

**MYAKKA RIVER BASIN BIOLOGICAL STUDY:
DOWN'S DAM TO SNOOK HAVEN**

FINAL REPORT

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TABLE OF CONTENTS

	<u>PAGE</u>
Title Page	i
Table of Contents	ii
List of Participants	iv
Erratum	iv
Acknowledgements	v
List of Tables	vi
List of Figures	x
Summary	xi
I. INTRODUCTION	1
II. METHODS	4
A. Study Area	4
B. Macroinvertebrates	6
1. Field Collection	6
a) Infauna	6
b) Epifauna	8
c) Qualitative	8
2. Laboratory Analysis	9
3. Statistical Analysis	9
c. Botanical	10
1. Forest Transects	10
a) Elevations	10
b) Tree Density and Basal Area	10
c) Vascular Plant Inventory	11
d) Vegetation Cover	11
2. Shoreline Stations	11
3. Vegetation Reconnaissance and Map	12
III. PHYSICAL PARAMETERS	13
A. Temperature	13
B. Dissolved Oxygen	13
C. Salinity	14
IV. MACROINVERTEBRATE INVENTORY	15
A. Results	15
1. Substrate Characterization	15
2. Community Analysis	17
a) Infaunal Composition	17
b) Comparison of Transect Communities	20
c) Epibenthic Fauna	34
d) Statistical Analysis	36
(1) Species Richness	36

(2) Faunal Density	37
(3) Species Diversity	38
(4) Equitability	40
(5) Cluster Analysis	41
B. Discussion	44
C. Future Considerations	54
V. BOTANICAL INVENTORY	55
A. Results	55
B. Discussion	61
1. Terrestrial Habitats	61
2. Sloughs	61
3. Vegetational Classification	62
4. Vegetation Type Descriptions	64
5. Species Ranges Along Myakka River	67
6. Point Bars	68
c. Future Considerations	68
1. Adequacy of the Vegetation	68
2. Detection Methods	69
VI. MANAGEMENT PERSPECTIVES	70
VII. LITERATURE CITED	74
APPENDIX 1: BOTANICAL NARRATIVE REPORT	
APPENDIX 2: DATA SHEETS	

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ERRATUM

***Polypedilum halteres* should read *Polypedilum halterale* throughout the report.**

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LIST OF TABLES

	<u>PAGE</u>
Table 1. Physical and chemical parameters recorded at macroinvertebrate sampling locations for each collection.	80
Table 2. Phylogenetic list of taxa from core and Hester-Dendy samples.	82
Table 3. Faunal abundance by major group for all transects and all dates.	90
Table 4. Rank order of all taxa with all sampling dates and stations combined.	91
Table 5. Faunal abundance by major groups for Transect 1, all dates.	96
Table 6. Rank order of taxa from each station and date from Transect 1.	97
Table 7. Faunal abundance by major group for Transect 1, April.	100
Table 8. Faunal abundance by major group for Transect 1, September.	101
Table 9. Faunal abundance by major group for Transect 1, November.	102
Table 10. Faunal abundance by major group for Transect 1, February.	103
Table 11. Rank order of taxa from Transect 1 for April 1989.	104
Table 12. Rank order of taxa from Transect 1, September 1989.	106
Table 13. Rank order of taxa from Transect 1, November 1989.	107
Table 14. Rank order of taxa from Transect 1, February 1990.	108
Table 15. Rank order of taxa from all transects for April sampling.	110
Table 16. Rank order of taxa from each station for September 1989.	115
Table 17. Rank order of taxa from each station for November 1989.	117

Table 18.	Rank order of taxa from each station for February 1990.	119
Table 19.	Faunal abundance by major group for Transect 2, April.	122
Table 20.	Rank order of taxa from Transect 2, April 1989.	123
Table 21.	Faunal abundance by major group for Transect 3, April.	125
Table 22.	Rank order of taxa from Transect 3, April 1989.	126
Table 23.	Faunal abundance by major group for Transect 4, April.	128
Table 24.	Rank order of taxa from Transect 4, April 1989.	129
Table 25.	Faunal abundance by major groups for Transect 5, all dates.	130
Table 26.	Rank order of taxa from Transect 5 for each sampling date.	131
Table 27.	Faunal abundance by major group for Transect 5, April.	134
Table 28.	Faunal abundance by major group for Transect 5, September.	135
Table 29.	Faunal abundance by major group for Transect 5, November.	136
Table 30.	Faunal abundance by major group for Transect 5, February.	137
Table 31.	Rank order of taxa from Transect 5, April 1989.	138
Table 32.	Rank order of taxa from Transect 5, September 1989.	140
Table 33.	Rank order of taxa from Transect 5, November 1989.	141
Table 34.	Rank order of taxa from Transect 5, February 1990,	143
Table 35.	Faunal abundance by major group for Transect 6, April.	145
Table 36.	Rank order of taxa from Transect 6, April 1989.	146

Table 37.	Faunal abundance by major group for Transect 7, all dates.	148
Table 38.	Rank order of taxa from Transect 7 for each sampling date.	149
Table 39.	Faunal abundance by major group for Transect 7, April.	151
Table 40.	Faunal abundance by major group for Transect 7, September.	152
Table 41.	Faunal abundance by major group for Transect 7, November.	153
Table 42.	Faunal abundance by major group for Transect 7, February.	154
Table 43.	Rank order of taxa from Transect 7, April 1989.	155
Table 44.	Rank order of taxa from Transect 7, September 1989.	157
Table 45.	Rank order of taxa from Transect 7, November 1989.	158
Table 46.	Rank order of taxa from Transect 7, February 1989.	159
Table 47.	Rank order of taxa collected from Hester-Dendy traps for each transect and date.	160
Table 48.	Rank order of taxa collected from Hester-Dendy traps for Transect 1, April 1989.	163
Table 49.	Rank order of taxa collected from Hester-Dendy traps for Transect 2, April 1989.	164
Table 50.	Rank order of taxa collected from Hester-Dendy traps for Transect 3, April 1989.	165
Table 51.	Rank order of taxa collected from Hester-Dendy traps for Transect 4, April 1989.	166
Table 52.	Rank order of taxa collected from Hester-Dendy traps for Transect 5, April 1989.	167
Table 53.	Rank order of taxa collected from Hester-Dendy traps for Transect 6, April 1989.	168
Table 54.	Rank order of taxa collected from Hester-Dendy traps for Transect 7, April 1989.	168

Table 55.	Rank order of taxa collected from Hester-Dendy traps for Transect 1, September 1989.	169
Table 56.	Rank order of taxa collected from Hester-Dendy traps for Transect 5, September 1989.	170
Table 57.	Rank order of taxa collected from Hester-Dendy traps for Transect 7, September 1989.	171
Table 58.	Rank order of taxa collected from Hester-Dendy traps for Transect 1, December 1989.	172
Table 59.	Rank order of taxa collected from Hester-Dendy traps for Transect 5, December 1989.	173
Table 60.	Rank order of taxa collected from Hester-Dendy traps for Transect 7, December 1989.	174
Table 61.	Rank order of taxa collected from Hester-Dendy traps for Transect 1, February 1990.	175
Table 62.	Rank order of taxa collected from Hester-Dendy traps for Transect 7, February 1990.	176
Table 63.	Number of taxa from each station and sampling date.	177
Table 64.	Margalef's index of species richness for each station and sampling.	178
Table 65.	Number of individuals per m² for each station and sampling.	179
Table 66.	Shannon's index of diversity for each station and sampling.	180
Table 67.	Gini's index for each station and sampling.	181
Table 68.	Simpson's index for each station and sampling.	182
Table 69.	Pielou's index for equitability for each station and sampling.	183
Table 70.	Stage gauge heights at Myakka River at control near Laurel for June 28-30, and July 1 and 26, 1989.	184
Table 71.	Stage gauge heights at Myakka River near Laurel for June 28-30, and July 1 and 26, 1989.	185
Table 72.	Number of trees per acre (at least 1 inch dbh) by transect.	186

Table 73.	Number of trees per acre (1-3 inches in dbh) by transect.	187
Table 74.	Basal area (square inches per acre) of tree species at least 4 inches in dbh.	188
Table 75.	Myakka River flora (alphabetical list).	189
Table 76.	Myakka River flora by life form	192
Table 77.	Estimated percent cover of overstory trees and herbaceous groundcover.	196
Table 78.	Number of intercepts by species at shoreline stations.	197
Table 79.	Transect dimensions.	200

LIST OF FIGURES

	<u>PAGE</u>
Figure 1. Myakka River Basin macroinvertebrate sampling sites.	5
Figure 2. Similarity matrix of each station/date combination using Bray-Curtis index.	42
Figure 3. Dendrogram with each station/date combination, based on Bray-Curtis similarity index and group averaged sorting.	43
Figure 4. Number of taxa for each transect for all sampling periods.	46
Figure 5. Number of individuals for each transect for all sampling periods.	47
Figure 6. Elevation profile, Transect 1.	56
Figure 7. Elevation profile, Transect 2.	56
Figure 8. Elevation profile, Transect 3.	57
Figure 9. Elevation profile, Transect 4.	57
Figure 10. Elevation profile, Transect 5.	58
Figure 11. Elevation profile, Transect 6.	58
Figure 12. Elevation profile, Transect 7.	59
Figure 13. Elevation profile, PCE (Pipeline Control - East).	59
Figure 14. Elevation profile, PCW (Pipeline Control - West).	60
Figure 15. Map of study area showing Transects T1 through T7, PCE, PCW and shoreline stations 1-1 through 6-3.	63

SUMMARY

1. The study area was designated based on Sarasota County's anticipation of freshwater withdrawal from the river next to the T. Mabry Carlton Memorial Reserve and return treated waste water to the river approximately three miles downstream. Seven benthic transects were quantitatively sampled in the Myakka River Basin from river mile 26 downstream to river mile 18. Infaunal benthic samples were collected using a diver operated coring device, and epifaunal macroinvertebrates were sampled using Hester-Dendy artificial substrates with an incubation period of two weeks. Samples from all transects were collected in April 1988 with three transects sampled quarterly (April, September, November and February, 1989 through 1990). Data on the distribution of the macroinvertebrates collected from this study will provide a baseline for Sarasota County to maximize their ability to make informed and proper land and water-use decisions relating to the management of the Myakka River watershed.
2. Temperatures ranged from 18°C in February to 29°C in September. Vertical stratification was minimal.
3. Dissolved oxygen concentrations ranged from 1.9 ppm in September to 9.7 ppm in February. These changes were correlated with temperature maxima and minima, respectively. Bottom D.O. concentrations were generally the lowest, but the differences were minimal.
4. Salinity measurements recorded during this investigation detected only negligible concentrations. Vertical stratification of salinity concentrations were considered insignificant.
5. A total of 200 benthic macroinvertebrate taxa was represented in the infaunal collections, and 82 taxa were identified from the artificial substrates. Thirteen taxa uniquely occurred in the latter.
6. Variations of the composition of the benthic communities between transects were analyzed. Transect 1 was characterized by an absence of *Corbicula* and a community dominated by *Limnodrilus hoffmeisteri* with the chironomids, *Polypedilum*, *Tanytarsus* and *Cladotanytarsus* comprising the majority of the remaining fauna. Transect 2 was characterized by

an abundance of *Corbicula* with *L. hoffmeisteri*, *Cladotanytarsus*, *Polypedilum*, *Tanytarsus*, *Caenis*, *Sphaerium partumeium* and *Pristina synclites* representing the majority of the remaining taxa. Transect 3 was also characterized by an abundance of *Corbicula* with the remaining community comprised primarily by Podocopa, *L. hoffmeisteri*, *Cladotanytarsus*, *Caenis*, *S. partumeium* and *P. synclites*. Transect 4 was characterized by an extremely low species richness and abundance. Species composition was similar to Transect 3, however, the decrease in the numbers of *Corbicula* and *L. hoffmeisteri* were primarily responsible for the low densities. Transect 5 was characterized by a faunal community comprised primarily of *Corbicula*, *L. hoffmeisteri*, *Cladotanytarsus* and *Polypedilum*. Transect 6 was characterized by a community dominated by high densities of *Tanytarsus* and *L. hoffmeisteri*, with substantial populations of *Nais pardalis*, *P. synclites*, and *S. partumeium*. Transect 7 was characterized by high concentrations of *L. hoffmeisteri*, *Polypedilum* and *Cladotanytarsus* with sporadic occurrences of *N. pardalis* and the polychaete, *Laeonereis culveri*.

7. Faunal community composition was dominated by only a few taxa. Twenty-six taxa accounted for at least 1% of the fauna at each station throughout the study. However, only 10 taxa were considered dominant, comprising at least 5% of each community during the study. The dominant taxa were *L. hoffmeisteri*, *Corbicula*, *Polypedilum*, *Tanytarsus*, *Cladotanytarsus*, Podocopa, Ceratopogonidae, *Caenis*, *N. pardalis* and *P. synclites*.
8. Seasonal variation of community composition and densities were similar for each transect: large communities occurring in April, decreasing in September then increasing through November to February.
9. Statistical analysis of species richness, diversity, and equitability performed on the data reflected the seasonal variation described above.
10. Based on similarity analysis, the benthic community throughout the study area was relatively homogeneous for each respective sampling period, but significant variations in community composition and abundance throughout the whole study area occurred between collections.

11. Variations of community structure due to the salinity regime of the river was most pronounced at Transect 7 during September.
12. Insecta was the most species-rich taxonomic group, representing more than half of all taxa collected.
13. Mollusca and Oligochaeta generally accounted for the remainder of the benthic community.
14. It was predicted that a significant withdrawal of freshwater from the Myakka River during the wet season would allow an increased movement of the salt wedge upstream due to low degree of mixing between the more dense saline water on the bottom and the freshwater of the surface. The mixing is hampered by the stratification known to exist during that season.
15. The resultant changes in community composition would be an upstream migration of the estuarine fauna of marine origin.
16. Based on Beck's Biotic Index, the entire study area is considered a Class I body of water indicating the absence of organic pollution.
17. Future benthic studies should be sampled more frequently based on the seasonality of the dominant taxa, and extended for a minimum of two years to examine annual cycles.
18. Additional benthic stations in Curry Creek and in the vicinity of the Myakkahatchee are suggested based on their proposed use as discharge canals for treated waste water and stormwater runoff, respectively.
19. A botanical investigation was conducted within the corridor for the Myakka River between Snook Haven and Myakka River State Park. Recent and historical aerial photographs were used in determining the lateral extent of the corridor.
20. Forest transects were established at 8 stations, in order to prepare topographic profiles across the corridor, to determine densities by species of trees and shrubs, and to determine basal areas of trees.
21. 27 shoreline stations were established to determine the species abundance by point-interception of herbs and low-growing shrubs and vines within 25 feet of the river's edge.
22. Reconnaissance by boat allowed aerial photographs to be ground-truthed along the length of the river and up larger sloughs.

23. Species lists and a vegetation map of the corridor were prepared.
24. Three vegetation types were recognized; (1) Hydric hammock dominated by live oak, laurel oak, and cabbage palm. Within these hammocks, shrubby swamps of willow, popash, and water locust followed along sloughs, frequently beneath a gallery of overhanging oaks and palms. (2) Mesic evergreen hammock, consisting of live oak, cabbage palm, and (uncommonly) slash pine, generally with an undergrowth of saw palmetto. (3) Marshes, consisting of loosely assembled collections of hydric herbs along river banks or of floating mats of pickerelweed and Cuban bulrush in sloughs.
25. Suggestions were advanced for detecting hydrological alterations, should they ever occur, by means of vegetation.

I. INTRODUCTION

The Myakka River Basin is a unique watershed in Southwest Florida due to the relatively unaltered nature of its undeveloped shoreline and complex flow characteristics associated with seasonal rainfall and tidal influence. Man's previous dependence on this waterway concentrated primarily as a source of food in terms of both shoreline vegetation and fish and wildlife flourishing in and along the river. Recently this river has also been considered as a major source of potable water for the people of Sarasota County, and indirectly, as a disposal site for treated waste waters.

The T. Mabry Carlton Memorial Reserve (MCMR) is a 33,000 acre tract of flatwoods, and wetlands adjacent to the Myakka River to the west and Myakka River State Park to the north. Sarasota County purchased this tract as a potential source of potable water, recreational area, and wildlife habitat.

Development of water resources on the MCMR may affect the timing, quantity, and quality of flows to the Myakka River estuary via reductions in leakage of the water table into the bed of the Myakka River and reductions of surface discharge by groundwaters to ponds in the southwest sector of the Reserve and the addition of treated effluents. Alterations of surface and/or groundwaters on the Reserve may or may not, therefore, have off-site impacts since the Reserve represents 13% of the total river watershed and approximately one-third of the watershed below State Road 72. Hydrological and engineering studies performed in 1985 indicated that on-site supplies of potable water may not be as extensive as originally believed. This finding has led engineers to consider water from the Reserve be augmented by additional water sources, possibly even the Myakka River, to be a reliable supply. Withdrawal of water will affect the discharge of freshwater to the river system and ultimately to the downstream estuary. Additionally, secondarily treated waste water is being introduced into Curry Creek, a major tributary of the Myakka River.

This study provides the technical basis for a comprehensive basin-wide management program for the Myakka River watershed by providing inventory data of the non-tidal river compatible with the existing data for the tidal river system. The principal components of this study were 1) a botanic inventory

of the river corridor, and 2) an inventory of the macroinvertebrate communities of the non-tidal Myakka River south of the Myakka River State Park.

The botanical survey is an essential component in evaluating the recent historical past concerning watershed disturbance, erosional or depositional conditions, presence of exotic vegetation, and areas of water retention. The invertebrate faunal survey will allow an evaluation of the relative health of the aquatic system

The botanic inventory was conducted along the river corridor which was defined as the flood plain and any other terrain that lay between the main stem of the Myakka River and the adjacent upland. The corridor was characterized by vegetation that was distinctive from the upland pine flatwoods, scrubs, and palmetto prairies.

The goals of the inventory were to produce a vegetation map of the river corridor, to establish transects for quantification of forest attributes, to characterize shoreline vegetation, and to tabulate the vascular plant flora of the corridor. The data were to be compatible with those of a previous study of the river corridor from Snook Haven to Charlotte Harbor, conducted by Mte Marine Laboratory (ML).

Benthic invertebrates and aquatic insects have long been known to be sensitive indicators of water quality. Although individual species have been considered to be "indicator organisms", their presence or absence may not be indicative of water conditions. Instead, the concentration of opportunistic species with respect to that of taxa less tolerant to alteration of environmental conditions must be considered. Examining the variation of dominant components within the benthic community and relating these changes to the environmental requirements of the various taxa enables an evaluation of the extent of environmental impacts resulting from a change in flow characteristics or water quality degradation.

Chironomid assemblages have been found to be useful indicators of trophic conditions and have been used to classify lakes (Saether, 1975; 1979). Warwick (1980) has assigned trophic index numbers to chironomid associations. These associations have been correlated with mean concentrations of total phosphorus/mean depth or with total chlorophyll/mean depth in many North

American and European lakes (Wiederholm and Erikson, 1979, Wiederholm 1980; Saether, 1980). Some aquatic oligochaete species are also known to be indicators of substratum and water quality (Brinkhurst and Jamieson, 1971). Species of Tubificidae are particularly common in sediments exhibiting high organic content and low dissolved oxygen levels. Species composition of the benthic community is dependent on substrate type, flow condition, levels of detritus and organics, and water quality.

The community structure and stability can be indicative of alterations of the physicochemical characteristics of the drainage basin, river channel and water column. Analysis of the benthic infauna will form a baseline to utilize as a comparative tool to discern future perturbations of the water quality, not necessarily detectable through standard chemical monitoring programs.

During 1985, the MML Lower Myakka River survey revealed significant numbers of estuarine organisms as far north as the I-75 bridge. Therefore, the precise river zone where estuarine fauna relinquish to freshwater fauna has not yet been defined. Knowledge of the extent and position of this zone is essential from a water management standpoint, as these organisms are a primary food component of many riverine fishes, are indicators of water quality, and define the fresh-saltwater transition area. Based on previous experience with aquatic systems and recognizing the management needs of Sarasota County, the goals of the macroinvertebrate survey of the Myakka River bordering the MCMR were to produce a species list of the infaunal and epifaunal macroinvertebrates of the Myakka River from the southern border of the Myakka River State Park to the suspected region of maximum tidal influence in the vicinity of Snook Haven for the purpose of establishing zones of aquatic invertebrate fauna and determining the presence of any useful indicator organism or areas that could be utilized as future measures in water quality and quantity.

II. METHODS

A. STUDY AREA

The Myakka River is approximately 60 miles in length and drains about 550 square miles of watershed. The focus on this study was the river corridor from the southern border of Myakka River State Park (RM26) in the area of "Down's Dam", extending downstream to Snook Haven (RM8), 1 mile south of the bridge from Interstate Highway 75 (Figure 1). This stretch of waterway is characterized by numerous diverse habitats and hydrologic conditions and is largely undeveloped except for some homes along the most southern region south of Border Road. The substrate in the channel is generally composed of medium to coarse sand with some areas of scoured limestone; whereas, the banks range from vertical cliffs of hard clay mixed with detritus to gently sloping fine sand beaches. Submerged logs and branches are frequently encountered throughout the channel. Although clarity of the water is high, organic acids from bordering river swamps impart a tea color to the water column.

One of the most unique hydrologic characteristics of the Myakka River is a feature described as "zero flow" exhibited during certain times of the year. This pattern is the result of a combination of low dry-season runoff and tidal influence.

For the initial sampling period in early April, three major transects were established across the river: a northern transect at the border of the T. Mabry Carlton Memorial Reserve and the Myakka River State Park; a southern transect just south of I-75 (to correspond with a station previously sampled by ML for comparative purposes); and a middle transect bisecting this section of river (Figure 1). Additionally, two transects were established between the northern and middle transects and the middle and southern transects, respectively.

The exact locations of the transects were based primarily on shoreline vegetation and reflect an average representation of each section of the river. After each transect was established, a permanent marker was placed in the upland just inland of the riverine wetland on the east bank.

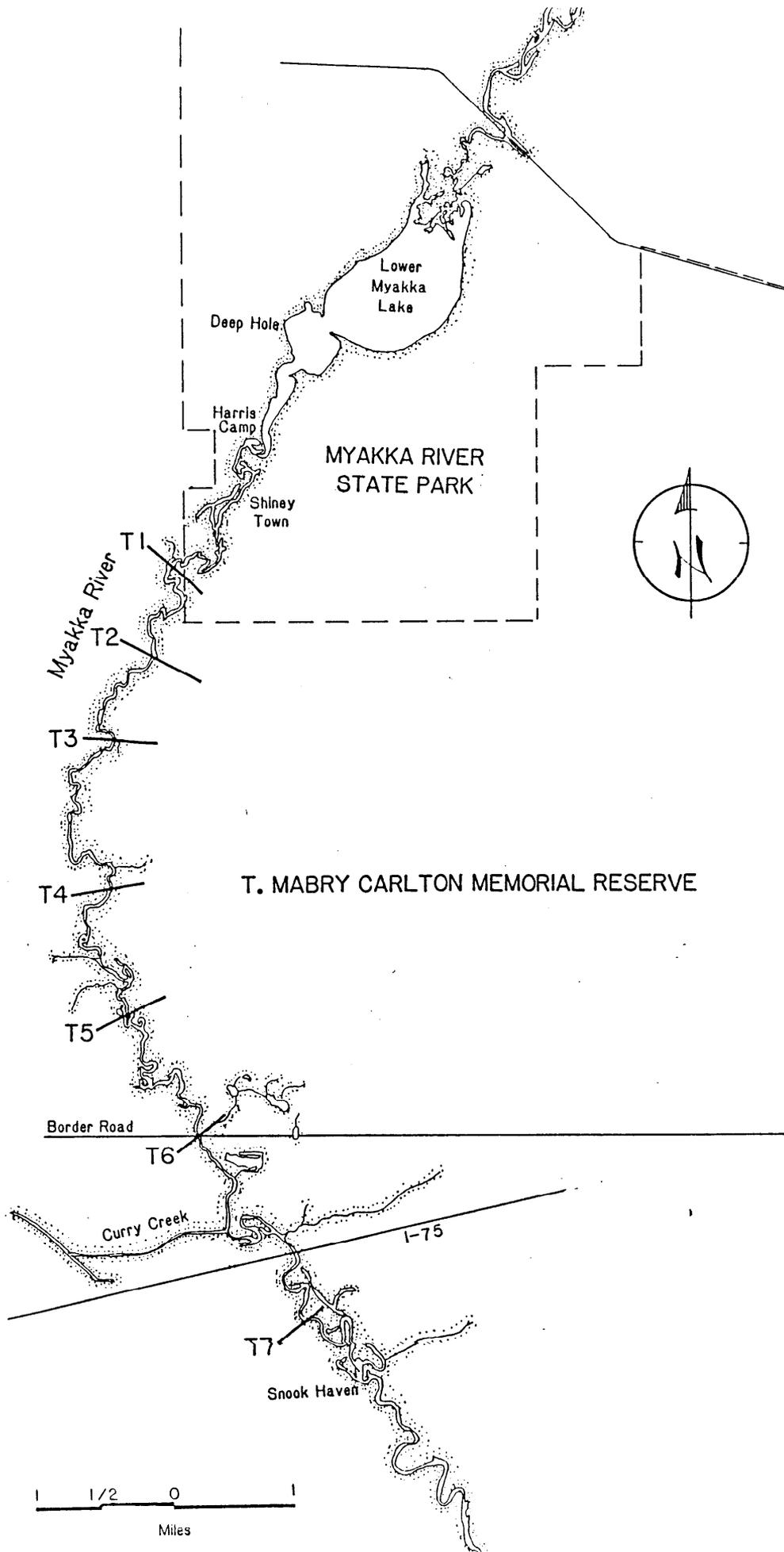


Figure 1. Myakka River Basin macroinvertebrate sampling sites

B. MACROINVERTEBRATES

Macroinvertebrates are those organisms retained on a 0.5 mm screen and are, for the purposes of this study, composed of two components: infauna and epifauna. Infauna are the organisms existing within the bottom sediments. The infauna are composed primarily of oligochaetes, with certain insect larvae frequently abundant but more seasonal in their distribution. Bivalves (primarily *Corbicula*) and crustaceans also frequently comprise a dominant component of infauna.

Epifauna are the organisms associated with the material lying on or attached to the substratum. Mobile insect larvae and crustaceans are generally the predominant components of this habitat. However, certain groups of oligochaetes (*Naididae*) are active swimmers which frequently enter the water column. *Naididae* reproduce primarily by asexual schizogony, producing long chains of zooids, resulting in dramatic population increases in a relatively short period of time.

Analysis of the community structure of both habitats provided valuable information necessary to evaluate long-term environmental conditions in the study area. The stability of certain populations of benthic macroinvertebrates is often indicative of stressful or pristine conditions.

1. Field Collection

a) Infauna

Of primary importance in determining the sampling schedule is to ensure that it corresponds to the wet and dry seasons to ascertain the largest biotic variation. Due to the various reproductive strategies and the ephemeral nature of the aquatic stages of the juvenile insects, a quarterly sampling was considered to be the minimum required to ensure an adequate representation of the macroinvertebrate community.

Historically the minimum stream flow of the Myakka River occurs in April and May; whereas, the maximum river discharge occurs in September. Consequently, the first two collections coincided with these hydrologic responses to the seasonal precipitation.

Two additional collections were made to correspond with the intermediate flow conditions. Samples were collected in November to correspond to the establishment of the low flow condition and also in February

corresponding to the intermediate minimal discharge. Additionally, these collections provided a more comprehensive outlook as to the seasonality of many of the occasionally dominant populations.

Three benthic stations were established on each transect: one station on each side of the river in approximately 1/2 meter of water, and one midstream location. The area in which the greatest faunal variation occurred and was most indicative of adjacent transects was determined after analysis of the benthic samples from the stations on all seven transects. The subsequent sampling, in September, was then concentrated upon only three transects: the northern and southern-most transects, and an intermediate transect based upon the initial faunal investigation. Transect 5, the site of the proposed pipeline crossing, was subsequently selected. Previous investigations have indicated that the infauna associated with the region of the southernmost transect is a combination of oligohaline and freshwater benthos. By initially establishing seven transects, we were able to pinpoint more accurately the extent of the saltwater intrusion by analyzing the macroinvertebrate community.

Analysis of both the shoreline and midstream habitats provided a complete characterization of the benthos. Additionally, historical data indicate that periodic stratification of the river depresses the oxygen levels on the bottom and may produce anoxic conditions. Under these stressful conditions, the benthic community in the middle of the river may die off and sampling this region at that time would yield minimal information. Sampling the shoreline habitats, which are less likely to become anoxic, enabled us to recover healthy benthic communities even during periods of intensive stratification.

An important consideration of the sampling methodology was the type of sampling device employed. Many devices are currently available. Core samplers have been considered to be the most appropriate method for shallow water sampling in a variety of substrates. A diver operated coring (12.5 cm²) device was used to collect the benthic infauna for this study. Because of the patchiness of available sediment in the river channel, it was necessary to use a diver to locate suitable substrate.

The number of replicate samples required to achieve an adequate representation of the benthic community is subject to budgetary constraints and the degree of accuracy required. To determine the degree of accuracy, a species saturation curve is frequently utilized. This analysis was performed for the benthic station corresponding to the proposed southern-most transect collected during the 1985 wet season survey on the lower Myakka River conducted by MML for Sarasota County. Based on this analysis, six replicate samples were required to achieve an adequate representation of the benthic community at each station. In addition to the six replicate samples which were analyzed, two backup samples were collected and archived to be analyzed in the event of sample loss.

After collection, each core was sieved through a 0.5 mm sieve, the residue rinsed into an appropriately labeled jar, fixed with 10% buffered formalin with rose bengal stain, and transported to the laboratory. Samples remained in 10% formalin for 48-72 hours to ensure proper fixation. They were then transferred to 70% isopropyl alcohol for storage prior to laboratory analysis.

b) Epifauna

Modified Hester-Dendy artificial substrate samplers were utilized to analyze epifaunal colonization. This method is approved as an invertebrate collecting technique by the U.S. EPA and has proven to be an important tool in the analysis of the environment based on the macroinvertebrate community structure in previous studies conducted by MML and other investigators.

Two sampling devices were deployed on each transect concurrent with the collection of benthic infauna and subsequently retrieved after two weeks incubation. The samples were then placed in 10% buffered formalin and transferred to the laboratory where they were disassembled and the epizoic growth removed and preserved in 70% isopropyl alcohol. One sample from each transect was analyzed. The replicate sample was archived in the event of sample loss or damage.

c) Qualitative

Information regarding the macroinvertebrate community is frequently lost by strictly adhering to a rigid sampling technique and schedule. To attain a more complete overall evaluation of the entire benthic community,

qualitative sampling of shoreline and submerged habitats which may be unique to a specific area and harbor a distinct community indicative of macroinvertebrates unattainable with the aforementioned sampling devices occurred as time allowed during each sampling event.

2. Laboratory Analysis

After the samples were preserved with 70% isopropyl alcohol, the organisms were sorted from the residue using a variable power stereozoom dissecting microscope, then separated into four categories: oligochaetes, chironomids, mollusks, and miscellaneous taxa. Each group was then identified to the lowest practical taxonomic level (genus and species in most cases) and the data entered on bench sheets. An internal reference collection is maintained to compare and verify all taxa. A separate reference collection of the dominant taxa has been compiled for Sarasota County. This collection is currently being archived at MM and is available to the County on request.

Internal and external labels accompanied each sample immediately after collection. Each label designates project number, station, replicate, date of collection, collection technique, surface area collected, and initials of collector.

All sorted sediment from the samples which have been analyzed will be disposed of pending satisfaction of the generic quality assurance program and acceptance of the final report.

3. Statistical Analysis

Statistical tests were used to determine the variation between stations and detect the seasonal impact on the benthic community structure. For any habitat there are variations in species composition and faunal distribution. Differences of the community structure within the study area are both temporal and spatial. The magnitude of variation about the mean of these parameters may be characteristic of a habitat type. Analysis of these variations provides for a quantitative comparison of the spatial and temporal changes. A variety of statistical analyses are available. The types of community analyses used for this study included Pielou's index for equitability, Margalef's index for species richness, Bray-Curtis index of faunal similarity, Shannon's, Simpson's and Gini's indices for diversity, and faunal densities (no. organisms/m²).

C. BOTANICAL

Field work of the this study was carried out by Brian Winchester of Winchester Environmental Assoc. (WEA) and Reed Beaman of A.F. Clewell, Inc. (AFCI) on 6/27-7/1/89, and by Andre Clewell and Mr. Beaman on 26-27 July 1989.

1. Forest Transects

Forest transects were established at the same seven locations, where MML had established benthic sampling transects in the river. The MML transects were designated as T1 through T7. Transect T5 was also known as the "pipeline transect". PC was the "pipeline control transect", and was located about 200 feet upstream from T5.

The forest transects were perpendicular to the river. Each of the forest transects began at the water's edge and extended across the corridor to the upland on either the east or the west side. The saw palmetto line served to indicate the edge of the upland. Nine forest transects were installed. Those on the east side of the river were T1, T2, T3, T4, T6, T7, and PCE (pipeline control-east). Those on the west side of the river were T5 and PCW (pipeline control-west). Plans called for the establishment of another transect at T5 on the east side of the river. The upland extended to the riverbank on that side, and so there was no place to put a transect.

At each of the transects, the following data were collected:

a) Elevations

Elevations were taken at intervals of 25 feet. Additional elevations were made within these intervals to depict topographic discontinuities, such as levees and swales. Elevation data were measured to the nearest 0.1 ft with a level and rod and were based on an elevation of 0.0 ft at the water's edge. Transect dimensions are given in Table 79.

b) Tree Density and Basal Area

Contiguous 25 by 20 ft quadrats were centered on each transect line and extended the entire length of each transect. (T4 was expanded to 40 feet wide so as to include more trees; other transects would have been expanded, had there been adequate terrain to do so.) Some terminal quadrats adjacent to uplands had lengths of less than 25 feet. All woody plants with diameters at breast height (dbh) of 1 inch or more were tallied. With the exception of

cabbage palms, the diameters of trees that equaled or exceeded 4 inches in dbh were measured to determine basal area. Cabbage palms were excluded, because their boles do not enlarge with age.

c) Vascular Plant Inventory

All vascular plants in the quadrats were identified to species or to the lowest taxon possible above the rank of species. Authorities for scientific plant names follow Wunderlin (1982). Species lists were compiled independently for every quadrat in each transect, with one exception. Plant lists were compiled for nine of the 35 quadrats in T1.

d) Vegetation Cover

Percent cover was estimated visually for arboreal vegetation, collectively, and for undergrowth, collectively, in each quadrat. Mean cover values for arboreal vegetation and undergrowth were calculated for each transect.

2. Shoreline Stations

Twenty-seven shoreline inventory stations were established for the quantification of non-arboreal vegetation. Transects T1 through T7 served as seven of these stations. Eighteen shoreline stations were selected at intervals between T1 and T7. These 18 intermediate stations were designated by the number for the ML transect immediately upstream and are shown on Figure 1. For example, shoreline vegetation stations 4-1, 4-2, and 4-3 lay between Mte transects T4 and T5, and shoreline station 5-0 overlapped transect T5. All of these stations were located on the east side of the river, except 6-1, which was located on the north side of Curry Creek, where it joins the Myakka River. The two final shoreline stations were established on the east and west sides of the river at the pipeline control transect.

At each shoreline station, three parallel lines were established at 10-ft intervals. They began at the water's edge and extended 25 feet inland, perpendicular to the river. The lines were placed within the zone of maximum ground cover and where topographic discontinuities were minimal. Non-arboreal species abundance was quantified by point-interception at 1-ft intervals along each line for a total of 78 points per station. This method provided data compatibility with a previous ML study on the Myakka River downstream of I-75. Woody plants were included in the data, as long as their stems were

less than 1 inch in dbh and displayed foliage within the ground cover, i. e., within 5 ft of the ground. If no vegetation existed at a given point, "bare soil" was recorded.

3. Vegetation Reconnaissance and Map

Vegetational reconnaissance was made along the river from Snook Haven to the dam below Lower Lake Myakka. Written and taped notes were made and were summarized in a Narrative Report, which is attached as Appendix 1. These notes were consulted during preparation of the Vegetation Map (attached to report).

III. PHYSICAL PARAMETERS

Concurrent with benthic surveys, midstream measurements of dissolved oxygen, temperature, conductivity, and salinity were taken at the surface, mid-depth, and bottom. Dissolved oxygen and temperature were determined using a YSI dissolved oxygen meter model 57; conductivity and salinity measurements were determined using a Beckman salinity, temperature, conductivity meter model RS5-3.

All measurements were collected *in situ* concurrent with the benthic collections and are presented in Table 1. Where midchannel depth was less than 1 meter, only the mid-depth measurements were recorded.

A. TEMPERATURE

Temperatures ranged from a low of 18° in February (Transect 1) to a high of 29° in September (Transects 1 and 5). The coldest average temperature for all transects on the river (20.5°C) was in November, whereas the warmest average river temperature (29.1°C) corresponded with the September collecting period. The greatest variation in temperature between transects for any given sampling period was in February when Transect 1 was 6° and 7° colder than Transects 5 and 7, respectively. However, this discrepancy could be accounted for by the lag period between sampling the respective transects. Transect 1 was sampled one week after collections from Stations 5 and 7. During that period a substantial amount of rainfall and associated cold front combined to cause the rapid decrease in temperature.

Vertical temperature stratification was minimal at all respective stations. Only at Station 5 in February was there a difference of more than 0.5°C between the surface and bottom and even then, the difference was still less than 1.0°C.

B. DISSOLVED OXYGEN

Dissolved oxygen measurements ranged from a low of 1.90 ppm at Transect 1 in September to a high of 9.7 ppm at Transect 1 in February. These extremes corresponded to the highest and lowest temperatures, respectively.

Although some degree of vertical stratification was noticeable at all locations, with the bottom measurements being the lowest for each sampling period, the differences were minimal and generally lower than 0.6 ppm between surface and bottom. The greatest difference occurred in September at Transect 7 with a difference of 0.8 ppm, whereas the water column at Transect 1 in February appeared to be fairly mixed, exhibiting no variation between surface and bottom measurements.

Transect 1 had the lowest average measurements during the April, September and November collections, and the highest measurements in February. The high reading at Transect 1 in February could be correlated to the correspondingly low temperatures at that station during that period (see Section IVA, Temperature).

C. SALINITY

Salinity readings at all stations in the study area were negligible, in all cases being less than 1.0 o/oo. Most of the measurements were less than 0.2 ppt. The highest salinity readings were recorded in April with an overall average for all stations being 0.5 ppt.

Vertical stratification of salinity throughout the water column was generally insignificant and displayed no apparent trends. Only at Transect 5 in February was there any indication of the possibility of a salt wedge, although it was extremely slight with about a 0.5 ppt difference between surface and bottom

IV. MACROINVERTEBRATE INVENTORY

A. RESULTS

1. Substrate Characterization

Substrate characterization of each station in the study area was determined by direct observation. Throughout the course of the study the substrate at all locations exhibited little, if any variation.

The Myakka River is a heterogenous mixture of a variety of habitats. Bottom sediment ranged from scoured limestone to hardpan clay scarps. Upstream regions of the study area were frequently characterized by coarse gravel sediments mixed with relict mollusk shells. Downstream, the main channel was primarily composed of medium to coarse sand, while the shoreline habitats were extremely variable. Following is a description of the various habitats encountered during this study. This characterization is a compilation of all field observations recorded at the time of collection. The variation of the depth given for each station is a reflection of variable river flow between the wet and dry seasons.

Transect 1

This location was immediately upstream of "Down's Dam". The river was approximately 30 meters wide at this point.

West bank: characterized by a marsh encroaching into the river. The substrate was mud mixed with large amounts of detritus and contained a small percentage of fine sand.

Midchannel: scoured limestone with pockets of coarse sediment and detritus. Numerous relict *Corbicula* shells were frequently encountered. A very large dead tree was submerged in the middle of the channel. Depth, 2-4 meters.

East bank: very steep with a great deal of overhanging vegetation. The sediment was fine to medium sand with some areas rich in detritus.

Transect 2

The river was about 4 meters wide at this transect.

West bank: cattails abundant along the shoreline. The substrate was soft mud. *Corbicula* shells were abundant.

Midchannel: scoured limestone with pockets of coarse gravel and medium sand. Depth, 0.5-1 meter.

East bank: Overhanging vegetation. The substrate was scoured limestone with pockets of coarse sand and detritus.

Transect 3

The river width was about 12 meters.

West bank: Overhanging vegetation. Substrate was coarse sand and shell with some detritus.

Midchannel: Sediment was coarse sand and gravel. Depth, 0.5-1 meter.

East bank: Grassy meadow leading to water's edge. Substrate was fine sand mixed with detritus.

Transect 4

The river was about 20 meters across at this transect.

West bank: grassy meadow leading to water's edge. Some overhanging vegetation. Sediment was fine sand.

Midchannel: Sediment was medium-fine sand. Depth, 0.5-1 meter.

East bank: Very steep bank with overhanging vegetation. Sediment was coarse sand. A small stream entered the river immediately upstream of the transect.

Transect 5

The river was about 20 meters across at this transect. This transect was located at the proposed pipeline crossing.

West bank: Sandy bank with a moderate slope. Sediment was fine sand.

Midchannel: Sediment was medium-fine sand mixed with small *Corbicula*. Depth, 2-4 meters.

East bank: Precipitous slope leading into river. Dead tree in water immediately downstream of transect. Sediment was fine sand.

Transect 6

The river was about 30 meters across at this location. This transect was located approximately 40 meters upstream of Border Road Bridge.

West bank: Very rocky scoured limestone ledge which drops off suddenly about 2 meters from the bank. Some overhanging vegetation. Pockets of coarse sand and gravel periodically encountered.

Midchannel: Scoured limestone with scattered patches of medium fine sand. Depth, 3 meters.

East bank: Abundant overhanging vegetation. Dead log in water in immediate vicinity. Shoreline was a very steep slope. Sediment was fine sand with a small amount of detritus. A small tributary entered the river just upstream from the transect.

Transect 7

The river was very wide at this point, about 60 meters across. This transect was located immediately upstream from Snook Haven.

West bank: Very steep with overhanging vegetation. Sediment was hard clay with small amounts of fine sand and detritus.

Midchannel: Sediment was coarse sand mixed with detritus. Depth, 2-3 meters.

East bank: Clean sandy bank with gentle slope leading into river. Sediment was fine sand.

2. Community Analysis

A total of 213 taxa was collected from all stations during the course of this study. Six phyla were represented: Cnidaria, Platyhelminthes, Annelida, Mollusca, and Arthropoda (Table 2). Two hundred taxa were represented in the infaunal analysis, whereas 82 epifaunal taxa were collected using the Hester-Dendy artificial substrates. Thirteen taxa were unique to the epifaunal community.

a) Infaunal Composition

Of the six phyla representing the infaunal community in the study area, Arthropoda was the most species-rich phylum comprising almost two-thirds (65%) of all taxa collected over the duration of the study. Insecta was the most diverse class of arthropods, primarily due to a single family, Chironomidae (Diptera), represented by 62 taxa. Chironomids accounted for almost one-third (31%) of all individuals collected during the study (Table 3). Three taxa (*Polypedilum halteres*, *Cladotanytarsus* and *Tanytarsus* sp.) were the third, fourth and fifth most abundant, respectively, over the course of the study, representing almost one-fifth of all organisms collected (Table 4). Although *Cryptotendipes*, *Cryptochironomus*, and *Dicrotendipes* were

frequently encountered, none of the remaining chironomids comprised in excess of 1% of the overall infaunal community.

Six additional orders of insects were also represented (Collembola, Ephemeroptera, Odonata, Hemiptera, Coleoptera, and Trichoptera), but were generally sporadic in their occurrence with the exception of three taxa: *Caenis*, (Ephemeroptera), *Dubiraphia* (Coleoptera) and *Oecetis* (Trichoptera). These taxa were fairly common throughout the study, being collected at most locations during each respective sampling period, frequently occurring in relatively high densities. Collembola was the least abundant order of arthropods accounting for less than 0.2% of the fauna collected during this study.

Crustacea was the second most diverse class of Arthropoda with 21 taxa. Five orders were represented; Amphipoda (7 species) contributed the highest diversity, with two species, *Hyallela azteca* and *Gammarus palustris* being the most frequently encountered; however, *Podocopa* (Ostracoda) was one of the most dominant organisms collected during the study, representing more than 5% of the total fauna (Table 3). None of the remaining orders (Mysidacea, Isopoda, or Decapoda) contributed in excess of 0.05% of the overall community.

Annelida was the second most species-rich phylum, with 30 taxa. Although two classes were present in the study area, Polychaeta rarely occurred. Only 62 polychaetes were found throughout the course of the study represented by three taxa.

The second class, Oligochaeta, was the most abundant group of organisms encountered during this investigation, comprising 30% of the total number of individuals collected (Table 3). Five families were represented in the study area: Tubificidae, Naididae, Enchytraeidae, Lumbriculidae, and Opisthocyttidae. Naididae was the most diverse family, with 17 taxa comprising 6% of the total fauna (Table 3). *Nais pardalis* accounted for about one-half of all naidids collected, accounting for 4% of the total fauna (Table 4). The remaining 16 taxa were sporadic in their occurrences, with only *Pristina synclites* contributing in excess of 0.3% of all organisms collected.

Tubificidae was the second most diverse family of oligochaetes in the study area represented by three species: *Aulodrilus pigueti*, *Haber speciosus* and *Limnodrilus hoffmeisteri*. *Aulodrilus pigueti* and *Haber speciosus* could

be identified from immature specimens. Whereas the former taxa occurred infrequently, comprising less than 0.2% of the total benthos, *H. speciosus* was somewhat more abundant, comprising slightly greater than 0.1% of all organisms collected (Table 4). The remaining species, *L. hoffmeisteri* could only be identified when mature. As a result, the immature forms were simply identified as "immature Tubificidae without capilliform setae". However, no other species with similar somatic characters were identified during the course of this study. Therefore, these immature forms were in all probability *L. hoffmeisteri*. If the specimens considered to be *L. hoffmeisteri* (imm Tubificidae w/out) are combined with the verifiable specimens, this species then becomes the most abundant organism collected, comprising 22% of the total number of individuals in the study area.

The latter three families of oligochaetes, Opisthocystidae, Enchytraeidae, and Lumbriculidae, were rarely encountered. The former two families were each represented by a single taxon with 31 and 9 organisms collected throughout the study respectively. Lumbriculidae was represented by two species, *Eclipidrilus palustris* and *Lumbriculus variegatus*. Neither taxa comprised in excess of 0.01% of the total benthos with *E. palustris* being slightly more abundant.

Mollusca was the third most diverse phylum, represented by three families of bivalves and gastropods respectively. Bivalvia was the third most abundant class of organisms during this study, comprising 24% of all individuals collected. One species, *Corbicula manilensis* was primarily responsible for this dominance, and was the most abundant organism encountered in the Myakka River, comprising 21% of all fauna. Although in certain stretches of the upstream area the substratum was littered with numerous dead valves of *Elliptio buckleyi*, live specimens of this species were only collected infrequently. The fingernail clams, Sphaeriidae, were represented by *Pisidium* and *Sphaerium partunium*. Both were relatively abundant accounting for about 3% of the total fauna. Of the remaining bivalves encountered, *Rangia cuneata* was occasionally found, whereas only three individuals of *Crassostrea virginica* were identified. The presence of the latter species was a single isolated incidence and may have been the result of anthropogenic influence, i. e., scraped off the hull of a boat.

Gastropoda was a fairly diverse group in the study area, represented by 21 taxa within six families. However, the combined occurrences of all taxa contributed less than 0.1% of the benthic fauna in the study area. Hydrobiids accounted for approximately one-quarter of all snails collected, whereas the remaining gastropod taxa were rarely collected.

The three remaining phyla (Platyhelminthes, Nemertea and Cnidaria) were each represented by a single taxon and collectively comprised less than 1% of all organisms collected. Of these three phyla, Platyhelminthes, represented by Tricladida (probably *Dugesia tigrina*), was the most frequently encountered, whereas Cnidaria, represented by *Hydra* sp., was the least abundant with only a single individual recorded over the entire study.

b) Comparison of Transect Communities

Seven transects were established in the Myakka River study area (Figure 1). All transects were sampled in April to provide an overview of the benthic community within the study area. Transects 1, 5 and 7 were subsequently sampled in September, November, and February to determine temporal variation. Three stations were established on each transect: Station a near the west bank of the river; Station b in the channel; and Station c near the east bank. Following is a description of the infaunal community on each transect.

Transect 1

Over the course of this study, Transect 1 had the highest overall cumulative number of taxa. A total of 121 taxa was identified from Transect 1 during this study (Table 5). Insects accounted for more than half (73) of the total number of taxa identified at this transect, with Chironomidae being the most species rich complex. Oligochaeta was the next most diverse group represented by 20 taxa. All species of Tubificidae encountered throughout the study area were collected at this transect, while 13 of the 20 total taxa of Naididae were also present. The third most diverse faunal assemblage was the mollusks with twelve taxa. Almost one-half (10) of all gastropod taxa collected from the study area were identified at this location. While two species of bivalves were identified from Transect 1, the complete absence of *Corbicula manilensis*, frequently the dominant species at the other transects, was notable.

The total number of individuals collected from all stations and all dates combined during this study was 12,640 organisms (Table 5). Insects accounted for one-half of all individuals collected, primarily represented by three taxa of chironomids: *Polypedilum halteres* (11%), *Tanytarsus* sp. (9%), and *Cladotanytarsus* sp. (6%) (Table 6). However, one species of oligochaete, *Limnodrilus hoffmeisteri*, combined with the immature forms, accounted for more than one-third (34%) of the total benthos on Transect 1. The Ephemeroptera, *Caenis* sp., comprised the remaining majority of the total fauna encountered on this transect.

The greatest number of taxa (89) and highest densities (4,675 organisms) on Transect 1 were collected during the April sampling period (Table 7). In the subsequent sampling, September, both the number of taxa and density decreased by one-half of April's totals (Table 8). This decrease was attributed to a sudden decline of the chironomid community. However, a gradual increase of both taxa and density of Chironomidae occurred in November (Table 9), and again in February (Table 10). The species composition and density of the second major group, Oligochaeta, followed this same general trend, except for September which had the lowest number of taxa, due to a decrease in Naididae, but the highest density, due to an increase of *L. hoffmeisteri*.

There was a slight difference between stations in overall densities. While the shoreline stations (a and c) had remarkably similar densities [4,421 vs. 4,492 organisms, respectively (Table 6)], the density at the channel station was somewhat lower (3,727 organisms). The dominant organism at all three stations in April (Table 11), September (Table 12) and November (Table 13) was the immature form of *L. hoffmeisteri*. However, in February, the chironomids *Tanytarsus* sp. and *Polypedilum halteres* predominated at Stations b and c, respectively (Table 14).

This transect could be differentiated from all other transects by the total absence of *Corbicula* during each sampling period [Tables 15-18]. Transect 1 could be characterized by a benthic community dominated by *L. hoffmeisteri* with the chironomids, *Polypedilum*, *Tanytarsus* and *Cladotanytarsus* and the mayfly, *Caenis*, comprising the majority of the remaining fauna.

Transect 2

This transect was only sampled in April, at which time eighty-seven taxa were identified. The breakdown of the fauna by major groups was very similar to Transect 1 in April, both with regards to taxonomic composition and, with few exceptions, number of organisms per major group. As at Transect 1, insects accounted for two-thirds (66%) of the total taxa, with Chironomidae being the most diverse group (Table 19). The species composition of the second and third major group, Oligochaeta and Mollusca, was almost identical, with 14 taxa and 11 taxa, respectively. The one major difference was the presence of *Corbicula*, the dominant organism at Transect 2.

The total number of individuals collected during the singular sampling was 7,616 combined from all three stations. The number of organisms comprising the respective major groups (Naididae, Tubificidae and Chironomidae) was very similar to those at Transect 1 in April. The major difference was the dominance of bivalves, primarily *Corbicula* at Transect 2. While *Corbicula* comprised 18% of the total benthos, another bivalve, the fingernail clam *Sphaerium partunium* was the fifth most abundant taxon, comprising 8% of the fauna (Table 20). This small clam was found rarely at Transect 1, comprising less than 0.5% of the fauna.

The density of the predominant group, Chironomidae, at this transect was remarkably similar to that of Transect 1, each with slightly more than 2,800 organisms. As at Transect 1, the most prevalent midges were *Polypedilum halteres*, *Cladotanytarsus* sp., *Tanytarsus* sp., and *Dicrotendipes neomolestus*, with their highest density occurring at the western shoreline station, 2a. The mayfly genus, *Caenis*, was again dominant at this transect comprising 6% of the total fauna, however, the densest populations were found at the midstream and east bank stations where the midge densities were lowest.

The immature form of *L. hoffmeisteri* was the second most abundant taxon with the largest populations occurring at the shoreline Stations 2a and 2c, with 568 and 498 organisms, respectively. Although the Naididae was fairly diverse with nine taxa, the density did not exceed 3% of the total fauna.

Except for the preponderance of *Corbicula*, this transect was similar to Transect 1, and could be characterized by a similar community of dominant taxa comprised of *L. hoffmeisteri*, *Cladotanytarsus*, *Polypedilum*, *Tanytarsus*

and *Caenis*. Additionally, the presence of *Sphaerium partunium* as a predominant taxon at Transect 2 was another differentiating factor.

Transect 3

This transect was also sampled only in April. The total number of taxa was 78 with the number of taxa within each major group closely reflecting that found at Transects 1 and 2. Insects were again the most diverse group comprising more than half (51%) of all taxa identified, with Chironomidae being the most diverse group (Table 21). The species composition of the second and third major groups, Oligochaeta and Mollusca was also similar with 15 and 13 taxa, respectively. As at Transect 2, *Corbicula* was the most abundant species comprising one-third of all fauna collected (Table 22).

The total number of organisms at this transect was substantially greater than at Transect 2, with 10,744 organisms. The total number of organisms within each major group also increased. However, the major factor for the overall increase was the profusion of *Corbicula* which had a population almost three times that of Transect 2 with 3,641 individuals. However, the number of the other dominant bivalve, *Sphaerium partunium* was almost half of what it was at Transect 2, but still comprised over 3% of the total benthos. Although insects represented 27% of the benthic fauna at this transect, Chironomidae only accounted for 9% of all organisms collected. This was a substantial decrease from Transect 2. The most abundant insect at this transect was the mayfly, *Caenis*, comprising 7% of the benthic community with 800 individuals. Although *Cladotanytarsus* and *Polypedilum halteres* were again dominant chironomids at this transect, *Cryptotendipes* comprised a substantial portion of the chironomid community. The number of Ceratopogonidae also increased from Transect 2 comprising 4% of the benthos.

Oligochaetes comprised 19% of the total benthos at Transect 3, with immature *L. hoffmeisteri* again the dominant taxon. However, another species, *Haber speciosus* became very abundant, comprising 3% of the total fauna, and was more abundant at this transect than anywhere else in the study area. Similar to Transect 2, naidids were diverse with 10 taxa, but comprised only 4% of the benthic community, and, as at Transect 2, the dominant naidid was *Pristina synclites*. The density of *L. hoffmeisteri* was greatest at the shoreline stations exhibiting the same trend as Transect 2. However the

largest concentration of the other dominant oligochaete, *Haber speciosus* occurred at the midstream station.

The composition of the predominant species at Transect 3 was similar to that of Transect 2. *Corbicula* was the predominant taxon with the majority of the remaining community comprised primarily of Podocopa, *L. hoffmeisteri*, *Cladotanytarsus*, *Caenis*, *S. partumeium* and *P. synclites*. However, the substantially larger densities of *Haber speciosus* and Ceratopogonidae serve to differentiate this transect from Transect 2.

Transect 4

Samples were only collected from this transect in April. This was the most species-poor transect in the study area, with only 44 taxa reported. The number of taxa which was identified within each major group reflected this low diversity. As at all upstream transects, insects comprised more than half (55%) of all taxa collected. However, the actual number represented only about half (24) of that recorded from Transects 1, 2 and 3, respectively. Chironomids were once again the most diverse group of insects identified (Table 23). Oligochaetes and mollusks had the second and third greatest numbers of taxa with nine and eight, respectively. But, again, those were only about half the number of the upstream locations. This decrease was primarily due to the decrease in the number of naidid and gastropod species, respectively. Although *Corbicula* was again a dominant species here, comprising 21% of the fauna, it ranked second behind the chironomid, *Cladotanytarsus*, which comprised 23% (Table 24) of the benthos.

The overall density at this transect was also the lowest in the study area, with only 2,734 organisms collected. Although all the major groups were less abundant on this transect (Table 23), the sharp decrease from 3,641 individuals of *Corbicula* at Transect 3 to 583 individuals at Transect 4 (Table 24) was primarily responsible for this low density. The other bivalve, *S. partumeium* a dominant species at Transect 2 and 3, was practically non-existent at this location, with only seven individuals identified from the 18 samples analyzed. Insects comprised almost half (48%) of all organisms collected on this transect. Chironomidae was the largest group, representing 36% of all the total benthos. The total number of midges collected at this transect (982) was very similar to the number recorded at Transect 3. This

represents about half of the densities at Transects 1 and 2. The dominant chironomid at this transect was also *Cladotanytarsus*, and was also the most abundant taxon. *Polypedilum halteres* was the fourth most abundant taxon, comprising 6% of the benthos. However, *Cryptochironomus fulvus* replaced *Cryptotendipes* as the third most dominant midge on this transect. Another insect, *Ceratopogonidae*, also contributed substantially to the overall density, comprising more than 5% of the total fauna. Although the mayfly, *Caenis*, was collected at Transect 4 and comprised 2% of the fauna, the density was much lower than at any of the upstream transects (Table 15).

Oligochaeta comprised 29% of the fauna; however, the density was less than half (791 organisms) than that at Transects 2 and 3. A sharp decrease in the number of immature *L. hoffmeisteri* was primarily responsible for this low overall density. As at Transect 3, *Haber speciosus*, was the second most abundant oligochaete, comprising 3% of the community. The diversity of naidids was lower on this transect than anywhere else in the study area. The dominant naidid was *P. synclites*; the same as at Transects 2 and 3.

The only major difference with regard to the benthic communities between stations on this transect was evident in the populations of *Cladotanytarsus* and *L. hoffmeisteri*. Both taxa occurred in highest densities along the western shoreline. The only other major difference regarding the dominant taxa was that *Corbicula* was more abundant at the midstream station, and the largest population of *Polypedilum halteres* was collected at the shoreline stations.

This transect could be characterized by the lowest density and species richness of any location in the study area. The dominant taxa remain basically the same as at Transect 3, but the order of abundance differed. The most obvious difference was the low number of *Corbicula* and *L. hoffmeisteri*. The reduction in the density of *Tanytarsus*, *Caenis*, *S. partunium* and Podocopa also serve to differentiate this location from Transect 3.

Transect 5

This transect was sampled in April, September, November and February. A total of 95 taxa were identified during the course of this study (Table 25). At all upstream transects, insects accounted for about half of all taxa identified (49%) with chironomids being the most diverse group. Mollusca was

the most species-rich complex. Gastropods were primarily responsible for this richness, with 13 taxa identified.

Oligochaeta was the next most diverse assemblage with 16 taxa. Naididae was primarily responsible for this diversity, accounting for 12 taxa.

The largest number of organisms recovered in the study area was at Transect 5. For all stations on this transect and dates combined, the total number of individuals was 18,718 (Table 25). Mollusks were primarily responsible for this high density. A single species of clam *Corbicula manilensis*, was the most abundant taxon at this transect throughout the study, accounting for almost half (48%) of all organisms recovered (Table 26). Insecta was the second most abundant group, representing approximately one-third of all organisms collected during this study (Table 25). This high density was attributed to the Chironomidae, which comprised one-fifth of the total fauna. Three chironomid taxa, *Cladotanytarsus* sp., *Tanytarsus* sp. and *Polypedilum halteres* were ranked as the third, fourth and fifth most abundant organisms throughout the study, comprising a cumulative total of 17% of the total benthos (Table 26). *Limnodrilus hoffmeisteri* together with the immature forms of Tubificidae was the second most abundant taxon, accounting for 16% of the fauna of this transect. The remaining majority of the benthic community was primarily composed of two insects: the mayfly, *Caenis*, and the biting midges, Ceratopogonidae. However, a beetle larva, *Dubiraphia*, and a naigid, *Nais pardalis*, periodically formed substantial populations at this transect, and were ranked as the ninth and tenth most abundant taxa overall.

Fifty taxa were represented in the April collection on Transect 5 (Table 27). More than half were insects, with Chironomidae representing 30% of all taxa. The second and third most diverse groups were mollusks (10 taxa) and oligochaetes (eight taxa), respectively. The total density in April was fairly evenly divided between three major groups: Insecta (primarily *Caenis* with 1,265 organisms, Bivalvia (primarily *Corbicula*) with 1,042 organisms, and Oligochaeta (primarily, *L. hoffmeisteri*). However, *Corbicula* was by far the single most abundant taxon, comprising 29% of the total fauna.

In September the density of total benthos decreased to less than one-third of what it was the previous sampling period with a corresponding decrease of species richness. The lowest density within the study area

occurred at this transect in September. Only 1,070 organisms, representing 21 taxa, were collected at that time (Table 28). The total absence of naidids and a depauperate insect fauna were responsible for the low density. The primary factors responsible for the reduction in density were also due to the reduction of insects and a substantial decrease of the *Corbicula* population. However, the number of Tubificidae (*L. hoffmeisteri*, almost exclusively) remained virtually unchanged.

In November, both the density and number of taxa more than doubled (Table 29). The reoccurrence of the insect fauna and a substantial increase of *Corbicula* were primarily responsible, although the oligochaete community did not exhibit any substantial differences.

In February, both the density and faunal richness again increased. In contrast to the September collection, which had the lowest faunal density in the study area, the largest number of organisms was collected at Transect 5 in February with 11,473 organisms (Table 30). The primary factors for this increase were once again *Corbicula*, comprising 58% of the fauna, and insects, representing the majority of the remaining benthic community. However, the density of tubificids did increase substantially for the first time, with a corresponding increase in the diversity and abundance of naidids (Table 30). The seasonal trend with respect to changes in faunal density at this transect was similar to that observed at Transect 1, i.e., a dramatic decrease in overall density from April to September, then increasing through November to February. However, the dominant organisms responsible for these seasonal fluctuations were not the same. *Corbicula* was the single most determinate taxa responsible for the density alteration at Transect 5, whereas it was totally absent at Transect 1. Conversely, *L. hoffmeisteri* was the determining factor regarding seasonal density differences at Transect 1, whereas its population remained relatively stable throughout the course of this study at Transect 5.

The overall density of total organisms between stations on Transect 5 was extremely variable. The west shoreline (Station a) had the highest density (9,436 organisms), whereas the east shoreline (Station c) had the lowest density (2,632 organisms). The density at the midstream station (Station b) was intermediate between the shoreline stations during each

sampling period. Although the composition of dominant fauna at each station were similar, the order of abundance of the dominant taxa was considerably variable.

In April *Caenis* and *Corbicula* were the two predominant organisms at Station a. However, *L. hoffmeisteri* was also considerably abundant, ranking third (Table 31). At Station b, *Corbicula* was the most abundant taxon, while at Station c, *L. hoffmeisteri* (immature forms) predominated. In September *L. hoffmeisteri* was the most abundant species at the shoreline stations, whereas *Corbicula* remained the most abundant taxon at Station b (Table 32). In November, *Corbicula* predominated at Stations a and b, whereas *L. hoffmeisteri* was still the most abundant at Station c (Table 33). In February *Corbicula* remained the dominant taxon at Stations a and b, and *L. hoffmeisteri* also maintained its status as the number one taxon at Station c (Table 34).

The composition of the dominant fauna at Transect 5 was similar to that of Transect 4 and could be characterized by a community primarily composed of *Corbicula*, *L. hoffmeisteri*, *Cladotanytarsus*, *Tanytarsus* and *Polypedilum halteres*. The major differentiating factor between these two transects was the preponderance of *Corbicula* and the greater abundance of *Tanytarsus* at Transect 5.

Transect 6

Samples were only collected from this transect in April. Sixty-six taxa were represented. As at all upstream transects, Insecta was the most diverse fauna, comprising 53% of the total taxa (Table 35) and was primarily composed of chironomids with 22 taxa. Oligochaetes and mollusks had the second and third most diverse fauna with 15 and nine taxa, respectively. The faunal composition of this transect was similar to Transect 4 in April, except that naidids and insects were represented by more taxa at the former transect.

The faunal density at Transect 6 was more than twice that of Transect 5 in April. The only other transect which had a larger density in April was Transect 3 where *Corbicula* overshadowed all other organisms, accounting for more than 38% of the total benthos. At Transect 6, *Corbicula* was not a major factor, comprising only 1% of the fauna with 89 individuals collected (Table 36).

Insects were the most abundant organisms at Transect 6, accounting for more than half of all organisms identified (53%). Chironomidae was responsible for the majority of this abundance, comprising more than one-third of the total benthos. One genus of midge, *Tanytarsus*, was the dominant organism at this transect, making up 23% of the total fauna. However, *Polypedilum* and *Pseudochironomus* were the sixth and ninth most abundant taxa, representing 5% and 2% of the benthic community, respectively. The second most abundant insect family at Transect 6 was Ceratopogonidae, which ranked as the third most abundant taxon overall (Table 36). Although biting midges commonly occurred throughout the study area, they were most prevalent at Transect 6, comprising 12% of the fauna with almost 1,000 organisms.

An insect commonly occurring as a dominant component of the upstream benthic communities was the mayfly, *Caenis*. Although present at this transect, it comprised only 1% of the fauna, whereas another mayfly, *Brachycercus*, was twice as abundant.

Oligochaeta was the second most abundant class, comprising 38% of all organisms collected. This group was more abundant at this transect than anywhere else in the study area during any sampling period. *L. hoffmeisteri* (primarily the immature forms) was primarily responsible for this high density. As at Transect 5 in April, the second most abundant tubificid in the study area, *Haber speciosus*, was rarely found. Naididae was fairly diverse at this transect and comprised a significant portion of the total benthos. Two species were primarily responsible, *Nais pardalis*, and *Pristina synclites*, ranking as the fourth and fifth most abundant taxa, respectively. The combined populations of these two worms accounted for 15% of the total benthos and was responsible for 91% of all naidids collected. *N. pardalis* was also the predominant naidid at Transects 4 and 5, replacing *P. synclites* which was the most abundant naidid at Transects 1, 2 and 3.

Mollusca was the third most abundant group of organisms at Transect 6. However, it comprised only 6% of the total benthos with *Corbicula* responsible for 20% of all mollusks collected. This was a sharp decrease from Transect 5 in April where there were over 1,000 individuals collected, as opposed to the 89 collected at Transect 6. The most abundant mollusk at this transect was the fingernail clam, *S. partunium* which comprised 3% of the total fauna.

This bivalve was also abundant at Transects 2 and 3, but was only rarely encountered at Transects 4 and 5.

Transect 6 could be characterized by high densities of *Tanytarsus* and *L. hoffmeisteri* with significant populations of Ceratopogonidae, *N. pardalis*, *P. synclites*, and *S. partumeium*. Additional major differentiating factors distinguishing the benthic community at this transect, was a low density of *Corbicula*, and the replacement of *Caenis* with *Brachycercus* as the most abundant Ephemeroptera.

Transect 7

Samples were collected on this transect in April, September, November and February. A combined total of 79 taxa was identified from all four sampling periods (Table 37). Insecta was the most diverse faunal assemblage, comprising half of all taxa collected. Chironomids accounted for the majority of insects, representing one-third of all taxa collected from Transect 7. Oligochaeta was the second most diverse group with 12 taxa. Naididae was primarily responsible for the high diversity of this group. Mollusca was the third most species-rich complex, represented by 11 taxa: 5 gastropods and 6 bivalves.

Of the three transects sampled quarterly (1, 5 and 7), the lowest number of taxa and total faunal density for all dates combined were found at this transect (Table 37). The total number of individuals identified during the course of this study at Transect 7 was 9,097.

Unlike most of the other locations in the study area (except Transects 1 and 6), *Corbicula* was not usually considered as a major component of the benthic community (Table 38). Oligochaetes accounted for half of all organisms collected during this study. *L. hoffmeisteri*, combined with the immature forms, was responsible for at least one quarter of the faunal community during each collection, and in September comprised almost two-thirds of the total benthos. Another oligochaete, the naidid, *Nais pardalis*, was sporadic in its appearance; however, it ranked as the fourth most abundant taxon overall, primarily because of large populations found during the April and February sampling periods.

Insecta was the second most abundant group, accounting for 41% of all organisms collected. Three chironomids, *Polypedilum halteres*, *Cladotanytarsus*

sp., and *Tanytarsus* were primarily responsible for this abundance, comprising 28% of the benthic community. These midges ranked as the second, third and sixth most abundant taxa, respectively, during the study. Another insect, Ceratopogonidae sp., was also a dominant component, ranking as the fifth most abundant taxon, comprising 4% of the benthos overall.

Although mollusca was the third most abundant group, it only accounted for 6% of the total fauna. A single species, *Corbicula manilensis*, was primarily responsible for this abundance, comprising about half of all mollusks collected.

Fifty-one taxa were represented in the April collection on Transect 7. More than half (55%) of all taxa identified at that time were insects, with chironomids accounting for 21 of the 28 insect taxa (Table 39). The second and third most diverse taxa were oligochaetes and mollusks, accounting for eight and six taxa, respectively.

Oligochaeta was the most abundant group collected in April, representing 53% of the 5,111 organisms identified. *L. hoffmeisteri* was the single most abundant species at that location, accounting for more than one-third of the benthic community. *Nais pardalis* was ranked as the second most abundant species, comprising 15% of the fauna.

Insecta was the second most abundant group in April, primarily composed of three taxa, *Polypedilum halteres*, *Cladotanytarsus* sp., and Ceratopogonidae sp., which ranked as the third, fourth and fifth dominant organisms, respectively.

In September both the number of taxa and total density decreased. Only 34 taxa were identified. A reduction in the number of naidids and chironomids were the principal factors for the decrease in species richness (Table 40). The number of mollusk taxa decreased slightly to a total of five, from six previously recorded in April.

The decrease in faunal density from 5,111 organisms in April to 556 organisms in September was primarily the result of a reduction of chironomids. A substantial decrease of the oligochaete community also occurred in September, primarily resulting from the almost total loss of naidids, but the greater reduction of chironomids resulted in oligochaetes comprising almost two-thirds of the benthos. For the first (and only) time, another group of

annelids, Polychaeta, was a dominant factor in the benthic community. The sudden appearance of *Laeonereis culveri* in September accounted for 7% of the fauna (Table 40). As with the other major groups, mollusks also exhibited a marked decrease in density, from 302 organisms in April to only 35 individuals collected in September. A reduction of Hydrobiidae and Sphaeriidae were responsible for this decrease.

In November the faunal density tripled from that of September, while the richness increased less dramatically. An increase in both number of taxa and abundance of all three major groups contributed to this increase. Forty-two taxa were collected in November (Table 41) represented by 1,635 organisms, with one species (*L. hoffmeisteri*) comprising almost half of the entire benthic community. Naidids also showed a slight, but insignificant, increase.

The second major group, Insecta, also increased substantially in November. Chironomids were the primary factor, increasing from 97 organisms in September to 416 organisms in November. An increase of *Polypedilum halteres* and, to a lesser extent, *Tanytarsus* sp. resulted in the increased density of chironomids. A sudden appearance of a relatively large population of *Corbicula* accounted for the abundance of mollusks in November.

The total density and faunal richness increased again in February; however, it was not as substantial as from September to November. Forty-six taxa were identified in February, represented by 1,795 organisms. The increase in density was attributed to the insect fauna, which increased both in species richness and doubled in abundance (Table 42). Chironomidae replaced oligochaetes as the major group in November, comprising 55% of the total benthos. The density of the oligochaetes decreased substantially in February, and comprised only one-third of the community. This was attributed to a reduction in the population of *L. hoffmeisteri*; however, an increase of the naigid community, primarily *N. pardalis*, offset the reduction somewhat. The disappearance of the *Corbicula* population resulted in an overall decrease of the mollusks.

The seasonal trend at this station, with respect to faunal densities, was identical to that exhibited by the other two transects (1 and 5) which were sampled quarterly. All transects started with similar densities of

between 3,521 to 5,111 organisms in April. These densities then decreased in September, followed by a subsequent increase in November, and again in February. The dominant organisms responsible for these fluctuations varied somewhat between transects. At Transect 1, the principal controlling factor was *L. hoffmeisteri*, whereas at Transect 5, *Corbicula* was the determining factor responsible for the seasonal trends. However, at Transect 7, a combination of *L. hoffmeisteri*, chironomids, and to a lesser degree, *Corbicula*, accounted for the seasonal variability observed.

The variation in faunal density between stations at Transect 7 was most similar to that observed at Transect 1. The two shoreline stations had somewhat larger benthic communities than the midstream station. However, the overall density of station (c), on the east shore, was more than twice as great as that of Station a, on the west bank. The overall composition of the dominant fauna at the three stations was similar. However, the order that the respective taxa ranked at each station was somewhat variable, except for the number one ranked taxa: *L. hoffmeisteri* was the predominant species at each station for all dates combined (Table 28); comprising from one-third at Station c to more than one-half of the total benthos at Station a.

In April *L. hoffmeisteri* was the predominant taxon at Stations a and b, being slightly overshadowed by Ceratopogonidae at Station b (Table 43). The density of the respective major taxa varied considerably between stations at this transect in April. The midstream area was fairly depauperate, whereas the density of most of the dominant organisms on the east bank was substantially higher than at the other stations, particularly with regards to the dominant oligochaete, *L. hoffmeisteri* and *N. pardalis*, and chironomids, *Polypedilum halteres*, and *Cladotanytarsus*.

In September the faunal density and diversity were very depressed. Only four taxa had more than 5 organisms at any station (Table 44). *L. hoffmeisteri* (immature forms) was by far the most abundant species at Stations a and b, but was totally absent from Station c. On the other hand, *Polypedilum halteres* was the predominant organism at Station c, but virtually absent at Stations A and B. Station c was also notable because of the substantial population of the polychaete *Laeonereis culveri* at this time. *N. pardalis* was also absent from all stations in September.

In November *L. hoffmeisteri* once again predominated over all taxa at each station. However, *Polypedilum halteres* was also a dominant benthic component at Station c, as in September, almost equaling the density of *L. hoffmeisteri* (Table 45). The absence of *N. pardalis* from all stations again was also of significant interest.

In February, as in April, the midstream station had the lowest density, with the station on the east bank having the highest density. The dominant taxon at Stations a and b, was *L. hoffmeisteri*, with *Polypedilum halteres* again the predominant species at Station c (Table 46). The order of dominance for the predominant taxa in February reflected that of November, and, to a lesser degree, of April. However, the reoccurrence of *N. pardalis* as a dominant species during this sampling was indicative of a reestablishment of the April benthic community structure.

The benthic community at this transect could be characterized by a community dominated by *L. hoffmeisteri*, *Polypedilum halteres*, and *Cladotanytarsus* sp. The sporadic predominance of *N. pardalis* signified a close similarity to Transect 6. However, the small populations of *Corbicula* and the occasional predominance of the polychaete, *L. culveri*, served to differentiate this transect within the study area.

c) Epibenthic Fauna

Hester-Dendy artificial substrates were deployed at each of the transects concurrent with the benthic sampling events to analyze the colonization of the epibenthic fauna. All seven transects were sampled in April. Transects 1, 5 and 7 were sampled quarterly (April, September, December and February). Two samplers were left at each transect and recovered after an incubation time of two weeks. Due to vandalism, Hester-Dendys from Transect 5 in February were not recovered and consequently not analyzed.

A total of 82 taxa was collected from artificial substrates during the course of this study (Table 2). More than two-thirds of the taxa identified were insects, primarily Chironomidae (31 taxa) and Ephemeroptera (ten taxa). The remaining insect community was composed of Trichoptera (six taxa) Coleoptera (five taxa), Odonata (two taxa) and a single occurrence of one species of Megaloptera. One additional family of Diptera, Ceratopogonidae, was also frequently collected, but the larvae could not positively be

identified beyond family level. Eight insect taxa were only collected from Hester-Dendy samplers and not represented in the infaunal community: 4 chironomids, 2 mayflies, 1 beetle and the alderfly.

Annelida was the second most species rich faunal assemblage with 13 taxa: 12 oligochaetes and one leech. All but two species of oligochaetes were in the family Naididae, with two of those uniquely collected from the Hester-Dendys.

The remainder of the epifauna was represented by six crustaceans, four snails, a flatworm and a hydroid. Of this assemblage, only two crustaceans (the amphipods, *Gammarus palustris* and *Hyalella azteca*) were commonly encountered. The crustacean, *Podocopa* sp. D, and the gastropod, *Menetus* sp., were only collected in the epifaunal samples.

Throughout the course of the study, 10 of the 12 most abundant taxa (Table 47) were insects, with five of the six highest ranked taxa being Chironomids. The other most predominant taxa included two Ephemeroptera (*Stenonema exiguum* and *Caenis* sp.), two Trichoptera (*Cheumatopsyche* and *Neureclipsis*), and the two Amphipoda, *Gammarus palustris* and *Hyalella azteca*. The remaining taxa were only sporadic in their occurrence. Overall, the number of taxa collected during each respective month was fairly consistent, ranging from a high of 49 in April to a low of 33 in December. In April, Transect 3 had the highest number of taxa, whereas Transect 1 was the most species rich location in September and December. Transect 7 had the highest diversity in February.

The highest and lowest faunal densities during the study were collected in April at Transects 2 (734 organisms) and 6 (150 organisms), respectively (Tables 48-54). The Ephemeroptera, *Stenonema exiguum* and the Trichoptera, *Cheumatopsyche* were primarily responsible for the high density at Transect 2. However, they were rarely found anywhere else for the remainder of the study. The most abundant organisms throughout the study area in April were the two midges, *Tanytarsus* and *Ablabesmyia parajunta*. Although absent at the upstream transects, *Gammarus palustris* was one of the most dominant species at Transects 6 and 7.

In September various taxa of Chironomidae predominated (Tables 55-57). However, a sporadic occurrence of the oligochaete, *Aeolosoma* cf. *niveum* was partially responsible for the high faunal abundance at Transect 1.

In December, the chironomid, *Tanytarsus* was one of the most frequently occurring taxa at all transects (Tables 58-60). However, the trichop, *Neureclipsis*, was responsible for the majority of the organisms at Transect 1, while *Gammarus palustris* was a dominant faunal component of the benthic community at Transects 5 and 7. Additionally, the chironomid, *Dicrotendipes neomdestus*, was the second most predominant species at Transect 7.

Due to the loss of the samplers at Transect 5 in February, only data from Transects 1 and 7 could be analyzed. The most abundant taxon at both transects was the midge, *Tanytarsus* (Tables 61-62). The mayfly, *Caenis*, comprised the majority of the remaining fauna at Transect 1, whereas two chironomids, *Dicrotendipes* and *Cladotanytarsus*, comprised most of the remaining community at Transect 7. *Nais pardalis* was also a predominant species at Transect 7 in February, but was rarely found elsewhere throughout the rest of the study.

d) Statistical Analysis

(1) Species Richness

Although a variety of indices to estimate species richness are available, none, except the actual number of species collected (S), are widely used. The concept that a healthy environment would be able to accommodate a greater number of species than a polluted environment is utilized as a valuative technique in impact studies. To provide a cohesive overview of species richness, the following two methods were utilized:

- i) The actual number of species collected in a unit area(s) (Table 63).
- ii) Margalef's index (Table 64). This index assumes a theoretical relationship between the number of individuals (N) and the number of species (S) in a sample and is expressed as follows:

$$M.I. = \frac{S-1}{\log_2 N} - (\text{Margalef, 1958})$$

The index logarithmically scales the value of S, and hence provides a means of comparison between stations with different ratios of S and N.

Species richness and number of taxa were generally higher at the upstream transects. The transects which were sampled quarterly (1, 5 and 7), all exhibited the same trend regarding number of taxa and species richness. At all these transects these values decreased from April to September, subsequently increasing in November and again in February.

In April, when all seven transects were sampled, the study area could be separated into two groups: the upstream transects (1, 2 and 3), and the downstream transects (4, 5, 6 and 7). At the upstream transects, the number of taxa was fairly similar ranging from 89 at Transect 1 to 79 taxa at Transect 3, with a slight tendency of decreasing number and richness from Transect 1 to 3. The species richness at the second region (Transects 4-7) was somewhat lower, ranging from 66 taxa at Transect 6 to 44 taxa at Transect 4, with Transects 5 and 7 fairly equal with 50 and 51 taxa, respectively.

The number of taxa in September was the lowest for each respective transect during the study, ranging from 34 taxa at Transect 7 to 21 taxa at Transect 5. The number of taxa increased at all transects in November with Transect 5 having the highest (57 taxa) and Transect 7 being the most species-poor (21 taxa). Species richness increased again at all transects during the subsequent sampling period in February. The largest number of taxa collected at that time was collected at Transect 1, with 75 taxa, and the smallest number found at Transect 7. Transect 5 had an intermediate richness with 67 taxa.

(2) Faunal Density

Faunal density is usually estimated at the number of organisms contained in a square meter. It is obtained by dividing the total number of organisms collected in a sample by the sampled area and is expressed as organisms/m². Caution should be exercised when faunal density is estimated in patchy environments or when sampling too small an area. Generally, faunal density has been used in assessing pollution impacts on benthic fauna (Filice, 1954; McNulty, 1970), and a reduction in faunal density is expected when

pollution occurs (exceptions: initial stages of high organic loading and some cases of thermal effluents).

Faunal density values (# organisms/m²) are presented in Table 65. The values cited in the following text will be the means for each transect on the respective date. The density ranged from a low of 1,980 organisms/m² at Transect 7 in September to a high of 40,858 organisms/m² at Transect 5 in February. The densities followed the same seasonal trends observed for the species richness previously discussed. At each transect which was sampled quarterly (1, 5 and 7), the density decreased from April to September. Subsequently, the number of individuals increased in November, and again in February.

During the April sampling, when all seven transects were sampled, the lowest number of organisms (9,736 organisms/m²) was collected at Transect 4, whereas the highest number (38,262 organisms/m²) was found at the adjacent upstream transect, Transect 3. No apparent trends could be discerned for the variations between transects. In September, Transect 1 had the highest density (6,553 organisms/m²), whereas the densities at Transects 5 and 7 were lower (3,811 and 1,980 organisms/m², respectively). In November and February the highest densities occurred at Transect 5 (9,452 and 40,858 organisms/m², respectively), and the lowest densities were found at Transect 7 (5,823 and 6,392 organisms/m², respectively).

(3) Species Diversity

Menzies et al. (1973) define diversity as a community ecological concept which refers to the heterogeneity (or lack of it) in a community or assemblage of different organisms. Thus, diversity is dependent upon the number of species present (species richness, S) and the distribution of all individuals among the species (Equitability or Evenness). Another definition of diversity is simply the number of species found in a unit area (Whittaker, 1972). Indices to measure diversity are so numerous that confusion is rampant (reviews in Hulbert, 1971; Whittaker, 1972; Fager, 1972; Sanders, 1968; Hairston, 1964; Pielou, 1975). The proliferation of indices has prompted Hulbert (1971) and Peet (1975) to recommend discarding diversity as a measure in ecological studies. However, placed in the proper perspective, diversity indices have shown to be useful in bioenvironmental studies (Boesch, 1972;

Borowitzka, 1972; Swartz, 1972; Pearson, 1975). Generally a decrease in diversity is expected with pollution impact. To provide an overview of diversity, the following two indices were calculated.

- a) **The Shannon-Weaver Index of Diversity (Shannon and Weaver, 1963):** This index is based on "information" theory, where diversity is equated to the amount of uncertainty which exists as to the identity of an individual collected at random from a community. The more species and the more evenly their representation of individuals, the greater the uncertainty and hence the greater the diversity. The computational formula for Shannon's index is:

$$H' = C/N (N \log_{10} N) - \left[\sum_{i=1}^S n_i \log_{10} n_i \right]$$

Where C = 2.3026 for units of "nats" and 3.3220 for units of "bits".
 N = total number of individuals in the i'th species. Lloyd et al. (1968) have presented the functions $n \log_{10} n$ for all integers from n = 1 to n = 1,050 to simplify the use of Shannon's index. Since Shannon's formula overestimates H' for samples of small size, Basharin (1959) suggested a modification as follows:

$$H'' = H' - \frac{S-1}{2N}$$

where H'' is the modified diversity estimate.

- b) **Gini's Index of Diversity (Simpson, 1949; Gini, 1912):** This index is a measure of the dominance in a sample. Although it is usually insensitive to rare species, it has been used commonly as a diversity index. The computational formula for dominance diversity (DM) is:

$$DN = \sum_{i=1}^S n(n-1)/N(N-1) \dots \dots \dots \text{Simpson's and complementary or actual diversity (D) is"} \quad D = 1 - DM \dots \dots \dots \text{Gini's.}$$

Diversity values represented by Shannon's index are presented in Table 66, and Gini's and Simpson's indices in Tables 67 and 68, respectively. Generally, the diversity indices reflect the same trends observed for species

richness and faunal density. Shannon's diversity values best illustrate this trend. All values were fairly even in April, ranging from a low (2.18) at Transect 5 to a high (2.71) at Transect 1. All values decreased in September, with Transect 7 having the highest value (1.19), whereas Transects 1 and 5 had comparable values (.65 and .68, respectively). All values increased in November and again in February, except at Transect 5 where they remained the same [even though there was a four-fold increase in density (Table 49)]. Generally, Simpson's and Gini's (1-Simpson's index) followed this same trend.

(4) Equitability

Equitability is considered a component of diversity, in that it provides an idea about the evenness of species distribution at a site. Usually, a positive correlation exists between diversity and equitability (De Jong, 1975) i.e., a high equitability would indicate a high diversity and probably a "healthy condition" of a fauna. Reduction of equitability almost always occurs with an increase in oligomixity. Pielou's (1966) method of measuring equitability is most widely used. The computational formula is:

$$J' = H' / \log_2 S$$

The index value ranges from 0 to 1, with a value of 1 being the maximum possible evenness in the community. Equitability indices may have the same pitfalls as described for diversity indices.

Equitability, or evenness of distribution values as measured by Pielou's index (J') are presented in Table 69 for all stations. The values presented in the following discussion refers to the mean values at each transect for each respective date. As previously stated, equitability values generally show a positive correlation, with diversity. Values calculated for this study proved to be no exception. As with diversity, equitability values were relatively consistent between transects in April, ranging from .58 to .69, indicating a fairly even distribution. The decrease in values at all transects in September, with all values being less than .45 was indicative of stressed conditions. The subsequent increase in November to values comparable to April's values reflect a return to "healthier" conditions. These high values continued through February. However, they were all slightly lower than those calculated for April.

(5) Cluster Analysis

A similarity index is a measure of the similarity of the structure of two communities. This value is based on the abundance of species and the degree to which individual species are shared spatially and/or temporally between locations. A number of similarity indices are available (Bray and Curtis, 1957; Sanders, 1960; Whittaker, 1967; Field and MacFarlane, 1968; Lie and Kelly, 1970; Grassle and Smith, 1976). The Bray-Curtis index (Bray and Curtis, 1957) is one of the most commonly used coefficients of similarity to determine niche overlap. In a comparison of similarity indices Bloom et al. (1972) found that "the only index which accurately reflected similarity was Czekanowski's Quantitative Index (=Bray-Curtis) . . . and can be expected to reflect actual overlap accurately for virtually any underlying distribution".

The computational formula for the Bray-Curtis index $1(CZ_{ik})$ is:

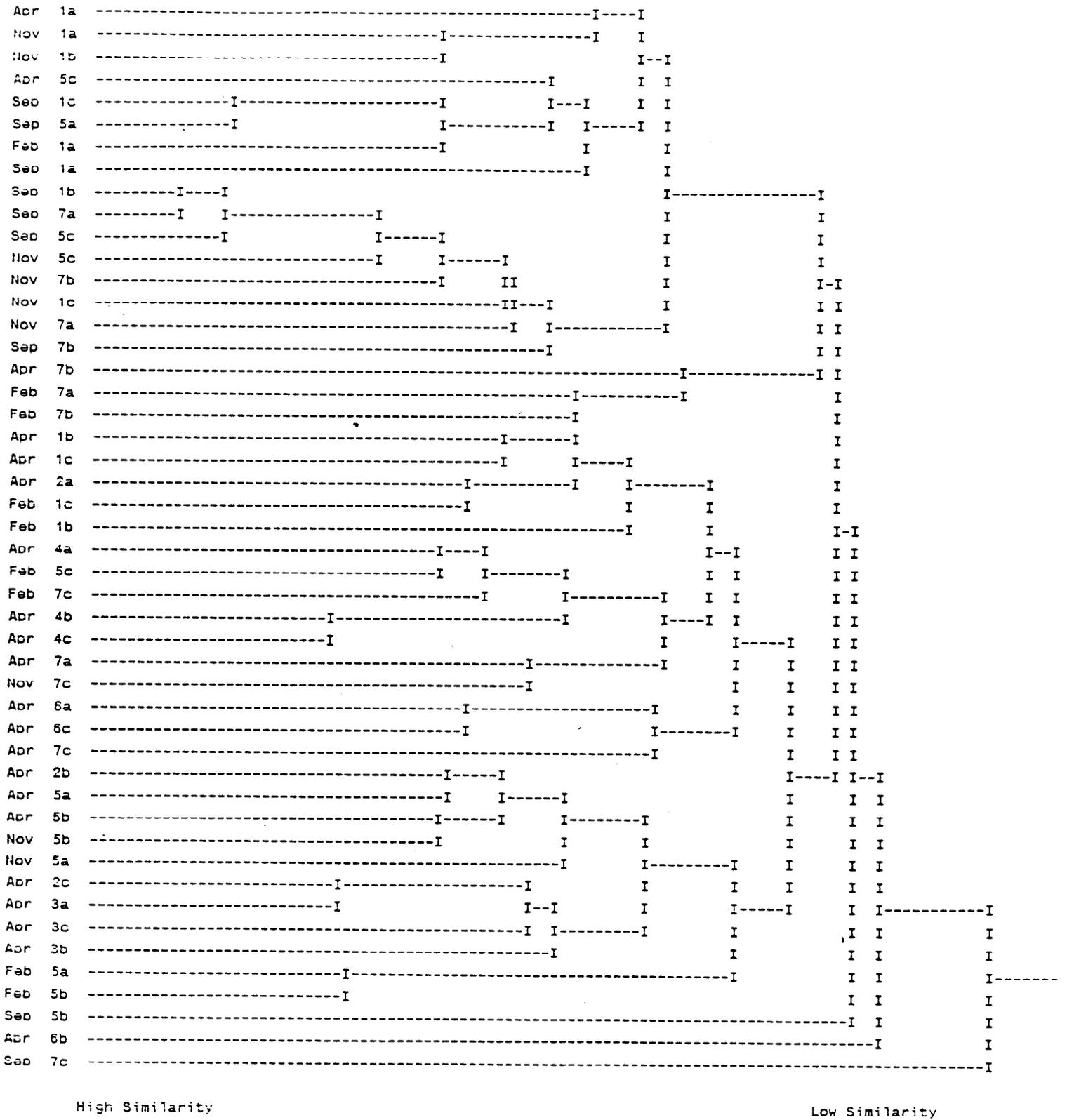
$$CZ_{ik} = \frac{2 \sum_{j=1}^S \min(x_{ij}, x_{kj})}{\sum_{j=1}^S (x_{ij} + x_{kj})}$$

where x_{ij} = occurrence of the j th item (species) in this i th sample; x_{kj} = occurrence of the same species in the k th sample; S = number of species over all samples.

The results of this analysis are presented as a matrix (Figure 2) and dendrogram cluster graph (Figure 3). For the matrix, each axis had 48 combinations of stations and dates (Figure 2). Of all the possible combinations (1,152), only eight instances of high similarity ($CZ < 0.26$) were found, six of which were between two stations collected on the same date. Two combinations of stations in April were highly similar: Stations 3a and 2c; and Stations 4b and 4c. In September, three combinations were highly similar: Stations 1c and 5a; Stations 1b and 5c; and Stations 1b and 7a. Only one combination of high similarity occurred in February; Station 6a and 5b. The remaining two combinations of high similarity were found between two stations in September (1b and 7a) and one in November (Station 5c).

These similarities can be seen diagrammatically in the dendrogram (Figure 3). As illustrated in the dendrogram, the three stations with the highest similarity were all collected in September. However, each station was

Figure 3. Dendrogram with each station/date combination, based on Bray-Curtis similarity, index and group averaged sorting.



on a different transect (Stations 1b, 5c and 7a) and each was collected from a different section of the respective transects. The next highest similarity was also found between two stations in September on different transects (Stations 1c and 5a). The two combinations with the next highest similarity were also collected during the same month, April. However, in these cases, one pair of stations was from the same transect (4b and 4c), and the second pair was from adjacent transects (2c and 3a). The last case of high similarity also occurred within the same month, February, and on the same transect (Stations 5a and 5b).

At a low level of similarity, the stations are separated into two major groups. With only a few exceptions, the first group was composed of those stations collected in April, while the second group was composed primarily of those stations collected in September. Station 7c in September was the most dissimilar station over the course of the study, and may have been a reflection of the large percentage of estuarine fauna comprising that community at that time.

B. DISCUSSION

The Myakka River is basically a freshwater system with a variety of diverse habitats harboring a rich assemblage of benthic macroinvertebrates. Previous studies concerning the freshwater portion of the Myakka River concluded that the benthic fauna is typical of that frequently encountered in the rivers and streams throughout Southwest Florida (Estevez, 1985; Cantrell, 1979; Culter and Mahadevan, 1982). Numerous additional studies by ML of the benthic fauna inhabiting the major estuaries on the west coast of Florida substantiates this conclusion based upon the results of this study.

The benthic community within the study area was composed of more than 200 taxa, primarily of freshwater origin. The only notable exceptions were infrequent occurrences of the euryhaline polychaete, *Laeonereis culveri*, and the common marsh clam *Rangia cuneata*. Both taxa were primarily collected at the transect located furthest downstream. This area coincided with the upstream locations of the 1985 study conducted by Estevez, where these two species were also prevalent. Both species are typically associated with communities of low salinity, generally ranging from 0-18 o/oo (Castagna and

Chanley, 1966). *Rangia* is one of the most abundant mollusks in brackish water environments along the southern Atlantic and Gulf coasts of the United States. It is generally considered to be more common in northwest Florida (Tenore et al., 1968) and is most commonly associated with a sand substrate such as that found at Station 7c where it was most common in this study area. Although salinity measurements taken concurrent with the benthic collections indicated the absence of any saltwater intrusion upstream from Snook Haven, previous investigations have revealed a more dynamic salinity regime, with concentrations as high as 15 ‰ upstream to Curry Creek. Significant measurements have also been reported at Down's Dam near Transect 1.

The density of estuarine organisms was generally negligible at all locations throughout the study, except in September at Transect 7 where 42 individuals of *L. culveri* were collected. This sampling corresponded to the wet season of the year when significant vertical stratification occurs in the deeper part of this estuary during high freshwater inflow (Fraser and Wilcox, 1981; Fraser, 1986; McPherson and Miller, 1990), preventing mixing of the saline water on the bottom (Cantrell, 1979). However, an additional contributing factor may have resulted in high saline water being introduced into the Myakka River from Curry Creek.

Other organisms of marine origin collected in the study were occasional occurrences of some miscellaneous crustaceans and a mussel, which were all generally found in the vicinity of Transect 7. The only exceptions to this was the presence of some fouling organisms, such as *Crassostrea virginica* and *Crepidula*, recovered at Transect 5. However, this distribution may have been anthropogenic, since evidence of a boat dragged along the bottom in the vicinity of the sampling location was noted, and may have resulted in dislodging those individuals.

Although over 200 taxa were identified from the study area, only 26 taxa comprised in excess of 1% at any station throughout the study, half of which were insects, mostly Chironomidae (Figures 4 and 5). The diversity of habitats within the study was primarily responsible for the richness encountered. Insects have exploited almost every ecological niche available. Although many are stenotopic, the majority are able to survive wide environmental fluctuations of their habitat. Variations of a variety of

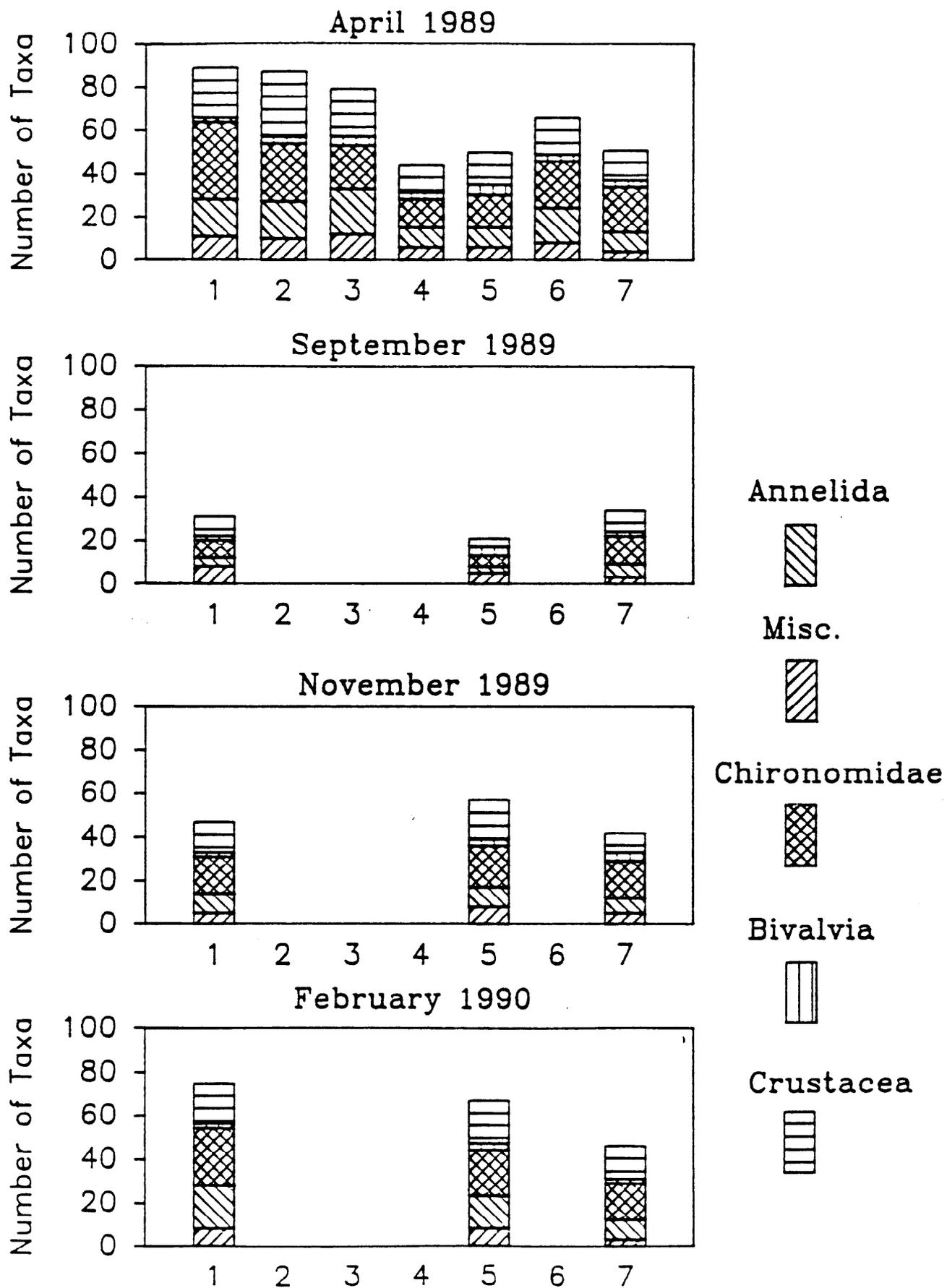


Figure 4. Number of taxa for each transect for all sampling periods.

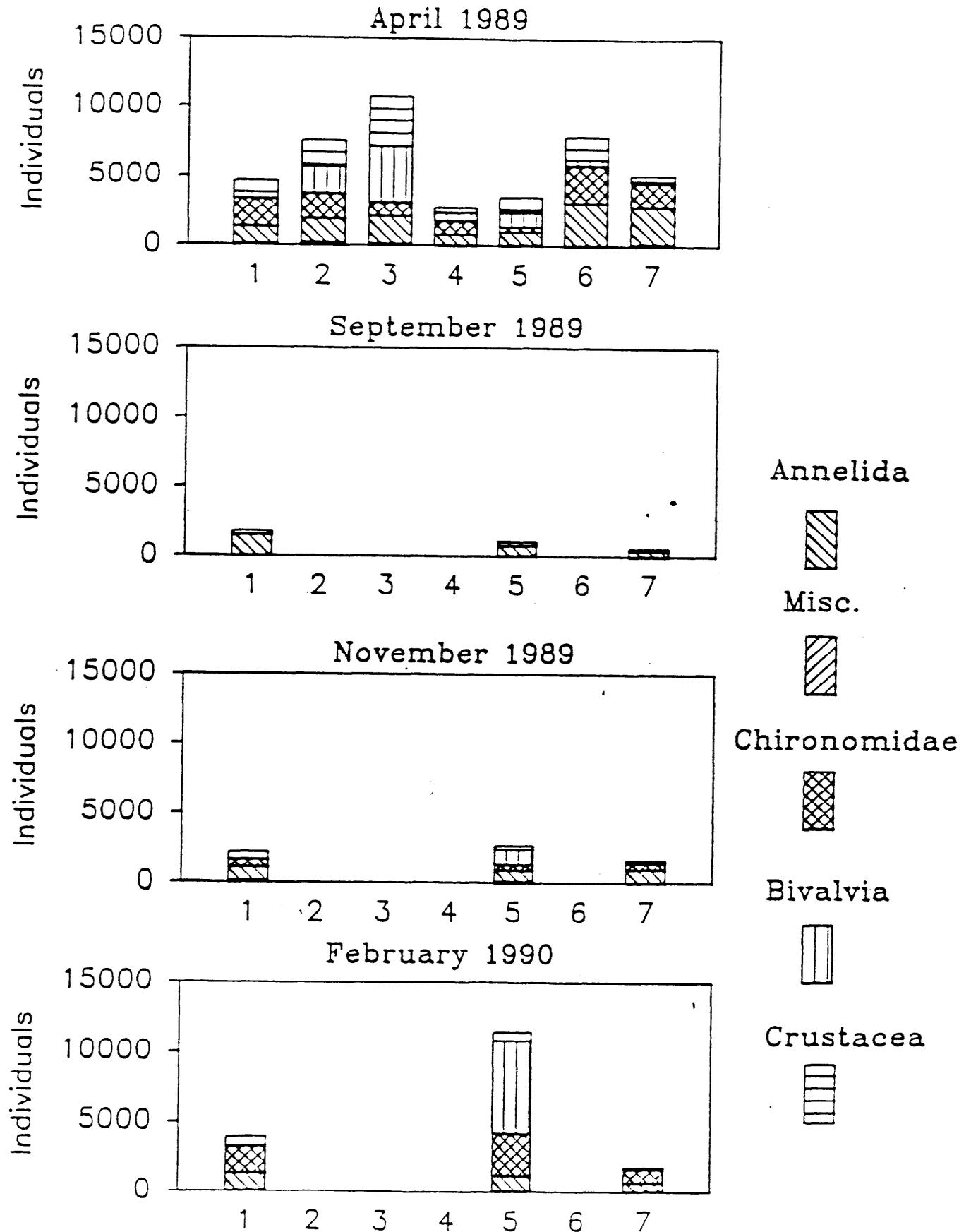


Figure 5. Number of individuals for each transect for all sampling periods.

physical parameters which have been documented as being limiting factors for many insects are known to occur in the Myakka River. However, those taxa comprising in excess of 5% of the benthic community are fairly cosmopolitan, able to thrive under unstable conditions. Eight taxa were responsible for more than 5% of the fauna at three or more transects: four insects (*Polypedilum halteres*, *Tanytarsus* sp., *Cladotanytarsus* sp. and *Caenis* sp.); two oligochaetes (*Limnodrilus hoffmeisteri* and *Nais pardalis*); one mollusk (*Corbicula manilensis*); and one crustacean (*Podocopa* sp.).

The ecological requirements of the four insects are well known. Pinder (1986), Warner (1973), Frayor (1970) and Fisher and Lavoy (1972) have indicated that water level fluctuations may be the most severely restricting factor affecting the distribution of these insects, and that nearly all chironomid have a specific depth preference (Pinder, 1986). Although many species are able to survive some degree of drying, they rapidly exploit a rise in water level. *Polypedilum* is known to exploit a variety of habitats and tolerates severe stressful conditions, such as extended periods of anoxic conditions and varying current velocities. This midge is common throughout Florida and may comprise up to 90% of the benthic community (Soponis and Russell, 1984). The mayfly, *Caenis*, is also able to tolerate a wide variety of conditions ranging from mud puddles to rivers and large lakes (Berner, 1950). The nymphs of this mayfly have been shown to tolerate extreme fluctuations in a wide variety of physical conditions such as temperature and pH. However, severe anaerobic conditions may be a limiting factor for some species. This insect was widely distributed throughout the study area, but less common in the downstream area, replaced by a closely related genus, *Brachycercus*.

Limnodrilus hoffmeisteri was the only organism comprising at least 5% of the fauna at each transect. This species is one of the most cosmopolitan benthic organisms throughout the world and has been often suggested as an "indicator species" to determine levels of pollution (Goodnight and Whitley, 1960; Shrivastava, 1962; Brinkhurst, 1965; Milbrink, 1973; Lauritsen et al., 1985). It can withstand extended periods of exposure to anaerobic conditions for at least ten weeks (Reynoldson, 1987). Since these conditions are known to occur during periods of intense stratification on the Myakka River in the

rainy season (Cantrell, 1979), *L. hoffmeisteri* has been opportunistic in its ability to predominate in areas subjected to those stresses unoccupied by less tolerant organisms.

The other predominant oligochaete, *Nais pardalis*, only comprised in excess of 1% of the fauna at the downstream transects (4, 5, 6 and 7). This is also a cosmopolitan species, commonly existing under a wide variety of conditions throughout North America, Europe, Asia and South America (Brinkhurst and Jamieson, 1971). The ability to enter the water column and swim with spiral motions has enabled *N. pardalis* to colonize rapidly a wide range of habitats. Large populations occur sporadically throughout the year due to its asexual mode of reproduction, producing long chains of zooids.

Corbicula manilensis was found in the highest concentration of any organism in the study area. However, it was only considered dominant at Transects 2-5, and totally absent from Transect 1. Since its introduction to North America in the 1930's in the Pacific Northwest, (Kemp et al., 1963) the Asiatic clam has exploited most major lentic and lotic systems in the southeastern U.S. (Sinclair, 1971) since its first appearance in the Ohio River Basin in 1957 (Sinclair, 1963). The ability for it to become extremely abundant under suitable conditions and tolerate even the most adverse situations (Edmondson, 1959), has enabled this domination. *Corbicula* has also been reported downstream of the study area, in fairly high concentrations by Estevez (1985; 1986). Although *Corbicula* is a freshwater bivalve, the ability for it to withstand high salinity concentrations for extended periods has been documented (Filice, 1958; Hayashi, 1956). The complete absence of *Corbicula* at Transect 1 could not be accounted for, even though a suitable substrate of sand and gravel [which it prefers (Kemp et al., 1963)] was predominant.

Although the composition of the benthic community between transects was somewhat variable, the similarity analysis performed on the data indicated that the invertebrate fauna throughout the study area was fairly homogeneous. The highest degree of similarity was found for three stations on three different transects, all within the same month. The benthic community of the river was distinctive for each sampling period as was demonstrated by the groupings at the lower levels of similarity, where most of the transects in April formed a cohesive unit. This illustrates the differences associated

with seasonality with respect to both composition and abundance of the macroinvertebrate fauna, particularly the dominant taxa.

The seasonal variation exhibited by the benthic community in the Myakka River study area, closely reflected that observed on the lower river (Estevez, 1986). The highest densities and species richness was found during the spring with a depauperate fauna corresponding to August and September. This seasonality closely corresponds to the life cycle of the two most dominant taxa, *L. hoffmeisteri* and Chironomidae (Soptonis and Russell, 1984; Brinkhurst and Kennedy, 1965; Reynoldson, 1987). However, as Drake (1982) noted, the annual change of abundance may vary from year to year. The increase of the benthic community in April-May, may have been a response for the opportunistic organisms to take advantage of the less stressful conditions associated with the unstratified condition of the river.

Although intensive qualitative surveys were conducted concurrent with the quarterly sampling, only two taxa were found not represented in the infaunal or epifaunal collections: the Hemiptera, *Ranatra* (the water scorpion) at Transect 6; and *Paludosus palucida* (the apple snail) between Transects 4 and 5. Thirteen taxa were identified from the artificial substrates which were not recovered during the infaunal analysis, however, the data for the artificial substrates reinforced some of the trends exhibited by the benthic fauna. As demonstrated by these findings, a comprehensive representation of the benthic fauna can only be obtained through a combination of infaunal and epifaunal sampling methodology, and efforts to study the variety of habitats associated with both sides and midstream regions of a lotic system is essential.

The Myakka River is a dynamic lotic system varying between conditions of almost pool-like conditions during "zero-flow" periods, to turbulent rapids at other times. Because of the wide range of conditions, a variety of habitats are created, resulting in the ability to support a high diversity. Because of the complex interaction of so many physical variables which can act as limiting factors in the distribution and abundance of benthic macroinvertebrates, only a cursory characterization can result from this one-year study. An extended research program to determine the annual variations would be required to produce a more complete ecological mosaic associated with

this river. As a result, the effects of a significant withdrawal of freshwater on the Myakka River would not be easy to predict accurately. It can safely be assumed, however, that a significant decrease in freshwater discharge of the river, even during periods of high flow, would result in the upstream migration of the euryhaline organisms of marine origin. This is particularly true if this study is indicative of "average" years, since the largest population of estuarine fauna was collected at the lower end of the study area at that time. The discharge of high saline water into the Myakka River is another contributing factor which needs to be researched further to assess this question.

One of the goals of this study was to develop a method using indicator organisms to evaluate changes in water quality. Changes in water quality may be the result of a reduction in freshwater inflow into an estuarine system such as that proposed for the Myakka River which will affect the organisms inhabiting the tidally influenced region of the downstream study area, as previously discussed. Or it may be caused by the introduction of unnatural substances, commonly referred to as "pollution". This is a nebulous term which has been defined as 'any impairment of the suitability of water for any beneficial human use, actual or potential; by any foreign material added therein.' (Goodnight, 1973). Albeit, this definition raises many questions regarding the interpretation of some of the key words or phrases. Nevertheless, one method to understand a clear picture of the condition of the water is to analyze the biological makeup of the community inhabiting that body of water.

Fauna comprising the ecosystem of a specific habitat are generally considered to be extremely sensitive to changes within the environment, not readily discernable through chemical tests. Many organisms have been suggested as "indicator species" to detect pollution. However, the lotic environment of the Myakka River is so dynamic that filtering out one factor affecting the community structure of a specific region of the river is difficult without a complete understanding of natural changes inherent within the ecosystem. The results of this study have indicated that the macroinvertebrate community within the study area is relatively homogeneous during any given period of time. Consequently, establishing specific zones

of aquatic invertebrate fauna useful from a management standpoint would be difficult since each area analyzed harbors a unique faunal assemblage, but is generally uniform with respect to the dominant components. While the presence of some numerically insignificant taxa may be useful in evaluating the alteration of a specific parameter, the variation of the dominant taxa comprising the community is the most useful indication of an environmental perturbation.

Many studies have been conducted relating environmental conditions to insect species. The lack of taxonomic studies on the larvae of many insect groups limits the accuracy of identifications generally to genus. Most species within a given genus will prefer a narrow range of physical and chemical parameters; however, generalities for certain genera or even orders may be possible. For example, an abundance of Trichoptera and Ephemeroptera (specifically *Caenis*) is indicative of unpolluted environments (Larimore, 1974). Although these organisms were collected throughout the study area, they were more predominant at the upstream transects, which would indicate a less polluted, or stressed, environment.

Numerous biotic indices have been suggested using primarily insect species to determine the relative "health" of lotic systems with regard to organic pollution. The most commonly accepted index in the state of Florida is a classification scheme proposed by Beck (1954) to categorize the streams of Florida into five classes based on the presence or absence of specific insect species or genera: Class I contains those organisms intolerant to any appreciable level of organic pollution. This water system would be very clean; Class II contains those organisms which can tolerate conditions approaching or reaching the anaerobic. This water system would be considered to be not heavily polluted; Class III contains organisms which have been found in heavily polluted areas. However, the presence of Class II organisms cannot be interpreted as being indicative of heavy pollution, since these organisms may also occur in clean or mildly polluted waters; Class IV and V were not considered applicable and were suggested simply as "categories of convenience".

It should be pointed out that each organism Beck suggested for stream classifications was supported by a minimum of 20 records. If, for instance,

a single record of a taxa was found in "mildly polluted" or "heavily polluted" waters, then that organism would automatically be designated as a Class II or Class III organism, respectively.

Of the 39 taxa Beck considered for his classification, 10 taxa were collected during this study on the Myakka. The majority of taxa was considered Class I indicators (*Corynoneura taris*, *Polycentropus* sp., *Stenonema exiguum*, *Stenonema* sp., *Oxyethira* sp. and *Hydroptila* sp.). Class I organisms were collected at all transects within the study area, except Transect 4. Their absence at this area could have been related to a variety of factors not related specifically to organic pollution.

Three taxa were considered Class II indicators (*Cheumatopsyche* sp., *Hazallela azteca*, and *Oecetis* sp.) and two genera were Class III indicators (*Chironomus* sp. *Cryptochironomus* sp.). Class II and III organisms were recovered from all Transects within the study area. However, as mentioned previously, the presence of the latter taxa does not necessarily indicate pollution. On the other hand, the presence of even one Class I indicator at a given area would strongly suggest the absence of organic pollution.

Additionally, the absence of such Class I organisms would not necessarily indicate polluted conditions; other hydrologic factors may be responsible for the absence of the Class I indicator organisms. An alternative method for detecting pollution in the absence of such indicators would be looking at the relative abundance of opportunistic Class III type of individuals. For example, other biotic indices examine the ratios of the dominant groups of organisms such as insects and tubificid worms (Goodnight and Whitley, 1960; King and Ball, 1964; Brinkhurst, 1966; and Chutter, 1972).

For the purposes of this study, Beck's (1954) index was most appropriate because it was most specific to Florida streams, and the introduction of organic pollution would be indicated by the extinction of Class I organisms from the study area. In this case, if waste water was introduced into the Myakka via Curry Creek, the elimination of Class I indicators at Transect 7, would provide substantial evidence indicating an alteration in environmental conditions.

Based on this evidence, the portion of the Myakka River analyzed for this study is considered to be a very clean system free of organic pollution.

The abundance of Class I organisms throughout the study area indicates a fairly homogeneous community of clean water organisms, and establishing specific zones of macroinvertebrate communities to be analyzed from a management standpoint would not be appropriate.

C. FUTURE CONSIDERATIONS

Sampling methodology employed for this investigation appeared to present an accurate representation of the macroinvertebrate communities throughout the study area. As indicated by the results of this study, sampling each bank and the midstream region across a transect is essential to provide a complete overview of the community structure for any given region of a stream or river.

Insects were the most diverse and frequently abundant group of organisms in the river, and were very seasonal in their occurrence. Although quarterly sampling provided some insight into this seasonality, a more frequent schedule would be necessary to furnish a more complete analysis of the natural variation of the community structure. This would allow for a more precise evaluation of potential perturbations. Sampling every two months would be adequate to achieve satisfactory results relating seasonality to population dynamics. However, a minimum of two years (preferably three or four) of data is necessary to determine the inherent annual variation associated with macroinvertebrate communities.

If a subsequent study was conducted, continuous monitoring of the three permanent transects established during this study should provide an adequate representation of the benthos within the study area, based on the relative homogeneity of the community structure. However, additional stations should be established in Curry Creek. Sampling should commence in that area as soon as possible to provide baseline data to detect the impact of introducing secondarily treated waste water into the Creek.

If studies such as this are to be conducted on any other lotic system in Florida, the methodology utilized during this study should provide an accurate portrayal of environmental conditions allowing for better management practices within the respective watersheds.

V. BOTANICAL INVENTORY

A. RESULTS

Elevation profiles for each transect are presented in Figures 6 through 14. Elevations are based on an elevation of 0.0 feet at water's edge. Elevation profiles can be correlated with USGS stage data only after elevations at transect markers are determined by professional surveyors. Stage data for the dates that transecting was accomplished are given in Tables 70 and 71 for two USGS Stage Gauges within the study area: Myakka River Control near Laurel (near Transect 1, 500 feet below the dam) and Myakka River near Laurel (between Transects 3 and 4). Stage data for the former gauge are given in feet above stage datum because the elevation of the stage datum has not been surveyed.

The forest along the Myakka River contained five overstory tree species: *Pinus elliottii* (slash pine), *Quercus laurifolia* (laurel oak), *Quercus virginiana* (live oak), *Sabal palmetto* (cabbage palm), and *Ulmus americana* (American elm). The common understory trees include *Cephalanthus occidentalis* (buttonbush), *Fraxinus caroliniana* (popash), *Gleditsia aquatica* (water locust), and *Salix caroliniana* (willow).

Table 72 presents species densities by transect for woody plants that were at least 1 inch in dbh. Table 73 duplicates Table 72, except that it includes only those plants with stems from 1 to 3 inches in dbh. To make the data comparable from different size transects, tree densities in Tables 72 and 73 are given as the number of trees per acre, and the sample size for each transect is noted. The overall density for all transects was 370 trees per acre. Table 74 shows basal area values per acre for stems that were at least four inches in dbh, excluding *Sabal palmetto* (cabbage palm).

All species encountered in the river corridor are listed alphabetically in Table 75 and by life-form in Table 76. These tables contain species recorded at study sites and others observed during reconnaissance. Species composition for individual transects and their component quadrats consisted of common species that were essentially ubiquitous in the forests throughout the river corridor. The only exceptions were the shoreline quadrats, for

TRANSECT 1

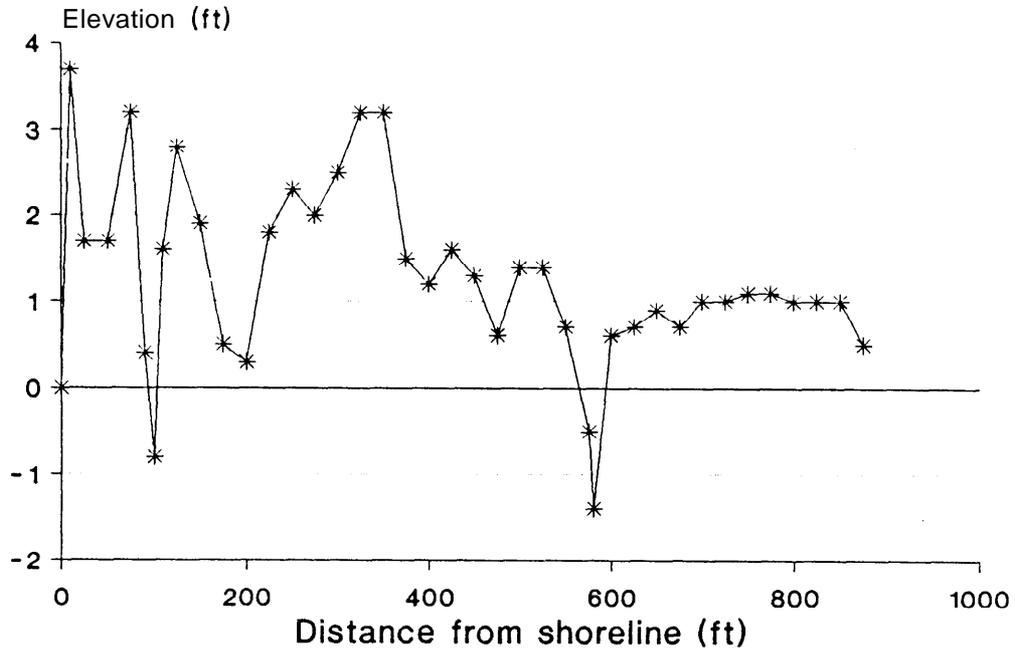


Figure 6. Elevation profile, Transect 1.

TRANSECT 2

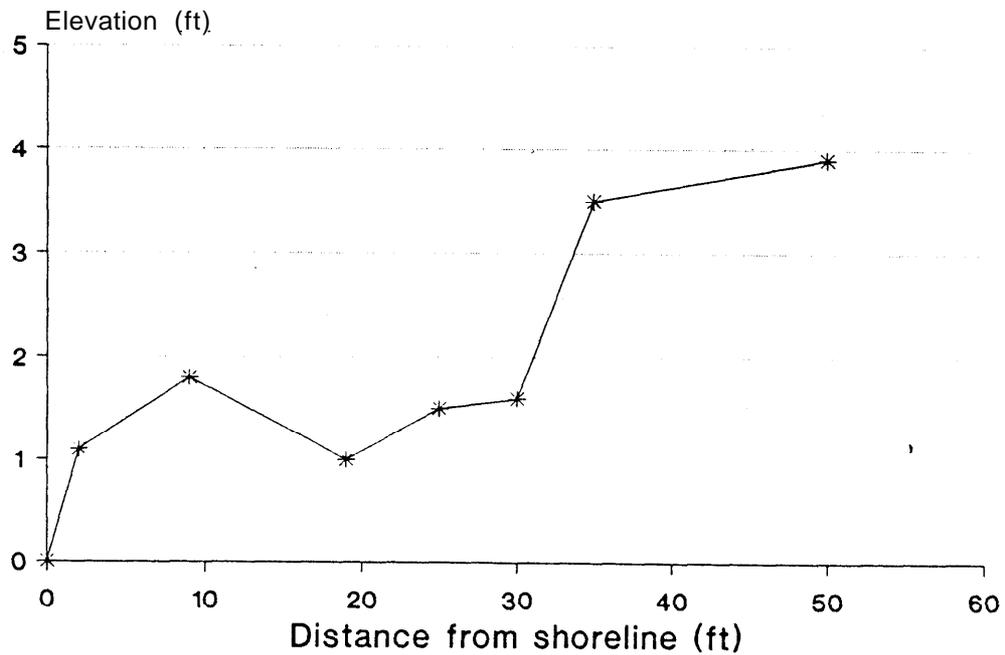


Figure 7. Elevation profile, Transect 2.

TRANSECT 3

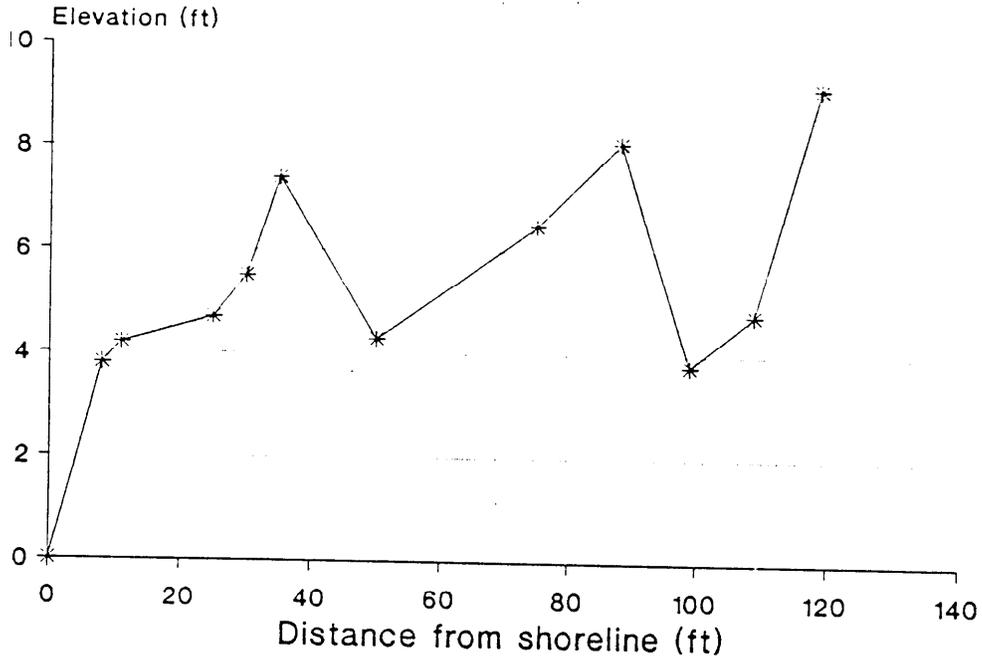


Figure 8. Elevation profile, Transect 3.

TRANSECT 4

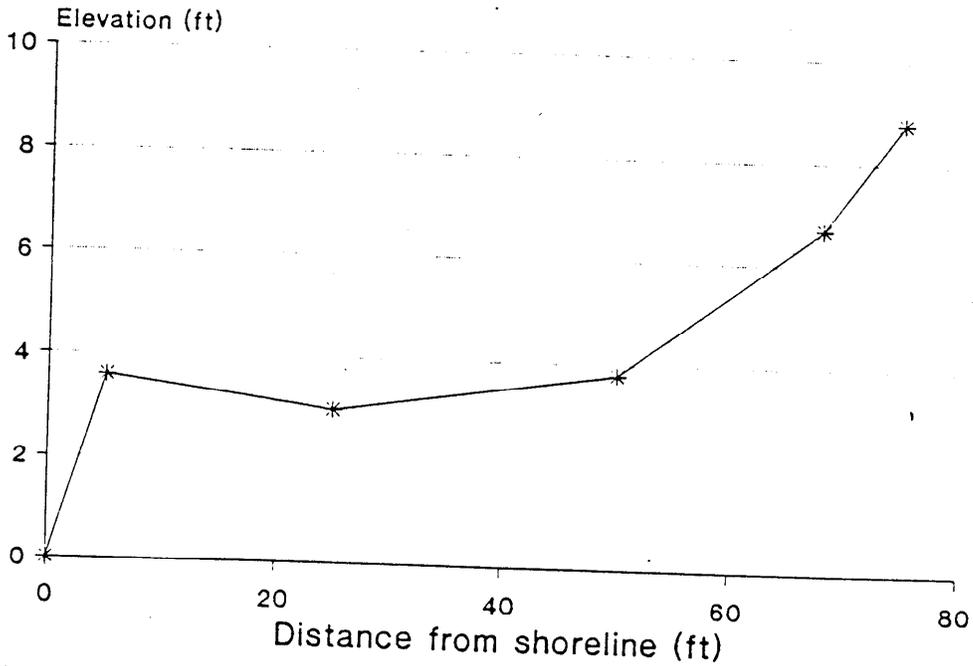


Figure 9. Elevation profile, Transect 4.

TRANSECT 5 (Pipeline-- West)

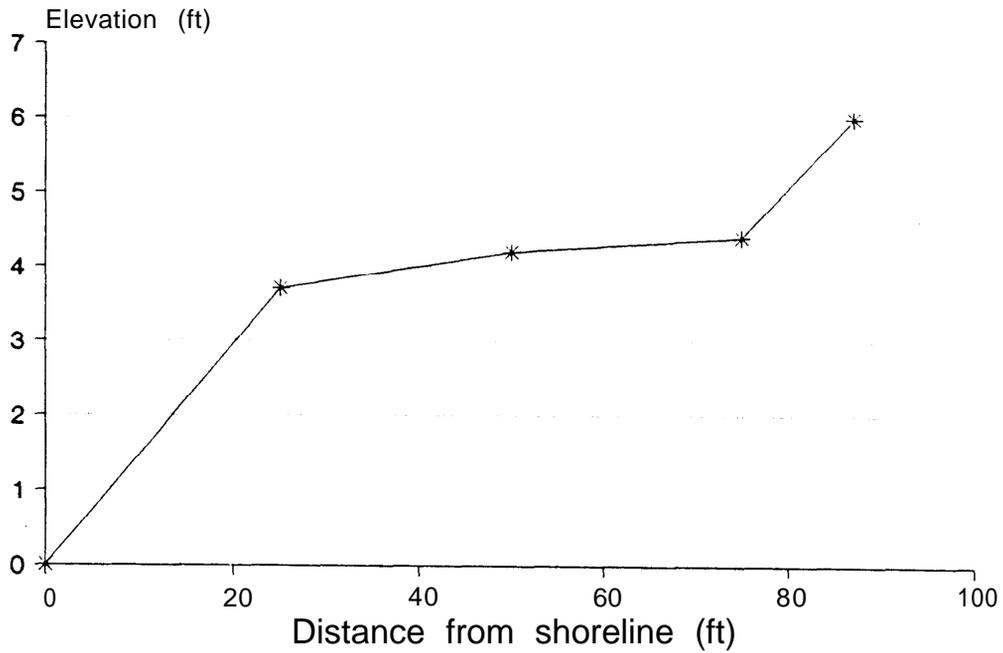


Figure 10. Elevation profile, Transect 5.

TRANSECT 6

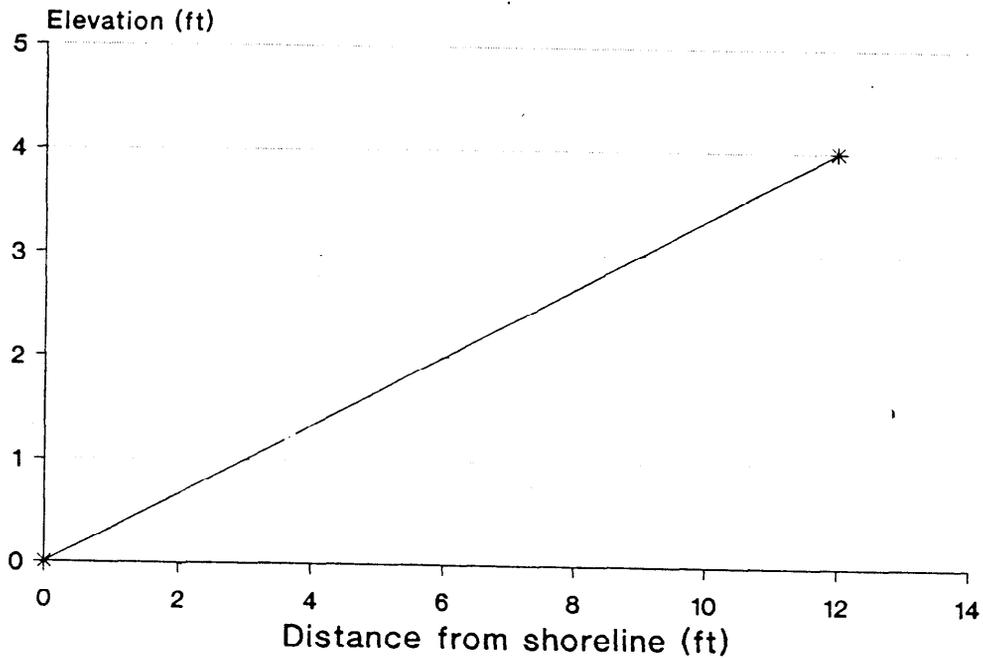


Figure 11. Elevation profile, Transect 6.

TRANSECT 7

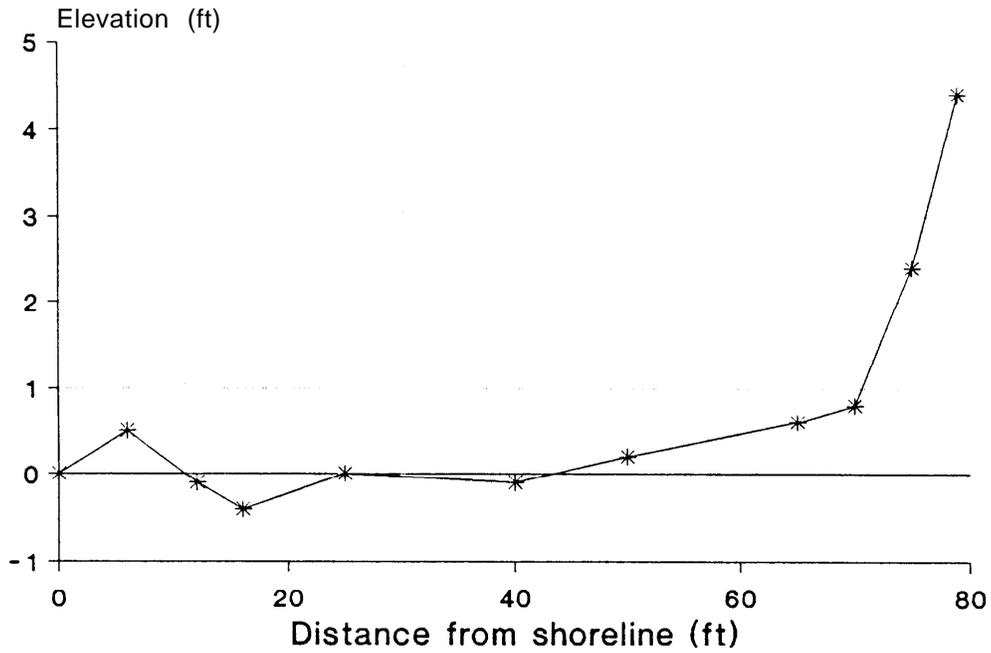


Figure 12. Elevation profile, Transect 7.

PCE (Pipeline Control--East)

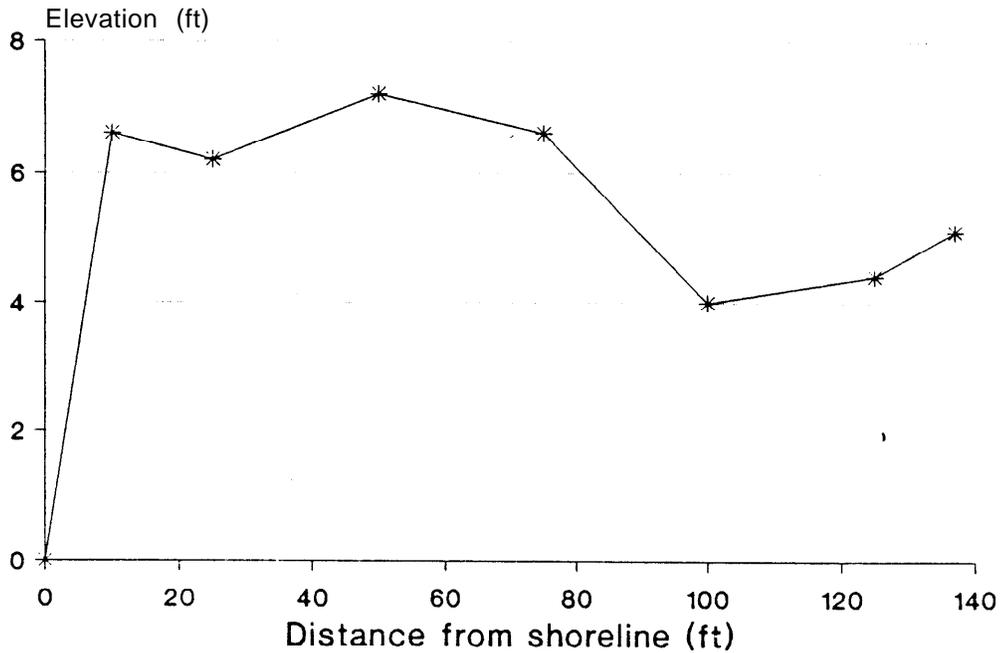


Figure 13. Elevation profile, PCE (Pipeline Control - East).

PCW (Pipeline Control-- West)



Figure 14. Elevation profile, PCW (Pipeline Control-West).

which the flora was quantified in shoreline stations at each transect site. Therefore, only the overall flora is listed.

Table 77 gives the percent cover for overstory trees and for ground cover by transect.

Table 78 presents the number of interceptions by species for the ground cover at each of the 27 shoreline stations. The occurrence of intercept points without vegetation (bare soil or leaf litter) was substantial for most transects. The more abundant species were: *Axonopus affinis*, *Brachiaria nutica*, *Cassia nictitans*, *Coreopsis leavenworthii*, *Cynodon dactylon*, *Cyperus* spp., *Digitaria serotina*, *Ludwigia repens*, *Lythrum flagellare*, *Panicum heniltonn*, *Paspalum caespitosum*, *Paspalum notatum*, *Phyla nodiflora*, *Pluchea odorata*, *Polygonum punctatum*, *Tripsacum dactyloides*, and *Vigna luteola*. In addition to herbs, low-growing shrubs, lianas and epiphytes were locally common within the ground cover.

B. DISCUSSION

1. Terrestrial Habitats

Two site types occupied that portion of the Myakka River corridor under study. The first type was distinctly mesic and consisted of relatively well drained sands. These sands sometimes contained a high water table, because of either a low elevation above normal pool of the river or of a shallow stratum of impermeable clay. Nonetheless, these sands were well drained within the root zone of trees, owing to rapid depletion of ground water as seepage from the riverbank.

The second site type was hydric, owing to poor drainage of the soil and sometimes to periodic inundation. Although the hydric soils were generally sandy, they were frequently darkened with organic matter and may have had somewhat clayey subsoils. Gradual changes in topographic relief commonly created broad transitions between clearly mesic and clearly hydric sites. The distinction between wetlands (hydric sites) and mesic uplands was frequently masked by these transitions.

2. Sloughs

The flood plain within the corridor was interrupted by sloughs, most of which were abandoned meander loops of the river. Sloughs were rare in the

downstream two-fifths of the corridor, designated as Zone I in Figure 15. These few sloughs were generally either incised or flanked by a steep bank on one side. Wetland vegetation was negligible along these sloughs.

The sloughs between T5 and a point half way to Border Road (Zone II in Figure 15) were more frequent, broader, and deeper. They were usually lined with small wetland trees (especially popash and willow), and several contained large floating mats of marsh plants.

The sloughs upstream of T5 were more frequent and tended to be narrow and shallow. They were largely or entirely overgrown with small wetland trees and shrubs (popash, willow, water locust, buttonbush, etc.).

3. Vegetational Classification

Live oaks and cabbage palms were ubiquitous and occurred in abundance on both mesic and hydric sites. Hydric forests also contained laurel oaks and American elms. Most mesic forests were distinguished by the lack of laurel oak and elm and by the presence of saw palmetto (*Serenoa repens*). Saw palmettos characteristically formed a dense, conspicuous undergrowth, which stopped abruptly at that elevation, where mesic conditions yielded to hydric conditions. The palmetto line, therefore, was an excellent indicator distinguishing mesic and hydric habitats.

Most, if not all, terrain containing palmettos may have once been open pine flatwoods. In recent decades, the pines were harvested, and the frequent fires were suppressed that once maintained the original pine flatwoods. Live oaks and cabbage palms colonized these sites in the absence of fire, creating much or most of what is now the mesic forest along the Myakka River.

Many forest stands were dominated by live oak and cabbage palm, which lacked both saw palmetto and any hydric indicators such as laurel oak and elm. Such stands could only be tentatively assigned as being hydric or mesic. They generally occupied the transition zones between mesic and hydric sites. It would have been difficult to establish a wetlands jurisdiction line in these transitional forests, using state or federal criteria.

Ordinarily, hydric and mesic forest types in river corridors are clearly distinguished by their distinctive tree species composition. The nearly universal presence of live oak and cabbage palm, coupled with the paucity of other tree species, obscured that distinction along the Myakka.

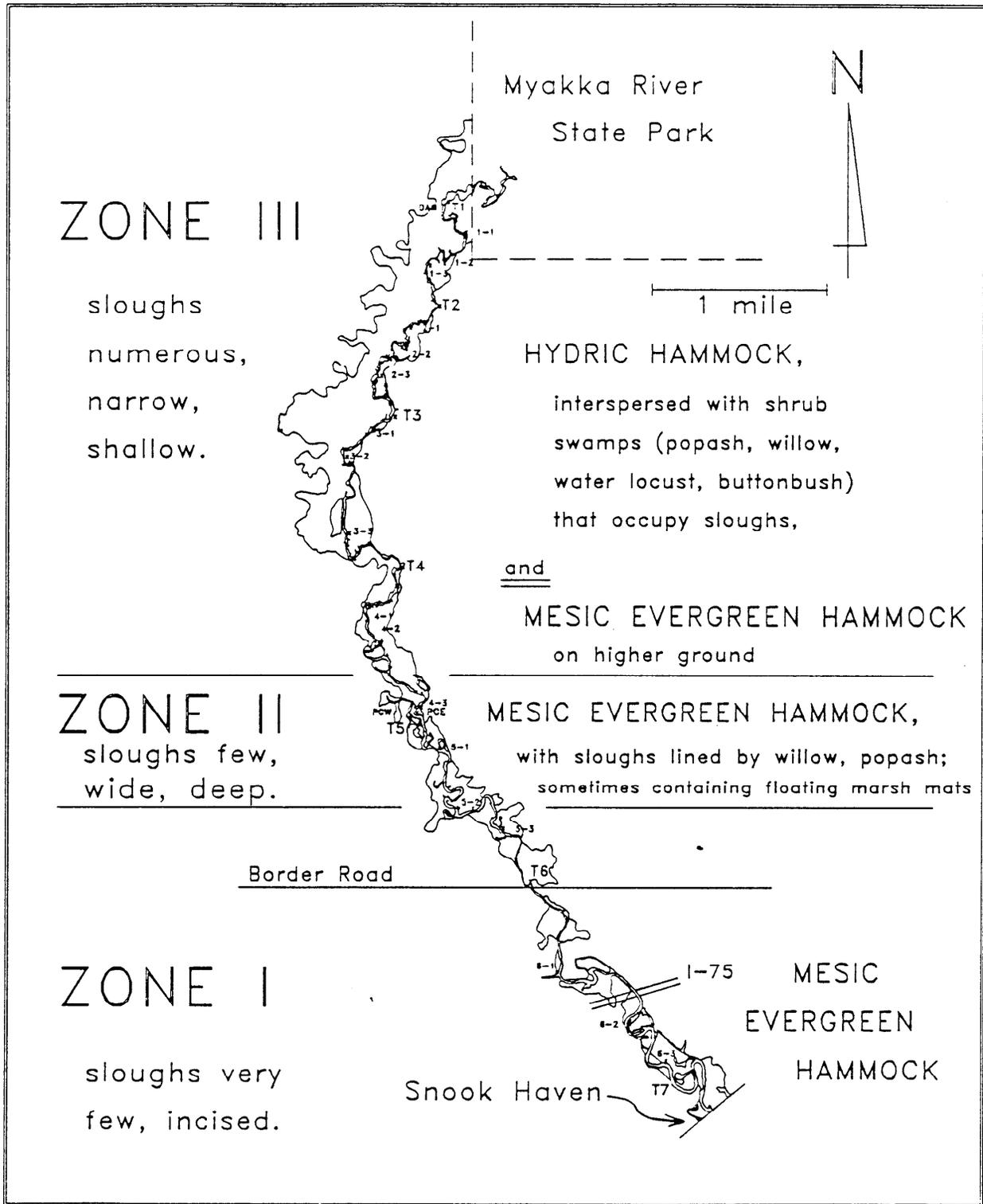


Figure 15. Map of study area showing Transects T1 through T7, PCE, PCW and shoreline stations 1-1 through 6-3.

Two forest types were recognized--hydric hammock on hydric sites and mesic evergreen hammock on mesic sites. These types could not be distinguished with confidence from aerial photographs and were not separated on the vegetation map. The forests of Zones I and II (Figure 15) consisted of mesic evergreen hammock. Downstream of T4 in Zone III, hydric hammocks occurred near the river. Upstream of T4, hydric hammocks were widespread, and mesic evergreen hammocks were restricted largely to peripheral sites that were somewhat elevated.

4. Vegetation Type Descriptions

Hydric Hammock. Hydric hammock is a common forest type in much of Florida. The type also extends northward as a distinctly minor forest element into Georgia and the Carolinas. It's greatest development is in the Gulf coastal region from St. Marks to Tarpon Springs. It occurs along many peninsular Florida streams, and comprises extensive forests associated with the St. Johns River.

The hydric hammock forest type was thoroughly described by Vince et al. (1989), based in part on original studies of representative forest stands. One such stand was sampled on Shep's Island in Myakka River State Park along Upper Lake Myakka (see pp. 25-26 for data and a photo on p. 27 in Vince et al. 1989). They listed five tree species at Shep's Island, which were, in order of importance, cabbage palm, live oak, laurel oak, water locust, and popash. There were 302 trees per acre with diameters of at least 10 cm (4 inches).

Hydric hammocks are commonly dominated by live oak, cabbage palm, and several additional hardwoods, such as laurel oak, sweetgum (*Liquidambar styraciflua*), American elm, loblolly pine (*Pinus taeda*), red maple (*Acer rubrum*), ironwood (*Carpinus caroliniana*), water oak (*Quercus nigra*), and red cedar (*Juniperus virginiana*, including *J. silicicola*). They occupy flood plains where flooding is gentle, often brief, and carries little sediment. Detrital accumulations are not necessarily removed by floods. Ground water is perched above a shallow impervious stratum, usually of clay (as at Myakka River), or is charged by springs from below through breaks in the confining layer. Soils remain moist or wet but not inundated most of the year.

Species composition varies considerably between stands. Some northern Florida stands occur north of the geographic range of cabbage palm, and these

usually conspicuous and characteristic trees are entirely absent. In southern Florida, including the Myakka River basin, tree species composition is depauperate, because trees such as sweetgum, loblolly pine, ironwood, and water oak do not occur that far south (Little, 1978).

The shrubby vegetation in sloughs is atypical of hydric hammocks. Ideally, these shrubby swamps of willow, popash, water locust, and buttonbush should be distinguished as a separate vegetation type. The nominal width of sloughs, though, makes these shrub swamps too narrow to map as a distinctive vegetation type, particularly in those many places where the sloughs were shaded beneath a gallery of tall, overhanging oaks.

The undergrowth in hydric hammocks ranged from scant to moderately dense. Woody species, particularly saplings of overstory trees, comprised the most conspicuous element of undergrowth. Understory trees and shrubs were conspicuous but usually not dense, such as *Ilex decidua* and *Viburnum obovatum*. Woody vines (species of *Vitis*, *Amelopsis*, *Smilax*, *Toxicodendron*) were common and added substantially to the woody aspect of the undergrowth.

Terrestrial herbs were decidedly uncommon. A small panic grass (*Dichanthelium laxiflorum*) and royal fern (*Osmunda regalis*) were among the very few characteristic forest herbs. Nearly all the other terrestrial herbaceous species observed in hydric hammocks were more typical of marshes than of forests, and most were common only near river banks. Among the more conspicuous riverbank herbs were a coarse panic grass (*Panicum dichotomiflorum*) and eastern gamagrass (*Tripsacum dactyloides*). Swamp lilies (*Crinum americanum*, *Hymenocallis* sp.) and sedges (especially *Carex lupulina*) were sometimes common in the shrub swamps along sloughs.

Epiphytes were the most conspicuous herbs and generally comprised the most abundant herbaceous element in hydric hammocks. Five species of airplants (*Tillandsia* spp.) were particularly abundant. Ferns (species of *Phlebodium*, *Polypodium*, *Vittaria*) and one orchid (*Encyclia tampensis*) comprised the remainder of the epiphytes. Even though epiphytes were abundant, the number of species (nine) was low relative to the epiphytes in the more tropical climate at the latitude of the Florida Everglades.

Missic Evergreen Hammock. The overstory consisted of live oak and cabbage palm. Slash pine was locally abundant in places but generally absent.

The undergrowth consisted largely of woody plants, especially saw palmetto and saplings of overstory trees. Shrubs, other than palmettos, and terrestrial herbs were generally sparse. Epiphytes were locally common.

Marsh. Three kinds of herbaceous emergent wetlands were observed: numerous shoreline marshes, several floating marshes, and a single isolated marsh (2,000 feet north of T1) of the type that generally occurs in pineland depressions.

Most shoreline marshes were approximately 0.1 to 0.7 acres in size. They were elongated or crescent-shaped and occupied low flats. Some larger ones colonized bars at the confluence of sloughs. Shoreline marshes downstream of T4 occurred with frequency and were both large and small. Most were species-rich and were somewhat differentiated into species zones. Shoreline marshes upstream of T4 were much less frequent, were mostly small in size, generally contained few species, were largely azonal, and were frequently interrupted by willows. Paragrass (*Brachiaria mutica*, an exotic) had captured the terrain at shoreline stations 1-0 and 1-3 (Table 78) and was abundant farther upstream within the state park. None of the shoreline marshes were well organized into communities, and all appeared to be haphazard collections of hydric herbs.

Flats at the mouths of sloughs were sometimes dominated by one or two species, such as cattails (*Typha domingensis*), pickerelweed (*Pontederia cordata*), or smartweed (*Polygonum punctatum*). Most shoreline marshes, though, contained several or many dominant species, of which one of the most pervasive was blue paspalum (*Paspalum caespitosum*). Blue paspalum was not observed upstream of T4. Other common shoreline marsh plants included species of *Alternanthera*, *Baccopa*, *Coreopsis*, *Cyperus*, *Echinochloa*, *Eleocharis*, *Hydrocotyle*, *Hypericum*, *Juncus*, *Lindernia*, *Ludwigia*, *Micranthemum*, *Mikania*, *Phyla*, *Pluchea*, *Rumex*, and *Sagittaria*. Species composition and abundance varied from marsh to marsh.

Several shoreline stations (Table 78) fell entirely within marshes, including stations 4-2, 5-1, and 6-1. Other, but not all, stations fell partially in marsh and partially in hydric hammock or on elevated weedy riverbanks and bars.

Floating marshes occupied oxbow portions of five broad sloughs in Zone II (Figure 15). These marshes consisted of dense mats of free-floating pickerelweed (*Pontederia cordata*). The pickerelweeds were tall and almost invariably sterile, although other pickerelweeds were blooming elsewhere along riverbanks. Cuban bulrush (*Scirpus cubensis*) was usually abundant; its shallowly submerged rhizomes were woven around the pickerelweeds. The diminutive floating fern, *Salvinia minima*, commonly covered the water's surface where there was space between the pickerelweeds. The mats were sufficiently dense to be colonized by occasional plants of other marsh species but not in abundance. The mats covered areas up to about three acres and entirely covered the water from one side to the other. They appeared with a bright crimson signature on color-IR aerial photos. A similar mat was described at Vanderipe Slough, just below the dam at Upper Lake Myakka (Clewell, 1984).

5. Species Ranges Along Myakka River

Plants of several species were observed that are characteristic of the zone of tidal influence. These plants grew along the shoreline in the lower portion of the river. These species are listed below, along with the furthest river segment upstream that they were observed. The river segments are shown on the vegetation map.

- Acrostichum aureum* -- 3
- Paspalum caespitosum* -- 35
- Sagittaria subulata* -- B
- Schinus terebinthifolius* -- 6
- Scirpus validus* -- 35
- Spartina bakeri* -- D

The last three species probably occur further inland but not within the river corridor.

Plants of several other species were common upstream but were not observed downstream. These species are listed below, along with the furthest river segment downstream in which they were recorded.

- Blechnum serrulatum* -- 19
- Brachiaria mutica* -- 71
- Cephalanthus occidentalis* -- 20

Fraxinus caroliniana -- 11

Gleditsia aquatica -- 20

Quercus laurifolia -- 39

6. Point Bars

Point bars are deposits of sand that prograde in slack water on the inside curves of streams. Typically, they are colonized by willows. Point bar formation on the Myakka River was modest, owing largely to the low gradient and small discharge. There was little evidence of recent deposition and growth. Some point bars were entirely forested by oaks, which had presumably replaced the willows. These observations suggested that point bar formation has been occurring at a much slower rate in recent years than previously. The reason may be that the dam at T1 is preventing sand from being imported into the lower Myakka River from further upstream

C. FUTURE CONSIDERATIONS

Natural and anthropomorphic alterations of the regional environment could cause changes to the Myakka River, such as lowering discharge or depressing groundwater tables. Such impacts could affect the vegetation within the river corridor. If so, are the methods employed for the botanical inventory described in this report adequate to detect those changes?

1. Adequacy of the Vegetation

In general, neither the shoreline vegetation nor the forests lend themselves for use in detecting subtle changes in hydrology. Marshes and other shoreline vegetation consists of species that are relatively ephemeral. If habitat conditions change, these plants will die and colonize elsewhere, wherever conditions are suitable. For example, if river stage is lowered, the marshes will simply shift in elevation to a lower position on the riverbank. There are no long-lived perennials that would persist indefinitely, such as saw palmetto does in uplands, following perturbation.

Forests also give little assistance towards detecting changes for two reasons. First, overstory trees tolerate gross changes in hydrology for several years or decades before succumbing, because they are well established. Second, the hydrological change would cause live oak and cabbage palm dominated hydric hammocks to become live oak and cabbage palm dominated

mesic evergreen hammocks. In short, there is too much overlap in species composition between the hydric and mesic forest types in the corridor to detect hydrologically-driven alterations in the forest.

Third, the flora of the corridor is depauperate, relative to river corridors elsewhere in Florida. Many northern species do not occur this far south, but the Myakka River is not far enough south to contain a significant tropical floristic element. As a result, there are not many species from which to select one or few sensitive indicators of hydrological changes.

2. Detection Methods.

Transects T1 through T7 could be employed as permanent study plots. Their corners would have to be permanently staked and professionally surveyed. They should be monitored annually, so that natural cycles of vegetational fluctuation could be documented prior to any hydrological alterations. The transects, as they presently exist, have two detractors, though. First, they traverse very uneven topography (Figures 6-14), which will confound interpretations of results between two periods of time. Second, they lack adequate numbers of trees for critical statistical tests. If transects are to be made permanent, it would be better to re-establish them parallel to the river on sites with nearly level elevation that contain many trees.

The shoreline stations could also be improved. First, they too should be permanently staked, surveyed, and annually monitored. Second, they should be configured in such a way that they are confined to a uniform vegetation type, e.g., blue paspalum marsh, elevated weedy riverbank, or hydric hammock. The number of interception points should be doubled at each station, to provide greater confidence in statistical testing. Some shoreline stations are more suitable than others. Only half as many stations would be adequate.

If permanent transect and shoreline stations are established, they should be photographed annually. If logistically possible, photos should be taken from a high vantage, perhaps from a stepladder.

VI. MANAGEMENT PERSPECTIVES

Many factors must be considered in the development of a monitoring program for the Myakka River. Each factor must be evaluated with regard to the anticipated effects on the biological integrity of the river. Factors to be considered include: organic loading, increased sediment load, shoreline development, increased phosphates and nitrogen load, contaminants due to storm water runoff, and anthropogenic causes of flow alteration. Each of the aforementioned factors will have an effect on different aspects of the benthic community such as species composition, number of species, density of overall benthic community, abundance of indicator organisms, and the range or distribution of salinity tolerant/intolerant organisms.

The primary land use within the area of watershed under investigation is cattle grazing on rangeland, unimproved pasture, and improved pasture. Generally, this type of activity, if it remains at the present level, will only affect the amount of organics introduced into the river through animal waste, and that appears to be minimal based on the analysis of the species composition of the benthic community of the watershed adjacent to those pasture lands. An increase in the degree of cattle grazing along the Myakka River corridor may result in an increased amount of organics introduced into the river. This would result in the possibility of producing anaerobic conditions. The resultant decrease in oxygen available to the bottom dwelling organisms would change the highly diverse benthic community which presently exists, to one dominated by a few opportunist taxa, and effectively exclude the organisms comprising the class I category of Beck's Biotic Index which are unable to tolerate any appreciable degree of organic pollution. Based on the biotic index, the region most likely to be affected by increased organics would be upstream from Rocky Ford to Down's Dam. The three transects located on this stretch of river had the highest biotic indices, indicating a low concentration of organic loading.

Sediment composition is one of the most important factors affecting the distribution of benthic organisms. Any management option which could increase the sediment load of the river adjacent to or upstream of the study area will change the species composition and structure of the benthic community.

Dredging and filling in the Myakka River are the most significant potential activities which would increase sedimentation and should be kept to a minimum. The most significant impact would be on the insect community which was the dominant component at most stations, and contributes substantially as prey items to the higher trophic levels, i.e. fish.

Additionally, any construction along the shoreline which may threaten shore stabilization by destroying emergent vegetation should be discouraged, as this would increase erosion and contribute to increased sediment load. The destruction of emergent vegetation will also eliminate an important habitat for many taxa such as gastropods and insect larvae which form an integral component in the diet of many fish.

Nutrients, such as nitrogen and phosphorus, are major factors in the stability and health of the benthic community. In the Myakka River nitrogen is the limiting factor to the primary productivity. Any increase in nitrogen would result in increased phytoplankton production, consequently increasing the biological oxygen demand (BOD) resulting in less dissolved oxygen available to the benthic organisms. Since the dissolved oxygen levels of the bottom waters are known to periodically fall below Florida's water quality standards [frequently less than 4 mg/l near Snook Haven (Transect 7)], any factor which may create a higher BOD could overload the system and create anaerobic conditions, particularly in the deeper portions of the river: Transects 5-7 in the study region. The freshwater organisms occurring within these transects are already under stressful conditions due to the unstable salinity regime, as indicated by the presence of euryhaline taxa. The opportunistic species, *Limnodrilus hoffmeisteri* was frequently found to be the most dominant macroinvertebrate within this section of the river. However, a highly diverse community of insects was also present. If anaerobic conditions were to occur for any extended period of time, the result would be a decrease in diversity, primarily the less tolerant insect fauna, such as mayflies, caddisflies, and beetle larvae. The population of *Limnodrilus hoffmeisteri* would also increase due to a decrease in predators (insect larvae) and the availability of previously occupied ecological niches. This would have a profound impact on the bottom feeding fish whose diet can be specific for certain taxa which may be eliminated.

An increase in nutrients is likely to occur through seepage water or as surface water runoff if increased agricultural pressure occurs in the areas adjacent to the study areas or upstream of Down's Dam. An already existing source of nutrient loading on the Myakka is from the inflow of Curry Creek due to the presence of a water treatment facility discharging its effluent into the creek. Further studies are required to determine the actual impact of this discharge on the river. A potential source of increased nutrient load would be the construction of a spray field for treated wastewater on the Walton Tract. This project has the potential for not only increasing the nutrient load, but also dissolved organic carbon (DOC). The effects of increasing the DOC would essentially be similar to those outlined for nutrient loading as discussed previously.

Contaminants from stormwater runoff are already being introduced into the river. These contaminants include sediments, nutrients, chemicals, oil and grease, petroleum hydrocarbons, litter, and metals. If future development of the land within the watershed is allowed to continue, the clearing of vegetation, drainage modifications, and the creation of an impervious surface layer would cause increased runoff with a corresponding increase in associated contaminants. The effects of this on the benthic community would be to create stressful conditions resulting in the decrease of diversity, and, if severe enough, depressing the populations of even the most tolerant of opportunistic species. Ultimately, this would have a negative impact on the secondary and tertiary producers throughout the river.

Phosphate mining is already occurring in regions upstream from the study area. The effects created by the actual physical disturbance are obvious, and produce conditions previously discussed, i.e., increased sediment load, alteration of the natural pH, removal of vegetation, and disruption of the natural hydrologic conditions. However, additional stress may be caused by the introduction of contaminants by the discharging of the effluent used in the mining process. Careful documentation should be maintained and closely monitored by regulatory agencies to determine the exact nature and quantity of the effluent.

The last factor to be addressed is the alteration of river flow by anthropogenic influences. The Myakka River is an extremely dynamic system

The natural flow of the river can fluctuate between periods of raging currents to sustained intervals of zero flow. Many of the benthic macroinvertebrates are sensitive to changes in these hydrologic events and this is reflected in their life cycle. Insect larvae are probably the most sensitive taxa in the Myakka. Many species attain maximum populations during periods of optimal flow. If water is removed from the river, even during periods of maximum flow, by the construction of reservoirs for domestic use, the impact of flow reduction will need to be evaluated, but will likely cause a change in the community structure of the benthos. However, more important to the potential alteration of the benthic community caused by freshwater withdrawal, will be the corresponding effects on the salinity regime. The decrease in flow will cause the tidal effects to encroach further upstream. This area of the river-estuary serves as a nursery ground for many estuarine/marine fish and invertebrates. Alteration of these natural conditions may force those taxa further upstream. However, the availability of suitable habitat in the upstream areas must be evaluated. Many taxa have specific requirements for their physical habitat, such as substrate preferences, current velocity, depth, and even the amount of available leaf litter. If these optimal conditions are not available in the upstream regions into which they are forced due to the increased salinity, certain taxa may be eliminated from the river.

Although the Myakka River is highly dynamic, it harbors a fairly sensitive ecosystem. The benthic community existing within this environment has adapted to these ever-changing, but recurring conditions. Any alteration in the environment, albeit ever so subtle, may cause a "trickle down" effect from the seemingly insignificant primary producers to the highest trophic level. The factors presented in this section for consideration of monitoring practices have been considered to have the most causal influences on the biological community of the Myakka River. However, these are not all inclusive and any management option must consider the potential consequences of what may seem to have even the most insignificant impact on the river.

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APPENDICES AND TABLES

AVAILABLE UPON REQUEST