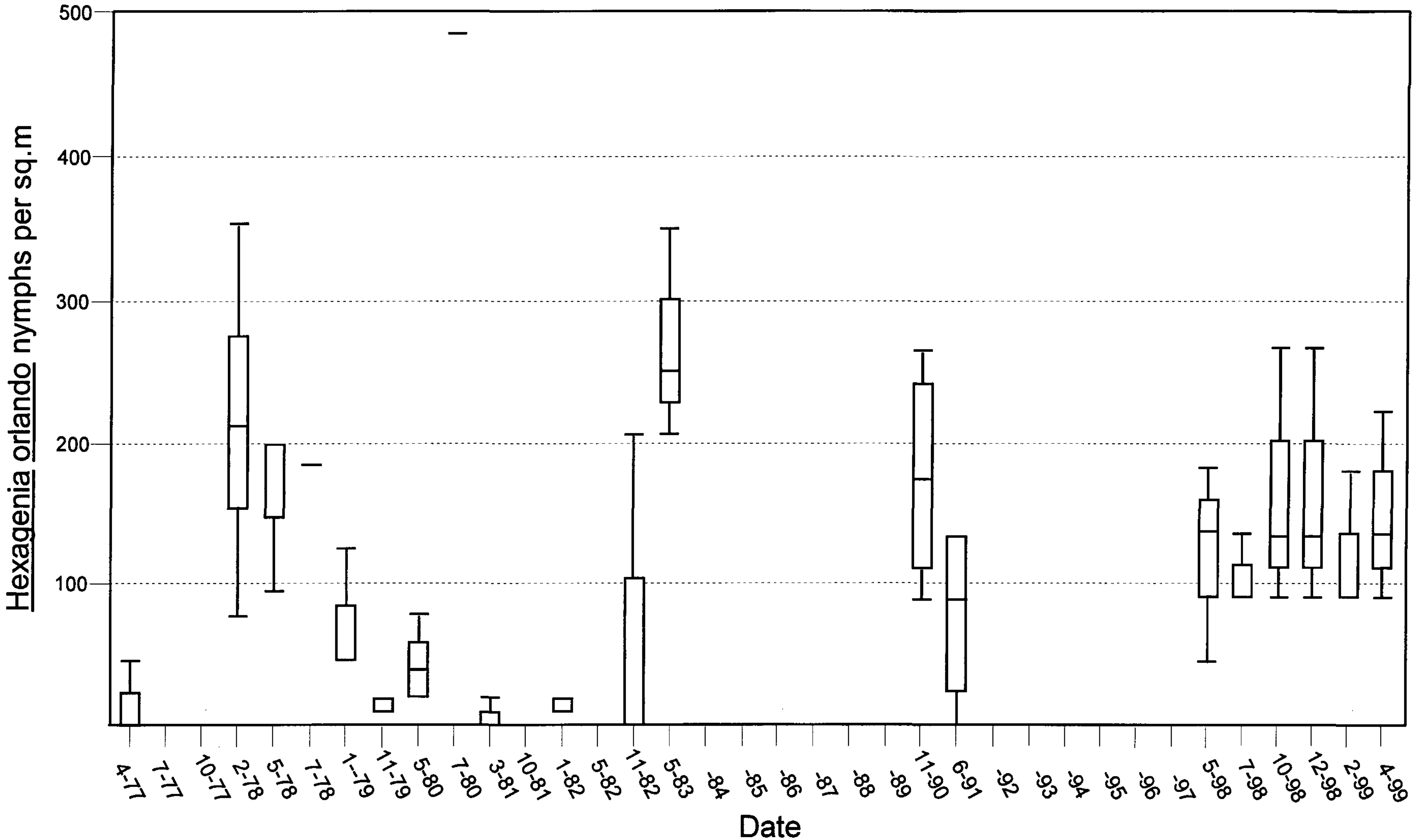

FIGURE 8. Box-whisker plot of Hexagenia orlando densities in Blue Cypress Lake (Indian River Co., FL) 1977 through 1999. Data are from lake center, mud sediments (n=3 or 4, depending upon sample period).

lake site is the location from which the longest-term data set exists. Differences in season, sampling methods, and mesh sizes may contribute to differences between DER and FWC density estimates. These same differences make parametric statistical comparisons inappropriate. Considerable variation in H. orlando densities among sampling events is apparent in Figure 8, with median densities ranging from 0 to nearly 500 individuals per square meter. The degree of variation is especially obvious in collections occurring from 1978 - 1983. From the results presented in Figure 8, we conclude that no strong trend toward declining or increasing densities is evident for the period of record, and that more frequent sampling at more locations is required to produce accurate density estimates. However, from our results and those of Rutter (1997, 1998, 1999, 2000), we can conclude that densities of the Blue Cypress Lake H. orlando population appear to be stable, and that these same densities are similar to H. orlando densities in the central Florida lakes that constitute the center of distribution for the species. The Blue Cypress Lake population was apparently very stable during the 1998-1999 study year, with July and February declines being attributable to normal emergences of subimagos (Figure 8).

Fish Diet Analysis

Hexagenia nymphs are among the largest of benthic insects and are consumed with high selectivity by many epilimnetic fish species (Klaassen and Marzolf 1971, Clady and Hutchinson 1976, Johnson 1977, Ryder and Kerr 1978). The greatest growth rates noted for some fish species have been associated with high Hexagenia consumption (Swedberg 1968, Hayward and Margraf 1987). To document the relative contributions of Hexagenia orlando, other aquatic invertebrates, and forage fish to the diets of Blue Cypress Lake sport fish, we conducted food habits analyses on five fish species collected during September 1995. Although not within the scope of work for the present project, results from these analyses are extremely indicative of the importance of invertebrates (especially H. orlando, Hyalella azteca, and Palaemonetes paludosus) in the diets of Blue Cypress Lake fish. Results are also indicative of a low abundance of forage fish, which has been confirmed via trawl sampling (Don Fox, FWC, personal communication). Fish diets examined included bluegill (Lepomis macrochirus), redbreast sunfish (Lepomis auritus), redear sunfish (Lepomis microlophus), black crappie (Pomoxis nigromaculatus) and largemouth bass (Micropterus salmoides). Results (Appendix 7) must be examined with the realization that they are from a one-time sampling event (samples from several seasons would be preferable) and that the M. salmoides specimens captured were small (range = 106 - 248 mm) and possibly not yet piscivorus. However, results indicated that H. orlando made significant contributions to the diets of black crappie (22.3 % of all diet items) and redear sunfish (13.3 %), and that gizzard shad (Dorosoma cepedianum) and other forage fish were virtually absent from sport fish diets.

The crustacean amphipod Hyalella azteca and the grass shrimp Palaemonetes paludosus also contributed substantially to the diets of the fish species sampled. Both M. salmoides and P. nigromaculatus fed heavily on grass shrimp, which comprised 75 and 42 percents of their respective diets (Appendix 6). Hyalella azteca accounted for the greatest proportion of stomach contents in L. macrochirus (57.3%), L. auritus (75.0%), and L. microlophus (43.3%). Anisoptera (dragonfly) nymphs and adults were consumed by L. macrochirus, L. auritus and P. nigromaculatus (0.1, 13.8 and 6.5 %, respectively; Appendix 7). Lepomis macrochirus consumed the greatest diversity of invertebrates (44 taxa) and were the only fish feeding heavily on Chironomidae (18 species, 22%; Appendix 7). One third of organisms consumed by L. microlophus were the aquatic gastropods Viviparus georgianus (26.6%) and Melanoides tuberculata (6.6%)(Appendix 7).

Water Level Manipulation and Sedimentation Effects

Many of Florida's aquatic resources are managed primarily to benefit domestic, agricultural, or industrial uses. This management has often occurred at the expense of resident biota; prime examples are Lake Okeechobee and Lake Apopka. Blue Cypress Lake has not been managed in such a manner, but the growing population along Florida's middle east coast and the presence of large agricultural tracts within the Upper St. Johns River Basin Project increase the potential for use of the lake as a reservoir. Consequences of such use would be extremely detrimental to the existing Blue Cypress Lake ecosystem.

Results from sediment thickness probes conducted by Coastal Planning and Engineering (1992) and Brenner and Shelske's (1995) sediment/nutrient accumulation investigation suggest that bottom habitat conditions for Hexagenia and other benthic animals in Blue Cypress Lake are deteriorating. Organic sediments have accumulated at an increasing rate since 1935 and the phosphorus accumulation rate since 1970 is more than double the 1920 rate (Brenner and Schelske 1995). Future development-related manipulations that raise water levels, extend hydroperiods, and increase inputs of allochthonous organic material have the potential to further accelerate benthic habitat degradation and transform Blue Cypress Lake into a sink for accumulation of additional nutrients and organic sediments. Sedimentation of organic material, and conditions associated with eutrophication, have been shown to extirpate Hexagenia mayflies and other embenthic invertebrates that are dependent upon firm sediments to maintain the integrity of burrows (Carr and Hiltunen 1965, Jacobsen 1966, Beeton 1969, Rasmussen 1988). Additionally, increased turbidity resulting from allochthonous inputs associated with prolonged periods of higher water levels has the potential to shade-out the small rooted aquatic macrophyte community that inhabits the lake, thus reducing the food source (attached algae) and habitat (Nuphar and Panicum) for important food-web and indicator species, including Hyalella azteca and Palaemonetes paludosus. Increased turbidity combined with extensive build-ups of unconsolidated organic sediments could, eventually, result in an undesirable shift in the species composition and relative abundances of the entire invertebrate community. Similar shifts in other lake systems have resulted in replacement of desirable benthic invertebrates assemblages by organic pollution tolerant segmented worm communities that are indicative of chronic low dissolved oxygen concentrations and, overall, poor habitat conditions (Carr and Hiltunen 1965, Thut 1969, Wiederholm 1980, Warren et al. 1995).

Conclusions

The structure of the invertebrate assemblage associated with Blue Cypress Lake sediments is indicative of good habitat conditions, and, overall, a mesotrophic lake ecosystem. Overwhelming dominance by the filter-feeding Asian clam Corbicula fluminea and the burrowing mayfly Hexagenia orlando is indicative of ample supplies of both phytoplankton and detrital food sources, low turbidities, and adequate concentrations of dissolved oxygen.

The primary determinant of benthic invertebrate community distribution in Blue Cypress Lake is sediment type. Although Corbicula numerically predominates all sediments (sand, mud, and peat), the most species rich, diverse, and evenly distributed benthic community in the lake inhabits the sand substrate that constitutes the eastern one-third of the lake bottom. The peat substrate occupying the eastern one-third of the lake and mud sediments of the central one-third support communities of substantially lower species richness and diversity, however the taxonomic composition of these communities reflects moderate to good habitat conditions relative to similar habitats in other Florida lakes.

Bottom depth plays a secondary role in structuring Blue Cypress invertebrate communities. Thirty-two of the 35 dominant taxa (91%) increased in density with decreasing depth. These results combined with those of canonical correspondence analysis imply that sustained periods of high water levels would result in reductions in densities and ranges many benthic taxa. Abundances and ranges of less desirable deep water species (primarily Oligochaeta) would likely expand.

Near-bottom dissolved oxygen concentrations were measured at less than 4.0 ppm on only one date at only one location, and are not considered to be limiting to the structure of Blue Cypress Lake invertebrate communities at this time.

Sport fish species of Blue Cypress Lake are dependent upon aquatic invertebrates as their primary food source. Even fish species that typically switch to piscivory during the juvenile stage (e.g. black crappie, Pomoxis nigromaculatus) are dependent upon invertebrates as a food source as adults. Forage fish species are apparently in low abundance. Environmental conditions that adversely affect populations of important fish food organisms, such as Hexagenia orlando, Hyalella azteca, or Palaemonetes paludosus, would be indirectly, if not directly, detrimental to the health of sport fish populations.

Comparisons with Lake Okeechobee and other, smaller, central and south Florida lakes indicated that taxonomic composition, abundance, and diversity of the Blue Cypress Lake aquatic invertebrate community were comparable to the corresponding metrics from lakes considered to be biologically healthy. The trophic status of Blue Cypress Lake, relative to the other lakes examined, appears to be mesotrophic.

The Hexagenia orlando population of Blue Cypress Lake should be considered, and monitored routinely as, the keystone indicator of the ecological health of the lake ecosystem. A trend of decreasing H. orlando density would signal a shift in trophic status and would have ramifications throughout the food web of the lake.

Water requirements of a growing Florida population and agriculture have prompted water managers to operate entire watersheds as reservoirs rather than natural systems, often to the detriment of the resident biota. Managing Blue Cypress Lake in such a manner (by raising lake levels over the bank and into the surrounding marsh for prolonged periods of time) would most likely alter benthic habitat conditions to the extent that the structure of the bottom-dwelling invertebrate fauna would be altered substantially. These changes would be initiated by increases in allochthonous particulate organic matter input, nutrient accumulation, and turbidity. As a consequence, the lake would be forced from mesotrophic to eutrophic status. The resulting benthic invertebrate community would be species poor and composed of tolerant taxa indicative of poor habitat conditions. Invertebrate species upon which sport fish depend as a food source would be negatively impacted by these conditions.

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APPENDIX 1.

Literature used by the Freshwater Invertebrate Resources Unit of the Florida Fish and Wildlife Conservation Commission for taxonomic identification of freshwater invertebrates

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APPENDIX 2.

Mean densities (no. m^{-2}), coefficients of variation (cv), and percent compositions of aquatic invertebrate taxa collected from four major habitat types in Blue Cypress Lake from May 1998 through April 1999.

APPENDIX 2. Mean densities (no. m^{-2}), coefficients of variation (cv), and percent compositions of aquatic invertebrate taxa collected from four major habitat types in Blue Cypress Lake from May 1998 through April 1999.

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Porifera	C	C	C	C	---
Cnidaria					
Hydrozoa					
Cordylophora lacustris	---	---	---	---	C
Hydra sp.	---	1 (7.35) <0.1	3 (5.15) 0.1	1 (7.59) <0.1	2 (2.80) 0.1
Turbellaria	---	2 (5.15) <0.1	8 (4.33) 0.1	3 (6.48) 0.1	1 (2.64) 0.1
Nemertea					
Prostoma spp.	---	20 (2.61) 0.4	30 (2.99) 0.5	16 (3.65) 0.3	---
Nematoda	13 (2.51) 0.6	185 (1.31) 3.5	192 (2.49) 3.1	130 (2.45) 2.8	1,042 (1.90) 38.4
Annelida					
Aphanoneura					
Aeolosomatidae					
Aeolosoma travencorense	---	---	---	---	1 (2.64) 0.1
Unknown Aphanoneura	---	---	---	---	2 (2.07)

APPENDIX 2. continued.

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Hirudinia	4 (3.16) 0.2	1 (7.35) <0.1	11 (3.91) 0.2	5 (5.01) 0.1	---
Oligochaeta (total)	300 (0.58) 13.0	542 (0.66) 10.2	663 (1.07) 10.7	502 (0.98) 10.9	239 (1.62) 8.8
Enchytraeidae	---	2 (5.15) <0.1	239 (2.10) 3.9	80 (3.85) 1.7	1 (3.87) <0.1
Naididae (total)	1 (7.35) <0.1	46 (2.19) 0.9	60 (2.57) 1.0	36 (3.05) 0.8	231 (1.67) 8.5
Amphichaeta americana	---	12 (2.46) 0.2	---	4 (4.47) 0.1	---
Bratislavia unidentata	---	---	---	---	5 (1.79) 0.2
Dero sp.	---	---	---	---	13 (2.77) 0.5
D. furcata	---	---	---	---	15 (2.53) 0.5
D. nivea	---	---	---	---	8 (2.55) 0.3
D. obtusa	---	---	---	---	7 (2.17) 0.3

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
D. nivea or *obtusa*	---	2 (5.44) 0.1	---	1 (9.46) <1.0	40 (2.14) 1.5
D. pectinata	---	7 (4.23) 0.1	---	2 (7.42) <1.0	100 (1.86) 3.7
D. trifida	---	---	---	---	2 (2.80) 0.1
Nais communis	---	1 (7.35) <0.1	---	1 (12.73) <0.1	1 (3.87) <0.1
N. variabilis	---	---	---	---	11 (1.65) 0.4
Pristina leidyi	---	2 (4.16) 0.1	14 (3.59) 0.2	5 (5.47) 0.1	9 (1.58) 0.3
Pristinella osborni	---	1 (7.35) <0.1	40 (2.94) 0.6	14 (5.15) 0.3	1 (3.87) <0.1
Slavina appendiculata	---	---	5 (5.44) 0.1	2 (9.46) <0.1	7 (2.24) 0.3
Specaria josinae	---	7 (5.31) 0.1	---	2 (9.25) <0.1	---

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Stephensoniana trivandrana	1 (7.35) <0.1	---	---	1 (12.73) <0.1	---
Stylaria lacustris	---	---	---	---	7 (2.45) 0.3
Unknown Naididae	---	14 (4.08) 0.3	1 (7.35) <0.1	5 (6.80) 0.1	3 (3.00) 0.1
Opistocystidae					
Crustipellis tribranchiata	---	---	---	---	1 (3.87) 0.1
Crustipellis or *Pristina*	---	---	---	---	4 (3.14) 0.1
Tubificidae (total)	298 (0.58) 12.9	390 (0.74) 7.4	142 (1.37) 2.3	277 (0.89) 6.0	1 (3.87) <0.1
Aulodrilus piqueti	17 (2.08) 0.7	15 (1.93) 0.3	30 (3.82) 0.5	21 (3.42) 0.4	---
Branchiura sowerbyi	---	91 (1.10) 1.7	---	30 (2.36) 0.7	---
Haber speciosus	---	7 (3.57) 0.1	2 (7.35) <0.1	3 (5.62) <0.1	---

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Imm. *H. speciosus*	---	11 (3.91) 0.2	2 (7.35) <0.1	4 (6.20) 0.1	---
Limnodrilus hoffmeisteri	35 (2.24) 1.5	8 (4.58) 0.2	---	14 (3.62) 0.3	---
UIWCS	---	75 (2.12) 1.4	24 (3.48) 0.4	33 (3.27) 0.7	1 (3.87) <0.1
UIWOCS	244 (0.62) 10.6	183 (1.49) 3.5	86 (1.48) 1.4	171 (1.19) 3.7	---
unknown imm. Oligochaeta	1 (7.35) <0.1	9 (3.22) 0.2	3 (7.35) 0.1	4 (5.07) 0.1	1 (2.64) 0.1
Lumbriculidae (total)	---	95 (1.31) 1.8	218 (1.13) 3.5	104 (1.75) 2.3	---
Eclipidrilus sp.	---	5 (3.35) 0.1	35 (2.55) 0.6	13 (4.08) 0.3	---
E. palustris	---	86 (1.39) 1.6	184 (1.38) 3.0	90 (1.97) 2.0	---
Lumbriculus variegatus	---	3 (3.57) 0.1	---	1 (6.30) <0.1	---
Mollusca					
Gastropoda (total)	3 (3.57) 0.1	119 (0.95) 2.2	43 (3.45) 0.7	55 (2.14) 1.2	44 (1.55) 1.6

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Ancylidae (imm.)	---	1 (7.35) <0.1	7 (5.15) 0.1	2 (8.09) <0.1	36 (1.87) 1.3
Laevapex sp.	---	---	---	---	1 (3.87) <0.1
Hydrobiidae (imm./unk.)	2 (5.15) 0.1	40 (1.31) 0.8	---	14 (2.56) 0.3	1 (3.87) 0.1
Aphaostracon pachynotus	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Hyalopyrgus aequicestatus	1 (7.35) <0.1	---	---	1 (12.73) <0.1	---
Pyrogophorus platyrachis	---	37 (1.89) 0.7	---	12 (3.55) 0.3	---
Planorbidae (imm./unk.)	---	1 (7.35) <0.1	5 (5.44) 0.1	2 (8.30) <0.1	1 (2.64) 0.1
Micromenetus dilatatus avus	---	---	---	---	1 (3.87) <0.1
Physidae					
Physella sp.	---	1 (7.35) <0.1	18 (4.28) 0.3	6 (7.19) 0.1	2 (2.80) 0.1
P. cubensis cubensis	---	1 (7.35) <0.1	2 (7.35) <0.1	1 (9.46) <0.1)	---

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Thiaridae					
Melanoides sp.	---	6 (3.01) 0.1	---	2 (5.38) <0.1	---
M. tuberculata	---	7 (2.75) 0.1	5 (5.15) 0.1	4 (4.72) 0.1	---
imm. Gastropoda	1 (7.35) <0.1	25 (1.81) 0.5	7 (5.15) 0.1	11 (3.17) 0.2	1 (3.87) 0.1
Pelecypoda (total)	1,388 (0.83) 60.0	2,516 (1.23) 47.6	2,880 (1.34) 46.4	2,261 (1.32) 49.1	---
Corbiculidae					
Corbicula fluminea	1,247 (0.86) 54.0	1,805 (1.58) 34.1	2,585 (1.50) 41.6	1,879 (1.53) 40.8	---
Sphaeriidae (imm.)	43 (1.12) 1.8	324 (1.62) 6.1	---	122 (2.75) 2.6	---
Pisidium sp.	34 (1.77) 1.5	108 (1.67) 2.0	---	47 (2.50) 1.0	---
Unionidae (imm./unk)	2 (5.15) 0.1	5 (2.85) 0.1	11 (4.70) 0.2	6 (5.31) 0.1	---
Elliptio ahenea or *waltoni*	---	2 (5.15) 0.1	---	1 (8.97) <0.1	---

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
E. buckleyi or *icterina*	---	2 (4.16) 0.1	7 (2.75) 0.1	3 (4.06) 0.1	---
E. monroensis	1 (7.35) <0.1	---	---	1 (12.73) <0.1	---
Toxolasma paulus	1 (7.35) <0.1	2 (4.16) 0.1	1 (7.35) <0.1	1 (5.62) <0.1	---
Villosa amygdala	2 (4.16) 0.1	---	2 (4.16) <0.1	2 (5.11) <0.1	---
imm. Pelecypoda	58 (2.45) 2.5	267 (1.83) 5.1	275 (1.70) 4.4	200 (2.04) 4.3	---
Arthropoda					
Crustacea					
Amphipoda (total)	63 (1.27) 2.7	21 (2.01) 0.4	830 (2.12) 13.4	304 (3.54) 6.6	8 (1.41) 0.3
Hyalellidae					
Hyalella azteca	49 (1.23) 2.1	12 (2.36) 0.2	459 (2.22) 7.4	173 (3.57) 3.8	5 (2.12) 0.2
imm. Amphipoda	14 (2.53) 0.6	9 (3.22) 0.2	370 (2.25) 6.0	131 (3.87) 2.8	3 (2.23) 0.1
Isopoda (total)	---	2 (7.35) <0.1	---	1 (12.73) <0.1	10 (2.48) 0.4

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Sphaeromidae					
Cassidinidea ovalis	---	2 (7.35) <0.1	---	1 (12.73) <0.1	10 (2.48) 0.4
Decapoda					
Palaemonidae (imm./unk.)	1 (7.35) <0.1	---	1 (7.35) <0.1	1 (8.97) <0.1	1 (3.87) <0.1
Aquaric Acari (total)	22 (1.39) 1.0	37 (1.54) 0.7	15 (2.79) 0.2	25 (1.83) 0.5	24 (1.08) 0.9
Hydracarina	21 (1.44) 0.9	22 (1.97) 0.4	15 (2.79) 0.2	19 (2.00) 0.4	10 (1.14) 0.4
Oribatidae	1 (7.35) <0.1	15 (2.54) 0.3	---	5 (4.39) 0.1	14 (1.28) 0.5
Insecta					
Collembola	---	---	---	---	2 (2.07) 0.1
Ephemeroptera (total)	159 (0.62) 6.9	867 (0.99) 16.4	314 (1.23) 5.0	446 (1.39) 9.7	66 (0.78) 2.4
Baetidae (e.i.)	---	1 (7.35) <0.1	2 (7.35) <0.1	1 (9.46) <0.1	19 (0.94) 0.7
Callibaetis sp.	---	---	---	---	1 (3.87) <0.1

APPENDIX 2 (continued).

	Habitat				
	Mud	Sand	Peat	All Sediments	Nuphar
Taxon	no. m^{-2} (cv) % n=54	no. m^{-2} (cv) % n=54	no. m^{-2} (cv) % n=54	no. m^{-2} (cv) % n=162	no. m^{-2} (cv) % n=15
Labiobaetis sp.	---	---	---	---	2 (3.87) 0.1
L. ephippiatus	---	---	---	---	8 (3.15) 0.3
Caenidae					
Brachycercus maculatus	---	4 (3.79) 0.1	---	1 (6.68) <0.1	---
Caenis diminuta	1 (7.35) <0.1	10 (5.57) 0.2	23 (2.72) 0.4	11 (4.34) 0.2	25 (0.87) 0.9
Ephemeridae					
Hexagenia orlando	156 (0.61) 6.8	782 (0.96) 14.8	254 (1.37) 4.1	397 (1.39) 8.6	---
Heptageniidae (e.i.)	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
unk. e.i. Ephemeroptera	2 (5.15) 0.1	69 (1.97) 1.3	35 (1.76) 0.6	35 (2.57) 0.8	10 (1.62) 0.4
Odonata (e.i.)	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Zygoptera (total)	---	---	2 (7.35) <0.1	1 (12.73) <0.1	1 (2.64) 0.1
Coenagrionidae (e.i.)	---	--- <0.1	2 (7.35) 0.1	1 (12.73) <0.1	1 (2.64)

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Anisoptera (total)	1 (7.35) <0.1	18 (1.62) 0.3	7 (2.75) 0.1	8 (2.51) 0.2	---
Corduliidae					
Epitheca sp.	---	---	2 (5.44) <0.1	1 (9.46) <0.1	---
Gomphidae e.i.	1 (7.35) <0.1	16 (1.68) 0.3	1 (7.35) <0.1	6 (3.02) 0.1	---
Aphylla williamsoni	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Gomphus sp.	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Stylurus sp.	---	---	1 (7.35) <0.1	1 (12.73) <0.1	---
Libellulidae					
Perythemis spp.	---	---	1 (7.35) <0.1	1 (12.73) <0.1	---
Macromiidae					
Macromia taeniolata	---	---	2 (5.15) <0.1	1 (8.97) <0.1	---
Trichoptera (total)	2 (4.16) 0.1	63 (1.44) 1.2	318 (1.14) 5.1	127 (2.00) 2.8	118 (1.44) 4.3

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Hydroptilidae e.i.	1 (7.35) <0.1	---	2 (7.35) <0.1	1 (9.46) <0.1	33 (1.83) 1.2
Hydroptila sp.	---	---	---	---	28 (2.37) 1.0
Orthotrichia sp.	---	---	---	---	21 (1.20) 0.8
Oxyethira sp.	---	---	---	---	24 (1.89) 0.9
Leptoceridae e.i.	---	---	3 (7.35) 0.1	1 (12.73) <0.1	---
Oecetis sp.	2 (5.15) 0.1	2 (5.15) <0.1	7 (4.43) 0.1	3 (5.54) 0.1	1 (3.87) <0.1
Polycentropodidae (e.i.)	---	33 (1.74) 0.6	146 (1.67) 2.3	59 (2.62) 1.3	10 (2.85) 0.4
Cernotina sp.	---	26 (1.66) 0.5	159 (1.15) 2.6	62 (2.08) 1.3	---
Cyrnellus fraternus	---	---	---	---	1 (3.87) <0.1
unk. e.i. Trichoptera	---	2 (5.15) <0.1	2 (7.35) <0.1	1 (7.75) <0.1	1 (3.87) <0.1

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Coleoptera (total)	---	4 (3.16) 0.1	5 (5.44) 0.1	3 (5.72) 0.1	2 (2.07) 0.1
Elmidae (e.i.)	---	---	---	---	1 (2.64) 0.1
Stenelmis sp.	---	4 (3.16) 0.1	5 (5.44) 0.1	3 (5.72) 0.1	1 (3.87) <0.1
Diptera					
Ceratopogonidae (total)	4 (3.16) 0.2	107 (1.09) 2.0	17 (2.80) 0.3	43 (2.01) 0.9	1 (2.64) 0.1
Bezzia sp. or Palpomyia sp.	---	1 (7.35) <0.1	1 (7.35) <0.1	1 (8.97) <0.1	1 (2.64) 0.1
Mallochohelia sp.	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Probezzia sp.	---	---	7 (4.63) 0.1	2 (8.09) <0.1	---
unk. e.i. Ceratopogonidae	4 (3.16) 0.2	105 (1.12) 2.0	9 (3.98) 0.1	39 (2.16) 0.8	---
Chaoboridae (total)	63 (1.34) 2.7	2 (4.16) 0.1	2 (5.44) <0.1	22 (2.52) 0.5	---
Chaoborus albatus	1 (7.35) <0.1	---	---	1 (12.73) <0.1	---

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
C. punctipennis	62 (1.37) 2.7	2 (4.16) 0.1	2 (5.44) <0.1	22 (2.55) 0.5	---
Chironomidae (total)	288 (0.50) 12.5	776 (0.61) 14.7	862 (1.32) 13.9	642 (1.18) 13.9	1,147 (0.73) 42.3
Tanypodinae (e.i.)	---	19 (1.97) 0.4	23 (3.68) 0.4	14 (3.87) 0.3	3 (2.64) 0.1
Ablabesmyia sp. e.i.	---	8 (2.36) 0.2	31 (2.96) 0.5	13 (4.24) 0.3	---
A. (*Karelia*) sp.	1 (7.35) <0.1	2 (5.15) <0.1	2 (5.44) <0.1	2 (5.93) <0.1	---
A. annulata	39 (1.18) 1.7	63 (1.33) 1.2	23 (3.96) 0.4	41 (1.86) 0.9	---
A. ramphe group	---	1 (7.35) <0.1	32 (2.84) 0.5	11 (4.97) 0.2	1 (3.87) <0.1
Coelotanypus sp. e.i.	111 (0.73) 4.8	142 (0.91) 2.7	115 (1.51) 1.9	123 (1.09) 2.7	---
C. scapularis	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
C. tricolor	72 (0.97) 3.1	41 (1.60) 0.8	18 (2.05) 0.3	44 (1.44) 0.9	---

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Djalmabatista pulchra	---	80 (1.61) 1.5	10 (2.72) 0.2	30 (2.79) 0.6	---
Labrundinia sp. e.i.	---	---	---	---	3 (1.72) 0.1
L. neopilosella	1 (7.35) <0.1	---	---	1 (12.73) <0.1	5 (3.87) 0.2
Labrundinia pilosella	---	---	---	---	16 (2.40) 0.6
Larsia sp.	---	---	---	---	1 (3.87) 0.1
Procladius sp.	9 (2.92) 0.4	49 (1.53) 0.9	79 (2.65) 1.3	45 (2.89) 1.0	1 (3.87) <0.1
Orthocladiinae (e.i.)	---	---	1 (7.35) <0.1	1 (12.73) <0.1	43 (1.49) 1.6
Corynoneura sp.	---	---	---	---	1 (3.87) 0.1
Cricotopus sp. e.i.	---	---	---	---	36 (2.25) 1.3
C. bicinctus	---	1 (7.35) <0.1	---	1 (12.73) <0.1	57 (1.58) 2.1
C. sylvestris	---	---	---	---	4 (3.14) 0.1

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Cricotopus or Orthocladius	---	---	---	---	37 (2.08) 1.4
Epoicocladius flavens	41 (1.36) 1.8	43 (1.35) 0.8	4 (6.03) 0.1	29 (1.75) 0.6	---
Nanocladius sp. e.i.	---	---	---	---	29 (1.25) 1.1
N. balticus	---	2 (5.15) <0.1	4 (6.03) 0.1	2 (7.89) <0.1	---
N. distinctus	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Parakiefferiella sp. e.i.	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
P. sp. C Epler	---	---	---	---	4 (2.70) 0.1
Thiennemaniella sp. e.i.	---	---	---	---	124 (1.05) 4.6
T. sp. A Epler	---	1 (7.35) <0.1	---	1 (12.73) <0.1	331 (0.98) 12.2
Chironominae					
Chironomini (e.i.)	---	22 (2.77) 0.4	46 (2.90) 0.7	23 (3.79) 0.5	14 (1.17) 0.5

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Apedilum sp.	---	---	---	---	1 (3.87) 0.1
Axarus sp.	---	---	389 (2.04) 6.3	130 (3.79) 2.8	---
Beardius sp. e.i.	---	---	---	---	1 (3.87) 0.1
_B_. _truncatus_	---	---	---	---	6 (2.64) 0.2
Chironomus sp. or _Einfeldia_ sp.	---	---	6 (5.20) 0.1	2 (9.06) <0.1	---
Cryptochironomus sp.	3 (3.57) 0.1	25 (1.59) 0.5	2 (5.44) <0.1	10 (2.64) 0.2	---
Cryptotendipes sp.	---	4 (4.82) 0.1	---	1 (8.41) <0.1	1 (2.64) 0.1
Demicryptochironomus sp.	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Dicrotendipes sp. (e.i.)	---	1 (7.35) <0.1	---	1 (12.73) <0.1	10 (1.54) 0.4
_D_. _simpsoni_	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---

APPENDIX 2 (continued).

Taxon	Habitat: Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Endotribelos hesperium	---	---	---	---	1 (3.87) <0.1
Glyptotendipes sp. e.i.	---	6 (3.37) 0.1	3 (7.35) 0.1	3 (5.95) 0.1	1 (3.87) 0.1
G. paripes	---	---	5 (3.78) 0.1	2 (6.65) <0.1	---
Harnischia sp.	7 (2.42) 0.3	7 (3.45) 0.1	3 (7.35) 0.1	6 (3.86) 0.1	---
Nilothauma sp.	---	1 (7.35) <0.1	7 (5.15) 0.1	2 (8.09) <0.1	3 (2.23) 0.1
Parachironomus sp.	---	1 (7.35) <0.1	3 (7.35) 0.1	1 (10.48) <0.1	2 (2.07) 0.1
P. carinatus	---	---	---	---	1 (3.87) <0.1
Paralauterborniella nigrohalterale	2 (4.16) 0.1	154 (0.88) 2.9	14 (2.88) 0.2	57 (1.88) 1.2	---
Polypedilum sp. e.i.	---	---	---	---	19 (1.10) 0.7
P. beckae	---	---	---	---	1 (3.87) <0.1

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
P. halterale	---	52 (1.44) 1.0	21 (4.17) 0.3	24 (2.84) 0.5	---
P. illinoense	1 (7.35) <0.1	---	2 (7.35) <0.1	1 (9.46) <0.1	49 (1.21) 1.8
P. scalaenum	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
P. trigonus	---	---	---	---	3 (3.87) 0.1
Xenochironomus xenolabis	---	3 (3.57) 0.1	4 (6.03) 0.1	2 (6.42) <0.1	---
Zavreliella marmorata	---	1 (7.35) <0.1	---	1 (12.73) <0.1	---
Pseudochironomini					
Pseudochironomus sp.	---	---	---	---	1 (2.64) 0.1
Tanytarsini					
Cladotanytarsus sp.	---	15 (2.85) 0.3	3 (7.35) 0.1	6 (4.75) 0.1	4 (2.64) 0.2
Stempellina sp.	---	16 (2.35) 0.3	---	5 (4.29) 0.1	2 (3.87) 0.1
Tanytarsus sp. (e.i.)	1 (7.3) <0.1	14 (2.75) 0.3	8 (4.33) 0.1	8 (4.00) 0.2	143 (1.51) 5.3

APPENDIX 2 (continued).

Taxon	Mud no. m^{-2} (cv) % n=54	Sand no. m^{-2} (cv) % n=54	Peat no. m^{-2} (cv) % n=54	All Sediments no. m^{-2} (cv) % n=162	Nuphar no. m^{-2} (cv) % n=15
Tanytarsus sp. E (Epler)	---	---	---	---	2 (2.80) 0.1
Tanytarsus sp. F (Epler)	---	---	---	---	7 (2.66) 0.2
Tanytarsus sp. T (Epler)	---	---	---	---	58 (1.89) 2.1
Tanytarsus sp. C or D (Epler)	---	---	---	---	115 (2.03) 4.2
unknown Chironomidae	---	1 (7.35) <0.1	2 (7.35) <0.1	1 (9.46) <0.1	1 (3.87) <0.1
Mean Total Organisms^{-2}	2,311 (0.54)	5,287 (0.69)	6,206 (1.06)	4,601 (1.02)	2,713 (1.07)
Total Species Richness	35	77	61	95	70
Mean Species Richness	9 (0.22)	17 (0.20)	9 (0.49)	12 (0.43)	19 (0.38)
Mean Diversity	2.17 (0.24)	2.84 (0.17)	2.09 (0.34)	2.37 (0.67)	2.80 (0.21)
Mean Evenness	0.70 (0.20)	0.70 (0.16)	0.68 (0.27)	0.69 (0.21)	0.68 (0.20)

--- = taxon not present.
C = colonial taxon not enumerated.
imm. = unidentifiable immature non-insect.
e.i. = unidentifiable early instar insect.
UIWCS = unidentifiable immature Oligochaeta with capilliform setae.
UIWOCS = unidentifiable immature Oligochaeta without capilliform setae.

APPENDIX 3.

Codes used to label Blue Cypress Lake dominant invertebrate taxa in canonical correspondence analysis biplots. Dominant taxa are those that accounted for at least 5 percent of the relative abundance in any one time-date combination.

APPENDIX 3. Codes used to label Blue Cypress Lake dominant invertebrate taxa in canonical correspondence analysis biplots. Dominant taxa are those that accounted for at least 5 percent of the relative abundance in any one time-date combination.

Taxon	Code
Nemertea	MGNTA
Nematoda	MGNEM
Oligochaeta	
Enchytraeidae	MGENC
Tubificidae	
Branchiura sowerbyi	BCHSO
Limnodrilus hoffmeisteri	LIMHO
unidentifiable immature oligochaetes with capilliform setae	UIWCS
unidentifiable immature oligochaetes without capilliform setae	WIWOCS
Lumbriculidae	
Eclipidrilus sp.	ECLSP
E. palustris	ECLPA
Gastropoda	
Hydrobiidae (imm./unk.)	HYDDE
Pelecypoda	
Corbicula fluminea	CRBFL
Sphaeriidae (imm.)	SPHDE
Pisidium sp.	PISSP
imm. Pelecypoda	IMPEL
Amphipoda	
Hyalella azteca	HYAAZ
imm. Amphipoda	IMAMP
Aquaric Acari	
Oribatidae	ORIDE
Insecta	
Ephemeroptera	
Caenis diminuta	CAEDI
Hexagenia orlando	HEXLI
unk. e.i. Ephemeroptera	IMEPH
Trichoptera	
Polycentropodidae (e.i.)	PCDDE
Cernotina sp.	CNASP
Diptera	
Ceratopogonidae	
Probezzia sp.	PZASP
unk. e.i. Ceratopogonidae	IMCER
Chaoboridae	
Chaoborus punctipennis	CHAPU
Chironomidae	
Tanypodinae (e.i.)	TNYPO
Ablabesmyia sp.	ABLSP
Ablabesmyia annulata	ABLAN

APPENDIX 3 (continued).

Taxon	Code
Chironomidae (continued)	
Coelotanypus sp. e.i.	CPSSP
Coelotanypus tricolor	CPSTR
Djalmabatista pulchra	DJAPU
Procladius sp.	PROSP
Epoicocladius flavens	EPOFL
Axarus sp.	AXASP
Paralauterborniella nigrohalterale	PBANI

Appendix 4

Physicochemical measurements obtained concurrently to aquatic invertebrate community sampling in Blue Cypress Lake from May 1998 through April 1999

APPENDIX 4A. Physicochemical measurements obtained concurrently to aquatic invertebrate community sampling in Blue Cypress Lake during May 1998.

	Habitat									
	Mud			Sand			Peat			Nuphar
Parameter	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Bottom Depth	3.0	2.8	2.6	2.0	1.8	1.8	2.5	2.2	1.8	0.5
D.O. Profile (ppm)										
Surface	6.2	7.1	6.4	6.3	6.8	5.8	6.1	7.7	6.6	6.8
0.5 m	6.2	7.1	6.4	6.4	6.8	5.8	6.1	7.5	6.4	2.5
1.0 m	6.2	6.9	6.4	6.3	6.8	5.5	6.0	7.0	5.9	
1.5 m	6.2	6.7	6.4	6.4	6.8	4.3	6.0	6.5	5.6	
2.0 m	6.2	6.6	6.4	6.2			5.9	6.2		
2.5 m	6.2	6.6	6.3				5.6			
3.0 m	6.0									
Bottom	6.0	6.0	6.0	6.2	6.8	4.7	5.6	6.2	5.3	2.5

APPENDIX 4A (continued).

Parameter	Habitat									
	Mud			Sand			Peat			Nuphar
	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Temp. Profile (°C)										
Surface	30.6	---	28.5	30.8	31.0	---	31.2	---	32.5	29.0
0.5 m	30.5	---	28.5	30.5	---	---	31.2	---	---	
1.0 m	30.9	---	28.5	30.2	---	---	31.2	---	---	
1.5 m	31.0	---	28.5	30.0	---	---	31.2	---	---	
2.0 m	31.1	---	28.6	30.1			31.2	---		
2.5 m	31.5	---	28.8				31.2			
3.0 m	31.9									
Bottom	31.9	---	28.8	30.1	---	---	31.2	---	---	
Conductivity (mmho)										
Surface	140	146	138	148	148	140	144	149	150	144
Bottom	190	168	140	146	142	142	150	149	142	144

APPENDIX 4B. Physicochemical measurements obtained concurrently to aquatic invertebrate community sampling in Blue Cypress Lake during July 1998.

	Habitat									
	Mud			Sand			Peat			Nuphar
Parameter	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Bottom Depth	2.9	2.8	2.6	1.8	2.1	1.7	2.0	2.1	1.7	
D.O. Profile (ppm)										
Surface	6.4	6.9	5.9	6.0	6.4	5.9	6.4	7.1	4.7	
0.5 m	6.4	6.8	5.9	5.9	6.1	5.8	6.4	7.1	4.8	
1.0 m	6.3	6.2	5.8	5.8	5.7	4.1	5.7	6.9	4.4	
1.5 m	6.0	6.2	5.7	5.2	5.7	3.5	5.3	5.7	4.4	
2.0 m	5.9	6.0	5.7		5.4		5.3	5.3		
2.5 m	5.9	5.9	5.0							
3.0 m										
Bottom	5.8	5.1	4.8	5.6	5.3	3.4	5.3	4.9	4.3	

APPENDIX 4B (continued).

Parameter	Habitat									
	Mud			Sand			Peat			Nuphar
	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Temp. Profile (°C)										
Surface	32.2	33.1	30.1	33.9	33.5	31.2	33.1	35.1	30.0	
0.5 m	32.1	31.8	30.1	33.9	31.3	31.1	32.8	34.8	29.9	
1.0 m	31.7	30.6	30.0	33.5	30.9	30.0	31.2	33.5	29.5	
1.5 m	31.1	30.5	30.0	32.5	30.2	29.9	31.8	31.9	29.5	
2.0 m	31.1	30.2	29.9		30.2		31.8	31.1		
2.5 m	31.1	30.0	29.8							
3.0 m										
Bottom	31.1	30.0	29.8	32.3	30.2	29.9	31.8	31.1	29.5	
Conductivity (mmho)										
Surface	158	165	152	165	164	156	164	168	151	
Bottom	158	152	152	162	154	155	160	160	151	

APPENDIX 4C. Physicochemical measurements obtained concurrently to aquatic invertebrate community sampling in Blue Cypress Lake during October 1998.

	Habitat									
	Mud			Sand			Peat			Nuphar
Parameter	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Bottom Depth	3.3	3.2	3.0	2.1	2.2	2.3	2.7	2.5	2.2	0.5
D.O. Profile (ppm)										
Surface	6.5	6.9	7.3	6.9	7.3	7.1	6.8	5.9	6.9	6.7
0.5 m	6.5	6.8	7.3	6.8	7.2	7.1	6.8	5.8	6.9	1.9
1.0 m	6.5	6.5	7.3	6.5	7.1	7.1	6.8	5.8	6.9	
1.5 m	6.3	6.5	7.3	5.9	6.9	7.0	6.8	5.3	6.9	
2.0 m	6.3	6.5	7.3	6.4	6.9	6.7	6.7	4.8	6.8	
2.5 m	6.3	6.5	7.2				6.2	4.7		
3.0 m	6.2	6.5	7.1							
Bottom	6.1	6.1	7.1	6.1	6.8	6.4	6.1	4.7	6.7	1.9

APPENDIX 4C (continued).

Parameter	Habitat									
	Mud			Sand			Peat			Nuphar
	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Temp. Profile (°C)										
Surface	27.0	29.6	24.0	29.5	29.8	24.1	28.0	28.2	23.8	24.5
0.5 m	26.9	28.8	24.0	28.5	29.6	24.1	27.5	28.1	23.8	23.1
1.0 m	26.8	27.1	24.0	28.2	27.8	24.0	27.0	27.0	23.8	
1.5 m	26.8	27.0	24.0	27.9	27.5	23.9	27.0	26.8	23.8	
2.0 m	26.8	27.0	24.0	27.5	27.5	23.8	26.9	26.7	23.8	
2.5 m	26.8	27.0	24.0				26.9	26.7		
3.0 m	26.8	27.2	24.0							
Bottom	26.8	27.2	24.0	27.5	27.5	23.8	26.9	26.7	23.8	23.1
Conductivity (mmho)										
Surface	151	158	142	160	166	150	155	160	152	156
Bottom	206	156	144	156	154	161	155	159	156	156

APPENDIX 4D. Physicochemical measurements obtained concurrently to aquatic invertebrate community sampling in Blue Cypress Lake during December 1998.

	Habitat									
	Mud			Sand			Peat			Nuphar
Parameter	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Bottom Depth	3.3	3.3	3.1	1.9	2.4	2.4	2.3	2.6	2.5	
D.O. Profile (ppm)										
Surface	8.3	7.6	8.3	7.4	8.7	7.7	7.3	7.2	7.3	
0.5 m	---	7.6	7.8	---	8.4	7.6	7.3	7.1	7.2	
1.0 m	---	7.5	7.8	---	8.4	7.6	7.3	7.0	7.1	
1.5 m	---	7.5	7.8	---	8.4	7.4	---	7.0	7.0	
2.0 m	---	7.5	7.7		8.4	7.4	---	7.0	6.9	
2.5 m	---	7.5	7.5					6.9	6.4	
3.0 m	---	7.5	7.3							
Bottom	7.7	7.2	7.0	6.5	8.0	6.8	5.5	6.9	6.4	

APPENDIX 4D (continued).

Parameter	Habitat									
	Mud			Sand			Peat			Nuphar
	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Temp. Profile (°C)										
Surface	23.7	23.5	24.2	24.1	24.1	24.9	23.1	23.1	24.2	
0.5 m	---	23.2	24.1	---	24.1	24.9	---	23.1	24.1	
1.0 m	---	23.1	24.1	---	24.1	24.8	---	22.9	23.9	
1.5 m	---	23.1	24.0	---	24.1	24.8	---	22.9	23.3	
2.0 m	---	23.1	23.8		24.1	24.5	---	22.9	23.1	
2.5 m	---	23.1	23.8					22.9	23.1	
3.0 m	---	23.1	23.8							
Bottom	23.0	23.1	23.8	23.6	24.1	24.1	22.6	22.9	23.1	
Conductivity (mmho)										
Surface	146	145	154	146	146	156	142	149	158	
Bottom	172	148	156	144	148	154	144	148	152	

APPENDIX 4E. Physicochemical measurements obtained concurrently to aquatic invertebrate community sampling in Blue Cypress Lake during February 1999.

	Habitat									
	Mud			Sand			Peat			Nuphar
Parameter	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Bottom Depth	3.4	3.3	3.0	2.5	2.6	2.2	2.2	2.3	2.5	0.6
D.O. Profile (ppm)										
Surface	7.8	7.9	7.7	7.4	8.1	8.5	7.4	7.3	7.6	7.3
0.5 m	7.7	7.9	7.7	7.4	8.0	8.4	7.2	7.3	7.6	6.8
1.0 m	7.7	7.7	7.7	7.3	7.9	8.4	7.1	7.3	7.5	
1.5 m	7.7	7.6	7.7	7.3	7.9	8.4	7.1	7.3	7.5	
2.0 m	7.7	7.5	7.7	7.3	7.2	8.3	7.0	7.3	7.5	
2.5 m	7.7	7.5	7.7	7.2	6.9				7.3	
3.0 m	7.7	7.4	7.5							
Bottom	7.2	7.3	7.5	7.2	6.8	7.1	6.9	7.2	7.3	6.6

APPENDIX 4E (continued).

Parameter	Habitat: Mud M1	M2	M3	Sand S1	S2	S3	Peat P1	P2	P3	Nuphar
Temp. Profile (°C)										
Surface	23.0	23.9	23.0	22.5	24.1	24.5	23.9	24.5	22.8	23.9
0.5 m	22.9	23.4	23.0	22.5	24.1	24.4	22.8	22.6	22.8	23.2
1.0 m	22.9	23.3	22.9	22.5	24.1	24.4	22.0	22.1	22.7	
1.5 m	22.9	22.5	22.9	22.5	24.0	24.2	21.9	22.1	22.7	
2.0 m	22.8	22.4	22.9	22.5	23.6	24.1	21.9	22.1	22.7	
2.5 m	22.6	22.4	22.9	22.5	22.9				22.6	
3.0 m	22.4	22.4	22.9							
Bottom	22.1	22.4	22.9	22.5	22.9	23.9	21.9	22.1	22.6	23.1
Conductivity (mmho)										
Surface	156	164	158	154	164	166	160	162	154	162
Bottom	156	158	160	152	161	166	156	158	156	162

APPENDIX 4F. Physicochemical measurements obtained concurrently to aquatic invertebrate community sampling in Blue Cypress Lake during April 1999.

	Habitat									
	Mud			Sand			Peat			Nuphar
Parameter	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Bottom Depth	2.8	2.7	2.6	2.1	1.8	1.8	2.0	2.0	2.3	0.5
D.O. Profile (ppm)										
Surface	8.3	8.3	8.7	7.5	7.9	9.1	8.2	7.7	8.9	10.3
0.5 m	8.2	8.3	8.7	7.4	7.8	9.1	8.1	7.7	8.9	8.1
1.0 m	8.2	8.1	8.5	7.5	7.8	9.1	8.1	7.7	8.5	
1.5 m	8.1	7.9	8.5	7.6	7.8	9.1	7.7	6.9	8.0	
2.0 m	8.1	7.8	8.5	7.6			7.5	6.7	7.5	
2.5 m	7.9	7.7	8.3							
3.0 m										
Bottom	7.8	7.3	7.6	7.5	7.6	8.6	7.5	6.7	7.3	8.1

APPENDIX 4F (continued).

	Habitat									
	Mud			Sand			Peat			Nuphar
Parameter	M1	M2	M3	S1	S2	S3	P1	P2	P3	
Temp. Profile (°C)										
Surface	24.1	24.3	26.1	25.5	27.0	28.0	23.9	22.8	26.4	30.6
0.5 m	24.0	24.2	26.0	25.2	26.1	28.0	23.9	22.6	26.2	26.0
1.0 m	23.9	23.6	25.7	24.1	25.6	28.0	23.9	22.1	25.0	
1.5 m	23.8	23.1	23.1	24.1	25.1	28.0	23.1	21.5	22.2	
2.0 m	23.2	23.0	22.9	24.1			23.1	21.5	22.0	
2.5 m	23.2	22.9	22.2							
3.0 m										
Bottom	23.2	22.9	22.2	24.1	25.0	27.1	23.1	21.5	21.9	26.0
Conductivity (mmho)										
Surface	185	186	192	190	196	200	185	180	194	210
Bottom	185	182	180	186	190	195	185	178	180	196

APPENDIX 5.

Functional group designations assigned to aquatic invertebrate taxa collected from major habitat types in Blue Cypress Lake, Indian River Co., FL, from May 1998 through April 1999.

APPENDIX 5. Functional group designations assigned to aquatic invertebrate taxa collected from major habitat types in Blue Cypress Lake, Indian River Co., FL, from May 1998 through April 1999.

Taxon	Functional Group
Porifera	Filterer
Cnidaria	
Hydrozoa	
Cordylophora lacustris	Predator
Hydra sp.	Predator
Turbellaria	Gatherer
Nemertea	Predator
Nematoda	*
Annelida	
Aphanoneura	
Aeolosomatidae	
Aeolosoma travencorense	Gatherer
Hirudinia	*
Oligochaeta	
Enchytraeidae	Gatherer
Naididae	
Amphichaeta americana	Grazer
Bratislavia unidentata	Grazer
Dero sp.	Grazer
D. furcata	Grazer
D. nivea	Grazer
D. obtusa	Grazer
D. nivea or *obtusa*	Grazer
D. pectinata	Grazer
D. trifida	Grazer
Nais communis	Grazer
N. variabilis	Grazer
Pristina leidyi	Grazer
Pristinella osborni	Grazer
Slavina appendiculata	Grazer
Specaria josinae	Grazer
Stephensoniana trivandrana	Grazer
Stylaria lacustris	Grazer
Opistocystidae	
Crustipellis tribranchiata	unknown
Crustipellis or *Pristina*	
Tubificidae	
Aulodrilus piqueti	Gatherer
Branchiura sowerbyi	Gatherer
Haber speciosus	Gatherer
Imm. *H. speciosus*	Gatherer
Limnodrilus hoffmeisteri	Gatherer
UIWCS	Gatherer
UIWOCS	Gatherer
Lumbriculidae	

APPENDIX 5 (continued).

Taxon	Functional Group
Eclipidrilus sp.	Gatherer
E. palustris	Gatherer
Lumbriculus variegatus	Gatherer
Mollusca	
Gastropoda	
Ancylidae	Grazer
Laevapex sp.	Grazer
Hydrobiidae	
Aphaostracon pachynotus	Grazer
Hyalopyrgus aequicestatus	Grazer
Pyrogophorus platyrachis	Grazer
Planorbidae (imm./unk.)	Gatherer
Micromenetus dilatatus avus	Gatherer
Physidae	
Physella sp.	Grazer
P. cubensis cubensis	Grazer
Thiaridae	
Melanoides sp.	Gatherer
M. tuberculata	Gatherer
Pelecypoda	
Corbiculidae	
Corbicula fluminea	Filterer
Sphaeriidae (imm.)	Filterer
Pisidium sp.	Filterer
Unionidae (imm./unk)	Filterer
Elliptio ahenea or *waltoni*	Filterer
E. buckleyi or *icterina*	Filterer
E. monroensis	Filterer
Toxolasma paulus	Filterer
Villosa amygdala	Filterer
Arthropoda	
Crustacea	
Amphipoda	
Hyalellidae	
Hyalella azteca	Grazer
imm. Amphipoda	
Isopoda	
Sphaeromidae	
Cassidinidea ovalis	Gatherer
Decapoda	
Palaemonidae (imm./unk.)	Grazer
Aquaric Acari	
Hydracarina	*
Oribatidae	Gatherer
Insecta	
Collembola	Gatherer
Ephemeroptera	

APPENDIX 5 (continued).

Taxon	Functional Group
Baetidae (e.i.)	Grazer
Callibaetis sp.	Grazer
Labiobaetis sp.	Grazer
L. ephippiatus	Grazer
Caenidae	
Brachycercus maculatus	Gatherer
Caenis diminuta	Gatherer
Ephemeridae	
Hexagenia orlando	Gatherer
Heptageniidae (e.i.)	Grazer
Odonata	
Zygoptera	
Coenagrionidae (e.i.)	Predator
Anisoptera	
Corduliidae	
Epitheca sp.	Predator
Gomphidae e.i.	Predator
Aphylla williamsoni	Predator
Gomphus sp.	Predator
Stylurus sp.	Predator
Libellulidae	
Perythemis spp.	Predator
Macromiidae	
Macromia taeniolata	Predator
Trichoptera	
Hydroptilidae	
Hydroptila sp.	Grazer/ Piercer
Orthotrichia sp.	Piercer
Oxyethira sp.	Grazer/ Piercer
Leptoceridae e.i.	
Oecetis sp.	Predator
Polycentropodidae	
Cernotina sp.	Predator
Cyrnellus fraternus	Gatherer
Coleoptera	
Elmidae	
Stenelmis sp.	Gatherer
Diptera	
Ceratopogonidae	
Bezzia sp. or *Palpomyia*	Predator
Mallochohelia sp.	Predator
Probezzia sp.	Predator
Chaoboridae	
Chaoborus albatus	Predator
C. punctipennis	Predator
Chironomidae	

APPENDIX 5 (continued).

Taxon	Functional Group
Tanypodinae (e.i.)	Grazer
Ablabesmyia sp. e.i.	Predator
A. (*Karelia*) sp.	Predator
A. *annulata*	Predator
A. *ramphe* group	Predator
Coelotanypus sp. e.i.	Predator
C. *scapularis*	Predator
C. *tricolor*	Predator
Djalmabatista *pulchra*	Predator
Labrundinia sp. e.i.	Predator
L. *neopilosella*	Predator
Labrundinia *pilosella*	Predator
Larsia sp.	Predator
Procladius sp.	Predator
Orthocladiinae	
Corynoneura sp.	Gatherer
Cricotopus sp. e.i.	Grazer
C. *bicinctus*	Grazer
C. *sylvestris*	Grazer
Cricotopus or *Orthocladius*	
Epoicocladius *flavens*	Gatherer
Nanocladius sp. e.i.	Gatherer
N. *balticus*	Gatherer
Nanocladius *distinctus*	Gatherer
Parakiefferiella sp. e.i.	Gatherer
P. sp. C Epler	Gatherer
Thiennemaniella sp. e.i.	Grazer
T. sp. A Epler	Grazer
Chironominae	
Chironomini (e.i.)	Gatherer
Apedilum sp.	Gatherer
Asheum *beckae*	Gatherer
Axarus sp.	Gatherer
Beardius sp. e.i.	Gatherer
B. *truncatus*	Gatherer
Chironomus sp. or *Einfeldia* sp.	Gatherer
Cryptochironomus sp.	Gatherer
Cryptotendipes sp.	Gatherer
Demicryptochironomus sp.	Gatherer
Dicrotendipes sp. (e.i.)	Gatherer
D. *simpsoni*	Gatherer
Endotribelos *hesperium*	Gatherer
Glyptotendipes sp. e.i.	Gatherer
G. *paripes*	Gatherer
Harnischia sp.	Gatherer
Nilothauma sp.	unknown
Parachironomus sp.	Predator

APPENDIX 5 (continued).

Taxon	Functional Group
P. carinatus	Predator
Paralauterborniella nigrohalterale	Gatherer
Polypedilum sp. e.i.	Gatherer
P. halterale	Gatherer
P. illinoense	Gatherer
P. scalaenum	Gatherer
P. trigonus	Gatherer
Xenochironomus xenolabis	Predator?
Zavreliella marmorata	Gatherer
Pseudochironomini	
Pseudochironomus sp.	Gatherer
Tanytarsini	
Cladotanytarsus sp.	Gatherer
Stempellina sp.	Gatherer
Tanytarsus sp. (e.i.)	Gatherer
Tanytarsus sp. E (Epler)	Gatherer
Tanytarsus sp. F (Epler)	Gatherer
Tanytarsus sp. T (Epler)	Gatherer
Tanytarsus sp. C or D (Epler)	Gatherer

imm. = unidentifiable immature non-insect.
e.i. = unidentifiable early instar insect.
UIWCS = unidentifiable immature Oligochaeta with capilliform setae.
UIWOCS = unidentifiable immature Oligochaeta without capilliform setae.
* = more than one functional group assignment for this taxa

APPENDIX 6.

Comparison of invertebrate communities in lakes with similar physical habitat qualities: mean densities (no. of organisms per square meter),coefficients of variation, and percent compositions of aquatic invertebrate taxa collected from Lake Okeechobee and Lake Blue Cypress, November 1990 and June 1991.

APPENDIX 6. Comparison of invertebrate communities in lakes with similar physical habitat qualities: mean densities (no. of organisms per square meter), coefficients of variation, and percent compositions of aquatic invertebrate taxa collected from Lake Okeechobee and Lake Blue Cypress, November 1990 and June 1991.

	MUD		SAND		PEAT	
	Okeechobee	Blue Cypress	Okeechobee	Blue Cypress	Okeechobee	Blue Cypress
Taxon/Parameter	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %
Porifera	---	---	---	---	---	6 (2.83) 0.1
Cnidaria						
Hydrozoa						
Cordylophora lacustris	---	---	---	---	P	P
Platyhelminthes						
Turbellaria						
Dugesia tigrina	---	---	---	---	200 (1.17) 0.8	6 (2.83) 0.1
Nemertea						
Prostoma spp.	---	---	---	---	383 (1.10) 1.3	6 (2.83) 0.1
Nematoda	---	6 (2.83) 0.3	17 (1.98) 0.9	94 (1.39) 1.9	1,567 (1.25) 6.5	228 (0.88) 4.9
Endoprocta						
Urnatella gracilis	---		---		P	---
Annelida						
Oligochaeta (total)	3,317 (0.47) 75.7	289 (0.66) 16.7	1,317 (0.80) 71.6	1,200 (0.73) 23.9	2,039 (0.76) 8.5	1,078 (0.74) 23.1
Enchytraeidae	---	---	---	---	244 (1.59) 1.0	294 (1.44) 6.3
Naididae						
Bratislavia unidentata	11 (2.83) 0.2	---	---	6 (2.83) 0.1	344 (1.16) 1.4	39 (2.83) 0.8

APPENDIX 6 (continued).

Taxon/Parameter	MUD Okeechobee $\bar{X}$ (cv) %	MUD Blue Cypress $\bar{X}$ (cv) %	SAND Okeechobee $\bar{X}$ (cv) %	SAND Blue Cypress $\bar{X}$ (cv) %	PEAT Okeechobee $\bar{X}$ (cv) %	PEAT Blue Cypress $\bar{X}$ (cv) %
Dero nivea	---	---	---	---	---	11 (2.83) 0.2
D. pectinata	---	---	---	---	---	139 (1.34) 3.0
D. trifida	---	---	---	---	17 (2.83) <0.1	---
Haemonais waldvogeli	---	---	---	---	---	6 (2.83) 0.1
Pristina spp.	---	---	---	---	6 (2.83) <0.1	---
P. leidyi	---	---	---	---	---	17 (1.38) 0.4
P. synclites	---	---	---	22 (1.85) 0.4	---	---
Slavina appendiculata	---	---	---	---	---	22 (2.14) 0.5
Stephensoniana trivandrana	50 (0.88) 1.1	---	---	---	678 (1.43) 2.8	---
Tubificidae						
Aulodrilus piqueti	94 (0.59) 2.2	33 (1.85) 1.9	33 (1.55) 1.8	---	6 (2.83) <0.1	261 (1.13) 5.6
Branchuria sowerbyi	---	---	11 (1.85) 0.6	67 (0.71) 1.3	---	11 (1.85) 0.2

APPENDIX 6 (continued).

	MUD		SAND		PEAT	
	Okeechobee	Blue Cypress	Okeechobee	Blue Cypress	Okeechobee	Blue Cypress
Taxon/Parameter	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %	$\bar{X}$ (cv) %
Haber speciosus	---	---	---	178 (1.23) 3.5	---	---
Ilyodrilus templetoni	11 (1.85) 0.2	---	6 (2.83) 0.3	---	---	---
Limnodrilus hoffmeisteri	11 (2.83) 0.2	28 (1.47) 1.6	44 (1.07) 2.4	17 (1.38) 0.3	6 (2.83) <0.1	--- ---
UIWCS	167 (0.66) 3.8	---	100 (0.91) 5.4	478 (1.00) 9.5	44 (0.76) 0.2	133 (1.32) 2.9
UIW/OCS	2,973 (0.51) 67.8	228 (0.58) 13.2	1,089 (0.84) 59.2	394 (0.60) 7.9	161 (0.87) 0.7	67 (1.42) 1.4
Imm. *H. speciosus*	11 (2.83) 0.2	---	---	439 (1.00) 8.8	28 (1.19) 0.1	100 (1.27) 2.1
Imm. *I. templetoni*	156 (0.79) 3.5	---	94 (0.92) 5.1	---	---	---
Lumbriculidae						
Eclipidrilus spp.	---	---	---	22 (1.51) 0.4	---	39 (1.97) 0.8
Lumbriculus variegatus	---	---	---	---	516 (1.27) 2.2	---
Hirudinea	---	28 (1.47) 1.6	---	6 (1.85) 0.2	---	6 (2.83) 0.1
Mollusca						
Gastropoda						
Ancylidae (unk)	---	---	---	6 (2.83) 0.1	---	17 (1.38) 3.6

APPENDIX 6 (continued).

Taxon/Parameter	MUD Okeechobee X (cv) %	MUD Blue Cypress X (cv) %	SAND Okeechobee X (cv) %	SAND Blue Cypress X (cv) %	PEAT Okeechobee X (cv) %	PEAT Blue Cypress X (cv) %
Hydrobiidae (unk)	33 (1.38) 0.8	6 (2.83) 0.3	---	17 (1.38) 0.3	894 (0.86) 3.7	11 (2.83) 0.2
Hyalopyrgus aequicostatus	39 (1.42) 0.9	22 (1.43) 1.3	---	---	---	---
Pyrogophorus platyrachis	17 (1.38) 0.4	---	---	---	350 (1.06) 1.4	6 (2.83) 0.1
Thiaridae						
Melanoides tuberculata	---	---	---	11 (1.85) 0.2	---	---
Pelecypoda (unk imm)	---	750 (1.36) 43.4	---	227 (0.23) 6.5	---	884 (1.35) 19.0
Sphaeriidae	---	6 (2.83) 0.3	---	6 (2.83) 0.1	---	39 (1.42) 0.8
Corbiculidae						
Corbicula fluminea	33 (1.38) 0.8	211 (1.42) 12.2	---	1,845 (0.38) 36.8	1,550 (0.59) 6.4	117 (1.63) 2.5
Unionidae						
Elliptio buckleyi	---	---	---	6 (2.83) 0.1	---	---
Arthropoda						
Crustacea						
Amphipoda (total)	261 (0.69) 5.9	6 (2.83) 0.3	28 (1.70) 1.5	33 (1.38) 0.7	9,301 (0.50) 38.7	50 (1.54) 1.0
Gammaridae						
Gammarus nr. *tigrinus*	261 (0.69) 5.9	---	28 (1.70) 1.5	---	9,301 (0.50) 38.7	---
Hyalellidae						
Hyalella azteca	---	6 (2.83) 0.3	---	33 (1.38) 0.7	---	50 (1.54) 1.0

APPENDIX 6 (continued).

Taxon/Parameter	MUD Okeechobee $\bar{X}$ (cv) %	MUD Blue Cypress $\bar{X}$ (cv) %	SAND Okeechobee $\bar{X}$ (cv) %	SAND Blue Cypress $\bar{X}$ (cv) %	PEAT Okeechobee $\bar{X}$ (cv) %	PEAT Blue Cypress $\bar{X}$ (cv) %
Isopoda						
Anthuridae						
Cyathura polita	11 (1.85) 0.2	---	17 (1.38) 0.9	---	322 (0.70) 1.3	---
Sphaeromidae						
Cassidinidea ovalis	6 (2.83) 0.1	---	---	---	1,306 (0.44) 5.4	---
Mysidacea						
Mysidae						
Mysidopsis almyra	6 (2.83) 0.2	---	17 (1.98) 0.9	---	---	---
Aquatic Acari	---	---	---	56 (1.45) 1.1	2,322 (1.51) 9.7	206 (1.53) 4.4
Insecta						
Ephemeroptera						
Caenidae						
Brachycercus maculatus	---	---	---	22 (1.51) 0.4	---	22 (1.51) 0.5
Caenis diminuta	---	---	---	22 (1.07) 0.4	6 (2.83) <0.1	44 (1.07) 1.0
Ephemeridae						
Hexagenia spp.	---	128 (0.68) 7.4	---	411 (1.09) 8.2	---	517 (1.22) 11.1
Trichoptera						
Hydroptilidae	---	---	---	---	---	6 (2.83) 0.1
Polycentropodidae	---	---	---	11 (1.85) 0.2	---	33 (2.82) 0.7
Polycentropus spp.	---	---	---	---	---	67 (1.67) 1.4

APPENDIX 6 (continued).

Taxon/Parameter	MUD Okeechobee $\bar{X}$ (cv) %	MUD Blue Cypress $\bar{X}$ (cv) %	SAND Okeechobee $\bar{X}$ (cv) %	SAND Blue Cypress $\bar{X}$ (cv) %	PEAT Okeechobee $\bar{X}$ (cv) %	PEAT Blue Cypress $\bar{X}$ (cv) %
Neuroclipsis spp.	---	---	---	---	---	11 (1.85) 0.2
Leptoceridae	---	6 (2.83) 0.3	---	22 (2.14) 0.4	---	44 (2.07) 1.0
Nectopsyche spp.	---	---	---	---	44 (1.41) 0.2	---
Oecetis spp.	---	---	---	17 (1.38) 0.3	11 (2.83) <0.1	28 (1.07) 0.6
Diptera						
Ceratopogonidae						
Palpomyia complex	---	6 (2.83) 0.3	---	161 (0.62) 3.2	---	94 (1.02) 2.0
Chaoboridae						
Chaoborus punctipennis	---	56 (1.02) 3.2	---	6 (2.83) 0.1	---	---
Chironomidae (total)	600 (0.64) 13.7	211 (0.50) 12.2	444 (0.57) 24.2	683 (0.41) 13.6	3,678 (0.68) 15.3	1,106 (0.62) 23.7
Tanypodinae						
Coelotanypus spp.	67 (1.51) 1.5	56 (1.95) 3.2	267 (0.96) 14.5	106 (0.55) 2.1	111 (0.98) 0.5	128 (0.94) 2.7
C. tricolor	311 (0.45) 7.1	94 (0.81) 5.5	178 (0.42) 9.7	---	11 (2.83) <0.1	56 (1.47) 1.2
Pentaneurini						
Ablabesmyia spp.	---	22 (1.07) 1.3	---	6 (2.83) 0.1	---	56 (1.85) 1.2
Larsia lurida	---	6 (2.83) 0.3	---	---	---	11 (2.83) 0.2

APPENDIX 6 (continued).

Taxon/Parameter	MUD Okeechobee $\bar{X}$ (cv) %	MUD Blue Cypress $\bar{X}$ (cv) %	SAND Okeechobee $\bar{X}$ (cv) %	SAND Blue Cypress $\bar{X}$ (cv) %	PEAT Okeechobee $\bar{X}$ (cv) %	PEAT Blue Cypress $\bar{X}$ (cv) %
Procladini						
Djalmabatista pulcher	---	---	---	228 (0.67) 4.5	228 (0.95) 0.9	39 (0.73) 0.8
Procladius spp.	---	---	---	---	---	33 (1.85) 0.7
Orthocladiinae						
Cricotopus spp.	---	---	---	---	111 (1.41) 0.4	6 (2.83) 0.1
Epoicocladius spp.	---	22 (1.51) 1.3	---	6 (2.83) 0.1	---	---
Nanocladius spp.	---	---	---	---	89 (1.10) 0.4	---
Chironominae						
Chironomini						
Axarus spp.	---	---	---	---	---	17 (1.98) 0.4
Chironomus crassicaudatus	217 (1.23) 4.9	---	---	---	---	---
Cryptochironomus fulvus	---	6 (2.83) 0.3	---	28 (1.47) 0.6	---	61 (1.22) 1.3
Cryptotendipes spp.	---	---	---	6 (2.83) 0.1	---	22 (2.14) 0.5
Dicrotendipes modestus	6 (2.83) 0.1	---	---	---	111 (1.47) 0.5	67 (1.01) 1.4
D. neomodestus	---	---	---	---	6 (2.83) <0.1	---

APPENDIX 6 (continued).

Taxon/Parameter	MUD Okeechobee $\bar{X}$ (cv) %	MUD Blue Cypress $\bar{X}$ (cv) %	SAND Okeechobee $\bar{X}$ (cv) %	SAND Blue Cypress $\bar{X}$ (cv) %	PEAT Okeechobee $\bar{X}$ (cv) %	PEAT Blue Cypress $\bar{X}$ (cv) %
Glyptotendipes spp.	---	---	---	---	---	33 (0.62) 0.7
Goeldichironomus spp.	---	---	---	---	6 (2.83) <0.1	---
Parachironomus directus	---	6 (2.83) 0.3	---	---	89 (1.71) 0.4	---
Paracladopelma spp.	---	---	---	---	---	11 (1.85) 0.2
Paralauterborniella spp.	---	---	---	106 (1.29) 2.1	11 (2.83) <0.1	33 (1.55) 0.7
Polypedilum halterale	---	---	---	22 (1.51) 0.4	172 (0.81) 0.7	44 (1.41) 1.0
P. illinoense	---	---	---	---	---	6 (2.83) 0.1
Tribelos spp.	---	---	---	---	---	11 (1.85) 0.2
Xenochironomus xenolabis	---	---	---	---	50 (1.38) 0.2	---
Zavreliella spp.	---	---	---	---	33 (1.98) 0.1	11 (2.83) 0.2
Unknown Chironomoni A	---	---	---	33 (1.82) 0.7	117 (1.44) 0.5	72 (0.87) 1.5

APPENDIX 6 (continued).

Taxon/Parameter	MUD Okeechobee $\bar{X}$ (cv) %	MUD Blue Cypress $\bar{X}$ (cv) %	SAND Okeechobee $\bar{X}$ (cv) %	SAND Blue Cypress $\bar{X}$ (cv) %	PEAT Okeechobee $\bar{X}$ (cv) %	PEAT Blue Cypress $\bar{X}$ (cv) %
Pseudochironomini						
Pseudochironomus spp.	---	---	---	6 (2.83) 0.2	1,572 (1.05) 6.6	---
Tanytarsini						
Cladotanytarsus spp.	---	---	---	122 (0.80) 2.4	945 (1.10) 3.9	239 (1.48) 5.1
Tanytarsus spp.	---	---	---	---	6 (2.83) <0.1	94 (0.73) 2.0
Unknown Tanytarsini	---	---	---	---	---	28 (1.47) 0.6
Total Species Richness	16	19	10	34	37	51
Mean Species Richness	8 (0.20)	7 (0.13)	5 (0.38)	16 (0.21)	20 (0.25)	22 (0.46)
Mean Diversity	1.69 (0.16)	1.85 (0.42)	1.42 (0.19)	2.67 (0.19)	2.85 (0.23)	3.51 (0.08)
Mean Evenness	0.56 (0.19)	0.65 (0.39)	0.70 (0.23)	0.67 (0.14)	0.66 (0.16)	0.82 (0.09)
Mean Total Organisms	4,384 (0.44)	1,728 (0.59)	1,839 (0.71)	5,011 (0.17)	24,020 (0.23)	4,662 (0.88)
O:C Ratio	5.53	1.37	2.97	1.76	0.55	0.97

Total Taxa Lake Okeechobee = 40
Total Taxa Blue Cypress Lake = 58

APPENDIX 7.

Abundance and percent composition of invertebrate food items identified from guts of five fish species collected from Blue Cypress Lake (Indian River Co., FL) during September 1995.

APPENDIX 7. Abundance and percent composition of invertebrate food items identified from guts of five fish species collected from Blue Cypress Lake (Indian River Co., FL) during September 1995.

	Fish Species									
	Lepomis macrochirus n=13 61 - 216 mm		*Lepomis auritus* n=2 164 - 174 mm		*Lepomis microlophus* n=2 226 - 229 mm		*Pomoxis nigromaculatus* n=8 225 - 340 mm		*Micropterus salmoides* n=4 106 - 248 mm	
Food Item	#	(%)	#	(%)	#	(%)	#	(%)	#	(%)
Mollusca										
Gastropoda	1	(0.1)	-		-		-		-	
Ancylidae	11	(1.6)	2	(5.5)	pts		-		-	
Micromenetus d. avus *	1	(0.1)	-		-		-		-	
Planorbella scalaris *	2	(0.3)	-		-		-		-	
Physidae	1	(0.1)	-		pts		-		-	
Physella cubensis	1	(0.1)	-		-		-		-	
Melanoides tuberculata	-		-		2	(6.6)	-		-	
Viviparus georgianus	-		-		8	(26.6)	-		-	
Crustacea										
Ostracoda	7	(1.0)	-		-		2	(2.6)	-	
Copepoda	9	(1.3)	-		-		-		-	
Amphipoda										
Hyalella azteca	380	(57.3)	27	(75.0)	13	(43.3)	1	(1.3)	-	
Decapoda										
Palaemonetes paludosus *	24	(3.6)	-		-		32	(42.1)	9	(75.0)
Aquatic Acari										
Hydracarina	1	(0.1)	-		-		-		-	
Oribatidae *	1	(0.1)	-		-		-		-	
Insecta										
Ephemeroptera										
Caenis diminuta	24	(3.6)	-		-		-		-	
Hexagenia orlando	1	(0.1)	-		4	(13.3)	17	(22.3)	-	
Odonata										
Anisoptera, adults	-		-		-		8	(10.5)	-	
Nymphs	1	(0.1)	5	(13.8)	-		5	(6.5)	-	

APPENDIX 7 (continued).

Food Item	Lepomis macrochirus n=13 #	(%)	Lepomis auritus n=2 #	(%)	Lepomis microlophus n=2 #	(%)	Pomoxis nigromaculatus n=8 #	(%)	Micropterus salmoides n=4 #	(%)
Hemiptera	-		-		-		1	(1.3)	-	
Belostomatidae *	7	(1.0)	-		-		-		-	
Naucoridae *	1	(0.1)	-		-		-		-	
Pleidae *	1	(0.1)	-		-		-		-	
Trichoptera	-		-		1	(3.3)	1	(1.3)	-	
Orthotrichia sp.*	1	(0.1)	-		-		-		-	
Ceraclea sp.	4	(0.6)	-		-		-		-	
Oecetis cinerascens	1	(0.1)	-		-		-		-	
Polycentropodidae	6	(0.9)	-		-		-		-	
Cyrnellus sp.	1	(0.1)	-		-		-		-	
Neuroptera										
Climacia aerolaris	1	(0.1)	-		-		-		-	
Coleoptera, adult	1	(0.1)	-		-		2	(2.6)	-	
Coleoptera, larvae	3	(0.4)	-		-		-		-	
Elmidae, adult	1	(0.1)	-		-		-		-	
Stenelmis sp., larvae	3	(0.4)	-		-		-		-	
Hydrophilidae, adult	1	(0.1)	-		-		-		-	
Noteridae, larvae *	-								1	(8.3)
Hydrocanthus sp., larvae *	1	(0.1)	-		-		-		-	
Suphisellus sp., larvae *	7	(1.1)	-		-		-		-	
Ceratopogonidae										
Bezzia/*Palpomyia* complex	10	(1.5)	-		-		-		-	
Chironomidae	-		1	(2.8)	-		-		-	
Tanypodinae	1	(0.1)	-		-		-		-	
Ablabesmyia perennis	1	(0.1)	-		1	(3.3)	-		1	(8.3)
Coelotanypus sp.	-		-		1	(3.3)	-		-	
Djalmabatista pulchra	1	(0.1)	-		-		-		-	
Labrudinia maculata	1	(0.1)	-		-		-		-	

APPENDIX 7 (continued).

Food Item	Lepomis macrochirus n=13 #	(%)	Lepomis auritus n=2 #	(%)	Lepomis microlophus n=2 #	(%)	Pomoxis nigromaculatus n=8 #	(%)	Micropterus salmoides n=4 #	(%)
Nanocladius sp.	3	(0.4)	-		-		-		-	
Axarus sp.	31	(4.6)	-		-		-		-	
Chironomus sp.	3	(0.4)	-		-		-		-	
C. (*lobochironomus*) sp.	2	(0.3)	-		-		-		-	
C. *decorus* gr.	1	(0.1)	-		-		-		-	
Cryptochironomus sp.	-		1	(2.8)	-		-		-	
Dicrotendipes sp.	10	(1.5)	-		-		-		-	
D. *simpsoni*	14	(2.1)	-		-		1	(1.3)	-	
Glyptotendipes sp.	2	(0.3)	-		-		-		-	
G. sp B (Epler)	1	(0.1)	-		-		-		-	
Parachironomus carinatus	1	(0.1)	-		-		-		-	
Polypedilum sp.	3	(0.4)	-		-		-		-	
P. *beckae*	5	(0.7)	-		-		1	(2.6)	-	
P. *illinoense*	1	(0.1)	-		-		-		-	
P. *scalaenum*	3	(0.1)	-		-		-		-	
Stenochironomus sp.	2	(0.3)	-		-		-		-	
Tribelos sp.	1	(0.1)	-		-		-		-	
T. *fusciorne*	9	(1.3)	-		-		-		-	
Xenochironomus xenobalis	7	(1.0)	-		-		-		-	
Chironomid Pupae	3	(0.4)	-		-		-		-	
Terrestrial Isopoda	38	(5.7)	-		-		-		-	
Terrestrial Insects	2	(0.3)	-		-		3	(3.9)	-	
Fish	-		-		-		2	(2.6)	1	(8.3)
Eggs	P		-		-		P		-	
Seeds	-		-		P		-		-	

* = associated exclusively with littoral vegetation.
P = food item was present.
\- = food item was not present.