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Structural Dynamics of Benthic Invertebrate Communities of the Lake Okeechobee Pelagic Region

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Introduction

The Comprehensive Everglades Restoration Plan (CERP), as established by the federal Water Resources Development Act of 2000, included as one of its primary goals the restoration of Lake Okeechobee to its natural condition and function. The Monitoring and Assessment Plan (MAP) developed by the CERP Restoration, Coordination, and Verification Program recognized the value of freshwater invertebrate communities as ecological indicators and included as one of its principal performance measures the documentation of benthic invertebrate community structure and variability in the Lake Okeechobee pelagic region. In August 2005 the Florida Fish and Wildlife Conservation Commission (FWC), with funding provided by the South Florida Water Management District, implemented a three year project with the goal of establishing a pre-CERP invertebrate community baseline. Most of the 2005-2008 data were collected in low water level conditions. FWC was able to provide additional insight into pelagic zone benthic invertebrate community dynamics by supplementing the information obtained during the 2005-2008 study period with additional data compiled from benthic samples collected from 1987 through 1997. The 1987-1997 data set was collected over a much wider range of water level conditions than the 2005-2008 data set, however, low water levels in the 1987-1997 period did not approach the historical low reached in July 2007 (8.82 MSL), and none of the 1987-1997 sampling was conducted in post-hurricane conditions.

This report provides a synthesis of the data from the two study periods to provide a pre-CERP restoration activity baseline. Continued monitoring of invertebrate community structure throughout, and beyond, the implementation of CERP management actions will provide a continual measure of the success of Lake Okeechobee ecosystem restoration efforts.

Freshwater Invertebrate Community Structure as an Assessment Tool

Freshwater invertebrate community structure has been used as a tool to evaluate the biological status of lakes since the origin of the science of limnology in the early 20th century (Thienemann 1925, Brundin 1949, Brinkurst 1974). Early limnologists recognized that invertebrate community structure was sensitive to prevailing environmental conditions, and, since freshwater invertebrate communities are essentially sessile and unable to escape disturbance, they are sculpted by, and reflect, the habitat conditions in which they develop.

The elements of invertebrate community structure most useful for evaluating the trophic status and ecological health of lakes are species composition, species richness, equitability of distribution (evenness as per Pielou 1977), diversity (e.g. Shannon's equation, Krebs 1999), relative abundance (usually as percent composition) and absolute abundance (usually expressed in units of areal density, such as no. of organisms m^{-2})(Jonasson 1969). The eutrophication process influences these elements by degrading and homogenizing habitat (via sedimentation of organic matter) and degrading water quality (Jonasson 1969). As a consequence of these degrading factors, species richness, diversity, and equitability of distribution become reduced (Brinkhurst 1974, Wiederholm 1980, Wetzel 1983). As eutrophication advances and loss of intolerant species continues, community dominance shifts to more tolerant, and often less desirable, taxa. Those taxa that require more complicated habitat structure and higher levels of dissolved oxygen, such as scuds (Amphipoda), snails and mussels (Mollusca), mayflies (Ephemeroptera), caddisflies (Trichoptera), and dragonflies and damselflies (Odonata) decline and invertebrate communities become dominated by groups of species physiologically adapted to withstand high degrees of organic loading and extended periods of low (<4.0 ppm) dissolved oxygen (Brinkhurst 1974). In cases of hypereutrophication, which is of concern for Lake Okeechobee, all but the most tolerant of segmented worm (Oligochaeta) species, such as the tubificid *Limnodrilus hoffmeisteri*, may be eliminated (Brinkhurst 1974, Wetzel 1983). Since invertebrates are an integral component of freshwater food webs and are vital to the decomposition and nutrient cycling processes, elimination of taxa intolerant of the habitat conditions associated with eutrophication can have ecosystem-wide ramifications.

Historical Perspective

The location and size of Lake Okeechobee make it one of North America's most unique and economically valuable natural resources. The lake is a multiple-use resource that supports the demands of a variety of user groups (Steinman et al. 2002). These demands range from a potable water source for surrounding municipalities and Florida's densely populated southeast coast, to commercial and recreational fisheries that fuel local economies. The annual combined recreational and commercial asset value of Lake Okeechobee has been estimated to be in excess of 100 million dollars (Bell 1987). As a consequence of its value to all user groups, the continued good health and productivity of Lake Okeechobee is of foremost importance.

The quality of Lake Okeechobee's water and habitat has been influenced by many factors. Most prominent among these have been reduction in lake area and impoundment by the Herbert Hoover Dike, artificially regulated water levels, and increased nutrient inputs (both allochthonous and autochthonous). Construction of the dike, which began in the 1920s, excised large areas of marsh from the basin and confined the lake to a smaller surface area. The dike also prevented natural sheet flow from the lake into the Everglades, thereby transforming the basin into a sink for accumulation of organic material. During the period from the early 1970s through the 1980s, the lake's phosphorus concentration doubled from 0.05 to 0.1 mg/liter (Janus et al. 1990). Large and frequent blue-green algae blooms in the late 1980s prompted concerns that the lake was becoming hypereutrophic. Results from the initial segment (1987-1992) of the FWC invertebrate community evaluation were indicative of an overall community low in species richness and diversity, and with a taxonomic composition indicative of poor habitat conditions (Warren et al. 1995).

South Florida was affected by several hurricanes during 2004 and 2005. Three of these passed very near, or over, Lake Okeechobee. These storms severely impacted the Lake Okeechobee ecosystem in a number of ways. Storm impacts that impacted invertebrate communities would, theoretically, include disturbance and scouring of bottom sediments by wave action, long-term high (> 6 months) turbidity levels (and corresponding reductions in light penetration) resulting from suspension of bottom sediments, elevated nutrient levels (e.g. total phosphorus exceeding 0.1 mg/l as per James et al. in press), and uprooting of aquatic vegetation. The current (2005-2008) study was planned within the CERP framework prior to the hurricanes of 2004-2005 and was implemented, with the originally planned objectives, a relatively short time after the last of these storms had passed. The work was begun with the realization that the invertebrate communities sampled throughout the three year duration of the project might have been severely impacted by lake conditions resulting from hurricanes.

Objectives

Pelagic region benthic invertebrate community structure was identified as a primary Lake Okeechobee performance measure within the MAP framework due to the importance of freshwater invertebrates as ecological indicators. Evaluation of the Lake Okeechobee pelagic region benthic invertebrate communities was, therefore, implemented in the context of the following broad goals of the monitoring plan:

1. Establish pre-CERP reference state, including variability, for each performance measure.

2. Determine the status and trend for each performance measure.

3. Detect unexpected responses of the ecosystem to changes in stressors resulting from CERP activities.

4. Support scientific investigations designed to increase understanding of ecosystem function, cause and effect, and unanticipated results.

Given these overall MAP goals, the evaluation of benthic invertebrate communities of the Lake Okeechobee pelagic region was implemented with the following objectives:

1. Sample Lake Okeechobee sublittoral zone benthic invertebrate communities in three areally dominant habitat zones (mud, sand, peat) twice annually for a three year period, duplicating the timing, locations, and methods of Warren et al. (1995).

2. Use results from sampling to evaluate the pelagic region benthic invertebrate community structure, thereby establishing a baseline for future evaluation and comparison. Elements of community structure to be documented include: taxonomic composition, taxa richness, absolute abundance, relative abundance, diversity (Shannon's equation, as per Krebs 1999), and evenness (as per Pielou 1977).

3. Compare current (2005-08) pelagic region benthic invertebrate community structure with corresponding structural elements of the 1987-96 study period. Based upon these comparisons, identify changes in invertebrate community structure and speculate on the implications to future invertebrate community health as well as the overall health of the Lake Okeechobee ecosystem.

4. Relate results from the study to CERP hypotheses and apply conclusions to the adaptive management process.

The intent of maintaining continuity with the methods and sampling sites utilized during the 1987-1996 FWC sublittoral zone evaluation (Warren 1991, Warren et al. 1995) was to supplement the pre-CERP implementation baseline (2005-2008 study) with additional data collected over a longer term and over a broader range of environmental conditions.

Unfortunately, FWC suspended its Lake Okeechobee invertebrate community evaluation program from 1997 to 2005, and, as a consequence, invertebrate community responses to the extreme weather conditions occurring during that time period, including a tropical storm (1999), drought (2001), and the hurricanes of 2004-2005, were not documented.

After the implementation of CERP management actions in Lake Okeechobee, expectations are that organic inputs to the lake and nutrient levels in the lake will decline. In response to these improvements, the extreme numerical dominance of invertebrate communities by pollution-tolerant segmented worms (Tubificidae), as documented by Warren et al. 1995, should slowly be reduced. Freshwater invertebrate communities are resilient and responsive, hence, as habitat conditions improve in the lake, the relative abundance of less tolerant taxa (e.g. certain snail, crustacean, mayfly, and caddisfly taxa) would be expected to increase, lost species should return, and invertebrate communities as a whole should become more ecologically balanced and diverse, thereby signaling a return to a less anthropogenically disturbed condition.

Methods

Rationale and Design

Sampling was conducted following the basic design and methods of Warren (1991) and Warren et al. (1995) to allow for statistical comparisons between the historical (1987-1997) and current (2005-2008) data sets. This design incorporated quantitative sampling at one-meter depth increments within each of the three major pelagic region benthic habitat zones (mud, sand, peat Figure 1) identified by Warren (1991). Six additional sample sites added by Warren in 1995 were also included in the design of the present study.

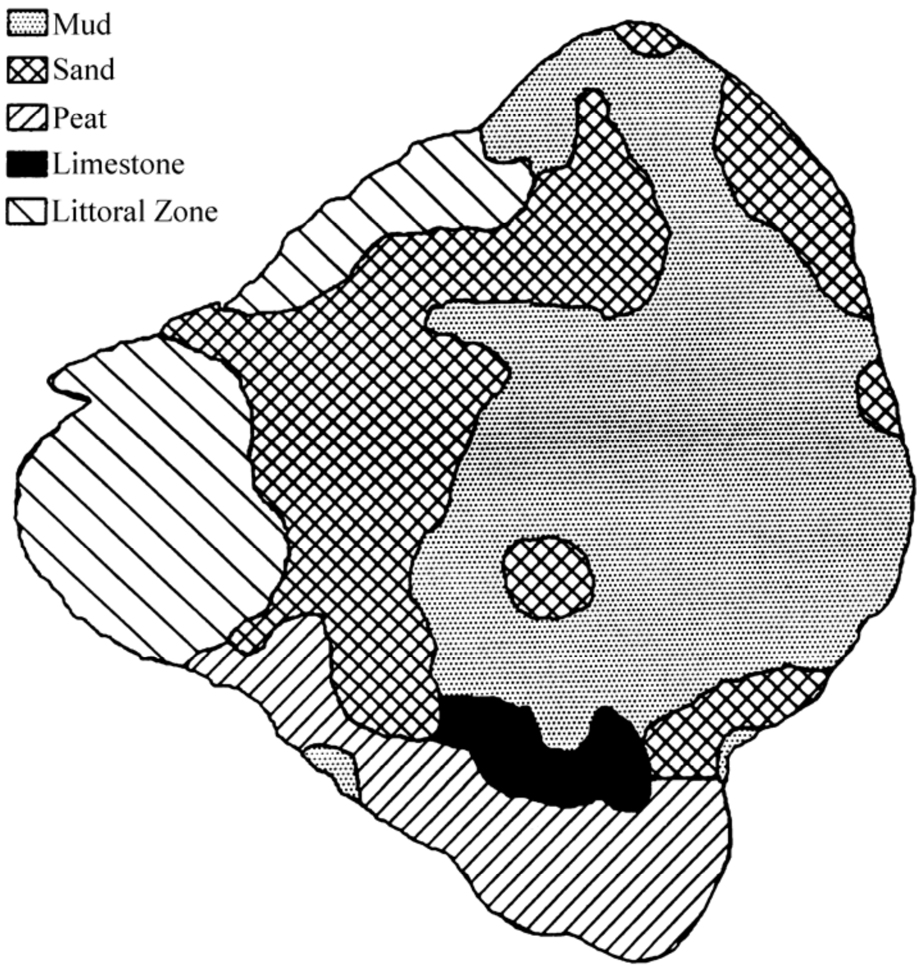

FIGURE 1. Major bottom-types of Lake Okeechobee, FL (modified from Reddy 1993).

Equal numbers of samples were obtained from the three benthic habitat zones during each collection. Timing of sampling events reflected the summer wet season (August), winter dry season (February) pattern implemented for the 1987-97 pelagic zone study.

Field Methods

Two sampling events were conducted during each of the three study years, resulting in a total of six field collections. Summer (wet season) collections were obtained during August of both 2005 and 2006. The summer 2007 collection was delayed until October 2007 because low water levels resulted in the de-watering of several sampling sites (P1, P4, P6, S1) and prevented access to many sampling sites during August. Delaying the summer 2007 sampling event until October allowed for re-establishment of the benthic communities at the previously de-watered sites. Winter (dry season) collections were obtained during February of each the three study years.

A network of 18 fixed sites was sampled during each of the six sampling events associated with the project (Figure 2, Table 1). As noted previously, sampling sites were distributed equally over the three major pelagic region benthic habitat zones (mud, sand, and peat, Figure 1). Six sites were located at one meter depth increments within each zone. Three samples were obtained from each sampling site during each sampling event, yielding totals of 54 samples per collection and 108 samples per study year.

All samples were collected from a boat using a Wildco® petite ponar dredge (area sampled = 232 cm^2). The inside screens of the petite ponar and all rinsing and sieving devices were fitted with 300 micron mesh Nitex to ensure collection of smaller taxa. After collection, samples were rinsed in the field to remove excess water, labeled, and preserved in separate containers using 95 percent ethanol. After field processing and preservation, samples were transported to the

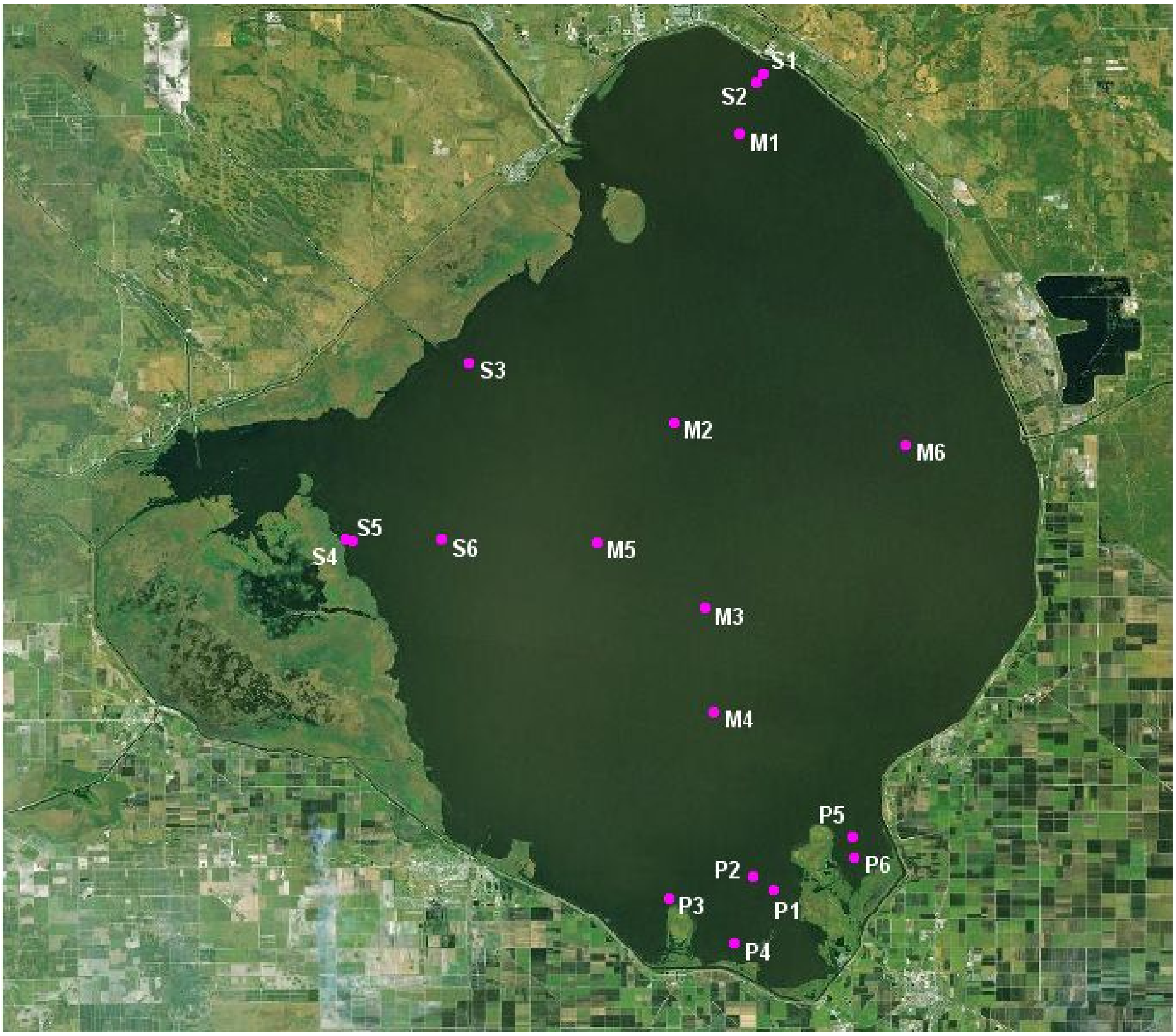

FIGURE 2. Location of Florida Fish and Wildlife Conservation Commission benthic invertebrate sampling sites in the Lake Okeechobee, FL, pelagic zone.

TABLE 1. Locations of Florida Fish and Wildlife Conservation Commission pelagic region benthic invertebrate sampling sites in Lake Okeechobee, Florida.

Site Identifier	Sediment Type	Latitude (DD)	Longitude (DD)
M1	Mud	N 27.15550	W 80.77300
M2	Mud	N 27.00000	W 80.80830
M3	Mud	N 26.90000	W 80.79170
M4	Mud	N 26.84430	W 80.78670
M5	Mud	N 26.93530	W 80.85000
M6	Mud	N 26.98830	W 80.68330
S1	Sand	N 27.18839	W 80.76004
S2	Sand	N 27.18300	W 80.76430
S3	Sand	N 27.03250	W 80.91850
S4	Sand	N 26.93692	W 80.98559
S5	Sand	N 26.93670	W 80.98180
S6	Sand	N 26.93700	W 80.93330
P1	Peat	N 26.74802	W 80.75491
P2	Peat	N 26.75530	W 80.76620
P3	Peat	N 26.74362	W 80.81095
P4	Peat	N 26.71920	W 80.77550
P5	Peat	N 26.77720	W 80.71270
P6	Peat	N 26.76613	W 80.71101

Florida Fish and Wildlife Conservation Commission's aquatic invertebrate ecology laboratory at the University of Florida, Gainesville, FL, for further processing.

A suite of environmental parameters was measured at each sampling site prior to the collection of benthic invertebrates. Depth was measured using a surveying rod calibrated in one centimeter increments. Water temperature, dissolved oxygen, specific conductance, and salinity were measured at the surface, bottom, and at 0.5 meter depth increments using a YSI Model 556 multi-probe meter.

Laboratory Methods

Each sample was processed separately in the laboratory; samples were not composited at any stage of processing. Samples were processed by trained laboratory technicians using stereo-dissecting microscopes having magnifications to 43X. Technicians placed small sample portions in water-filled glass petri plates and then, with the aid of forceps and a stereo-scope, removed invertebrates. The technicians identified and sorted invertebrates to major taxonomic groups, enumerated each taxon, and preserved the organisms with 95 percent ethanol in three-dram vials. A taxonomist then verified counts and identified all organisms in each sample to the lowest taxonomic level possible, given the age and condition of specimens. To facilitate identification of Oligochaeta, Chironomidae, and Ceratopogonidae, specimens of these taxa were slide-mounted using CMC-10 and then identified using a compound interference-contrast microscope with magnification to 1000X.

A laboratory sheet was prepared for each sample. Taxonomic composition and taxa abundances were recorded on these sheets, along with ancillary measurement data, and station/date identifiers.

Analytical Methods

Sample site identifiers, taxa codes, and raw counts of organisms were entered from laboratory sheets into a database maintained in Microsoft Excel. Taxa richness, diversity (Shannon's equation as per Krebs 1999), and evenness (Pielou 1977) were computed for each sample and entered into the database. Descriptive statistics and univariate analyses were computed using SYSTAT® 12 (SYSTAT Software, Inc. 2007) and JMP® 7 (SAS Institute Inc., 2007) statistical software. Multivariate analyses were computed using PC-ORD 5® (MjM Software Design, 2005).

Results

Overall Lake Community 2005-2008

A total of 118 individual aquatic invertebrate taxa representing 28 major taxonomic groups were collected from the three benthic habitat zones of the Lake Okeechobee pelagic region during the three year (2005-2008), six sampling event, period of study (Appendices 1A – 1F). Overall, the lake community was numerically dominated by segmented worms (Oligochaeta) and larval non-biting midges (Chironomidae), which together accounted for 64.3 percent of the total organisms collected and 73 of the 118 total taxa (61.9%). Separately, segmented worms and midges accounted for 40.8 and 23.5 percent, respectively, of the total organisms and were present in mean densities of 3,212 m^{-2} and 1,851 m^{-2}, respectively. Remaining major taxonomic groups that accounted for more than five percent of the total organisms included only Pelecypoda (12.3%, 965 m^{-2}, one taxon), aquatic Acari (7.9%, 619 m^{-2}, two taxa), and Amphipoda (6.1%, 478 m^{-2}, three taxa). Other major taxonomic groups that are typically among the numerical dominants in many Florida lakes, such as Gastropoda (snails), Isopoda (sow bugs), Ephemeroptera (mayflies), and Trichoptera (caddisflies) each accounted for less than two percent of the Lake Okeechobee pelagic zone total abundance during the 2005-2008 study period.

An ecologically diverse group of individual taxa dominated the overall lake benthos during the 2005-2008 study period. Most abundant of these was the segmented worm *Limnodrilus hoffmeisteri*, which was present with a mean density of 1,351 m^{-2} and accounted for 17.2 percent of all organisms collected. *L. hoffmeisteri* has been among the most abundant taxa in the lake since the initiation of FWC benthic studies and is noted for its tolerance of poor, organically enriched, habitat conditions (Brinkhurst 1986, Milligan 1997). The introduced Asian clam, *Corbicula fluminea*, was the second-most abundant individual taxon present (lakewide mean = 965 m^{-2}), accounting for 12.3 percent of the total organisms. Other individual taxa accounting for more than five percent of the total organisms collected included the epibenthic midge *Cladotanytarsus* sp. (8.2%, 645 m^{-2}), Hydracarina (water mites; 6.7%, 529 m^{-2}), the amphipod *Gammarus* nr. *tigrinus* (5.6%, 443 m^{-2}), the midge *Pseudochironomus* sp. (5.6%, 440 m^{-2}), and the naidid worm *Nais variabilis* (5.4%, 428 m^{-2}).

The tubicolous chironomid detritivore *Chironomus crassicaudatus*, which accounted for an appreciable percentage of the pelagic zone benthos in past collections (1987–1996 mean = 533 m^{-2}; Warren et al. 1995), and has been a primary component in the diets of game fish species, was collected rarely (mean = 0.3 m^{-2}, st.dev.= 3.5) during the 2005–2008 study period. Other taxa that were notably important in past collections (as per Warren et al. 1995), but were absent or present only in low numbers during the 2005-2008 study period included: the gastropods (snails) *Pyrgophorus platyrachis*, *Viviparus georgianus* and *Melanoides* sp., the amphipod crustaceans *Hyalella azteca* and *Corophium louisianum*, the isopod crustaceans *Cyathura polita* and *Cassidinidea ovalis*, Trichoptera (caddisflies) of the genera *Nectopsyche* and *Oecetis*, and larvae of several of the non-biting midge taxa (Chironomidae).

Lakewide means of taxa richness, diversity, evenness, and total organisms for the 2005-2008 study period were 8.8, 1.87, 0.67 and 7,869 m^{-2}, respectively, and ranked low to average for all descriptive statistics relative to other Florida lakes (see Warren 1991) and Lake Okeechobee during the 1987-1997 study period.

Variability Among Sample Years and Habitats 2005-2008

A principal goal of CERP baseline determination is documenting variability within the biological communities inhabiting areas slated for restoration. Freshwater invertebrates typically exhibit aggregated (negative binomial) distributions, hence, a considerable amount of temporal and spatial variability within populations and communities is expected. To compensate, we employed power analyses, data transformations, and distribution-free multivariate techniques to ensure maximum confidence in the results of our analyses.

Total taxa collected and per sample means of taxa richness, diversity, evenness, and total organisms are regarded as simple and reliable measures of the quality of freshwater invertebrate communities. Comparisons of these parameters across all habitats and seasons during the 2005-2008 study period are indicative of increased productivity and species richness in the overall Lake Okeechobee benthic community with each successive study year (Table 2). However, not all of these changes should be considered as improvements in benthic community quality. Total taxa collected increased by 20 (41.7%) from year one to year two and by 26 (38.2%) from year two to year three (Table 2). Mean taxa richness, diversity, and total organisms increased significantly (ANOVA, $p \leq 0.05$) with each year (Table 2).

TABLE 2. Descriptors of benthic invertebrate community quality in the Lake Okeechobee pelagic region, 2005 - 2008. Means with the same letter superscript are not significantly different (ANOVA, $p \leq 0.05$). Total organisms m^{-2} transformed by LOG(X+1).

Descriptor	Study Year 2005-2006	2006-2007	2007-2008
Total Taxa	48	68	94
Mean Species Richness	5.7^{a}	8.9^{b}	11.8^{c}
Mean Diversity	1.54^{a}	1.88^{b}	2.18^{c}
Mean Evenness	0.69^{a}	0.66^{a}	0.66^{a}
Mean Total Organisms m^{-2}	$3{,}338^{a}$	$7{,}591^{b}$	$12{,}678^{c}$

The trend toward increasing values with each successive study year was also reflected in the densities of several major taxonomic groups and individual dominant taxa. Not all instances of this trend are necessarily desirable. Densities of total Oligochaeta and the pollution tolerant tubificid *L. hoffmeisteri* increased significantly with each study year (Table 3), although percent composition of these taxa declined after the 2005-2006 study year. Two numerically importanttaxa, the Asian clam *Corbicula fluminea* and Hydracarina attained peak densities in study year two, then declined in numbers in study year three (Table 3). Desirable overall increases in densities of taxa important to the Lake Okeechobee food web were noted for Gastropoda (snails), the amphipod *Gammarus* nr. *tigrinus*, total isopods (sow bugs), total Ephemeroptera (mayflies), and total Chironomidae (Table 3).

Warren et al. (1995) showed that bottom substrate type was a principal determinant of benthic invertebrate community structure in the Lake Okeechobee pelagic zone. Four primary benthic habitat zones are present in the sublittoral region of the lake: mud, sand, peat, and limestone bedrock (Reddy 1993; Figure 1 herein). The mud zone accounts for more than 50 percent of the

TABLE 3. Abundance (no. m^{-2}) and percent composition (%) of major taxonomic groups and individual dominant taxa collected from all habitat types within the Lake Okeechobee pelagic region. Means with the same letter superscript are not significantly different (ANOVA, $p \leq 0.05$). Invertebrate densities transformed by LOG(X+1).

	Study Year		
	2005-2006	2006-2007	2007-2008
Major Group	no. m^{-2} (%)	no. m^{-2} (%)	no. m^{-2} (%)
Nematoda	137^{a} (4.1)	406^{a} (5.3)	255^{a} (2.0)
Oligochaeta	$2{,}147^{a}$ (64.3)	$2{,}669^{b}$ (35.2)	$4{,}819^{c}$ (38.0)
Nais variabilis	0^{a} (0.0)	297^{b} (3.9)	988^{b} (7.8)
Limnodrilus hoffmeisteri	974^{a} (29.1)	$1{,}069^{b}$ (14.1)	$2{,}008^{c}$ (15.8)
Gastropoda	32^{a} (0.9)	53^{a} (0.7)	199^{b} (1.6)
Pelecypoda			
Corbicula fluminea	314^{a} (9.4)	$1{,}985^{b}$ (26.1)	596^{a} (4.7)
Amphipoda	142^{a} (4.2)	725^{b} (9.5)	568^{a} (4.5)
Gammarus nr. *tigrinus*	142^{a} (4.2)	658^{b} (8.7)	528^{a} (4.2)
Isopoda	10^{a} (0.3)	82^{b} (1.1)	318^{c} (2.5)
Mysidacea	8^{a} (0.2)	7^{a} (0.1)	7^{a} (<0.1)
Aquatic Acari	398^{a} (11.9)	$1{,}109^{a}$ (14.6)	349^{a} (2.8)
Hydracarina	130^{a} (3.9)	$1{,}109^{a}$ (14.6)	349^{a} (2.8)
Ephemeroptera	9^{a} (0.2)	17^{a} (0.2)	338^{b} (2.7)
Trichoptera	1^{a} (<0.1)	3^{ab} (<0.1)	25^{b} (0.2)
Chaoboridae	21^{a} (0.6)	3^{a} (<0.1)	4^{a} (<0.1)
Chironomidae	92^{a} (2.7)	383^{a} (5.0)	$5{,}078^{b}$ (40.1)
Pseudochironomus sp.	0^{a} (0.0)	0^{a} (0.0)	$1{,}319^{b}$ (10.4)
Cladotanytarsus sp.	1^{a} (<0.1)	151^{b} (2.0)	$1{,}785^{c}$ (14.1)

total bottom surface area of the pelagic zone. It occupies the central and north-central areas of the lake (Figure 1) and is distinguished by a deep (>20 cm), fine-particle sized, organic sediment. These sediments often become re-suspended in the water column, causing high turbidities, in association with storm events such as the hurricanes of 2004 and 2005. The sand zone is located at the periphery of the pelagic region in the northeastern, northern, and northwestern lake areas and, in the western lake area, extends lakeward for several miles from the shoreline of the open water zone (Figure 2). The peat habitat zone is located in the southern quarter of the lake and is characterized by areas of both fine and coarse peat (Figure 1). The fourth primary habitat type is a limestone bedrock reef that separates the peat habitat zone from the mud habitat zone. For the purposes of this study, only the mud, sand, and peat habitat zones were sampled. The limestone reef has not been sampled quantitatively since the initiation of FWC benthic studies because of difficulties obtaining legitimate samples with the petite ponar dredge from the hard limestone substrate.

Since FWC initiated sampling in 1987, the mud zone has consistently supported a benthic community composed mostly of taxa known for tolerance of poor, organically enriched, habitat conditions (e.g. the segmented worms *L. hoffmeisteri* and *Ilyodrilus templetoni*, the snails *Viviparus georgianus* and *Melanoides* sp., midges of the genus *Chironomus*). Total taxa collected and means of taxa richness, diversity, and total organisms have always been lowest in the mud habitat (Warren et al 1995). Homogenous habitat structure and low dissolved oxygen levels in the organic sediments are thought to be responsible for the relatively poor mud benthic invertebrate community. Invertebrate communities of the sand and peat habitat zones have always differed substantially from those of the mud zone, and from each other, in taxonomic composition. Sand and peat habitat zone communities consistently exhibited substantially greater species richness, diversity, and numeric density than the mud-associated community.

Examination of the 2005-2008 data set shows that the benthic communities associated with the three habitat zones have remained structurally distinct, and also that the recent three year study segment was characterized by dynamic changes within each of the three communities (Tables 4 and 5). The communities associated with all three habitat zones are numerically dominated by taxa that are collecting or filtering detritivores as adults. Total taxa richness and per sample means of species richness and diversity were consistently lowest in the mud zone. Mean total organisms m^{-2} increased significantly (ANOVA; $p \leq 0.05$) in the mud zone with each successive study year and more than doubled over the course of the three year study period (Table 4). During the same period, mud zone community diversity and evenness of distribution declined annually. These dynamics were attributable to large, statistically significant (ANOVA, $p \leq 0.05$), increases in the densities of two segmented worm species, *L. hoffmeisteri* and *I. templetoni*, which together accounted for over 70 percent of all organisms collected from the mud zone each study year (Table 5). Increases in mud zone taxa numbers during the three year study period (Table 4) were attributable primarily to the return of segmented worm taxa (other than *L. hoffmeisteri* and *I. templetoni*) that were present in the mud zone during the 1987-1997 study period, but were absent during the 2005-2006 study year.

Both the sand and peat habitat zone invertebrate communities were characterized by large annual increases in mean total organisms m^{-2}, total taxa collected, mean taxa richness, and mean diversity during the 2005-2008 study period (Table 4). Most of these increases were statistically significant (ANOVA, $p \leq 0.05$). The increases in total organisms m^{-2} can be attributed to rapid growth in the populations of benthic taxa whose numbers may have been negatively impacted by

TABLE 4. Descriptors of benthic invertebrate community quality in the three major habitat zones sampled in the Lake Okeechobee pelagic region, 2005 - 2008. Means with the same letter superscript are not significantly different (n=36; ANOVA, $p \leq 0.05$; total organisms m^{-2} transformed by LOG(X+1)).

Descriptor	Study Year 2005-2006	2006-2007	2007-2008
Mud Habitat Zone			
Total Taxa	15	23	22
Mean Taxa Richness	3.3^{a}	4.3^{b}	4.2^{b}
Mean Diversity	1.52^{a}	1.36^{a}	1.24^{a}
Mean Evenness	0.71^{a}	0.66^{ab}	0.61^{b}
Mean Total Organisms m^{-2}	$1{,}522^{a}$	$2{,}741^{b}$	$4{,}151^{c}$
Sand Habitat Zone			
Total Taxa	35	43	61
Mean Taxa Richness	7.4^{a}	8.5^{a}	12.5^{b}
Mean Diversity	1.79^{a}	1.97^{a}	2.38^{b}
Mean Evenness	0.65^{a}	0.66^{a}	0.67^{a}
Mean Total Organisms m^{-2}	$5{,}841^{a}$	$6{,}081^{a}$	$10{,}058^{b}$
Peat Habitat Zone			
Total Taxa	34	54	64
Mean Taxa Richness	6.3^{a}	14.0^{b}	18.8^{c}
Mean Diversity	1.67^{a}	2.32^{b}	2.94^{c}
Mean Evenness	0.71^{a}	0.66^{a}	0.71^{a}
Mean Total Organisms m^{-2}	$2{,}652^{a}$	$13{,}952^{b}$	$23{,}825^{c}$

TABLE 5. Dynamics in the abundance (no. m^{-2}) and percent composition of numerically dominant (>5% of total organisms) individual taxa in the three benthic habitat zones in the Lake Okeechobee pelagic region, 2005-2008. Means with the same letter superscript are not significantly different (n=36; ANOVA, $p \le 0.05$; organism densities m^{-2} transformed by LOG(X+1)).

Descriptor	Study Year 2005-2006 no. m^{-2} (%)	2006-2007 no. m^{-2} (%)	2007-2008 no. m^{-2} (%)
Mud Habitat Zone			
Limnodrilus hoffmeisteri	895[a] (58.8)	1,356[a] (49.5)	2,710[b] (65.3)
Ilyodrilus templetoni	215[a] (14.1)	606[b] (22.1)	847[b] (20.4)
Stephensoniana trivandrana	58[a] (3.8)	457[a] (16.7)	307[a] (7.4)
Coelotanypus sp.	95[a] (6.2)	74[a] (2.7)	96[a] (2.3)
Gammarus nr. *tigrinus*	7[a] (0.5)	100[b] (3.6)	22[a] (0.5)
Sand Habitat Zone			
Limnodrilus hoffmeisteri	1,928[a] (33.0)	1,664[a] (27.4)	2,941[a] (29.2)
Corbicula fluminea	577[a] (9.9)	1,631[b] (26.8)	1,532[b] (15.2)
Haber speciosus	1,740[a] (29.8)	311[a] (5.1)	144[a] (1.4)
Djalmabatista pulchra	1[a] (<0.1)	0[a] (0.0)	1,322[b] (13.1)
Stephensoniana trivandrana	257[a] (4.4)	274[b] (4.5)	578[b] (5.7)
Cladotanytarsus sp.	4[a] (<0.1)	432[b] (7.1)	653[c] (6.5)
Gammarus nr. *tigrinus*	212[a] (3.6)	717[b] (11.8)	101[a] (1.0)
Peat Habitat Zone			
Corbicula fluminea	364[a] (13.7)	4,318[b] (30.9)	212[a] (0.8)
Cladotanytarsus sp.	0[a] (0.0)	20[b] (0.1)	4,701[c] (19.7)
Hydracarina	303[a] (11.4)	3,283[b] (23.5)	1,003[c] (4.2)
Pseudochironomus sp.	0[a] (0.0)	0[a] (0.0)	3,955[b] (16.6)
Nais variabilis	0[a] (0.0)	890[b] (6.4)	2,929[b] (12.3)
Gammarus nr. *tigrinus*	207[a] (7.8)	1,157[b] (8.3)	1,462[a] (6.1)

conditions associated with the 2004-2005 hurricanes (scouring, turnover of bottom sediments, high turbidity preventing light penetration), but then responded positively to the drought conditions that characterized the post-hurricane period. These drought conditions included low water levels, low turbidity, improved light penetration regimes, low total phosphorus, greatly reduced allochthanous organic loading, and transport of sediments from the central mud zone. The responsive invertebrate taxa included prolific, multi-voltine, midges such as *Cladotanytarsus* sp., *Pseudochironomus* sp., and *Djalmabatista pulchra*, as well as the segmented worms *L. hoffmeisteri* and *Nais variabilis*, the Asian clam *C. fluminea*, and water mites (Hydracarina; Table 5). Annual increases in total taxa collected, mean number of taxa, and mean diversity in the sand and peat- associated communities are attributable to the return of taxa that were present during the 1987-1997 study period, but were absent in the study year following the hurricanes of 2004-2005 (Table 5, Appendix 1). Added habitat complexity provided by expansive growths of the macro-alga *Chara* during the 2007-2008 drought period may also have been at least partially responsible for increases in density and taxa richness in the peat-associated community.

2005-2008 Community Dynamics in the Context of the 1987-1997 Study Period

Data from the present study were combined with the FWC 1987-1997 data set to facilitate analyses and comparisons that would enable a broader perspective on the current status of pelagic zone benthic communities. This perspective is hampered somewhat by the eight year data gap between 1997 and 2005. Interpretation of results of comparisons between the 1987-1997 and 2005-2008 sample periods must be made with caution because the pre-hurricane, pre- and post-drought, status of pelagic zone benthic communities is unknown.

One convenient method for conducting simple comparisons is the use of box-whisker plots, which provide a graphic display not only of the central tendencies of the data, but also of variability within individual sample years. Key community descriptor and taxa variables were plotted by habitat zone to illustrate trends and variation over the entire range of FWC benthic invertebrate collections from the Lake Okeechobee pelagic region (Figures 3 through 8). Plots of mean taxa richness (Figure 3) illustrate a pattern evident in most plots: in all habitat zones mean taxa richness during August 2005 and February 2006 was lower than in any sampling event during the 1987-1997 study period (Figure 3). Richness values then increased during most of the successive collections (Figure 3). This trend is most profound in the mud habitat zone and is especially evident in the mean species richness and mean total organism plots (Figures 3 and 5). A tendency toward increasing diversity (as per Shannon's equation) throughout the 2005-2008 sample period is evident in Figure 4; however, the interquartile ranges of the 2005-2008 study period overlap substantially with the corresponding ranges of the 1987-1997 study period (especially in the sand and peat habitat zones), indicating similar distributions in the ranges of diversity values of the two study periods.

Box-whisker plots of mean densities of total Oligochaeta and total Chironomidae illustrate the tendency toward decreased densities of many taxa during the 2005-2008 study period (Figures 6 and 7). Although oligochaetes numerically dominated the lake's pelagic region benthic communities in all sample periods, their 2005-2008 densities were relatively depressed in all habitat zones compared to the 1987-1997 study period (Figure 6). Slight increases in total oligochaete densities were noted during the final study year in the both the mud and peat habitat zones (Figure 6).

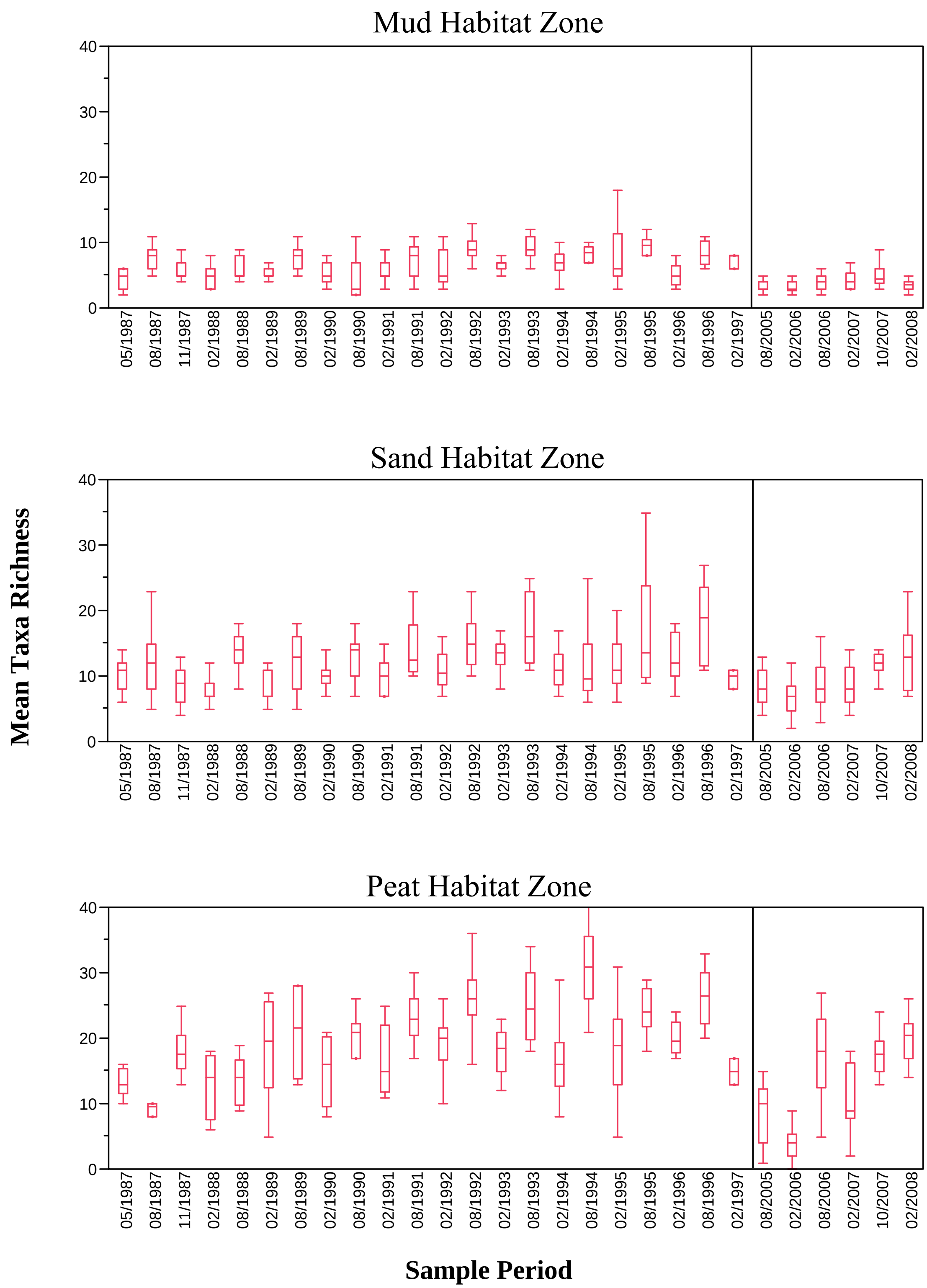

FIGURE 3. Box-whisker plots of aquatic invertebrate taxa richness in the three major benthic habitat zones of the Lake Okeechobee pelagic region, 1987-2008. The vertical black line denotes data gap from 1997-2005.

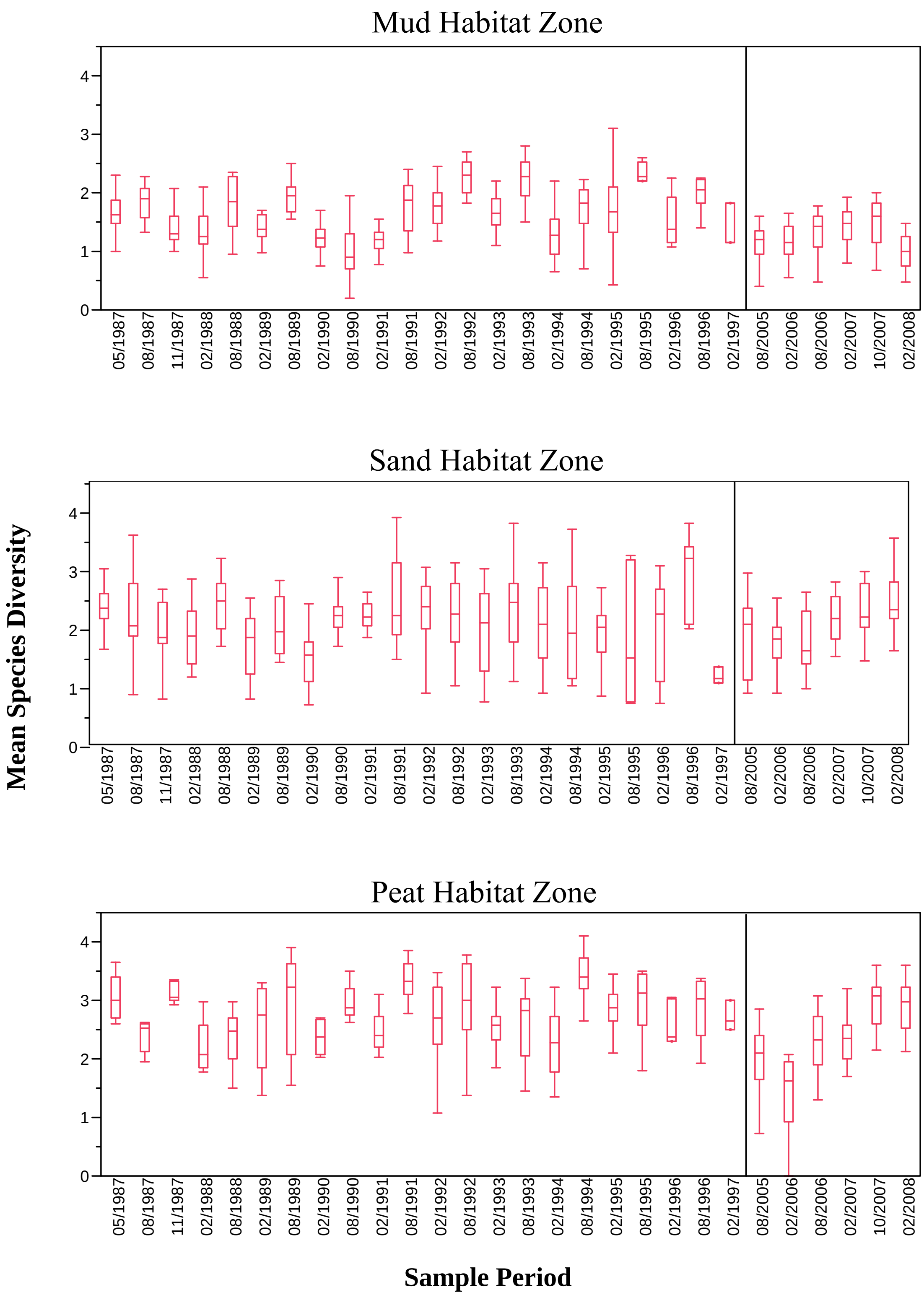

FIGURE 4. Box-whisker plots of aquatic invertebrate taxa diversity (Shannon's equation) in the three major benthic habitat zones of the Lake Okeechobee pelagic region, 1987-2008. The vertical black line denotes data gap from 1997-2005.

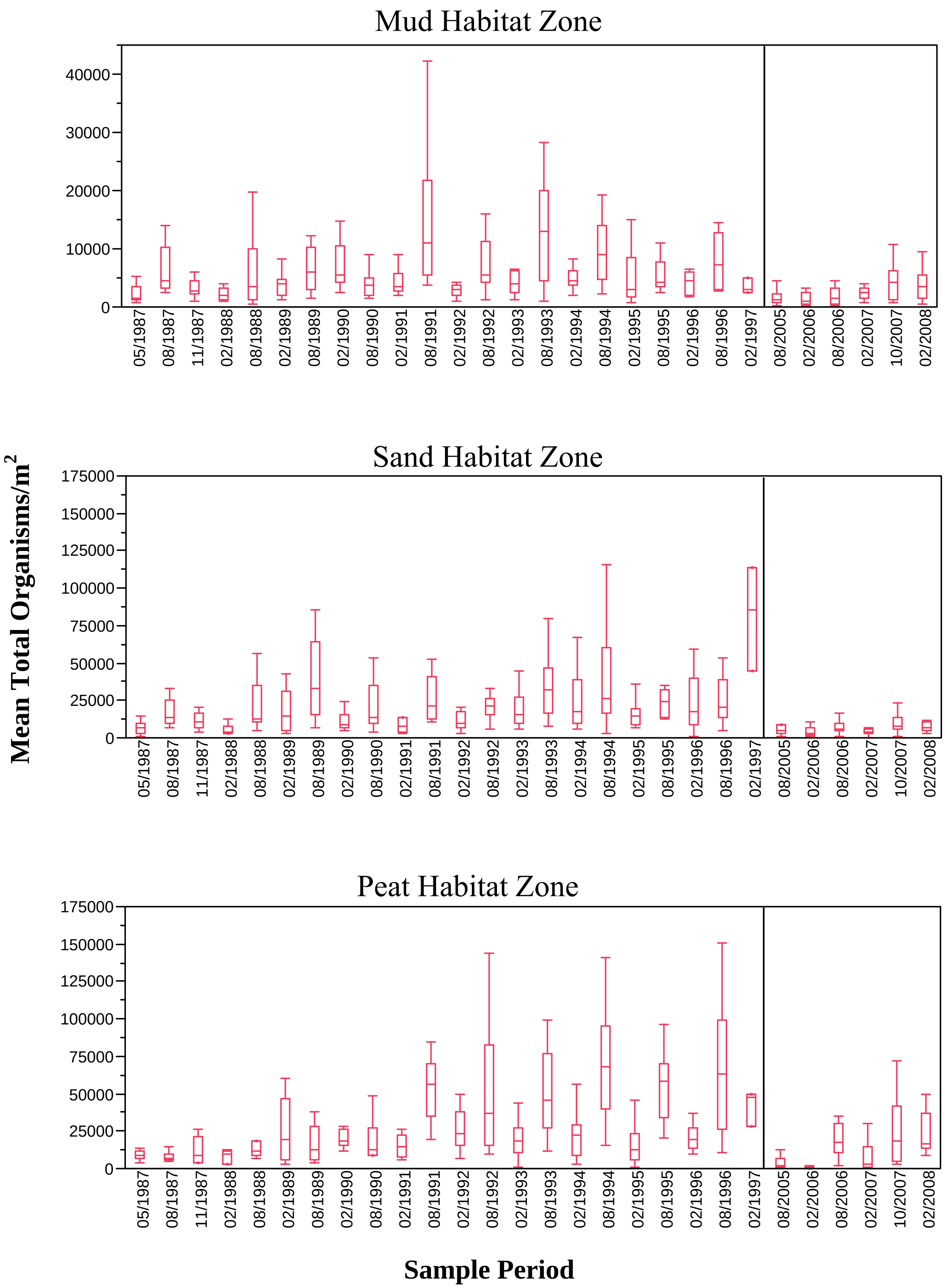

FIGURE 5. Box-whisker plots of aquatic invertebrate total organisms m^{-2} in the three major benthic habitat zones of the Lake Okeechobee pelagic region, 1987-2008. The vertical black line denotes data gap from 1997-2005.

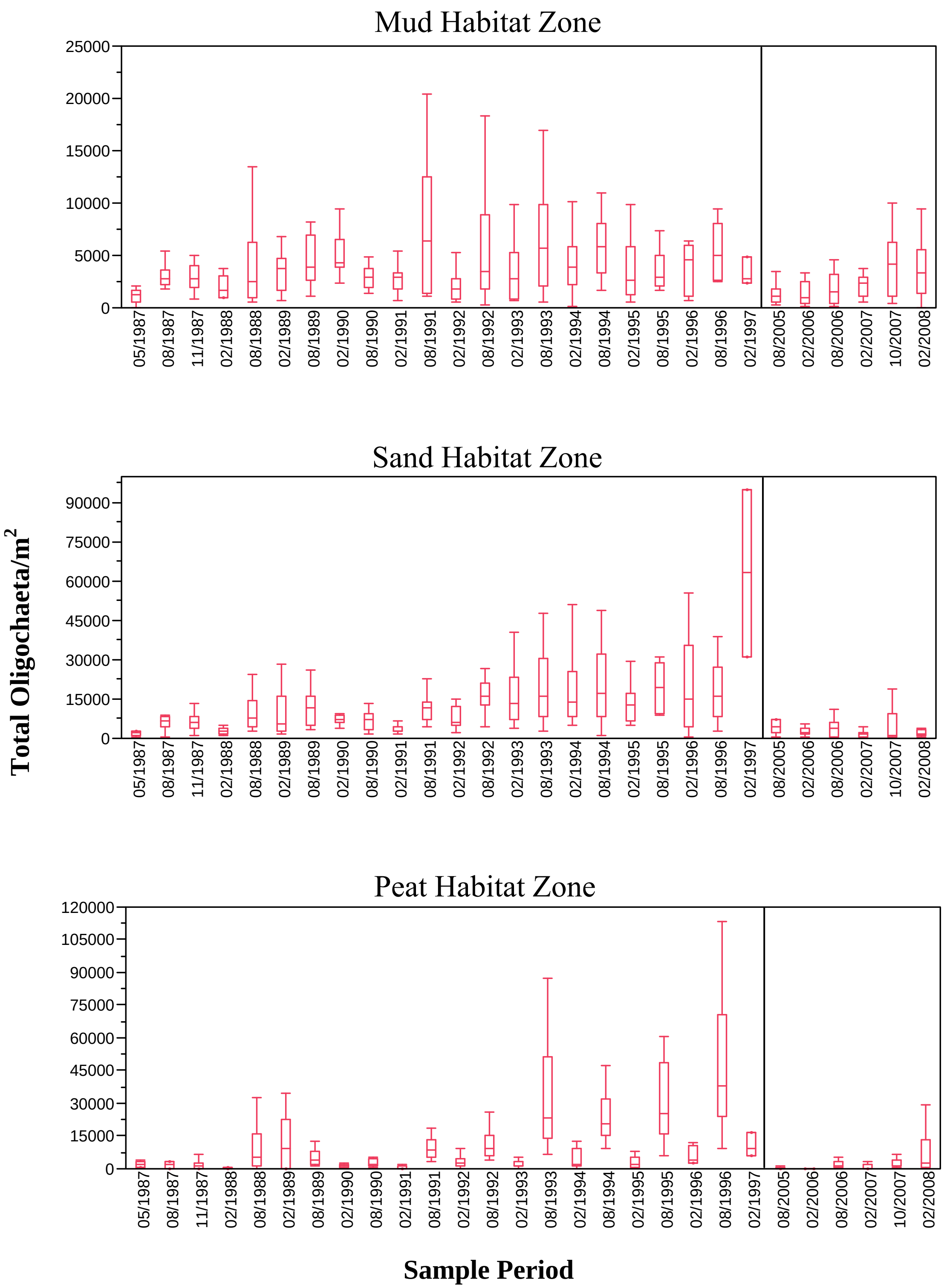

FIGURE 6. Box-whisker plots of total Oligochaeta m^{-2} in the three major benthic habitat zones of the Lake Okeechobee pelagic region, 1987-2008. The vertical black line denotes data gap from 1997-2005.

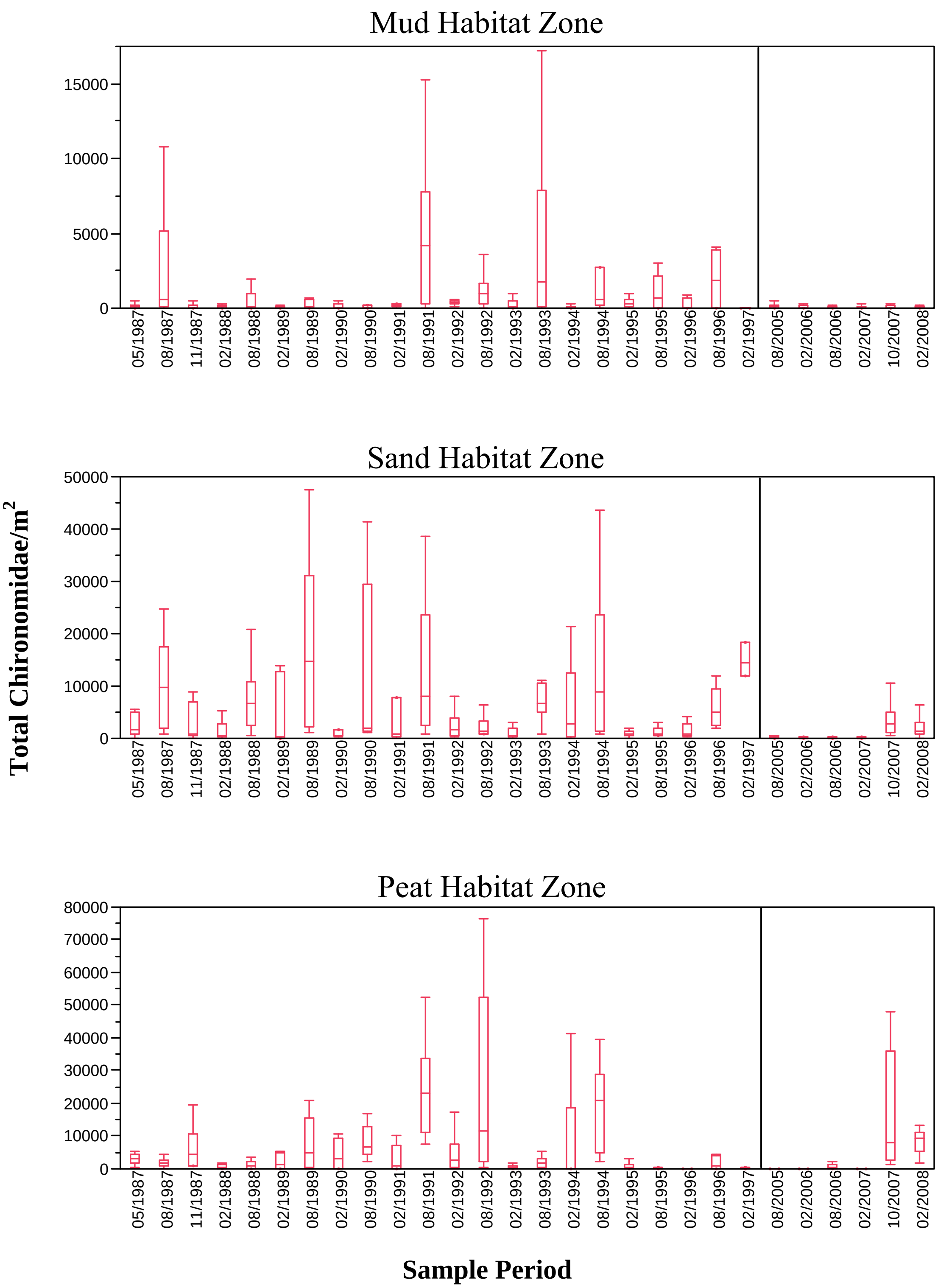

FIGURE 7. Box-whisker plots of total Chironomidae m^{-2} in the three major benthic habitat zones of the Lake Okeechobee pelagic region, 1987-2008. The vertical black line denotes data gap from 1997-2005.

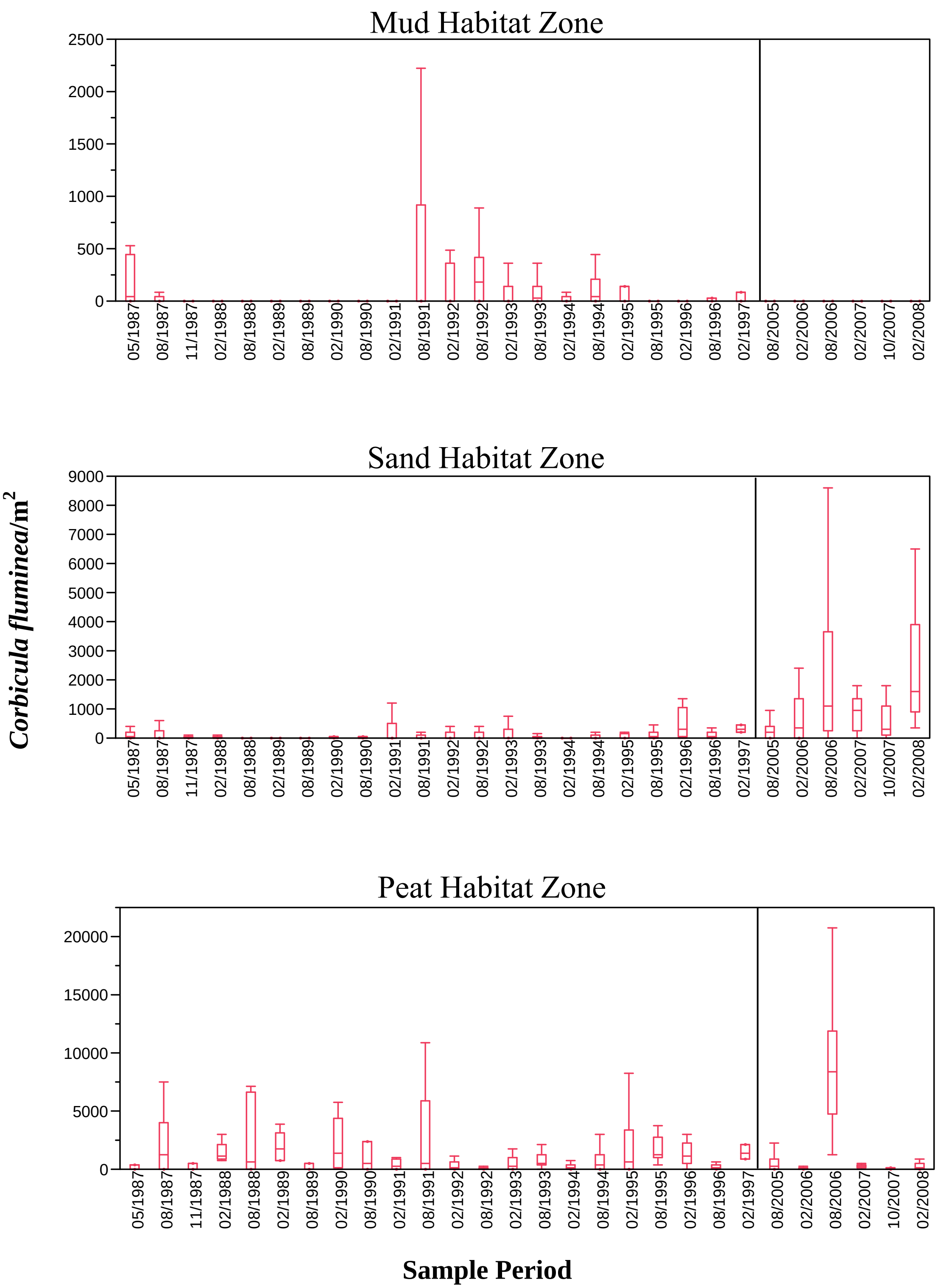

FIGURE 8. Box-whisker plots of mean number of *Corbicula fluminea* m^{-2} in the three major benthic habitat zones of the Lake Okeechobee pelagic region, 1987-2008. The vertical black line denotes data gap from 1997-2005.

Densities of total Chironomidae varied greatly throughout both study periods, but were reduced to near zero in all habitat zones in the post hurricane period (Figure 7). Chironomidae then increased substantially in the sand and peat habitat zones during the final study year (especially *Cladotanytarsus* sp., *Djalmabatista pulchra*, and *Pseudochironomus* sp., Table 5), probably in response to post-hurricane re-colonization, low water conditions, and the presence of *Chara*.

Figure eight provides a similar example of positive response to low water levels associated with the drought of 2006-2008. *Corbicula fluminea* densities exhibited substantial variation in all habitat zones during the 1987-1997 study period, but increased substantially at the shallow sand sites (S1, S2, S3, S4) during 2005-2008.

Nonmetric multiple dimensional scaling (NMS; Ludwig and Reynolds 1988, Jongman et al. 1995, McCune et al. 2002), was used to visualize sample site, sample year, and taxa relationships in the complete 1987-2008 data set. NMS is an iterative optimization ordination method that seeks the strongest structure in large data sets and can be used with data that is not normally distributed. The method places sample sites and time periods with similar community structures (taxonomic compositions and abundances) near each other in two-dimensional graph space and locates dissimilar sites/time periods relatively far from each other. When species are ordinated using NMS, those taxa that occur together often and in similar densities are placed near each other and taxa with dissimilar areal distributions and abundances are located relatively far from each other. The advantages of NMS are that is does not assume linear relationships between variables and it allows the use of any distance measure or relativization method (McCune et al. 2002).

To implement the analysis, density data from the complete 1987-2008 data set were converted to percents and arcsine transformed. The data were then sorted by habitat zone (mud, sand, or peat), season (August, October-wet, November-wet, February-dry, and May-dry), and sample year. Mean values were calculated for each habitat zone by season and year (i.e., 15 mud samples collected in the spring of 1987). The relativized data was analyzed for species assemblage differences using NMS set for the Sorenson (Bray-Curtis) distance measure in PC-ORD version 5 (McCune and Medford 1999). The ordination analysis plotted axis scores for each site and species. Axis scores for sites were compared to corresponding environmental data (i.e., water depth, conductivity, dissolved oxygen, and temperature) for possible correlations. Extreme dominance (71% of total abundance) of 1997 dry season (February) sand habitat zone sites by the segmented worm *Haber speciosus* worm produced an outlier that was removed from the analysis matrix for clarification purposes.

The resulting ordination revealed the presence of distinct species assemblages in each of the mud, sand, and peat habitat zones (Figure 9). Variation in species composition over time and season was least in the mud habitat zone and greatest in the peat habitat zone. There were small differences in the wet season species assemblages compared to dry season assemblages within the mud and sand habitat zones, whereas in the peat habitat zone a greater seasonal difference in the taxonomic composition of the assemblage was observed.

To facilitate visualization of temporal patterns, annual date labels were placed on the ordination (Figure 10). Annual changes in species composition were least apparent in the mud habitat and greatest in the peat habitat; however, no distinct pattern separating 1987-1997 sample dates from 2005-2008 sample dates was apparent (Figure 10).

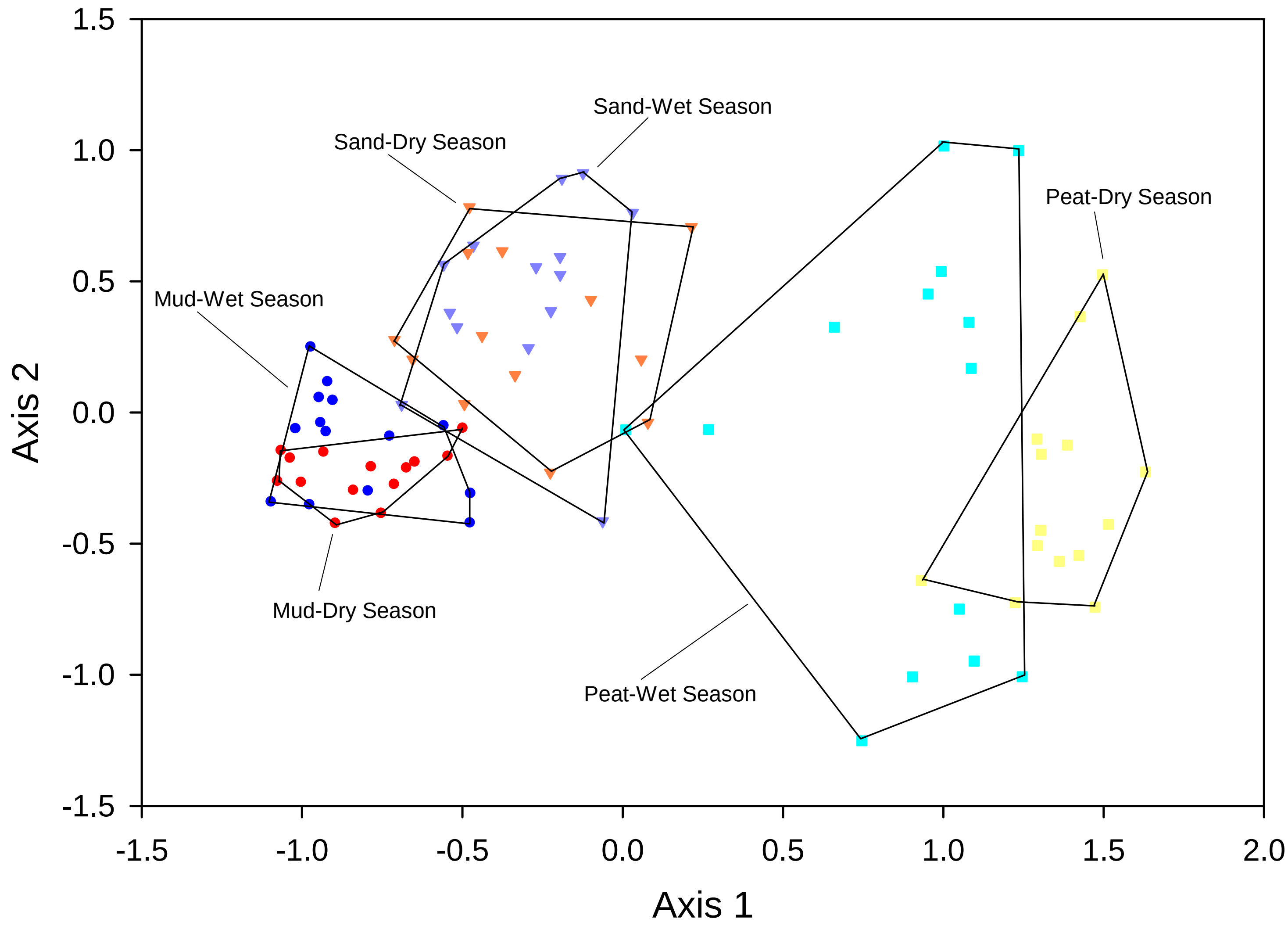

FIGURE 9. Non-metric multidimensional scaling of Lake Okeechobee pelagic region relativized invertebrate species densities averaged by habitat (mud, sand, or peat), season (wet or dry), and year, 1987-2008.

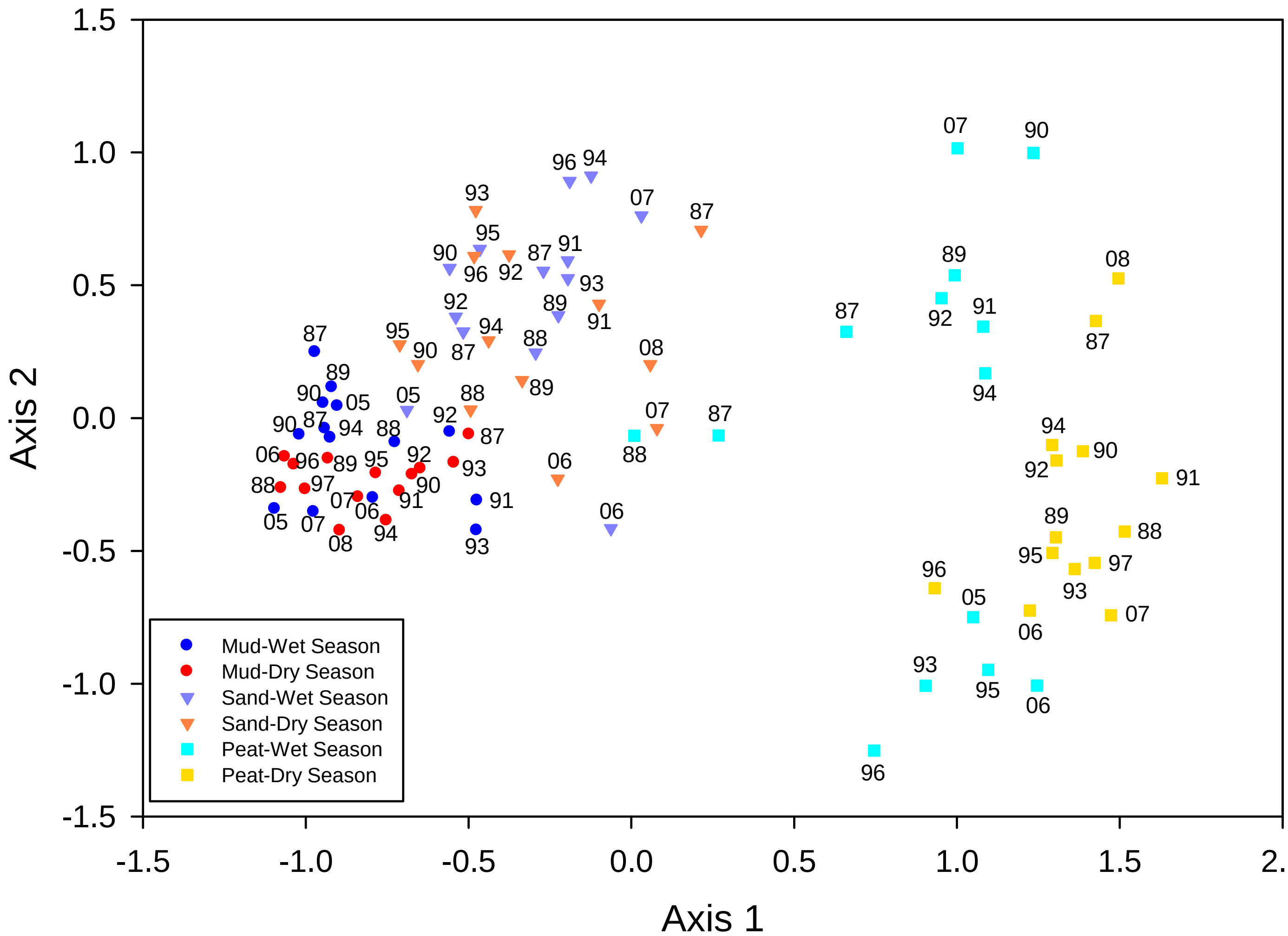

FIGURE 10. Non-metric multidimensional scaling of Lake Okeechobee pelagic region relativized invertebrate species densities averaged by habitat (mud, sand, or peat), season (wet or dry), and year, 1987-2008. Labels designate sample year.

Pearson correlations between depth at site/lake stage and axis scores revealed weak but significant (p=0.05) correlations. A significant negative correlation was observed between axis 1 scores and depth at site for all sites (Figure 11). A significant negative correlation was observed between axis 1 scores for sand and mean lake stage (Figure 12). A significant negative correlation was observed between axis 2 scores for peat and mean lake stage (Figure 13). No other significant correlations were observed between axis scores and any other environmental parameter data.

Individual taxa were ordinated using NMS to elucidate taxa-habitat associations (Figure 14, Appendix 2). Fifteen taxa were determined to be associated with the mud habitat, 6 taxa with mud/sand, 46 with sand, 13 with sand/peat, and 90 with peat (Figure 14, Appendix 2).

Discussion

The structure of Lake Okeechobee pelagic region benthic invertebrate communities exhibited rapid and considerable change during the 2005-2008 study period. Community dynamics during this time were most probably driven by habitat conditions that were products of the hurricanes of 2004 and 2005 and the extended drought that followed. Wave action during the storms scoured and displaced bottom sediments, and undoubtedly severely impacted embenthic and epibenthic species in all habitat zones. The extended period of high turbidity following the storms limited primary and secondary production in sublittoral habitats where light typically penetrates to the bottom and indirectly structures invertebrate communities. Since no data were collected during the seven-year period preceding the storms, the exact condition of invertebrate communities prior to the summer of 2004 is unknown. However, data collected immediately following the storms showed that taxa richness, diversity, and densities of many important taxa, including even

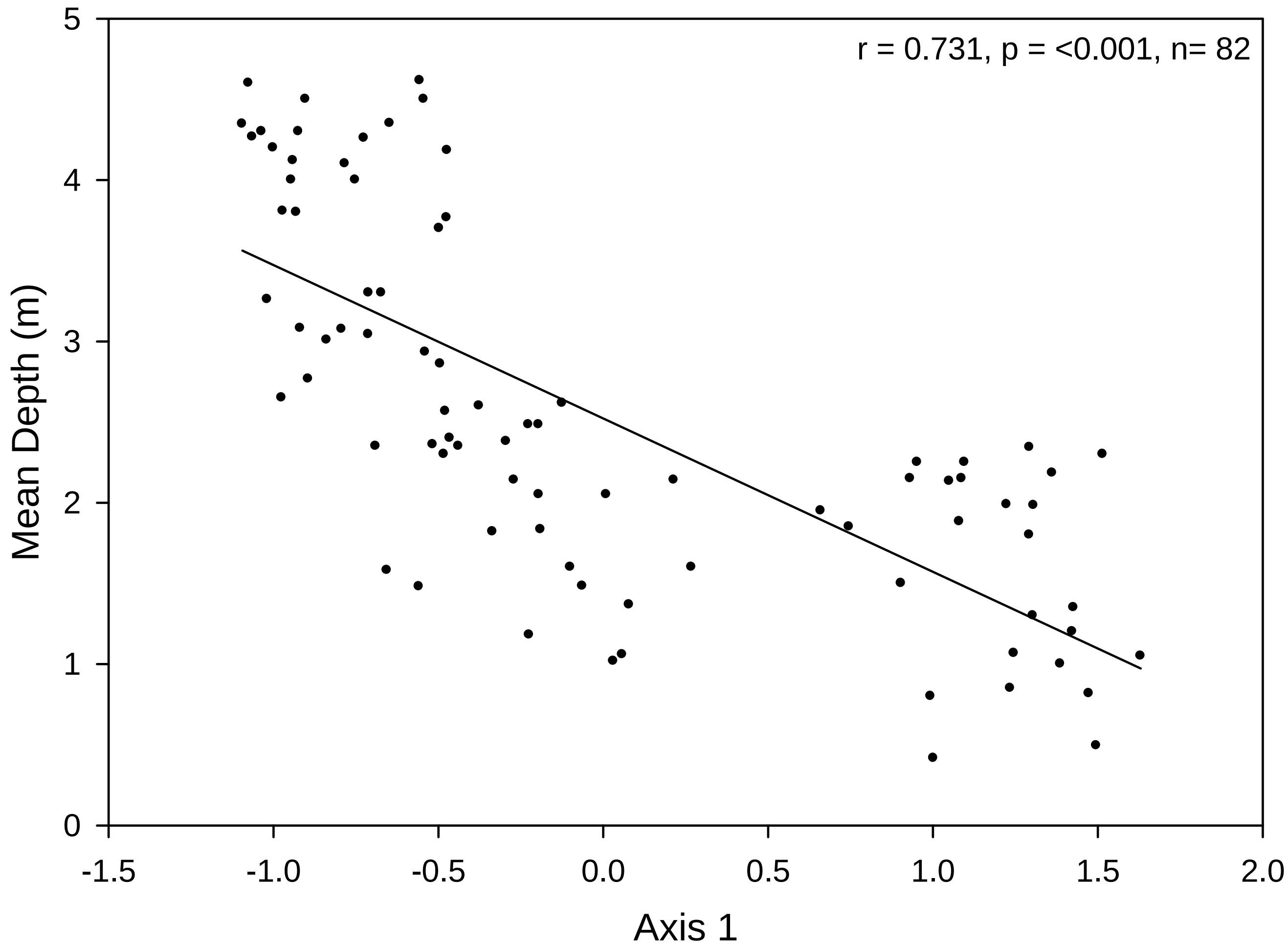

FIGURE 11. Linear correlation between axis 1 scores from nonmetric multidimensional scaling of Lake Okeechobee pelagic region relativized invertebrate densities (1987 to 2008) and mean depth (meters) at site

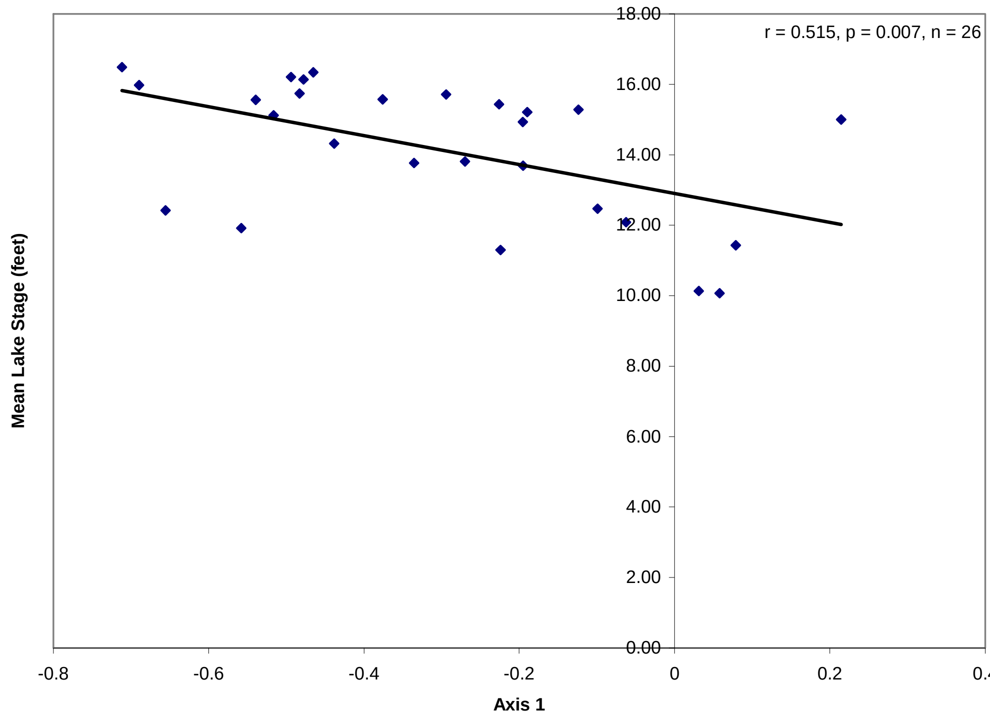

FIGURE 12. Linear correlation between axis 1 scores from nonmetric multidimensional scaling of relativized Lake Okeechobee pelagic region sand habitat invertebrate densities (1987 to 2008) and mean lake stage (feet).

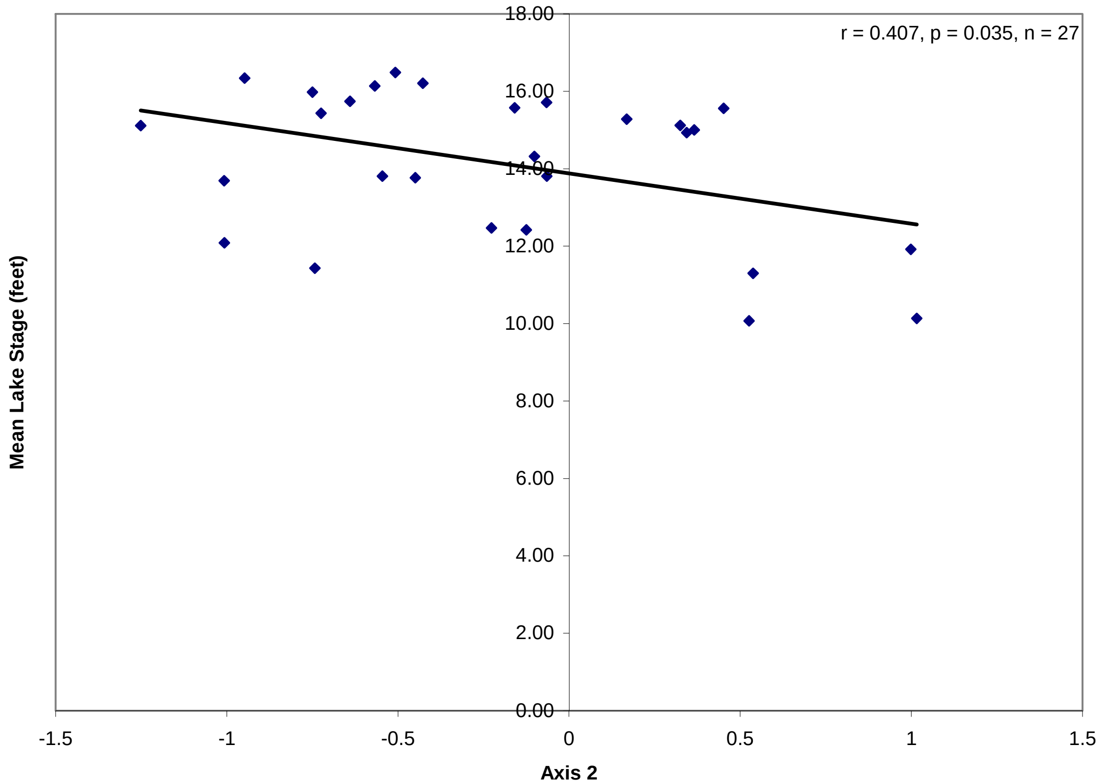

FIGURE 13. Linear correlation between axis 2 scores from non-metric multidimensional scaling of relativized Lake Okeechobee pelagic region peat habitat invertebrate densities (1987 to 2008) and mean lake stage (feet).

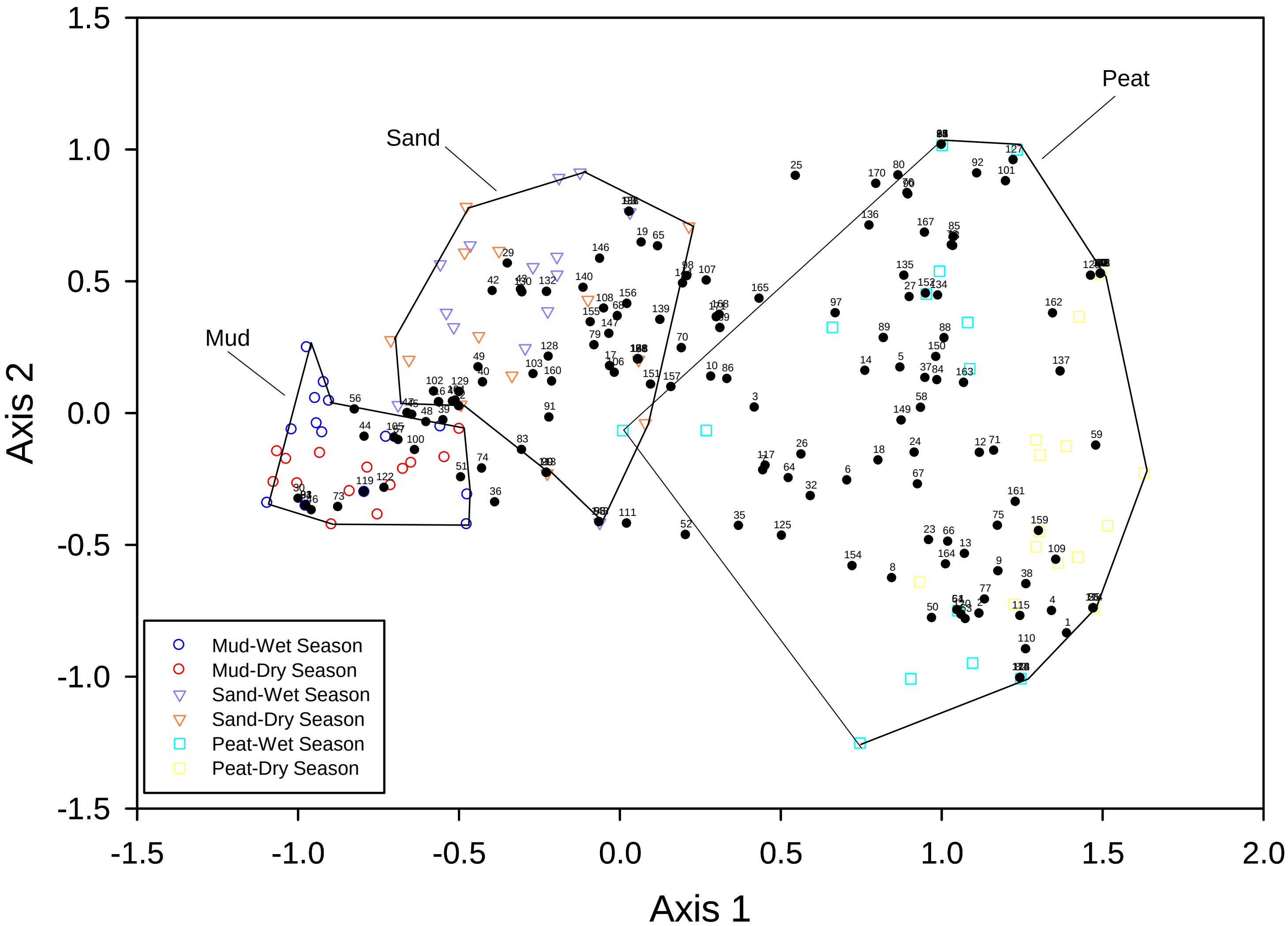

FIGURE 14. Non-metric multidimensional scaling of relativized Lake Okeechobee pelagic region invertebrate species densities averaged by habitat (mud, sand, or peat), season (wet or dry), and year, 1987-2008. Black circles designate species scores with numeric labels corresponding to species listed in Appendix 2.

the pollution-tolerant segmented worm species that dominated the mud habitat zone, were at the lowest levels measured since the initiation of FWC benthic studies in 1987 (Tables 2-5, Figures 3-8). We believe that these low levels were artifacts of the storms of 2004 and 2005. An additional consequence of the storms was loss of key species. An example is the tubicolous non-biting midge *Chironomus crassicaudatus*. *C. crassicaudatus* was the third most abundant taxon present in the mud zone during the 1987 – 1997 study period (mean = 702 m^{-2}; 11.0%), but was nearly completely absent from all collections during the 2005 – 2008 study period (Appendix 1). Studies of the food habits of black crappie (*Pomoxis nigromaculatus)* in Lake Okeechobee during the early 1990s found *C. crassicaudatus* to be the principal diet component during summer months. Permanent elimination of *C. crassicaudatus* from the food web could have consequences to an economically important fish species. Other species with similar ecological value were not collected, or were present in very reduced densities, during 2005-2008. These included the amphipods *Gammarus* nr. *tigrinus* and *Corophium louisianum*, the isopods *Cyathura polita* and *Cassinididea ovalis*, and the snail *Viviparus georgianus*.

The second half of the 2005-2008 study period was characterized by an extensive drought that resulted in lake levels dropping to an historic low monthly mean (8.8 MSL, July 2007), greatly reduced turbidity, and expansion of the macro-alga *Chara* in shallow areas. The precipitous density increases exhibited by a number of pioneer taxa at shallower sites in the sand and peat habitat zones were responses to these conditions. As illustrated in Figures 11 through 13, densities of many dominant taxa and depth were negatively correlated. The chironomids *Cladotanytarsus* sp. and *Pseudochironomus* sp. and the naided worm *Nais variabilis* are examples of rapidly reproducing multivoltine taxa that were able to capitalize on the low water levels. Populations of these taxa were very low during the study year following the hurricanes, but exploded shortly thereafter (Table 5), illustrating that, despite problems related to eutrophication, invertebrate communities of Lake Okeechobee retain their viability.

However, despite the upturn of population numbers of some taxa in the sand and peat habitat zones during the final study year, overall benthic community quality in the pelagic zone remained below that of the 1987-1997 study period. The mud habitat remains a homogeneous, harsh, habitat for invertebrate species survival as demonstrated by low species richness (Tables 4 and 6, Appendix 1), low annual and seasonal variation in taxonomic composition as demonstrated by nonmetric multidimensional scaling (Figure 14, Appendix 2), and the prevalence of tolerant species (Appendix 1). The tubificid worms *Limnodrilus hoffmeisteri* and *Ilyodrilus templetoni* have consistently dominated the mud zone community, however, their densities, as well as the densities of most other dominant taxa of the mud zone, appear to have declined an order of magnitude from the 1987-96 study period to the 2005-08 study period. As previously noted, species associated with the mud habitat zone are generally detritivores that have an affinity for very fine organic substrates and are tolerant of low levels of dissolved oxygen.

Compared to the mud zone, the sand zone appears to be more a heterogeneous habitat for invertebrate survival as demonstrated by higher annual and seasonal variation in assemblage composition and the higher species richness (Figure 14, Tables 4 and 6). The majority of the species associated with the sand habitat have an affinity for fine substrates and are tolerant of low dissolved oxygen, thus the sand is still a difficult environment for species survival. The species assemblages inhabiting the sand habitat during the 2005-2008 study period were more similar to the peat habitat assemblages compared to previous study years. This response probably reflects that the fact that some sand sites (S1, S5) were characterized by accumulations of organic material in the post-hurricane period.

The coarse bottom of the peat zone provides the most heterogeneous habitat for invertebrate species habitation as demonstrated by the higher annual and seasonal variation in assemblage composition and the highest values for total and mean taxa richness (Figure 14, Tables 4 and 6). The peat zone is typically inhabited by the most densely populated, species rich, and diverse benthic community of the entire pelagic region. It is apparent, however, that despite the increases in some populations during the 2007-2008 study year, species richness, total organisms, and densities of the individual dominant species within this zone have declined from the 1987–1996 study period. The majority of the species currently associated with the peat habitat are detritivores that have an affinity for fine substrates, and many are tolerant of low levels of dissolved oxygen. The higher annual and seasonal variation in assemblage composition (relative to the mud and sand zone communities) reflects the heterogeneity in habitat conditions.

Overall, results from the 2005-2008 study period show that benthic invertebrate communities of the Lake Okeechobee pelagic region have clearly declined in quality relative to the 1987-1997 study period. The poor community quality that characterized the 2005-2006 study year was an artifact of the hurricanes of 2004 and 2005. Taxonomic composition, species richness, diversity, and organism densities documented during the 2007-2008 study year suggest that some community components are recovering and, at least in the sand and peat zones, are progressing through successional changes indicative of response to disturbance. If this is the case, the 2005-2008 study period may not be ideal for use as a baseline. The continued absence or low densities of key species such as *Viviparus georgianus*, *Corophium louisianum*, *Cyathura polita*, and

Chironomus crassicaudatus are cause for concern for the complete recovery of the lake's invertebrate fauna, even with the implementation of CERP management actions.

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APPENDIX 1

Mean densities (no. m^{-2}), coefficients of variation (c.v.)*, and percent compositions (%) of aquatic invertebrates collected from the three sublittoral habitat zones (mud, sand, peat) of Lake Okeechobee during the summer and winter sampling events of study years 2005 - 2006, 2006 - 2007, and 2007 - 2008.

APPENDIX 1A. Mean densities (no. m^{-2}), coefficients of variation (c.v.)*, and percent compositions (%) of aquatic invertebrates collected from the Lake Okeechobee mud habitat zone during the August sampling events of 2005, 2006, and 2007.

	Study Year		
	2005	2006	2007
Taxon	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %
Platyhelminthes			
Turbellaria			
Dugesia sp.	2 (4.24) 0.2	---	---
Nematoda	---	2 (2.24) 0.1	---
Annelida			
Oligochaeta (total)	1,452 (0.81) 91.7	2,084 (0.93) 94.7	4,159 (0.73) 94.0
Naididae (total)	49 (1.34) 3.1	548 (1.65) 24.9	659 (1.12) 14.9
Pristinella jenkinae	15 (2.30) 0.9	---	79 (4.24) 1.8
Pristinella osborni	2 (4.24) 0.2	---	---
Pristinella sima	---	---	2 (4.24) <0.1
Stephensoniana trivandrana	20 (2.59) 1.2	548 (1.65) 24.9	578 (1.21) 13.1
unknown Naididae	12 (3.45) 0.8	---	---
Tubificidae (total)	1,402 (0.81) 88.6	1,494 (0.78) 67.9	3,484 (0.72) 78.7
Ilyodrilus templetoni	25 (2.33) 1.6	368 (1.71) 16.7	852 (0.98) 19.3
Limnodrilus hoffmeisteri	1,119 (0.85) 70.7	1,025 (1.37) 46.6	2,592 (0.73) 58.6

APPENDIX 1A (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %
UIWCS	200 (1.16) 12.6	101 (2.22) 4.5	---
immature Oligochatea			15 (2.52) 0.3
Pelecypoda			
Corbiculidae			
Corbicula fluminea	---	4 (2.91) 0.1	81 (2.56) 1.8
Arthropoda			
Amphipoda (total)	15 (1.78) 0.9	44 (0.77) 2.0	20 (1.76) 0.5
Gammaridae			
Gammarus nr. *tigrinus*	15 (1.78) 0.9	44 (0.77) 2.0	17 (1.99) 0.4
Hyalella azteca	---	---	2 (4.24) <0.1
Mysidacea (total)	2 (4.24) 0.2	7 (2.30) 0.3	20 (1.15) 0.4
Mysidae			
Taphromysis bowmani	2 (4.24) 0.2	4 (2.91) 0.1	10 (1.93) 0.2
Hemiptera			
Belostomatidae			
Belostoma flumineum	---	---	2 (4.24) <0.1
Coleoptera			
Elmidae			
Microcylloepus pusillus	---	---	2 (4.24) <0.1

APPENDIX 1A (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Diptera			
Chaoboridae			
Chaoborus punctipennis	5 (4.24) 0.3	4 (2.91) 0.1	2 (4.24) <0.1
Chironomidae (total)	109 (1.23) 6.9	51 (1.07) 2.3	138 (1.53) 3.1
Coelotanypus sp.	54 (1.58) 3.4	14 (2.52) 0.6	111 (1.63) 2.5
Colelotanypus tricolor	41 (1.64) 2.6	29 (1.36) 1.3	22 (1.71) 0.5
Coelotanypus scapularis	---	2 (4.24) <0.1	---
Djalmabatista pulchra	---	---	2 (4.24) <0.1
Tanypodinae e.i.	7 (3.09) 0.5	---	---
Chironomus sp.	2 (4.24) 0.2	---	---
Polypedilum halterale	2 (4.24) 0.2	---	---
Chironominae e.i.	---	---	2 (4.24) <0.1

APPENDIX 1A (continued).

Total Taxa	12	11	15
Mean Total Organisms	1,583 (0.75)	2,200 (0.87)	4,425 (0.71)
Mean Taxa Richness	3.44 (0.33)	4.11 (0.29)	4.83 (0.33)
Mean Diversity	1.14 (0.29)	1.30 (0.30)	1.49 (0.27)
Mean Evenness	0.67 (0.25)	0.67 (0.28)	0.66 (0.29)

*coefficient of variation expressed as proportion (not percent).
--- = taxon not present.
P = colonial taxon present in samples.
UIWCS = unidentified immature Oligochaeta with capilliform setae.
e.i. = early instar insect too immature to identify to species.

APPENDIX 1B. Mean densities (no. m^{-2}), coefficients of variation (c.v.)*, and percent compositions (%) of aquatic invertebrates collected from the Lake Okeechobee sand habitat zone during the August sampling events of 2005, 2006, and 2007.

	Study Year		
	2005	2006	2007
Taxon	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %
Cnidaria			
Hydrozoa			
Hydra sp.	5 (4.24) <0.1	---	22 (2.08) 0.2
Nemertea			
Hoplonemertea			
Prostoma sp.	---	2 (4.24) <0.1	2 (4.24) <0.1
Nematoda	42 (1.87) 0.6	15 (3.09) 0.1	30 (2.36) 0.3
Annelida			
Oligochaeta (total)	6,544 (1.08) 88.9	4,049 (0.83) 50.5	4,938 (1.40) 48.9
Enchytraeidae	---	2 (4.24) <0.1	---
Naididae (total)	514 (1.06) 7.0	481 (2.36) 6.0	1,254 (2.14) 12.4
Chaetogaster sp.	---	4 (4.24) <0.1	---
Dero digitata	47 (2.17) 0.6	---	---
Pristina aequiseta	---	7 (3.09) <0.1	17 (4.24) 0.2
Pristina leidyi	---	2 (4.24) <0.1	40 (4.24) 0.4
Pristina synclites	---	19 (2.47) 0.2	2 (4.24) <0.1

APPENDIX 1B (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Pristinella jenkinae	2 (4.24) 0.9	---	---
Pristinella osborni	---	4 (2.91) <0.1	---
Stephensoniana trivandrana	464 (1.03) 6.3	442 (2.56) 5.5	1,156 (2.33) 11.4
Tubificidae (total)	6,030 (1.18) 81.9	3,563 (0.88) 44.4	3,684 (1.36) 36.5
Aulodrilus pigueti	91 (3.51) 1.2	7 (4.24) <0.1	768 (2.57) 7.6
Branchiura sowerbyi	40 (2.25) 0.5	4 (2.91) <0.1	7 (2.30) 0.1
Haber speciosus	3,013 (2.33) 40.9	482 (2.18) 6.0	5 (2.91) <0.1
Ilyodrilus templetoni	202 (2.44) 2.7	25 (2.98) 0.3	304 (2.14) 3.0
Limnodrilus hoffmeisteri	2,309 (0.60) 31.4	2,376 (0.76) 29.7	2,590 (1.50) 25.7
UIWCS	375 (0.96) 5.1	669 (2.06) 8.3	10 (4.24) 0.1
Hirudinea (total)	---	5 (2.91) <0.1	---
Mollusca			
Gastropoda (total)	7 (4.24) 0.1	9 (2.47) <0.1	156 (1.93) 1.5

APPENDIX 1B (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %
Thiaridae			
Melanoides sp.	7 (4.24) 0.1	9 (2.47) <0.1	---
Melanoides tuberculatus	---	---	158 (1.89) 1.6
Pelecypoda			
Corbiculidae			
Corbicula fluminea	272 (1.33) 3.7	2,405 (1.23) 30.0	563 (1.04) 5.6
unidentifiable Unionidae	---	---	2 (4.24) <0.1
Arthropoda			
Amphipoda (total)	86 (1.30) 1.2	1,022 (1.04) 12.7	91 (1.29) 0.9
Corophiidae			
Corophium louisianum	---	52 (3.84) 0.6	---
Gammaridae			
Gammarus nr. *tigrinus*	86 (1.30) 1.2	970 (0.93) 12.1	91 (1.28) 0.9
Isopoda (total)	22 (1.57) 0.3	98 (1.60) 1.2	472 (0.76) 4.7
Anthuridae			
Cyathura polita	22 (1.57) 0.3	96 (1.65) 1.1	472 (0.76) 4.7
Sphaeromidae			
Cassidinidea ovalis	---	2 (4.24) <0.1	---
Mysidacea (total)	40 (1.72) 0.5	4 (2.91) <0.1	17 (1.56) 0.2
Mysidae			
Mysidopsis almyra	---	---	5 (2.91) <0.1

APPENDIX 1B (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Taphromysis bowmani	40 (1.72) 0.5	4 (2.91) <0.1	12 (1.66) <0.1
Aquatic Acari (total)	---	64 (3.28) 0.7	2 (4.24) <0.1
Hydracarina	---	64 (3.28) 0.7	2 (4.24) <0.1
Collembola	---	---	52 (3.32) <0.5
Ephemeroptera			
Caenidae			
Caenis diminuta	---	---	2 (4.24) <0.1
Zygoptera			
Coenagrionidae e.i.	---	---	5 (4.24) <0.1
Trichoptera (total)	2 (2.24) <0.1	10 (2.47) 0.1	12 (2.07) 0.1
Hydroptilidae			
Hydroptila sp.	---	2 (2.24) <0.1	---
Leptoceridae e.i.	2 (2.24) <0.1	7 (3.09) <0.1	---
Oecetis sp.	---	---	12 (2.07) 0.1
Coleoptera			
Noteridae			
Hydrocanthus sp.	---	---	2 (4.24) 0.1

APPENDIX 1B (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %
Diptera			
Ceratopogonidae (total)	---	2 (4.24) <0.1	22 (1.85) 0.2
Atrichopogon sp.	---	2 (4.24) <0.1	---
Bezzia or *Palpomyia*	---	---	2 (4.24) <0.1
Culicoides sp.	---	---	20 (2.07) 0.2
Chaoboridae			
Chaoborus punctipennis	116 (1.45) 1.6	14 (2.52) 0.1	20 (1.93) 0.2
Chironomidae (total)	222 (0.78) 3.0	212 (1.7) 2.6	3,667 (0.85) 36.3
Coelotanypus sp.	138 (1.73) 1.7	14 (2.3) 0.1	343 (2.01) 3.4
Coelotanypus scapularis	---	---	2 (4.24) <0.1
Colelotanypus tricolor	15 (2.06) 0.2	12 (2.98) <0.1	15 (2.52) 0.1
Djalmabatista pulchra	2 (4.24) <0.1	---	2,318 (1.17) 23.0
Procladius sp.	2 (4.24) <0.1	---	---
Tanypodinae e.i.	15 (2.52) 0.2	---	5 (4.24) <0.1

APPENDIX 1B (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Cricotopus or *Orthocladius*	---	2 (4.24) <0.1	---
Nanocladius sp.	---	2 (4.24) <0.1	---
Chironomus sp.	3 (4.24) <0.1	---	---
Chironomus crassicaudatus	2 (4.24) <0.1	---	---
Cryptochironomus sp.	5 (4.24) 0.1	41 (2.19) 0.5	54 (1.45) 0.5
Dicrotendipes sp.	---	---	14 (2.30) 0.1
Dicrotendipes tritomus or *modestus*	---	---	15 (3.09) 0.1
Goeldichironomus carus	---	2 (4.24) <0.1	---
Microchironomus sp.	---	---	2 (4.24) <0.1
Polypedilum sp.	---	5 (4.24) <0.2	5 (2.91) <0.1
Polypedilum scalaenum group	15 (2.30) 0.2	---	202 (1.34) 2.0
Chironominae e.i.	2 (4.24) <0.1	---	5 (2.91) <0.1
Tanytarsini (e.i.)	---	---	5 (4.24) <0.1

APPENDIX 1B (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Cladotanytarsus sp.	7 (3.09) 0.1	130 (1.94) 1.6	504 (0.94) 4.9
Tanytarsus sp.	12 (2.07) 0.2	---	123 (1.30) 0.9
Tanytarsus limneticus	---	---	10 (3.29) 0.1
Total Taxa	26	36	38
Mean Total Organisms	7,361 (1.01)	8.008 (0.72)	10,097 (0.64)
Mean Taxa Richness	8.06 (0.33)	8.50 (0.38)	12.5 (0.21)
Mean Diversity	1.87 (0.35)	1.79 (0.31)	2.29 (0.19)
Mean Evenness	0.63 (0.32)	0.60 (0.20)	0.63 (0.20)

*coefficient of variation expressed as proportion (not percent).
--- = taxon not present.
P = colonial taxon present in samples.
UIWCS = unidentified immature Oligochaeta with capilliform setae.
e.i. = early instar insect too immature to identify to species.

APPENDIX 1C. Mean densities (no. m^{-2}), coefficients of variation (c.v.)*, and percent compositions (%) of aquatic invertebrates collected from the Lake Okeechobee peat habitat zone during August 2005, 2006, and 2007.

	Study Year		
	2005	2006	2007
Taxon	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %
Porifera	---	P	---
Cnidaria			
Hydrozoa			
Cordylophora lacustris	P	P	---
Hydra sp.	---	118 (2.17) 0.5	30 (2.06) 0.1
Platyhelminthes			
Turbellaria			
Dugesia sp.	7 (2.30) 0.2	9 (3.29) <0.1	52 (1.45) 0.2
Nemertea			
Hoplonemertea			
Prostoma sp.	69 (1.67) 1.6	135 (1.22) 0.6	---
Nematoda	637 (1.66) 15.0	1,901 (1.22) 9.4	427 (1.0) 1.7
Annelida			
Polychaeta	---	32 (1.56) 0.2	---
Aphanoneura			
Aeolosomatidae	10 (4.24) 0.2	318 (1.56) 1.5	7 (4.24) <0.1
Oligochaeta (total)	753 (1.84) 17.7	1,914 (0.84) 9.5	3,862 (1.50) 15.8
Enchytraeidae	86 (2.56) 2.0	108 (1.89) 0.5	---
Naididae (total)	336 (3.30) 7.9	1,375 (1.01) 6.8	3,328 (1.80) 13.6

APPENDIX 1C (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %
Bratislavia unidentata	---	---	353 (3.06) 1.4
Chaetogaster sp.	---	145 (1.31) 0.7	59 (1.78) 0.2
Dero sp.	---	---	54 (2.27) 0.2
Dero pectinata	---	---	504 (1.61) 2.1
Nais behningi	---	---	2 (4.24) <0.1
Nais variabilis	---	---	2 (4.24) <0.1
Nais elinguis or *variabilis*	---	---	2 (4.24) <0.1
Nais communis complex	---	360 (1.28) 1.7	363 (2.97) 1.5
Pristina sp.	---	25 (1.97) 0.1	44 (3.76) 0.2
Pristina aequiseta	---	91 (3.66) 0.4	1,129 (2.06) 4.6
Pristina leidyi	5 (4.24) 0.1	259 (1.72) 1.2	578 (2.38) 2.4
Pristinella longisoma	---	---	10 (4.24) <0.1
Pristinella osborni	---	385 (1.51) 1.9	44 (2.17) 0.2

APPENDIX 1C (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Slavina appendiculata	---	---	2 (4.24) <0.1
Stephensoniana trivandrana	331 (3.29) 7.8	44 (2.57) 0.2	378 (1.03) 1.5
unknown Naididae	---	88 (1.37) 0.4	35 (3.62) 0.1
Tubificidae (total)	331 (1.17) 7.8	398 (1.67) 1.9	319 (1.37) 1.3
Aulodrilus pigueti	20 (2.88) 0.5	5 (4.24) <0.1	10 (4.24) <0.1
Haber speciosus	---	---	12 (4.24) 0.1
Ilyodrilus templetoni	---	5 (4.24) <0.1	2 (4.24) <0.1
Limnodrilus hoffmeisteri	183 (1.46) 4.3	323 (2.08) 1.6	274 (1.50) 1.1
UIWCS	128 (1.48) 3.0	64 (2.03) 0.3	20 (1.76) 0.8
Lumbriculidae (total)	---	30 (1.54) 0.1	---
Eclipidrilus sp.	---	30 (1.54) 0.1	---
immature Oligochaeta	---	---	2 (4.24) <0.1

APPENDIX 1C (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Mollusca			
Gastropoda (total)	116 (1.16) 2.7	239 (1.3) 1.1	390 (1.27) 1.6
Hydrobiidae (unk.)	106 (2.36) 2.5	237 (1.32) 1.1	385 (1.30) 1.6
Planorbidae			
Planorbella scalaris	---	---	5 (4.24) <0.1
Physidae			
Physella cubensis	5 (4.24) 0.1	---	---
unidentifiable immature Gastropoda	5 (4.24) 0.1	2 (4.24) <0.1	---
Pelecypoda			
Corbiculidae			
Corbicula fluminea	630 (1.46) 14.8	8,435 (0.60) 42.1	62 (1.71) 0.3
unidentifiable immature Unionidae	2 (4.24) 0.1	---	---
Arthropoda			
Amphipoda (total)	294 (1.48) 6.9	1,232 (0.81) 6.1	190 (2.53) 0.8
Corophiidae			
Corophium louisianum	---	121 (1.61) 0.6	---
Gammaridae			
Gammarus nr. *tigrinus*	294 (1.48) 6.9	1,111 (0.79) 5.5	190 (2.53) 0.8

APPENDIX 1C (continued).

Taxon	2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
	Study Year		
Isopoda (total)	17 (1.56) 0.4	96 (1.85) 0.4	451 (1.09) 1.8
Anthuridae			
Cyathura polita	3 (4.24) 0.1	81 (2.09) 0.4	338 (0.91) 1.4
Sphaeromidae			
Cassidinidea ovalis	12 (2.07) 0.3	14 (2.91) <0.1	114 (2.30) 0.5
Mysidacea (total)	5 (2.91) 0.1	17 (2.94) <0.1	---
Mysidae			
Taphromysis bowmani	5 (2.91) 0.1	17 (2.94) <0.1	---
Aquatic Acari (total)	1,605 (1.50) 37.7	4,585 (1.49) 22.8	1,042 (1.82) 4.3
Hydracarina	1,605 (1.50) 37.7	4,585 (1.49) 22.8	1,042 (1.82) 4.3
Insecta			
Collembola	---	---	146 (0.97) 0.6
Ephemeroptera (total)	54 (1.55) 1.3	88 (1.26) 4.3	1,254 (4.24) 5.1
Caenidae			
Brachycercus maculatus	54 (1.55) 1.3	88 (1.26) 4.3	2 (4.24) <0.1
Caenis diminuta	---	---	1,252 (1.20) 5.1
Odonata			
Anisoptera (total)	---	---	2 (4.24) <0.1

APPENDIX 1C (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %
Zygoptera (total)	2 (4.24) 0.1	---	---
Coenagrionidae e.i.	2 (4.24) 0.1	---	---
Hemiptera			
Corixidae e.i.	---	---	2 (4.24) <0.1
Trichoptera (total)	4 (2.91) 0.1	7 (2.30) <0.1	67 (1.77) 0.3
Hydroptilidae (unknown imm.)	---	5 (2.91) <0.1	---
Leptoceridae			
Nectopsyche sp.	2 (4.24) 0.1	---	---
Oecetis sp.	2 (4.24) 0.1	---	---
Oecetis inconspicua complex	---	---	67 (1.77) 0.3
Leptoceridae e.i.	---	2 (4.24) <0.1	---
Coleoptera			
Elimidae			
Stenelmis sp.	---	---	2 (4.24) <0.1
Hydrophilidae			
Berosus sp.	---	---	7 (3.09) <0.1

APPENDIX 1C (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %
Diptera			
Ceratopogonidae (total)	---	2 (4.24) <0.1	2 (4.24) <0.1
Bezzia or *Palpomyia*	---	2 (4.24) <0.1	---
Culicoides sp.	---	---	2 (4.24) <0.1
Chironomidae (total)	42 (1.38) 1.0	827 (0.99) 4.1	16,325 (1.02) 66.7
Coelotanypus sp.	5 (2.91) 0.1	2 (4.24) <0.1	27 (2.81) 0.1
Procladius sp.	12 (3.45) 0.3	---	---
Djalmabatista pulchra	---	---	2,278 (1.15) 11.3
Tanypodinae e.i.	2 (4.24) 0.1	---	44 (4.00) 0.2
Cricotopus bicinctus	---	390 (1.39) 1.9	---
Nanocladius sp.	---	17 (1.79) <0.1	---
Nanocladius crassicornus	---	2 (4.24) <0.1	---
Nanocladius distinctus	---	5 (2.91) <0.1	---

APPENDIX 1C (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Parakiefferiella sp.	7 (4.24) 0.2	2 (4.24) <0.1	---
Thienemanniella xena	---	2 (4.24) <0.1	---
Apedilum sp.	---	2 (4.24) <0.1	---
Chironomus sp.	2 (4.24) 0.1	---	---
Chironomus crassicaudatus	2 (4.24) 0.1	---	---
Cryptochironomus sp.	---	---	2 (4.24) <0.1
Dicrotendipes sp.	---	7 (2.30) <0.1	239 (3.14) 1.0
Dicrotendipes neomodestus	---	---	1,946 (1.50) 7.9
Dicrotendipes tritomus	---	12 (1.66) <0.1	---
Polypedilum sp.	---	---	2 (4.24) <0.1
Polypedilum scalaenum group	---	---	168 (1.32) 0.7
Polypedilum tritum	---	2 (4.24) <0.1	---
Chironominae e.i.	7 (2.30) 0.2	17 (2.52) <0.1	99 (1.57) 0.4

APPENDIX 1C (continued).

Taxon	Study Year 2005 no. m^{-2} (c.v.) %	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %
Tanytarsini (e.i.)	---	---	30 (1.99) 0.1
Cladotanytarsus sp.	---	32 (2.17) 0.1	6,453 (1.02) 26.4
Tanytarsus sp.	2 (4.24) 0.1	214 (1.36) 1.0	210 (1.16) 0.9
Tanytarsus limneticus	---	---	128 (1.78) 0.5
unknown Chironomidae	---	---	2 (4.24) <0.1
Total Taxa	29	43	46
Mean Total Organisms	4,252 (1.22)	20,022 (0.76)	24, 482 (0.89)
Mean Taxa Richness	8.72 (0.51)	17.06 (0.38)	17.61 (0.17)
Mean Diversity	1.94 (0.36)	2.32 (0.22)	2.96 (0.14)
Mean Evenness	0.68 (0.29)	0.58 (0.12)	0.73 (0.11)

*coefficient of variation expressed as proportion (not percent).
--- = taxon not present.
P = colonial taxon present in samples.
UIWCS = unidentified immature Oligochaeta with capilliform setae.
e.i. = early instar insect too immature to identify to species.

APPENDIX 1D. Mean densities (no. m^{-2}), coefficients of variation (c.v.)*, and percent compositions (%) of aquatic invertebrates collected from the Lake Okeechobee mud habitat zone during the February sampling events of 2006, 2007, and 2008.

	Study Year		
	2006	2007	2008
Taxon	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %
Nematoda	---	5 (2.91) 0.2	---
Annelida			
Aphanoneura			
Aeolosomatidae	10 (3.29) 0.7	---	---
Oligochaeta (total)	1,351 (0.79) 92.5	3,052 (1.05) 93.0	3,373 (0.70) 97.3
Naididae (total)	99 (1.48) 6.8	367 (2.07) 11.2	47 (1.32) 1.2
Nais communis complex	---	2 (4.24) <0.1	---
Pristinella osborni	---	---	10 (2.91) 0.3
Stephensoniana trivandrana	96 (1.53) 6.6	365 (2.09) 11.1	37 (1.66) 0.96
unknown Naididae	2 (4.24) 0.1	---	---
Tubificidae (total)	1,240 (0.75) 84.9	2,632 (0.96) 80.2	3,726 (0.70) 96.1
Aulodrilus pigueti	---	49 (4.02) 1.5	10 (2.47) 0.25
Haber speciosus imm.	---	---	2 (4.24) 0.1
Ilyodrilus templetoni	405 (1.49) 27.7	845 (1.04) 25.7	649 (0.77) 21.7

APPENDIX 1D (continued).

Taxon	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
Limnodrilus hoffmeisteri	672 (0.70) 46.0	1,687 (1.06) 51.4	277 (1.19) 7.1
Limnodrilus claparedianus	---	---	25 (2.98) 0.6
IWOCS	---	---	2,550 (0.73) 65.8
UIWCS	163 (2.03) 11.2	56 (2.81) 1.7	20 (4.24) 0.5
Mollusca			
Gastropoda (total)	2 (4.24) 0.2	2 (4.24) <0.1	---
unidentified Hydrobiidae	---	2 (4.24) <0.1	---
Thiaridae			
Melanoides sp.	2 (4.24) 0.2	---	---
Pelecypoda			
Corbiculidae			
Corbicula fluminea	---	9 (2.91) 0.2	2 (4.24) 0.1
Arthropoda			
Amphipoda (total)	---	158 (2.91) 4.8	27 (3.47) 0.7
Gammaridae			
Gammarus nr. *tigrinus*	---	155 (2.96) 4.8	27 (3.47) 0.7
Hyalellidae			
Hyalella azteca	---	3 (4.24) <0.1	---

Study Year

APPENDIX 1D (continued).

Taxon	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
	Study Year		
Mysidacea (total)	---	5 (2.91) 0.1	7 (2.30) 0.2
Mysidopsis sp.	---	5 (2.91) 0.1	7 (2.30) 0.2
Aquatic Acari (total)	2 (4.24) 0.2	7 (3.09) 0.1	2 (4.24) 0.1
Hydracarina	2 (4.24) 0.2	7 (3.09) 0.1	2 (4.24) 0.1
Insecta			
Trichoptera (total)	---	2 (4.24) <0.1	---
Hydroptilidae			
Hydroptila sp.	---	2 (4.24) <0.1	---
Diptera			
Chaoboridae			
Chaoborus punctipennis	---	---	5 (2.91) 0.1
Chironomidae (total)	94 (1.05) 6.4	133 (1.55) 4.0	59 (1.56) 1.5
Coelotanypus sp.	54 (1.21) 3.7	61 (2.15) 1.8	37 (1.81) 1.0
Coelotanypus scapularis	---	---	2 (4.24) 0.1

APPENDIX 1D (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
Colelotanypus tricolor	40 (1.27) 2.7	39 (1.63) 1.1	20 (4.24) 0.5
Cricotopus or *Orthocladius*	---	5 (4.24) 0.1	---
Thienemanniella sp.	---	12 (2.07) 0.3	---
Orthocladiinae (unknown)	---	2 (4.24) <0.1	---
Dicrotendipes neomodestus	---	5 (4.24) 0.1	---
Polypedilum sp.	---	2 (4.24) <0.1	---
Polypedilum flavum	---	2 (4.24) <0.1	---
Tanytarsini (unknown)	---	2 (4.24) <0.1	---
Total Taxa	8	20	14
Mean Total Organisms	1,459 (0.70)	3,281 (0.96)	3,877 (0.66)
Mean Taxa Richness	3.17 (0.27)	4.56 (0.31)	3.5 (0.25)
Mean Diversity	1.16 (0.28)	1.41 (0.22)	0.98 (0.29)
Mean Evenness	0.74 (0.24)	0.68 (0.15)	0.56 (0.23)

*coefficient of variation expressed as proportion (not percent).
--- = taxon not present.
P = colonial taxon present in samples.
UIWCS = unidentified immature Oligochaeta with capilliform setae.
IWOCS = unidentified immature Oligochaeta without capilliform setae.
e.i. = early instar insect too immature to identify to species.

APPENDIX 1E. Mean densities (no. m^{-2}), coefficients of variation (c.v.)*, and percent compositions (%) of aquatic invertebrates collected from the Lake Okeechobee sand habitat zone during the February sampling events of 2006, 2007, and 2008.

	Study Year		
	2006	2007	2008
Taxon	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %
Cnidaria			
Hydrozoa			
Cordylophora lacustris	P	---	---
Hydra sp.	---	---	2 (4.24) <0.1
Nematoda	59 (2.81) 1.4	81 (2.02) 1.9	207 (2.04) 2.1
Platyhelminthes			
Turbellaria			
Dugesia sp.	---	111 (4.14) 2.7	2 (4.24) <0.1
Nemertea			
Hoplonemertea			
Prostoma sp.	---	10 (2.47) 0.2	---
Entoprocta			
Urnatella gracilis	P	---	---
Annelida			
Aphanoneura			
Aeolosomatidae	---	9 (2.47) 0.2	---
Oligochaeta (total)	2,724 (0.76) 63.0	1,753 (0.82) 42.1	4,938 (1.46) 49.3
Enchytraeidae	2 (4.24) 0.1	4 (2.91) 0.1	---
Naididae (total)	96 (1.38) 2.2	158 (1.79) 3.8	1, 017 (2.72) 10.2

APPENDIX 1E (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Chaetogaster sp.	---	5 (4.24) 0.1	---
Chaetogaster diastrophus	---	10 (4.24) 0.2	---
Dero digitata complex	---	---	296 (2.92) 3.0
Haemonais waldvogeli	2 (4.24) 0.1	---	---
Nais variabilis	---	---	40 (2.47) 0.4
Nais communis complex	---	5 (4.24) 0.1	---
Pristina sp.	2 (4.24) 0.1	---	---
Pristina aequiseta	42 (2.73) 1.0	24 (2.64) 0.5	---
Pristina synclites	---	2 (4.24) <0.1	10 (4.24) 0.1
Pristinella osborni	---	5 (4.24) 0.1	672 (2.89) 6.7
Stephensoniana trivandrana	49 (2.00) 1.1	106 (2.75) 2.5	---
Tubificidae (total)	2,445 (0.84) 56.6	1,587 (0.82) 38.2	3,921 (1.31) 39.1

APPENDIX 1E (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Aulodrilus pigueti	32 (1.95) 0.7	37 (2.98) 0.8	217 (1.02) 2.2
Branchiura sowerbyi	22 (3.77) 0.5	2 (4.24) <0.1	---
Haber speciosus	467 (3.80) 10.8	141 (1.65) 3.4	284 (1.87) 2.8
Ilyodrilus templetoni	81 (2.19) 1.9	373 (1.66) 9.0	54 (2.18) 0.5
Limnodrilus hoffmeisteri	1,548 (0.75) 35.8	953 (0.93) 22.9	551 (1.95) 5.5
IWOCS	---	---	2,741 (1.53) 27.4
UIWCS	343 (1.33) 7.9	81 (2.0) 1.9	59 (2.86) 0.6
Lumbriculidae (total)	---	2 (4.24) <0.1	---
Eclipidrilus sp.	---	2 (4.24) <0.1	---
unidentifiable Oligochaeta	89 (2.28) 2.1	---	---
Mollusca			
Gastropoda (total)	---	2 (4.24) <0.1	10 (3.29) 0.1
Thiaridae			
Melanoides sp.	---	2 (4.24) <0.1	---

APPENDIX 1E (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Melanoides tuberculatus	---	---	10 (3.29) 0.1
Pelecypoda			
Corbiculidae			
Corbicula fluminea	884 (1.46) 20.5	856 (0.71) 20.6	2,502 (0.75) 25.0
Arthropoda			
Amphipoda (total)	338 (1.93) 7.8	476 (1.19) 11.4	116 (1.75) 1.2
Corophiidae			
Corophium louisianum	---	12 (1.66) 0.3	---
Gammaridae			
Gammarus nr. *tigrinus*	338 (1.93) 7.8	464 (1.19) 11.1	111 (1.82) 1.1
Hyalellidae			
Hyalella azteca	---	---	5 (4.24) <0.1
Isopoda (total)	17 (1.79) 0.4	106 (1.01) 2.5	143 (0.85) 1.4
Anthuridae			
Cyathura polita	17 (1.79) 0.4	106 (1.01) 2.5	143 (0.85) 1.4
Mysidacea	---	2 (4.24) <0.1	---
Taphromysis bowmani	---	2 (4.24) <0.1	---
Aquatic Acari (total)	170 (2.50) 3.9	17 (2.19) 0.4	84 (1.68) 0.8

APPENDIX 1E (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Hydracarina	170 (2.50) 3.9	17 (2.19) 0.4	84 (1.68) 0.8
Insecta			
Ephemeroptera			
Caenidae			
Caenis diminuta	---	---	22 (3.77) 0.2
Odanata			
Anisoptera			
Brachymesia gravida	---	---	2 (4.24) <0.1
Trichoptera (total)	---	---	17 (2.52) 0.2
Hydroptilidae			
Hydroptila sp.	---	---	2 (4.24) 0.2
Leptoceridae e.i.	---	---	15 (2.91) 0.1
Diptera			
Ceratopogonidae (total)	15 (1.78) 0.3	---	27 (2.11) 0.3
Culicoides sp.	---	---	27 (2.11) 0.3
Probezzia sp.	12 (2.07) 0.3	---	---
unidentified Ceratopogonidae	3 (4.24) <0.1	---	---
Chaoboridae			
Chaoborus punctipennis	5 (2.91) 0.1	---	---

APPENDIX 1E (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Chironomidae (total)	86 (1.34) 2.0	810 (2.12) 19.4	1,943 (0.94) 19.4
Coelotanypus sp.	59 (1.56) 1.4	37 (2.23) 0.8	47 (3.41) 0.5
Colelotanypus tricolor	20 (2.21) 0.5	7 (3.09) 0.1	5 (2.91) <0.1
Procladius sp.	---	---	22 (2.08) 0.2
Djalmabatista pulchra	---	---	326 (1.40) 3.3
Tanypodinae e.i.	2 (4.24) 0.1	---	---
Corynoneura sp.	2 (4.24) <0.1	---	---
Cricotopus bicinctus	---	---	5 (4.24) <0.1
Cricotopus or *Orthocladius*	---	2 (4.24) <0.1	---
Nanocladius distinctus	---	---	2 (4.24) <0.1
Parakiefferiella species B	---	---	2 (4.24) <0.1
Thienemanniella sp.	2 (4.24) <0.1	---	---
Orthocladiinae unknown	---	2 (4.24) <0.1	---

APPENDIX 1E (continued).

Taxon	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
	Study Year		
unknown Chironomini a	---	---	2 (4.24) <0.1
Chironomus sp.	---	---	7 (4.24) 0.1
Cryptochironomus sp.	---	---	32 (2.32) 0.3
Cryptochironomus or *Harnischia* complex D	---	---	5 (2.91) <0.1
Dicrotendipes modestus	---	---	10 (2.47) 0.1
Dicrotendipes tritomus	---	---	5 (4.24) <0.1
Glyptotendipes sp.	---	---	2 (4.24) <0.1
Glyptotendipes paripes	---	---	2 (4.24) <0.1
Kiefferulus sp.	---	---	5 (2.91) <0.1
Microchironomus sp.	---	2 (4.24) <0.1	52 (2.36) 0.5
Paralauterborniella nigrohalteralis	---	---	2 (4.24) <0.1
Polypedilum flavum	---	---	2 (4.24) <0.1
Polypedilum halterale	2 (4.24) <0.1	---	---

APPENDIX 1E (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
Polypedilum scalaenum	---	20 (2.07) 0.5	363 (1.55) 3.6
Cladotanytarsus sp.	---	733 (2.33) 17.6	803 (1.54) 8.0
Paratanytarsus sp.	---	---	2 (4.24) <0.1
Rheotanytarsus sp.	---	2 (4.24) <0.1	---
Tanytarsus sp.	---	2 (4.24) <0.1	55 (1.69) 0.5
Tanytarsini (e.i.)	---	---	5 (4.24) <0.1
Chironominae unknown e.i.	2 (4.24) <0.1	---	7 (2.30) 0.1
Total Taxa	23	32	42
Mean Total Organisms	4,322 (0.66)	4,154 (0.70)	10,018 (0.84)
Mean Taxa Richness	6.83 (0.39)	8.44 (0.35)	12.55 (0.39)
Mean Diversity	1.72 (0.28)	2.16 (0.19)	2.46 (0.19)
Mean Evenness	0.66 (0.25)	0.73 (0.18)	0.70 (0.16)

*coefficient of variation expressed as proportion (not percent).
--- = taxon not present.
P = colonial taxon present in samples.
UIWCS = unidentified immature Oligochaeta with capilliform setae.
IWOCS = unidentified immature Oligochaeta without capilliform setae.
e.i. = early instar insect too immature to identify to species.

APPENDIX 1F. Mean densities (no. m^{-2}), coefficients of variation (c.v.)*, and percent compositions (%) of aquatic invertebrates collected from the Lake Okeechobee peat habitat zone during the February sampling events of 2006, 2007, and 2008.

	Study Year		
	2006	2007	2008
Taxon	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %	no. m^{-2} (c.v.) %
Porifera			
Spongillidae	---	P	---
Cnidaria			
Hydrozoa			
Cordylophora lacustris	---	P	---
Hydra sp.	---	---	18 (1.59) 0.1
Platyhelminthes			
Turbellaria			
Dugesia sp.	---	5 (4.24) <0.1	27 (1.87) 0.1
Nemertea			
Hoplonemertea (total)	---	12 (2.41) 0.2	5 (2.91) <0.1
Prostoma sp.	---	---	5 (2.91) <0.1
Nematoda	81 (1.88) 7.7	432 (1.91) 5.4	864 (1.55) 3.7
Entoprocta			
Urnatella gracilis	P	---	---
Annelida			
Aphanoneura			
Aeolosomatidae	5 (2.91) 0.5	25 (2.64) 0.3 0.3	---
Oligochaeta (total)	57 (1.44) 5.4	3,163 (2.11) 40.1	7,243 (1.33) 31.3

APPENDIX 1F (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
Enchytraeidae	37 (2.07) 3.5	1,244 (2.07) 15.7	---
Naididae (total)	---	1,778 (2.28) 22.5	6,747 (1.37) 29.1
Chaetogaster sp.	---	---	2 (4.24) <0.1
Chaetogaster diastrophus	---	2 (4.24) <0.1	35 (2.48) 0.1
Dero digitata	---	---	74 (3.45) 0.3
Dero pectinata	---	17 (3.20) 0.2	52 (1.96) 0.2
Nais sp.	---	40 (2.56) 0.5	---
Nais communis complex	---	1,420 (2.22) 18.0	---
Nais elinguis	---	---	81 (2.63) 0.4
Nais variabilis	---	---	5,853 (1.58) 25.3
Pristina aequiseta	---	2 (4.24) <0.1	15 (2.06) 0.1
Pristina leidyi	---	---	5 (4.24) 0.2
Pristinella osborni	---	316 (2.89) 4.0	2 (4.24) <0.1

APPENDIX 1F (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
Stephensoniana trivandrana	---	2 (4.24) <0.1	282 (2.73) 1.2
unknown Naididae	---	2 (4.24) <0.1	---
Tubificidae (total)	20 (1.93) 1.9	138 (1.93) 1.7	496 (1.69) 2.1
Aulodrilus sp.	---	67 (2.91) 0.8	---
Aulodrilus limnobius	---	7 (4.24) <0.1	---
Aulodrilus pigueti	2 (4.24) 0.2	---	---
Haber speciosus	---	12 (2.41) 0.1	10 (2.91) <0.1
Limnodrilus hoffmeisteri	15 (2.06) 1.4	52 (2.60) 0.7	2 (4.24) <0.1
IWOCS	---	---	469 (1.82) 2.0
UIWCS	2 (4.24) 0.2	2 (4.24) <0.1	15 (2.30) 0.1
Polychaeta (damaged)	2 (4.24) 0.2	37 (1.38) 0.4	---
Mollusca			
Gastropoda (total)	67 (1.60) 6.3	64 (2.41) 0.8	640 (0.78) 2.8

APPENDIX 1F (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
Ancylidae			
Hebetancylus excentricus	---	2 (4.24) <0.1	---
Hydrobiidae			
Pyrgophorus platyrachis	49 (2.14) 4.7	---	121 (1.02) 0.5
Tryonia aequicestatus	---	---	5 (2.91) <0.1
unidentified Hydrobiidae	17 (2.67) 1.6	61 (2.52) 0.7	514 (0.91) 2.2
Pelecypoda			
Corbiculidae			
Corbicula fluminea	99 (1.84) 9.4	200 (0.70) 2.5	363 (1.54) 1.6
Arthropoda			
Amphipoda (total)	119 (1.58) 11.3	1,415 (1.51) 17.9	2,966 (0.96) 12.8
Corophiidae			
Corophium louisianum	---	212 (1.12) 2.7	---
Gammaridae			
Gammarus nr. *tigrinus*	119 (1.58) 11.3	1,202 (1.83) 15.2	2,734 (0.96) 1.0
Hyalellidae			
Hyalella azteca	---	---	89 (1.78) 0.4
immature Amphipoda	---	---	138 (2.0) 0.6
Isopoda (total)	5 (2.91) 0.5	190 (1.24) 2.4	842 (1.55) 3.6

APPENDIX 1F (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Anthuridae			
Cyathura polita	3 (4.24) 0.2	86 (1.39) 1.0	47 (1.32) 0.2
Sphaeromidae			
Cassidinidea ovalis	2 (4.24) 0.2	104 (1.79) 1.3	795 (1.59) 3.4
Mysidacea (total)	---	2 (4.24) <0.1	---
Taphromysis bowmani	---	2 (4.24) <0.1	---
Aquatic Acari (total)	612 (1.67) 58.2	1,980 (1.53) 25.1	963 (1.34) 4.2
Hydracarina	605 (1.66) 57.5	1,980 (1.53) 25.1	963 (1.34) 4.2
Oribatidae	7 (2.30) 0.7	---	---
Insecta			
Collembola	2 (4.24) 0.2	---	---
Ephemeroptera			
Caenidae			
Brachycercus maculatus	---	15 (2.06) 0.2	2 (4.24) <0.1
Caenis diminuta	---	---	748 (1.14) 3.2
Trichoptera			
Hydroptila sp.	---	---	5 (2.91) <0.1

APPENDIX 1F (continued).

Taxon	2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
	Study Year		
Leptoceridae e.i.	---	---	10 (3.29) <0.1
Nectopsyche tavara	---	---	5 (4.24) <0.1
Oecetis sp.	---	---	30 (1.70) 0.1
Oecetis inconspicua complex	---	---	2 (4.24) <0.1
Coleoptera			
Berosus sp.	---	---	2 (4.24) <0.1
Diptera			
Chironomidae (total)	---	264 (2.17) 3.3	8,336 (0.44) 36.0
Tanypodinae (e.i.)	---	---	12 (2.98) 0.1
Coelotanypus sp.	---	---	7 (4.24) <0.1
Procladius sp.	---	2 (4.24) <0.1	54 (1.55) 0.2
Djalmabatista pulchra	---	---	951 (1.57) 4.1
Cricotopus sp.	---	---	7 (4.24) <0.1
Cricotopus bicinctus	---	170 (2.43) 2.2	163 (0.90) 0.7

APPENDIX 1F (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	2007 no. m^{-2} (c.v.) %	2008 no. m^{-2} (c.v.) %
Cricotopus or *Orthocladius*	---	2 (4.24) <0.1	---
Nanocladius minimus	---	---	2 (4.24) <0.1
Thienemanniella lobapodema	---	---	5 (4.24) <0.1
Orthocladiinae unknown	---	30 (2.36) 0.4	---
Apedilum sp.	---	---	12 (2.96) 0.1
Cryptochironomus sp.	---	---	7 (4.24) <0.1
Dicrotendipes sp.	---	---	44 (2.30) 0.2
Dicrotendipes modestus	---	---	10 (2.91) <0.1
Dicrotendipes neomodestus	---	---	37 (1.98) 0.2
Dicrotendipes tritomus	---	---	52 (1.67) 0.2
Glyptotendipes sp.	---	---	22 (2.59) 0.1
Glyptotendipes species B	---	---	12 (2.98) 0.1
Glyptotendipes species E	---	---	5 (4.24) <0.1

APPENDIX 1F (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Goeldichironomus amazonicus	---	---	5 (4.24) <0.1
Goeldichironomus fluctuans	---	---	17 (3.20) 0.1
Polypedilum flavum	---	2 (4.24) <0.1	---
Polypedilum halterale	---	---	5 (4.24) <0.1
Polypedilum scalaenum group	---	---	99 (1.14) 0.4
Xenochironomus xenolabis	---	7 (2.30) <0.1	---
unknown Chironomini a	---	---	138 (1.06) 0.6
unknown Chironominae	---	---	10 (3.29) <0.1
Cladotanytarsus sp.	---	7 (2.30) <0.1	2,949 (0.71) 12.7
Rheotanytarsus sp.	---	2 (4.24) <0.1	---
Tanytarsus sp.	---	2 (4.24) <0.1	5 (4.24) <0.1
unknown Chironomidae	---	---	2 (4.24) <0.1

APPENDIX 1F (continued).

Taxon	Study Year 2006 no. m^{-2} (c.v.) %	Study Year 2007 no. m^{-2} (c.v.) %	Study Year 2008 no. m^{-2} (c.v.) %
Total Taxa	16	35	48
Mean Total Organisms	1,052 (1.49)	7,882 (1.23)	23,168 (0.59)
Mean Taxa Richness	3.94 (0.59)	10.89 (0.42)	19.94 (0.18)
Mean Diversity	1.40 (0.48)	2.31 (0.22)	2.91 (0.16)
Mean Evenness	0.74 (0.41)	0.73 (0.18)	0.68 (0.12)

*coefficient of variation expressed as proportion (not percent).
--- = taxon not present.
P = colonial taxon present in samples.
UIWCS = unidentified immature Oligochaeta with capilliform setae.
IWOCS = unidentified immature Oligochaeta without capilliform setae.
e.i. = early instar insect too immature to identify to species.

APPENDIX 2. Species associated with habitats designated by nonmetric multidimensional Scaling of Lake Okeechobee pelagic region invertebrate species densities (1987-2008) averaged by habitat (mud, sand, or peat), season (wet or dry), and year. Label number corresponds to species point labels listed in Figure14.

APPENDIX 2. Species associated with habitats designated by nonmetric multidimensional scaling of Lake Okeechobee pelagic region invertebrate species densities (1987-2008) averaged by habitat (mud, sand, or peat), season (wet or dry), and year. Label number corresponds to species point labels listed in Figure14.

Label #	Mud	Label #	Mud Sand	Label #	Sand	Label #	Peat Sand	Label #	Peat
	Nematoda		Nematoda		Nematoda		Nematoda	1	Porifera
	Oligochaeta		Oligochaeta		Oligochaeta		Oligochaeta		Cnidaria
51	immature Oligochaeta		Naididae		Naididae		Naididae		Hydrozoa
	Naididae	36	Unknown Naididae	16	*Dero digitata*	25	*Nais communis* complex	2	*Cordylophora lacustris*
30	*Pristinella jenkinae*		Tubificidae	17	*Dero nivea*	52	immature "worm"		*Hydra* sp.
33	*Pristinella sima*	39	*Aulodrilus limnobius*	19	*Dero trifida*		Arthropoda		Platyhelminthes
	Tubificidae	47	*Limnodrilus hoffmeisteri*	20	*Haemonais waldvogeli*		Crustacea		Turbellaria
44	*Ilyodrilus templetoni*	45	imm. *Illyodrilus templetoni*	29	*Pristina synclites*		Isopoda	5	*Dugesia tigrina*
46	*Limnodrilus claparedianus*		Arthropoda		Tubificidae		Anthuridae		Nemertea
48	UIWOCS		Crustacea	40	*Aulodrilus pigueti*	70	*Cyathura polita*		Enopla
	Mollusca		Isopoda	41	*Branchiura sowerbyi*		Insecta		Hoplonemertea
	Gastropoda		Mysidacea	42	*Haber speciosus*		Odonata	6	*Prostoma* sp.
	Thiaridae		Mysidae	49	UIWCS	80	Anisoptera	7	Nematoda
56	*Melanoides tuberculatus*	74	*Taphromysis bowmani*	43	imm. *Haber speciosus*		Diptera	8	Aphanoneura
	Viviparidae		Insecta	53	Hirudinia		Ceratopogonidae		Oligochaeta
57	*Viviparus georgianus*		Diptera		Mollusca	98	*Culicoides* sp.	9	Enchytraeidae
	Pelecypoda		Chironomidae	65	Unionidae (imm.)		Chironomidae	10	Naididae
	Arthropoda		Chironominae		Arthropoda		Tanypodinae	11	*Allonais pectinata*
	Crustacea		Chironomini		Crustacea		Procladini	12	*Bratislavia unidentata*
	Isopoda	129	*Chironomus crassicaudatus*		Amphipoda	107	*Djalmabatista pulchra*	13	*Chaetogaster* sp.
	Mysidacea				Hyalellidae		Orthocladiinae	14	*Chaetogaster diastrophus*
	Mysidae	6	= Total Taxa	68	*Hyalella azteca*	111	*Cricotopus* or *Orthocladius* sp.	15	*Dero* sp.
73	*Mysidopsis* sp.				Isopoda		Chironominae	18	*Dero pectinata*
	Insecta				Mysidacea		Chironomini	21	*Nais* sp.
	Hemiptera				Mysidae	144	*Goeldichironomus amazonicus*	22	*Nais behningi*
	Belostomatidae			72	*Mysidopsis almyra*	170	Tanytarsini	24	*Nais elinguis*
81	*Belostoma flumineum*				Insecta	165	*Cladotanytarsus* sp.	23	*Nais variabilis*
	Coleoptera				Odonata	168	*Rheotanytarsus* sp.	26	*Pristina* sp.
	Elimidae			79	Zygoptera	169	*Tanytarsus* sp.	27	*Pristina aequiseta*
94	*Microcylloepus pusillus*				Trichoptera	171	unknown Chironomidae	28	*Pristina leidyi*
	Diptera			83	*Hydroptila* sp.			31	*Pristinella longisoma*
	Ceratopogonidae			91	*Orthotrichia* sp.	13	= Total Taxa	32	*Pristinella osborni*
100	*Bezzia* sp.				Coleoptera			34	*Slavina appendiculata*
	Chironomidae				Noteridae			35	*Stephensoniana trivandrana*
	Tanypodinae			93	*Hydrocanthus* sp.				Opistocystidae
	Coelotanypodini				Diptera			37	*Crustipellis tribranchiata*
105	*Coelotanypus tricolor*				Ceratopogonidae				Tubificidae
	Orthocladiinae			96	*Atrichopogo* n sp.			38	*Aulodrilus* sp.
119	*Orthocladius dorenus*			99	*Probezzia* sp.				Lumbriculidae
122	*Thienemanniella* sp.				Chaoboridae			50	*Eclipidrilus* sp.
				102	*Chaoborus punctipennis*			4	Polychaeta
15	= Total Taxa				Chironomidae				Mollusca
				103	Tanypodinae				Gastropoda
					Coelotanypodini			63	imm. Gastropoda
				104	*Coelotanypus* sp.				Ancylidae
				106	*Coelotanypus scapularis*			55	*Hebetancylus excentricus*
					Procladini			58	Hydrobiidae
				108	*Procladius* sp.			54	*Aphaostracon pachynotum*
					Orthocladiinae			59	*Pyrgophorus platyrachis*
				113	*Corynoneura* sp.			60	*Tryonia aequicestatus*
				121	*Parakiefferiella* species B				Planorbidae
					Chironominae			62	*Planorbella scalaris*
					Chironomini				Physidae
				128	*Chironomus* sp.			61	*Physella cubensis*
				130	*Chironomus stigmaterus*				Pelecypoda
				131	*Cladopelma* sp.				Corbiculidae

APPENDIX 2. Continued.

Label #	Mud	Label #	Mud Sand	Label #	Sand	Label #	Peat Sand	Label #	Peat
				132	*Cryptochironomus* sp.			64	*Corbicula fluminea*
				133	*Cryptochironomus/Harnischia* complex D				Arthropoda
				138	*Dicrotendipes tritomus* or *modestus*				Crustacea
				139	*Glyptotendipes* sp.				Amphipoda
				140	*Glyptotendipes paripes*				Corophiidae
				143	*Goeldichironomus carus*			66	*Corophium louisianum*
				146	*Goeldichironomus natans*				Gammaridae
				147	*Kiefferulus* sp.			67	*Gammarus* nr. *tigrinus*
				148	*Microchironomus* sp.			69	immature Amphipoda
				151	*Parachironomus directus*				Isopoda
				153	*Paralauterborniella nigrohalteralis*				Sphaeromidae
				160	*Polypedilum* sp.			71	*Cassidinidea ovalis*
				155	*Polypedilum halterale*			75	Aquatic Acari
				156	*Polypedilum scalaenum* group				Insecta
				158	*Polypedilum trigonus*			76	Collembola
					Tanytarsini				Ephemeroptera
				166	*Paratanytarsus* sp.				Caenidae
								77	*Brachycercus maculatus*
				46	= Total Taxa			78	*Caenis diminuta*
									Trichoptera
								82	Hydroptilidae
								84	Leptoceridae
								85	*Nectopsyche* sp.
								86	*Nectopsyche candida*
								87	*Nectopsyche tavara*
								88	*Oecetis* sp.
								89	*Oecetis cinerascens*
								90	*Oecetis inconspicua* complex
									Coleoptera
									Elimidae
								95	*Stenelmis* sp.
									Hydrophilidae
								92	*Berosus* sp.
									Diptera
									Ceratopogonidae
								97	*Bezzia* or *Palpomyia* sp.
								101	*Dasyhelea* sp.
									Chironomidae
								125	Orthocladiinae
								110	Cricotopus sp.
								109	*Cricotopus bicinctus*
								112	*Cricotopus sylvestris*
								114	*Eukiefferiella grace*i group
								115	*Nanocladius* sp.
								116	*Nanocladius crassicornus*
								117	*Nanocladius distinctus*
								118	*Nanocladius minimus*
								120	*Parakiefferiella* sp.
								123	*Thienemanniella lobapodema*
								124	*Thienemanniella xena*
								164	Chironominae
									Chironomini
								127	*Apedilum* sp.
								134	*Dicrotendipes* sp.
								135	*Dicrotendipes modestus*

APPENDIX 2. Continued.

Label #	Mud	Label #	Mud Sand	Label #	Sand	Label #	Peat Sand	Label #	Peat
								136	*Dicrotendipes neomodestus*
								137	*Dicrotendipes tritomus*
								141	*Glyptotendipes* species B
								142	*Glyptotendipes* species E
								145	*Goeldichironomus fluctuans*
								149	*Parachironomus* sp.
								150	*Parachironomus hirtalatus*
								152	*Parachironomus pectinellae*
								154	*Polypedilum flavum*
								159	*Polypedilum illinoense*
								157	*Polypedilum tritum*
								161	*Xenochironomus xenolabis*
								163	*Zavreliella* sp.
								162	*Pseudochironomus* sp.
								126	unknown Chironomini A
									Tanytarsini
								167	*Tanytarsus limneticus*
								90	= Total Taxa