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SEDIMENT AND WATER QUALITY OF CANDIDATE OCEAN DREDGED MATERIAL DISPOSAL SITES FOR PORT EVERGLADES AND PALM BEACH, FLORIDA

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By:

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SEDIMENT AND WATER QUALITY OF CANDIDATE OCEAN DREDGED MATERIAL DISPOSAL SITES FOR PORT EVERGLADES AND PALM BEACH, FLORIDA

1.0 INTRODUCTION

The U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers have the responsibility under Section 102 of the Marine Protection, Research and Sanctuaries Act (MPRSA), for the management and monitoring of Ocean Dredged Material Disposal Sites (ODMDSs). EPA has the responsibility under the MPRSA for designation of sites for dredged material disposal. The Corps of Engineers Jacksonville District has requested that EPA Region 4 designate disposal sites off shore Palm Beach, Florida and Port Everglades, Florida for the disposal of dredged material.

To date, EPA and the COE have identified four candidate sites for Palm Beach and three for Port Everglades. In accordance with 40 CFR §228.4 of the Ocean Dumping regulations site designations will be made based on environmental studies of each site. Various surveys have been conducted in the past in the vicinity of these candidate site. These surveys along with this effort and a literature search will be used to characterize the candidate sites and adjacent regions to support dredged material disposal site designations offshore Port Everglades and Palm Beach, Florida. Survey station location and analyte selection for this survey were based on guidance provided in the Ocean Dumping regulations (40 CFR §228.13(a-f)) and in, *Revised Procedural Guide for Designation Surveys of Ocean Dredged Material Disposal Sites* (Pequegnat, 1990).

This report details the methods and results of an environmental characterization survey of the candidate sites for Ocean Dredged Material Disposal Sites (ODMDSs) offshore Port Everglades and Palm Beach, Florida conducted in 1998. Survey sampling was conducted by EPA Region 4 personnel aboard the OSV Peter W. Anderson. Water samples were collected on April 1, 1998 and sediment and biological samples were collected from May 18 through May 20 and from August 13 through August 14, 1998. Water and Sediment analysis was conducted by PPB Environmental Laboratories under contract to the Corps of Engineers Jacksonville District. Biological analysis was conducted by Water and Air Research under contract to the Corps of Engineers Jacksonville District.

2.0 METHODS

2.1 Station Locations

A sufficient number of stations were selected in order provide the minimum number of stations within and outside each of the candidate sites in conjunction with previous surveys conducted in the area. Ocean Dumping regulations (40 CFR §228.13c) recommend that sampling be conducted within the site and in the contiguous area including at least two stations down current of the site and at least two stations up current of the site. Pequegnat recommended that

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the number of sampling stations within a site range from two to six (Pequegnat, 1990). This survey in conjunction with previous surveys will provide two benthic stations (physical and biotal) within each candidate site and two up current and down current of the sites. It will also provide two water column stations within each site and two up current and down current of the sites (see figures 1 and 2). The discrete water samples were collected at 4 depths (surface, within the thermocline, between the thermocline and bottom and near bottom) for stations in greater than 200 meter depths and at 3 depths (surface, within the thermocline, and near bottom) for shallower stations in accordance with Pequegnat (1990). Water column profiles were taken at each sample station during each sampling event. Station locations, depths and analysis are shown in table 1.

Table 1: Sample Stations

Station	Latitude		Longitude		Depth	Candidate Site	Benthic Analysis			Benthic Sampler	Water Analysis		
#	Degrees	Minutes	Degrees	Minutes	(M)		B	SC	SGS		WP	WQ	No. of Depths
Palm Beach ODMDS Candidate Sites													
1	26	49.9980	79	57.0000	158	4.5 Mile	X		X	Young	X		
2	26	46.9980	79	56.2500	183	4.5 Mile	X	X	X	Young	X	X	4
3	26	46.9980	79	57.0000	166	4.5 Mile	X		X	VanVeen	X		
4	26	45.4980	79	58.5000	148	Interim					X	X	3
5	26	43.9980	79	57.0000	183	4.5 Mile					X	X	4
6	26	48.4980	79	52.0020	283	9 Mile	X	X	X	VanVeen	X		
7	26	46.0020	79	51.4980	297	9 Mile	X	X	X	VanVeen	X	X	4
8	26	46.0020	79	52.5000	278	9 Mile	X	X	X	VanVeen	X		
9	26	43.0020	79	52.0020	289	9 Mile	X	X	X	VanVeen	X	X	4
Port Everglades ODMDS Candidate Sites													
10	26	9.0000	80	4.0020	61	Interim					X		
11	26	6.4980	80	4.0020	110	Interim					X	X	3
12	26	4.9980	80	4.0020	116	Interim					X	X	3
13	26	9.0000	80	1.5000	207	4 Mile	X	X	X	VanVeen	X		
14	26	7.0200	80	1.5000	211	4 Mile	X	X	X	VanVeen	X	X	4
15	26	4.9980	80	1.5000	221	4 Mile	X	X	X	VanVeen	X	X	4
16	26	10.0020	79	58.6200	241	7 Mile	X	X	X	VanVeen	X		
17	26	7.5000	79	57.9000	266	7 Mile	HB	HB	HB	VanVeen	X	X	4
18	26	7.5000	79	59.1000	231	7 Mile	HB	HB	HB	VanVeen	X		
19	26	4.9980	79	58.6200	238	7 Mile	HB	HB	HB	VanVeen	X	X	4
20	26	8.3120	79	59.2060	238	7 Mile	X	X	X	Young	X		

Key:
B=Community Analysis SC=Sediment Chemistry X=Analysis Completed
WP=Water Profile (Depth, Temp., Salinity, Density & Transmissivity) WQ=Water Samples (lab analysis & onboard turbidity)
HB=Hard Bottom Encountered
Van Veen=Deep Ocean Van Veen (1 foot by 2 foot sampling area) Young=Large Young Grab (1 foot by 1 foot sampling area)

Positioning data was obtained using a Northstar 941 Differential GPS.

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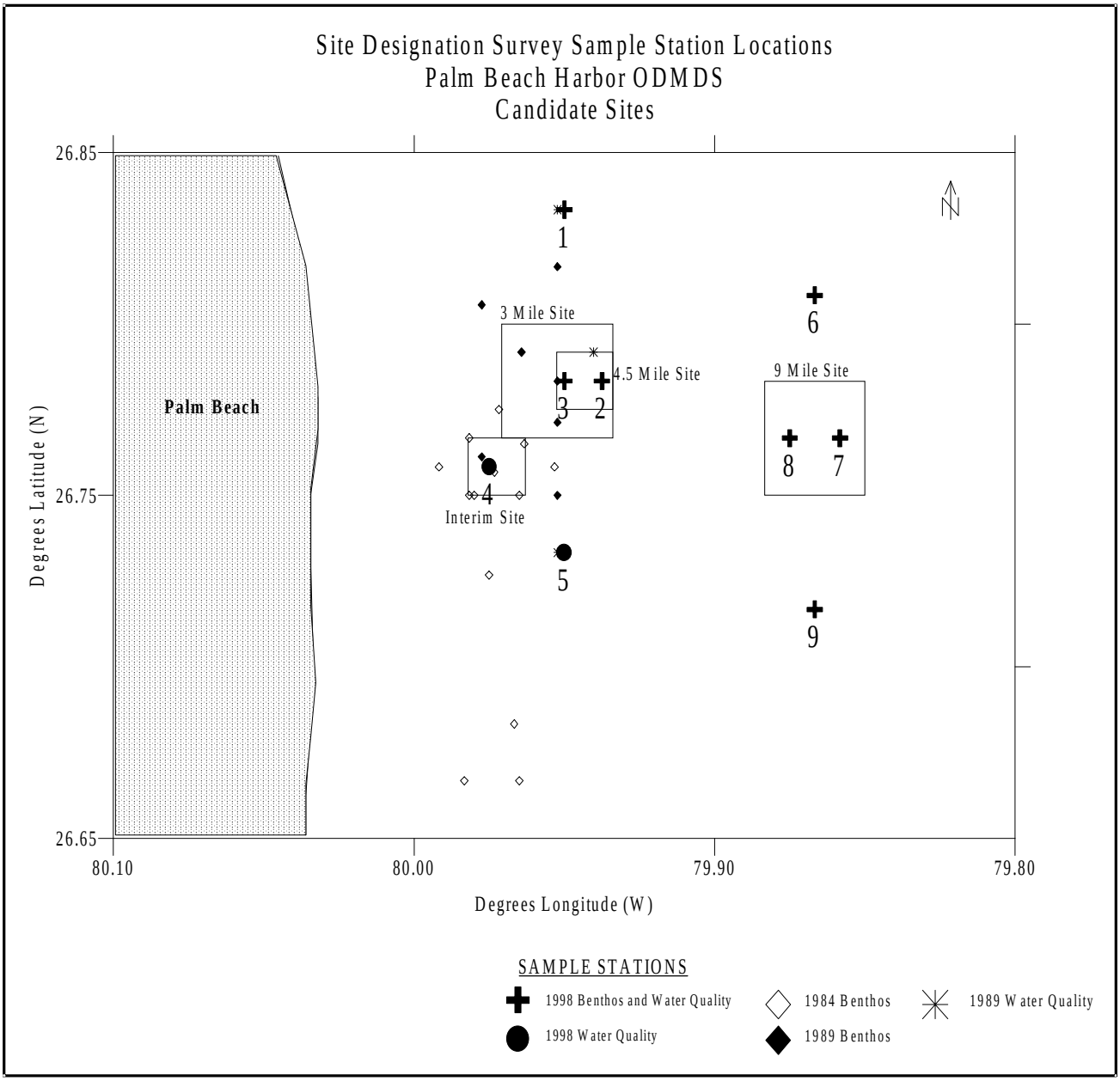

Figure 1

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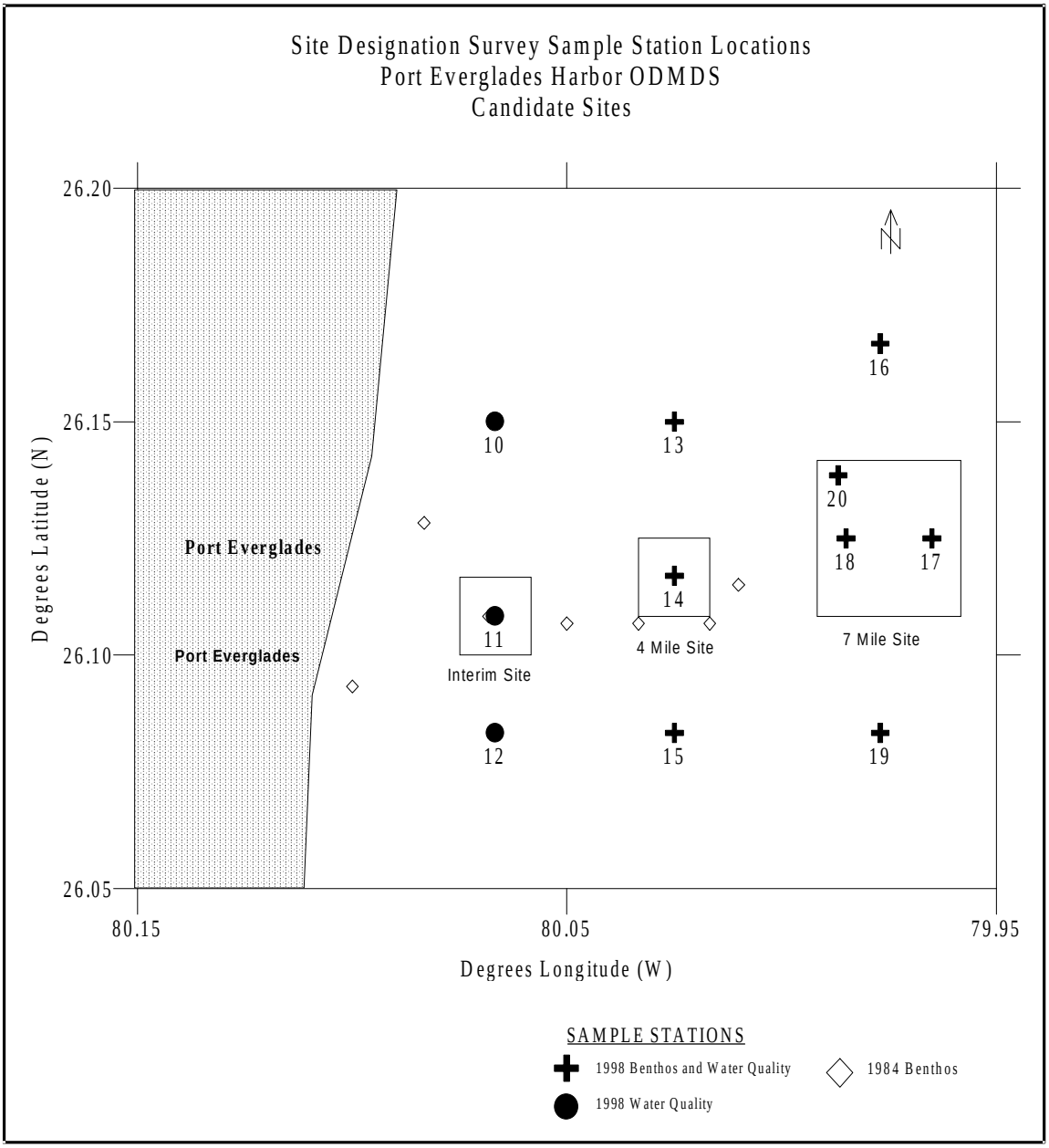

Figure 2

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2.2 Water Quality

Water column analysis consisted of depth profiles and discrete samples for lab analysis. Discrete samples were collected on April 1, 1998. Hydrographic profiles were conducted at each of the water and sediment stations on April 1, May 18-20 and August 13-14, 1998. Selection of variables for analysis was based on recommendations in Pequegnat (1990). The time, date and tidal state for each station is presented in table 2.

Table 2: Water Quality Stations

Station	Associated Candidate Site	Date Sampled	Time Sampled	Tidal Stage
1	Palm Beach 4.5 Mile	05/19/98	2311h	Low
2	Palm Beach 4.5 Mile	04/01/98	0855h	Slack
2	Palm Beach 4.5 Mile	05/19/98	2215h	Low
3	Palm Beach 4.5 Mile	05/19/98	1852h	Low
5	Palm Beach 4.5 Mile	04/01/98	1030h	High
6	Palm Beach 9 Mile	05/20/98	0142h	High
6	Palm Beach 9 Mile	08/14/98	1259h	Slack
7	Palm Beach 9 Mile	04/01/98	1225h	High
7	Palm Beach 9 Mile	05/20/98	0907h	Low
7	Palm Beach 9 Mile	08/13/98	1933h	Low
8	Palm Beach 9 Mile	05/20/98	0838h	Low
8	Palm Beach 9 Mile	08/13/98	1616h	High
9	Palm Beach 9 Mile	04/01/98	1119h	High
9	Palm Beach 9 Mile	08/13/98	2029h	Low
4	Palm Beach Interim	04/01/98	0955h	Slack
4	Palm Beach Interim	05/20/98	0952h	Low
5	Palm Beach Interim	05/20/98	1011h	Low
13	Port Everglades 4 Mile	05/19/98	0720h	Low
14	Port Everglades 4 Mile	04/01/98	2013h	Low
14	Port Everglades 4 Mile	05/19/98	1224h	High
15	Port Everglades 4 Mile	04/01/98	1932h	Low
15	Port Everglades 7 Mile	05/18/98	2146h	Low
16	Port Everglades 7 Mile	05/19/98	0905h	Low
17	Port Everglades 7 Mile	04/01/98	1751h	Low
17	Port Everglades 7 Mile	05/19/98	1033h	Low
18	Port Everglades 7 Mile	05/19/98	1105h	Low
19	Port Everglades 7 Mile	04/01/98	1845h	Low
19	Port Everglades 7 Mile	05/19/98	1153h	Slack
20	Port Everglades 7 Mile	05/20/98	1528h	High
10	Port Everglades Interim	04/01/98	2139h	Slack
10	Port Everglades Interim	05/19/98	1335h	High
11	Port Everglades Interim	04/01/98	2117h	Low
11	Port Everglades Interim	05/19/98	1316h	High
12	Port Everglades Interim	04/01/98	2052h	Low
12	Port Everglades Interim	05/19/98	1255h	High

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2.2.1 Hydrography

Hydrographic profiles were taken at each of the water and sediment stations utilizing a Sea-Bird SBE-9 CTD aboard the OSV Anderson. Because temperature, salinity, and oxygen data can provide information on water flow, it was recommended that profiles be conducted at every station (Pequegnat, 1990). Profile measurements consisted of temperature, salinity, dissolved oxygen and transmissivity. The depth (pressure), temperature, and conductivity probes and transmissometer are calibrated annually at the first of the year. The dissolved oxygen sensor was calibrated prior to each survey.

2.2.2 Water Chemistry

Samples for chemical analysis were collected with teflon lined Niskin bottles. Samples were collected at 4 depths (surface, within the thermocline, between the thermocline and bottom and near bottom) for stations in greater than 200 meter depths and at 3 depths (surface, within the thermocline, and near bottom) for shallower stations. Samples were analyzed for: turbidity; total suspended sediments; dissolved cadmium, copper, lead and mercury; total petroleum hydrocarbons; pesticides; and PCBs based on the recommendations of Pequegnat (1990). Turbidity was measured utilizing a Hach Turbidimeter Model 2100A. Standardization was performed prior to each measurement. Methods of preservation and analysis for the remaining analytes are given in Appendix A.

2.3 Benthos Characteristics

Characterization of the benthos consists of physical properties (granulometry and chemistry) of the sediments and macroinfauna descriptions of the sampled stations. Stations 1 and 3 did not have chemistry analysis conducted due to availability of data from previous surveys in this area. Stations 4 and 5 did not have benthic analysis conducted due to availability of data from previous surveys.

Sample collection was attempted on April 1, 1998 utilizing a Deep Ocean Box Corer. This method provided insufficient sample and sampling was aborted. Sample collection in May 18-20 was conducted utilizing a stainless steel Deep Ocean Van Veen (see figure 3) with a 1 foot by 2 foot footprint. Damage to the Van Veen occurred due to encounter with rocky bottom. Stations 1, 2, and 20 were successfully sampled utilizing the Large Young Grab with a 1 foot by 1 foot footprint. Stations 6 through 9 could not be sampled utilizing the Large Young Grab. Sampling at these stations was completed August 13 to14, 1998 following repair of the Van Veen.

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2.3.1 Granulometry

One gallon of sample was collected at each station. Samples were stored in glass jars and chilled. Grain size was determined following Plumb (1981).

2.3.2 Sediment Chemistry

Two gallons of sample were collected at each station utilizing the Van Veen or Young Grab. The samples were transferred from the sampling device to a stainless steel pan to glass jars. Samples were stored in glass jars and chilled. The sampling devices were cleansed with Liquinox and rinsed with isopropal alcohol between stations. Methods of preservation and analysis for the analytes are given in Appendix B.

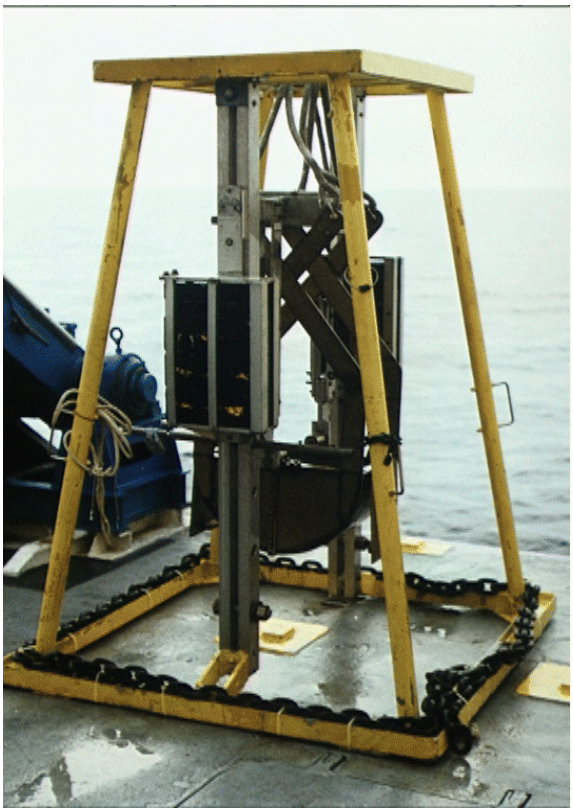

Figure 3: Deep Ocean Van Veen

2.3.3 Biotal Characteristics

Three replicate macroinfauna grab samples were collected at each station utilizing the Deep Ocean Van Veen or Large Young Grab as identified in table 2. The Van Veen samples 2 square feet (0.19 m^2) and the Young Grab 1 square foot (0.09 m^2). Upon collection, samples were sieved (500 µ mesh) and preserved in the field with 10 percent formalin stained with Rose Bengal (200 mg/L). In the laboratory samples were rinsed with tap water, re-sieved (500 µ mesh), sorted under dissecting scope, and re-preserved using 70 percent ethanol. Ten percent of the samples were re-examined by a co-worker to ensure all organisms were removed from sediments for future enumeration and identification. Organisms were counted and identified under a dissecting microscope (up to 80x). Representative specimens were preserved in a reference collection.

Benthic macroinvertebrate communities or infauna are defined as those small invertebrates living in or on the sediments that are retained by a 0.5 mm mesh sieve. In this study infaunal communities are described by a number of community parameters such as composition (species present), dominant taxa (most abundant species) density (number of individual/m^2), and species richness (number of species). Additionally, a number of community indices were calculated to allow comparison and evaluation of the candidate sites within and between locations (Palm Beach or Port Everglades). Species diversity was estimated by the Shannon -Weaver diversity index H', (Shannon and Weaver, 1963). The formula applied was as follows:

$$H' = -\sum_{i=1}^{s} P_i(\log_e p_i)$$

Where: s - is the number of taxa in the sample,
i - is the i'th species in the sample, and
Pi - is the number of individuals of the i'th species divided by the total number of individuals of all species in the sample.

Species diversity is determined by both the number of taxa present in the community (richness) and the distribution of individuals among those species. Species richness was estimated as Margalef's species richness index D, (Margalef, 1957). The formula is D = S-1/$\log_e$ N, where S is the number of taxa and N is the number of individuals in the sample. Evenness, the distribution of individuals among taxa was estimated by Pielou's evenness index J' , (Pielou, 1966). Pielou's Index J' was calculated as J' = H' / $\log_e$ S, where H' is the Shannon-Weaver diversity index and S is the number of taxa in the sample. Simpson's dominance diversity index Si, provides an estimate of community dominance based on the distribution of individuals among species. Simpson's dominance diversity is calculated as:

$$Si = 1 - \frac{1}{N^2} \times \sum_{i=s} n_i^2$$

Where: N - is the total number of individuals
S - is the number of different species
n_i - is the number of individuals in sample i

3.0 RESULTS AND DISCUSSION

3.1 Water Quality

3.1.1 Hydrography

A total of 13 CTD profiles were conducted. Salinity, temperature, dissolved oxygen and transmissivity were recorded. Data for each station is presented in Appendix C.

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3.1.1.1 Temperature

Water temperatures for the survey ranged from a high of 31ºC to a low of 7ºC at the bottom (300m). Surface temperatures ranged from 25 to 31ºC. Bottom temperature ranged from 7 to 11ºC. In general, offshore stations were warmer than nearshore stations. Thermoclines were observed between 20 and 50 meters at most stations. Average temperature profiles for the candidate sites are shown in figures 4 and 5.

3.1.1.2 Transmissivity

The water at all stations was very clear, as would be expected of Gulf Stream waters. Transmissivity was highest near the surface and relatively constant over the upper 140 meters. Surface transmissivities ranged from 62 to 70%. Nearshore stations in less than 150 meters of water experienced little or no decrease in transmissivity with depth. In the deeper stations transmissivity decreased below 150 meters reaching ranges of 42 to 65% near the bottom. Average transmissivity profiles for the candidate sites are shown in figures 6 and 7.

3.1.1.3 Salinity

Salinities within the survey areas fell within the range of 34.8 to 36.5 $^{o}/_{oo}$. Salinities were highest in the upper 100 meters. Salinities tended to increase from the surface to a depth of about 20 to 80 meters and then decrease as depth decreased. Average salinity profiles for the candidate sites are shown in figures 8 and 9.

3.1.1.4 Dissolved Oxygen

Dissolved oxygen levels in the water column ranged from 2.7 to 6.6 mg/l. For most stations, dissolved oxygen was approximately 4.5 mg/l over the upper 50 meters, dropped to 3.4 mg/l by a depth of 120 meters and remained at that level until bottom was reached. Stations sampled in April had dissolved oxygen concentrations approximately 2 mg/l higher in surface waters and 1 mg/l higher in bottom waters. Average dissolved oxygen profiles for the candidate sites are shown in figures 10 and 11.

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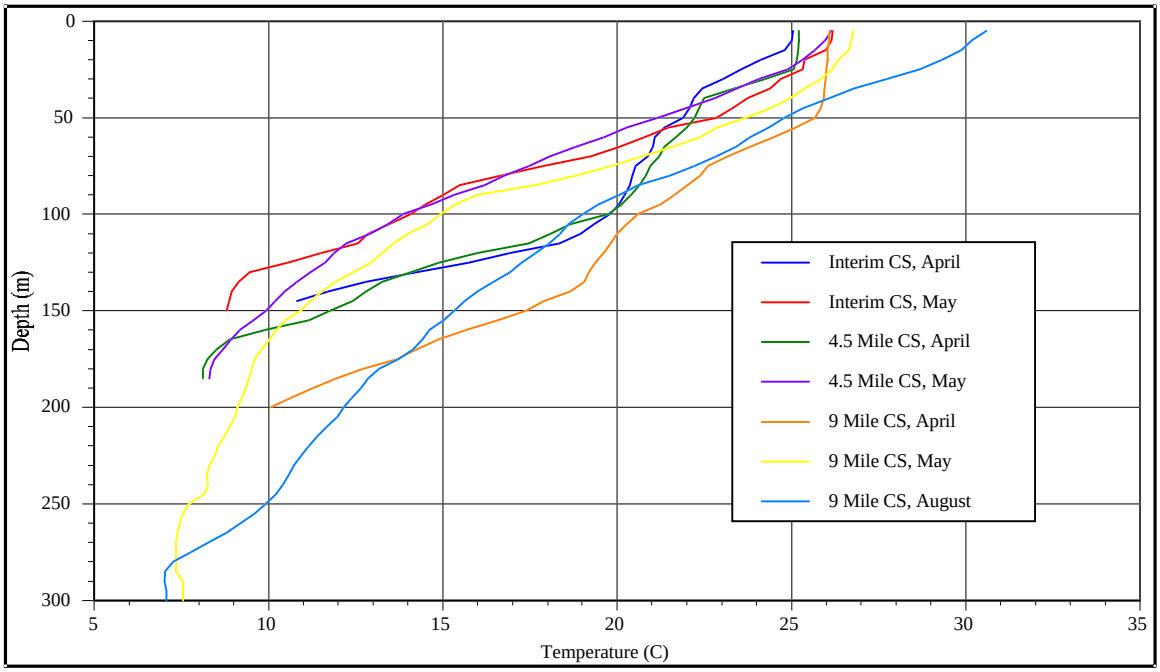

Figure 4: Average Temperature Profiles from CTD stations at the Palm Beach Candidate Sites (CS)

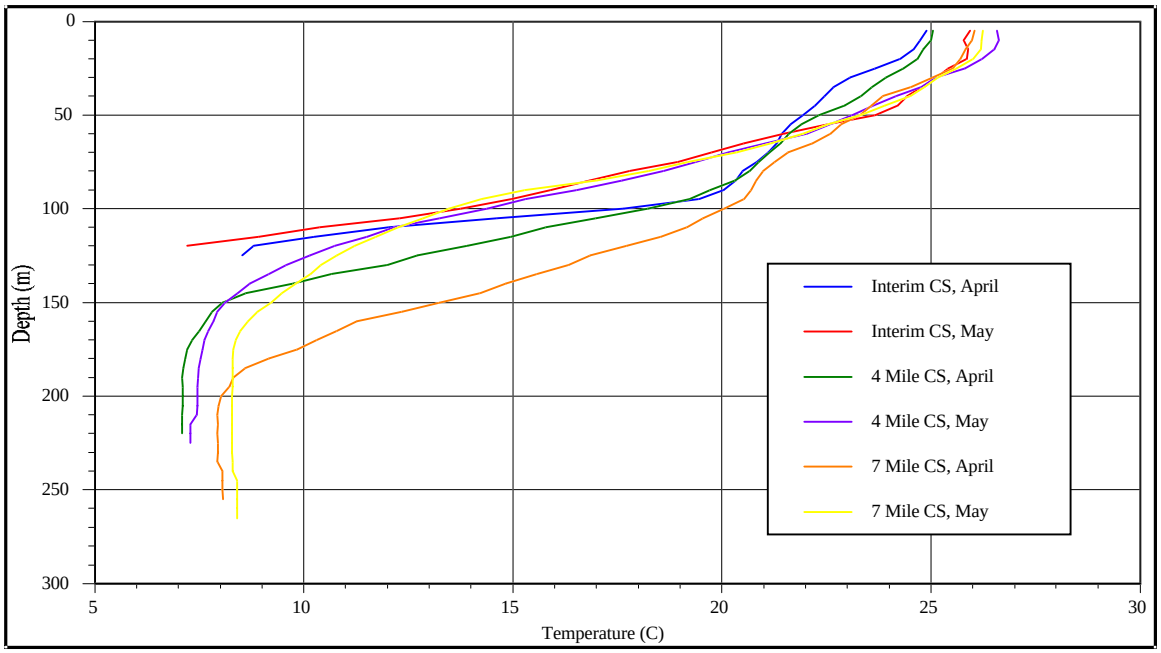

Figure 5: Average Temperature Profiles from CTD stations at the Port Everglades Candidate Sites (CS)

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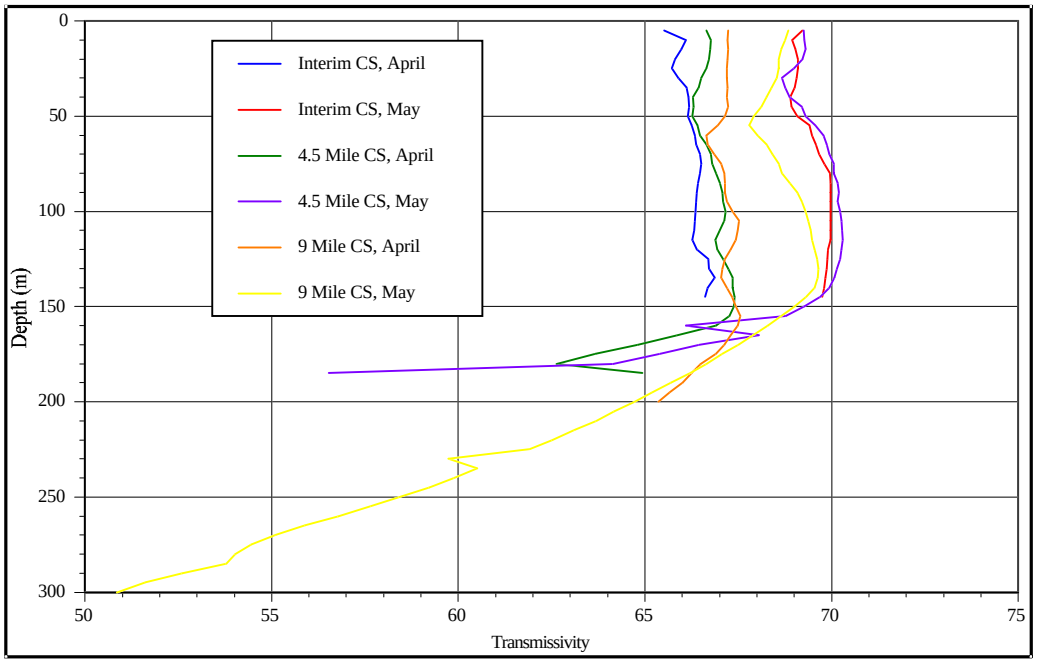

Figure 6: Average Transmissivity Profiles from CTD stations at the Palm Beach Candidate Sites (CS)

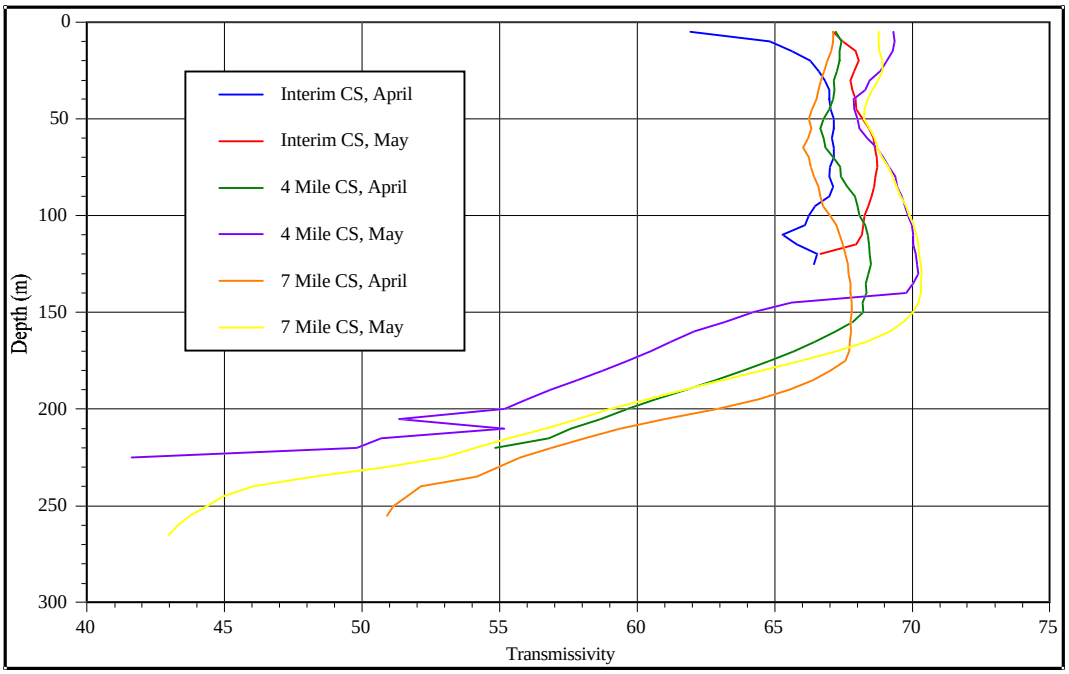

Figure 7: Average Transmissivity Profiles from CTD stations at the Port Everglades Candidate Sites (CS)

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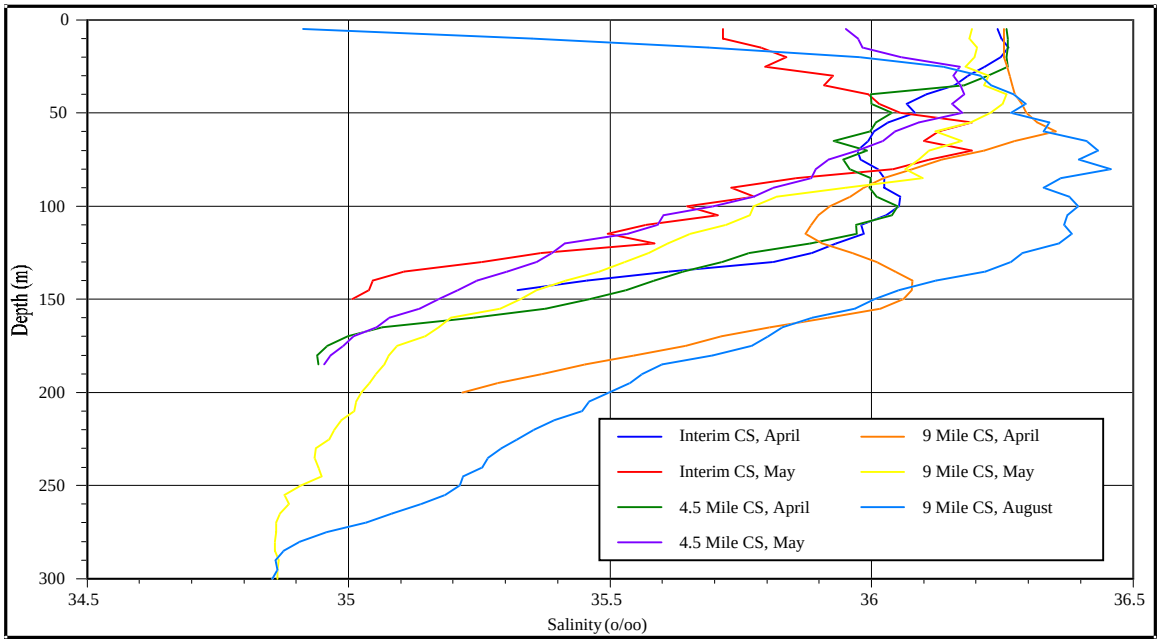

Figure 8: Average Salinity Profiles from CTD stations at the Palm Beach Candidate Sites (CS)

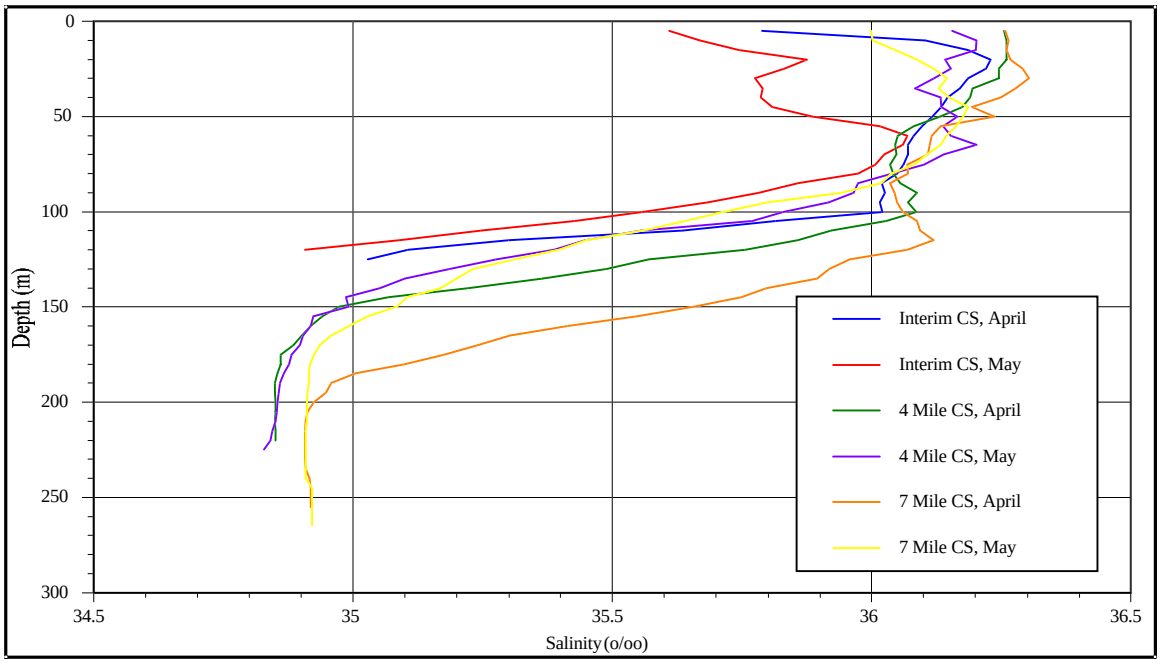

Figure 9: Average Salinity Profiles from CTD stations at the Port Everglades Candidate Sites (CS)

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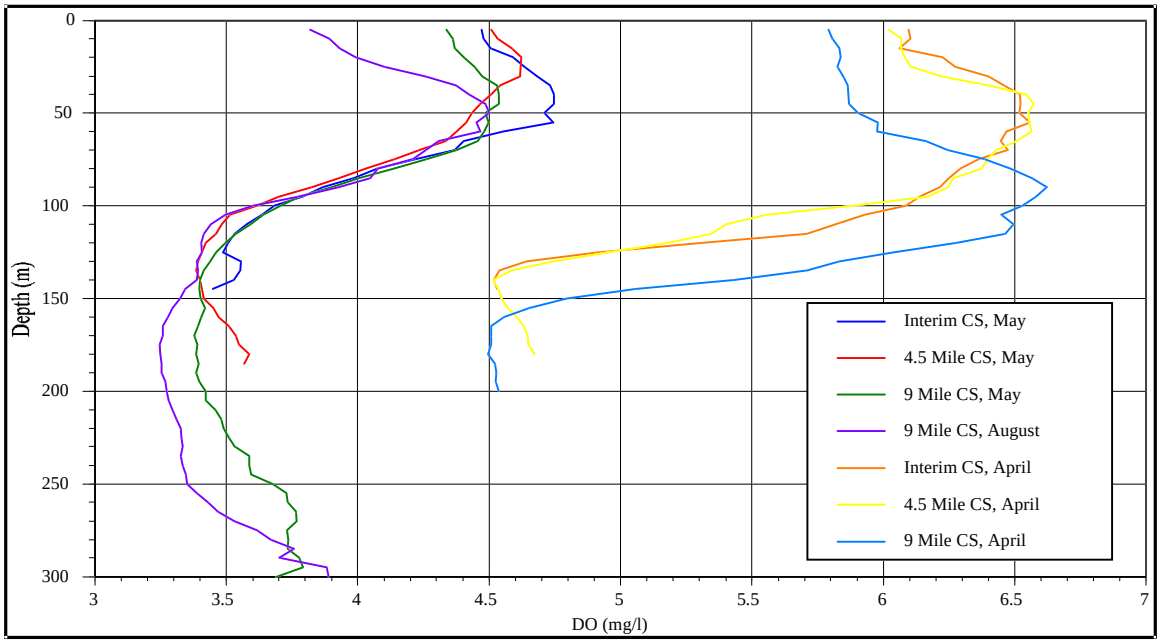

Figure 10: Average Dissolved Oxygen Profiles from CTD stations at the Palm Beach Candidate Sites (CS)

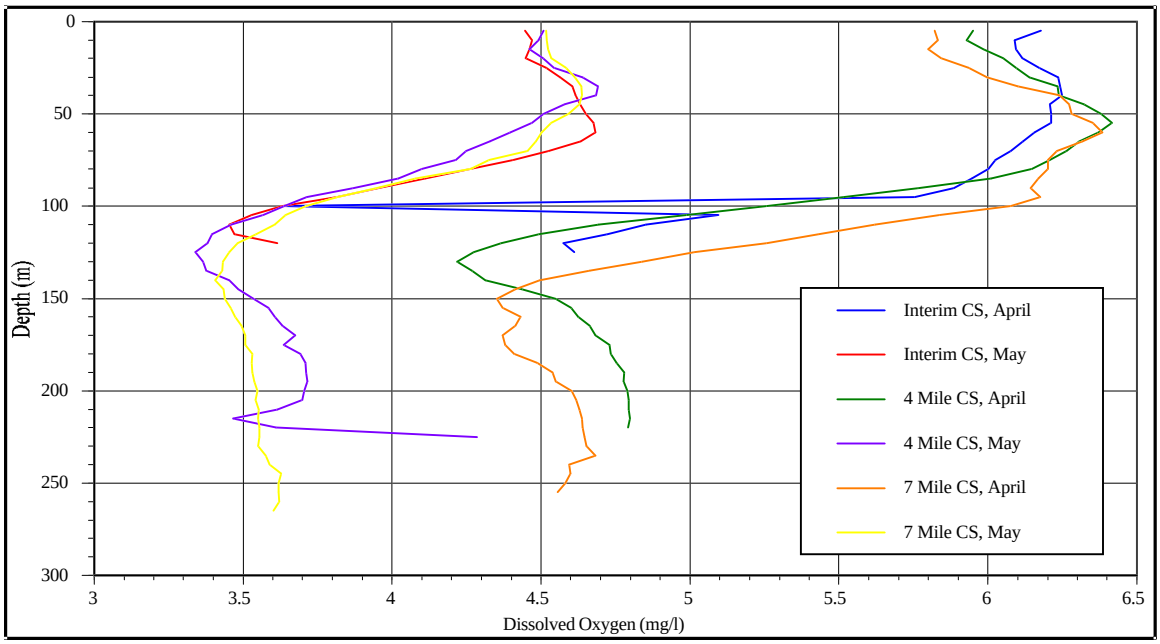

Figure 11: Average Dissolved Oxygen Profiles from CTD stations at the Port Everglades Candidate Sites (CS)

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3.1.2 Water Chemistry

Samples were collected at 4 depths (surface, within the thermocline, between the thermocline and bottom and near bottom) for stations in greater than 200 meter depths and at 3 depths (surface, within the thermocline, and near bottom) for shallower stations. Data for each station is presented in Appendix A.

3.1.2.1 Turbidity & Total Suspended Solids

Turbidity values ranged from a low of 0.65 NTU to a high of 2.50 NTU. In general, higher turbidity values were observed at the Port Everglades Candidate Sites. Turbidity values ranged from 0.75 to 2.50 at the Port Everglades Candidate Sites and 0.65 to 1.2 at the Palm Beach Candidate Sites. No trends with depth or proximity to shore were observed. Box plots of the data are shown in figure 12.

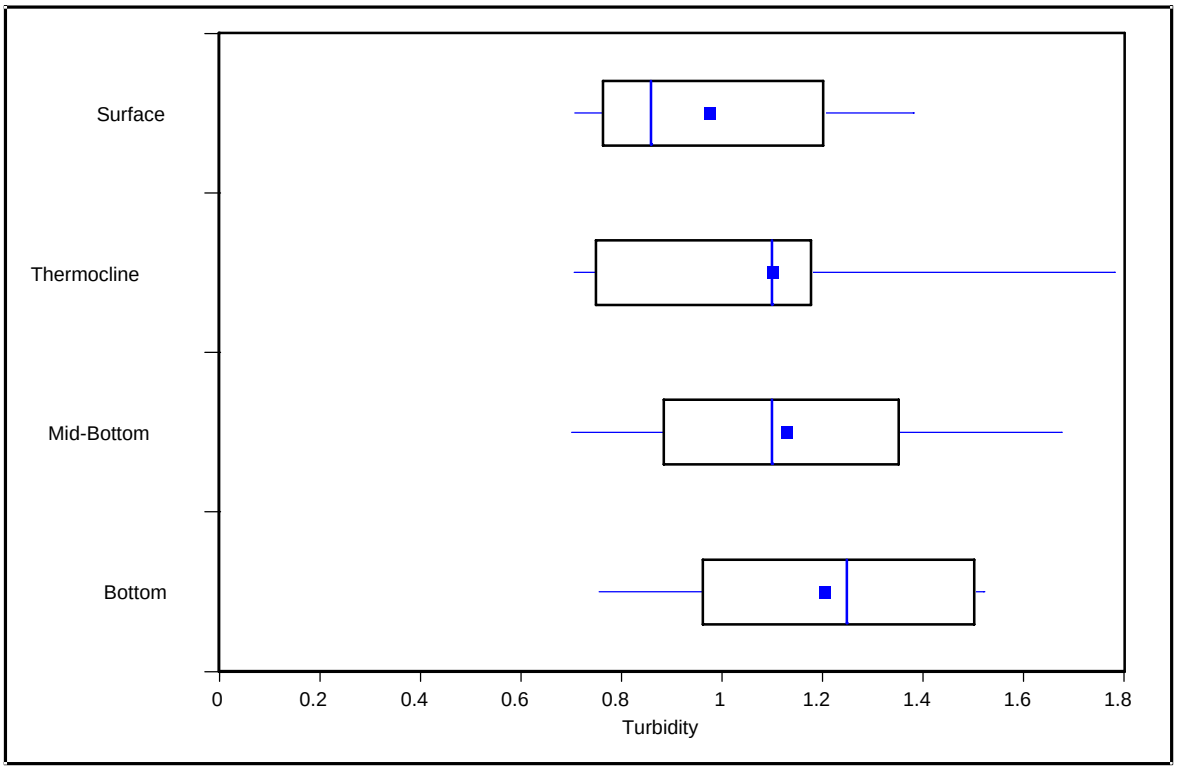

Figure 12: Box Plot for Turbidity Concentrations (NTU) in Water Samples from the Port Everglades and Palm Beach ODMDS Candidate Sites. The left, right and line through the middle of the box correspond to the top quartile, the bottom quartile and the median respectively. The whiskers extend from the bottom decile and top decile and the square represents the arithmetic mean.

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Total suspended solids values ranged from a low of 3 mg/L to a high of 26 mg/L. The highest values were found within the thermocline of the Port Everglades 4 Mile Candidate Site. No correlation is apparent between turbidity and total suspended solids. Box plots of the data are shown in figure 13.

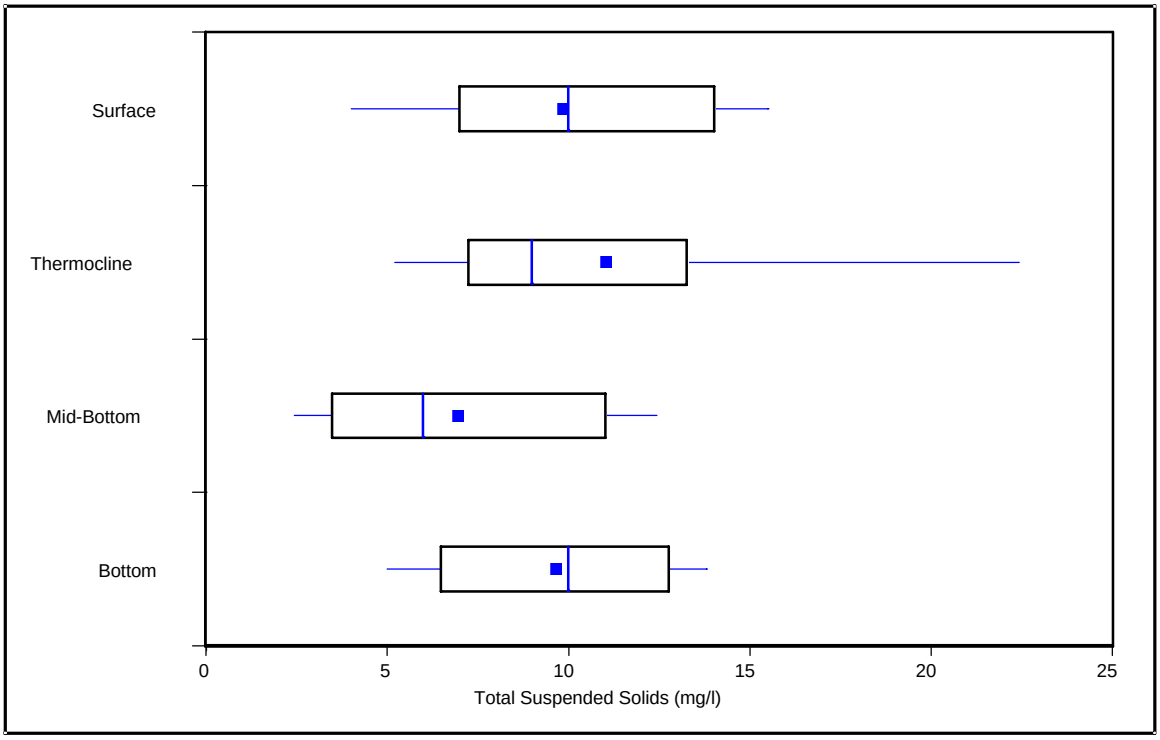

Figure 13: Box Plot for Total Suspended Solids Concentration in Water Samples from the Port Everglades and Palm Beach ODMDS Candidate Sites. The left, right and line through the middle of the box correspond to the top quartile, the bottom quartile and the median respectively. The whiskers extend from the bottom decile and top decile and the square represents the arithmetic mean.

3.1.2.2 Trace Metals

Water samples for mercury, copper, cadmium, and lead were collected. Levels of cadmium and mercury were below the level of detection (1.0 µ/L and 0.2 µ/L respectively) for all samples. Lead was detected in only 5 samples ranging from 1.3 to 6.4 µ/L. Copper levels ranged from below detection limits (1.0 µ/L) to 3.9 µ/L. Box plots for copper are shown in figure 14. Only copper had sufficient number of samples with detected levels for plotting.

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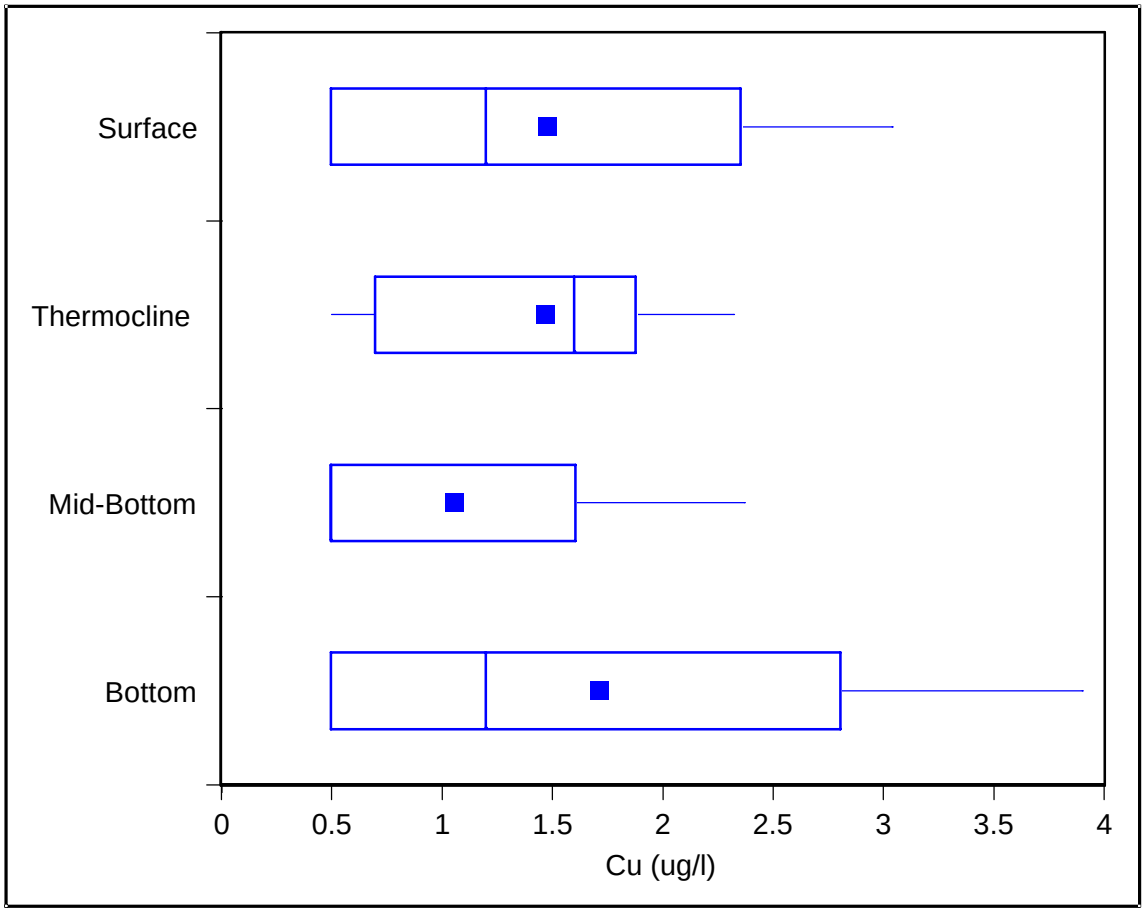

Figure 14: Box Plot for Copper Concentrations in Water Samples from the Port Everglades and Palm Beach ODMDS Candidate Sites. The left, right and line through the middle of the box correspond to the top quartile, the bottom quartile and the median respectively. The whiskers extend from the bottom decile and top decile and the square represents the arithmetic mean.

3.1.2.3 Pesticides and PCBs

All samples analyzed for PCBs and pesticides were below detection limits.

3.1.2.4 Total Petroleum Hydrocarbons

Total petroleum hydrocarbon (TPH) concentrations were found in concentrations from below detection limits (100 µg/L) to 6300 µg/L. Box plots for TPH for each candidate site are shown in figures 15 and 16. In general TBH concentrations were higher in the offshore stations than the nearshore stations.

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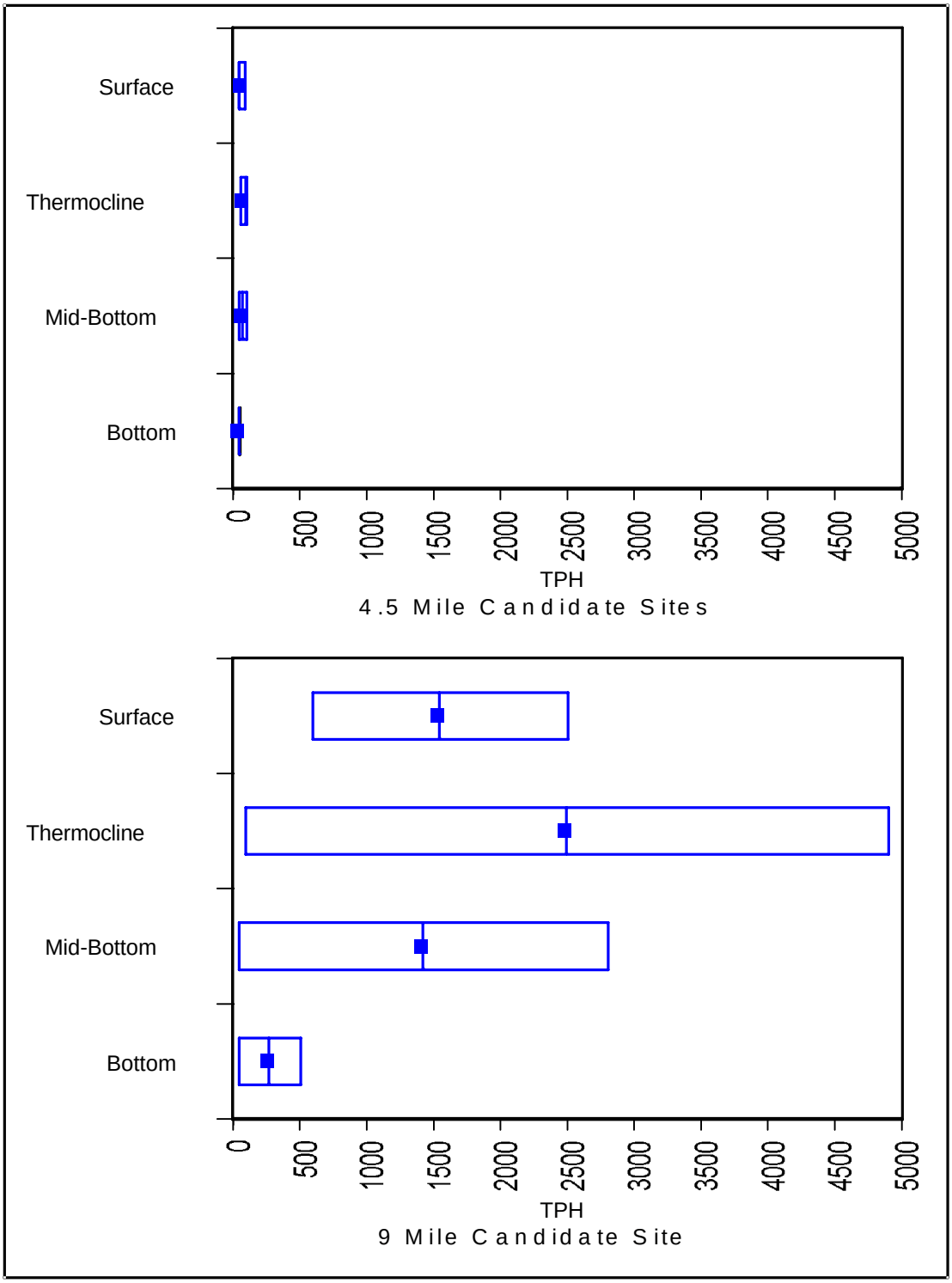

Figure 15: Box Plot for Total Petroleum Hydrocarbons Concentrations (µg/L) in Water Samples from the Palm Beach ODMDS Candidate Sites.

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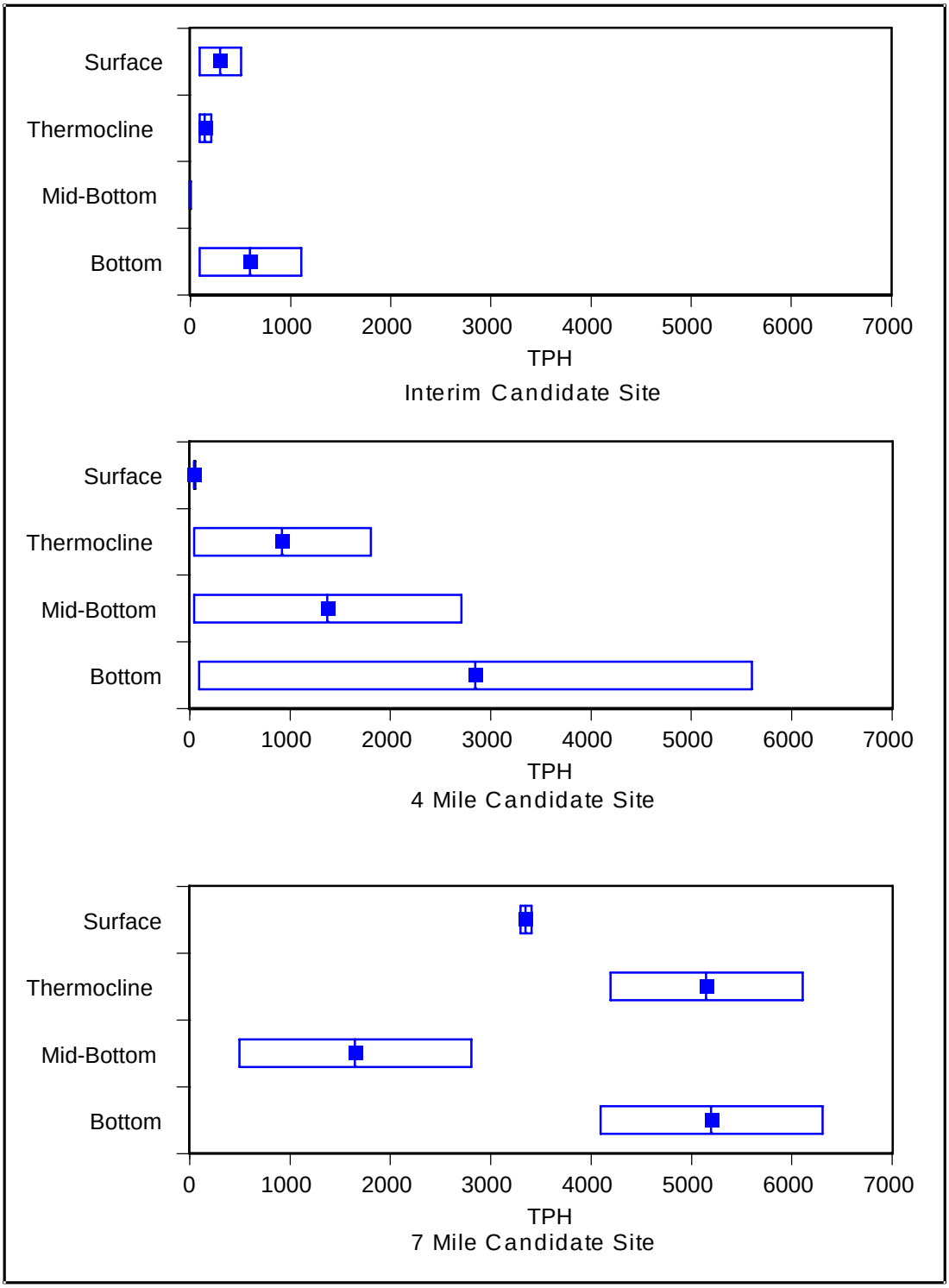

Figure 16: Box Plot for Total Petroleum Hydrocarbons Concentrations (µg/L) in Water Samples from the Port Everglades ODMDS Candidate Sites.

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3.2 Benthos Characteristics

All benthos samples were collected on May 18-19 except for stations 6 through 8 which were sampled on August 13 due to damage of the sampling device in May. Rock bottom was encountered at stations 17, 18 and 19. Epifaunal samples were collected from the rock retrieved and were analyzed separately.

3.2.1 Granulometry

Table 3 lists the grain size percent composition for each sample station. Complete results and particle size distributions are in Appendix D. Most stations consisted of grey slightly to very silty fine sand with shell fragments. Stations 6 through 9 (Palm Beach 9 Mile Candidate Site) had a greenish grey color. Mean grain sizes for each station are shown in figure 17. The Port Everglades candidate sites had slightly larger mean grain sizes and higher percentages of sand. For both locations the offshore stations had larger mean grain sizes and higher percentages of sand. Percent silts and clays ranged from 19 to 35 percent for the Palm Beach candidate sites and 11 to 18 percent for the Port Everglades candidate sites. Sample collection was attempted at stations 17 through 19, but hard bottom was encountered. The hard bottom rocks retrieved consisted of fossiliferous limestone that was slightly dolomitic with magnesite dendrites. They are from the Floridan Aquifer of the Suwanee Formation (McManus, 1998).

Table 3: Grain Size Composition

Station	Candidate Site	% Sand	% Silt and Clay
1	Palm Beach 4.5 Mile Candidate Site	74.2	25.8
2	Palm Beach 4.5 Mile Candidate Site	71	29
3	Palm Beach 4.5 Mile Candidate Site	64.8	35.2
6	Palm Beach 9 Mile Candidate Site	76.6	23.4
7	Palm Beach 9 Mile Candidate Site	79.2	20.8
8	Palm Beach 9 Mile Candidate Site	81.2	18.8
9	Palm Beach 9 Mile Candidate Site	81.5	18.5
13	Port Everglades 4 Mile Candidate Site	84.3	15.7
14	Port Everglades 4 Mile Candidate Site	83	17
15	Port Everglades 4 Mile Candidate Site	84.5	15.5
16	Port Everglades 9 Mile Candidate Site	89.5	10.5
20	Port Everglades 9 Mile Candidate Site	81.9	18.1

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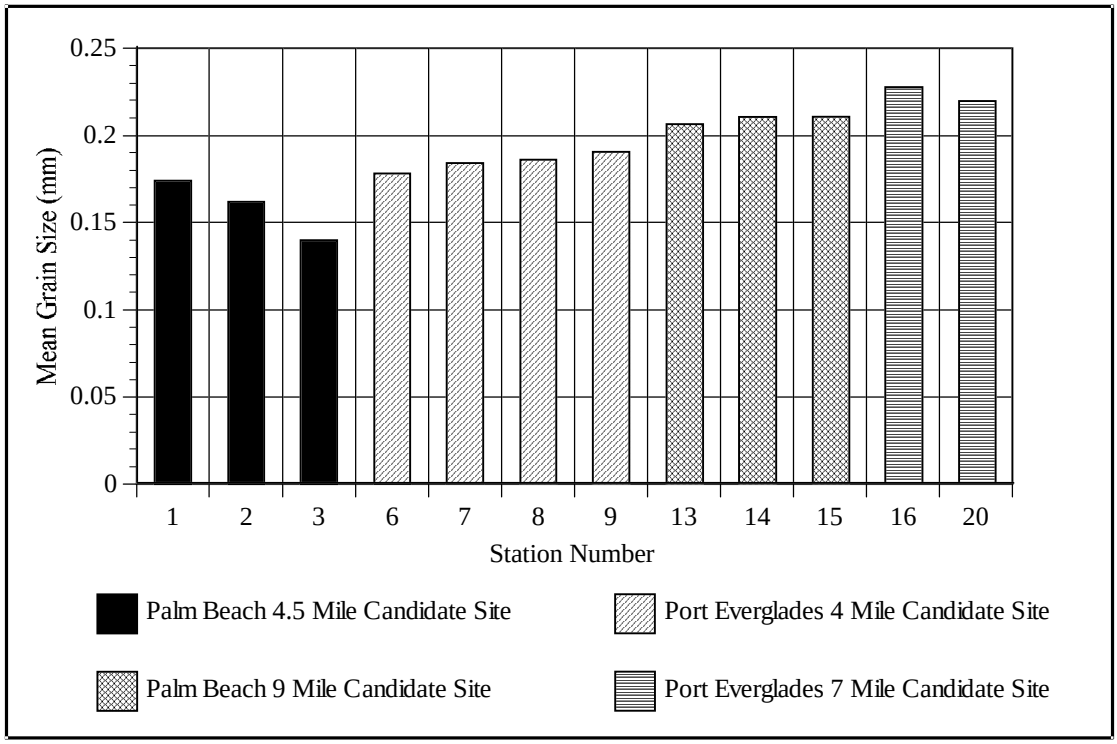

Figure 17: Mean Grain Size

The grain size distributions were within the ranges encountered during previous surveys in the area. Median grain size diameter for the November 1984 Palm Beach survey ranged from 0.10 to 0.33 mm with an overall average of the means of 0.21 mm. Median grain size diameter for the November 1984 Port Everglades survey ranged from 0.08 to 0.25 mm with an overall average of the means of 0.16 mm (BVA, 1985). Median grain size data was not available from the 1989 Palm Beach survey. However, percent silt and clays ranged from 15 to 33 percent (CSA, 1989).

3.2.2 Sediment Chemistry

3.2.2.1 Total Organic Carbon

Total organic carbon concentrations were reported ranging from 6.0 to 13.2%. However, these results are unreliable due to quality control issues. Sample matrix spikes were not within acceptance criteria. Previous sampling in the Palm Beach 3/4.5 Candidate Site area reported results ranging from 0.3 to 0.6% (CSA, 1989) and in the Miami ODMDS area 1.1 to 1.8% (CC, 1985).

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3.2.2.2 Oil & Grease, Total Petroleum Hydrocarbons, Pesticides, and PCBs

Oil and grease were generally below detection limits (50 µg/g) except for two stations, station 13 (86 µg/g) and station 2 (590 µg/g). Total petroleum hydrocarbons, pesticides and PCBs were all below detection limits. Analytical results can be found in Appendix B.

3.2.2.3 Metals

Cadmium levels ranged from below detection limits (0.10 µg/g) to 0.15 µg/g. Copper levels were in the range of 1.8 to 4.8 µg/g with the highest levels at the Palm Beach 9 Mile Candidate Site (See figure 18). Lead levels were in the range of 1.3 to 31.3 µg/g with the lowest levels at the Palm Beach 9 Mile Candidate Site (see figure 19). Mercury was not detected (0.05 µg/g) at any station. Results can be found in Appendix B. The 1989 Palm Beach Survey reported values of 0.03 to 0.05 µg/g for Cadmium, 1.8 to 8.2 µg/g for lead and 0.01 to 0.3 µg/g for mercury (CSA, 1989).

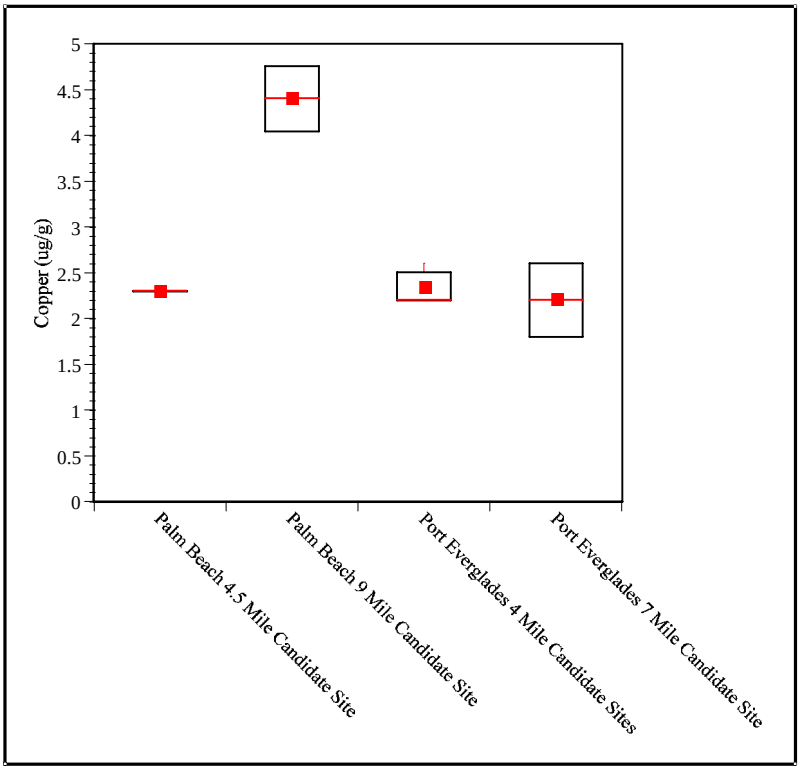

Figure 18: Sediment Copper Concentrations

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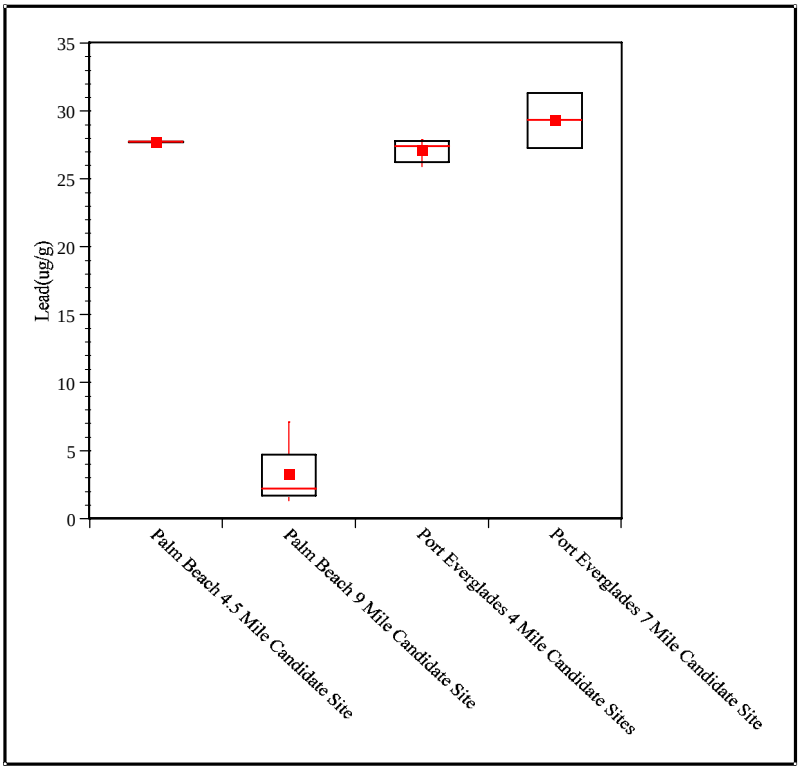

Figure 19: Sediment Lead Concentrations

3.2.3 Biotal Characteristics

Palm Beach Harbor Candidate ODMDSs

The taxonomic composition of the Palm Beach Harbor Candidate ODMDSs infauna is presented in Appendix E. A total (all samples and all stations) of 1,318 individuals and 160 taxa across 71 families were collected in 1998. Densities ranged from 305 individuals/m^2 to 592 individuals/m^2 with a mean density of 421 individuals/m^2. This contrasts with a 1984 study that found 392 taxa present and a mean density of 2840 individuals/m^2 at the Palm Beach Candidate ODMDSs and control stations (BVA, 1985). A 1989 study showed 124 families and a mean density of 2,246 individuals/m^2 at the Palm Beach Candidate ODMDS (CSA, 1989). Annelids (Polychaeta and Oligochaeta) and arthropods were the most abundant groups overall representing 50.72% and 9.27% of the total fauna respectively. Past studies showed similar trends with 60.8% and 13.7% respectively in the 1984 study (BVA, 1985) and 30.6% and 32.3% respectively in the 1989 study (CSA, 1989).

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The infauna composition was distributed differently between the candidate sites. At the Candidate 4.5 Mile (CS4.5) site annelids and arthropods comprised 42.03% and 13.24% of the total community respectively, while comprising 80.42% and 5.29% of the total fauna respectively at the Candidate 9 Mile (CS9) site. The mean number of taxa among CS4.5 site and CS9 site stations was 46 and 62 respectively. The mean densities among CS4.5 site and CS9 site stations was 405 individuals/m^2 and 433 individuals/m^2 respectively. Table 4 shows community indices for Palm Beach ODMDS candidate sites.

Table 4: Benthic infauna community indices for the Palm Beach Harbor Candidate sites from the 1998 surveys and 1984 survey[1]. Index values are expressed as means.

Candidate Site	Diversity (H')	Evenness (J')	Richness (D)	Dominance (Si)
Palm Beach 4.5 Mile Candidate Site	4.70	0.857	9.08	0.055
Palm Beach 9 Mile Candidate Site	5.26	0.886	11.37	0.036
ODMDS 1984	3.64	0.830	13.58	

[1] BVA 1985

Community indices calculated for the Palm Beach Harbor ODMDS CS4.5 and CS9 sites were generally similar. The slightly higher mean H' diversity in the CS9 site (5.26) was due to the higher number of taxa found there which can be seen in the higher D richness value. Diversity was slightly lower during the 1984 survey though the number of species was higher than during the 1998 survey (392 vs. 160) which is shown by the higher D richness (BVA, 1985). The 1984 survey resulted in a much large number of samples collected than in 1998 which typically produces more rare species. Rare species are usually lower in abundance which, in turn, lowers H' which relies on species richness and evenness (distribution of individual among species). The lower Si dominance value in the CS9 site versus the CS4.5 site (0.036 vs. 0.055) indicates that a smaller number of species accounted for a higher proportion of individuals in the CS4.5 site.

Overall, infaunal communities at both the CS4.5 and CS9 sites are represented by most of the same families within the major taxonomic groups. Several families of annelids (Class Polychaeta), mollusks (class Bivalvia) and crustaceans (order Cumacea) represented at CS9 were not present at the CS4.5 site. These were relatively low in numerical abundance and are most likely due to natural community variation.

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*Port Everglades Candidate ODMDS*s

The taxonomic composition of the Port Everglades Candidate ODMDS infauna is presented in Appendix F. A total (all samples and all stations) of 1,973 individuals and 159 taxa across 65 families were collected at Port Everglades ODMDS in 1998. Organism densities ranged from 488 individuals/m^2 to 1,239 individuals/m^2 with a mean density of 756 individuals/m^2. A 1984 study of the Port Everglades ODMDS found 453 taxa present and a mean density of 4637 individuals/m^2 (BVA, 1985). Annelids were the most abundant group overall representing 49.65% of the total fauna. The arthropods were the second largest group overall with 36.86% of the total fauna. The 1984 Port Everglades study found annelids dominant with 61.8%, mollusks second with 11.8% and arthropods third with 9.9% of the total fauna.

The infaunal community composition differed between the Port Everglades Candidate 4 Mile (CS4) and Candidate 7 Mile (CS7) sites. At the CS4 site arthropods were the most abundant group overall representing 52.71% of the total fauna. The ampeliscid amphipods (Ampeliscidae) comprised 23.80% of the total. Annelids were the second largest group overall with 36.86% of the total fauna. Annelids dominate the fauna at the CS7 site with 62.49% of the total, while arthropods followed with 22.87% of the total fauna. Mean densities among stations at the CS4 site ranged from 392-440 individuals/m^2 and total taxa ranged from 73-77 taxa. Mean densities among stations at the C7 site ranged from 488-1,239 individuals/m^2 and total taxa ranged from 38-79 taxa. Table 5 shows community indices for Port Everglades ODMDS candidate sites.

Table 5: Benthic infauna community indices for the Port Everglades Candidate sites from the 1998 surveys and 1984 survey[1]. Index values are expressed as means.

Candidate Site	Diversity (H')	Evennes s (J')	Richness (D)	Dominance (Si)
Port Everglades 4 Mile Candidate Site	4.92	0.789	12.28	0.077
Port Everglades 7 Mile Candidate Site	4.45	0.756	10.73	0.113
ODMDS 1984	3.62	0.780	15.53	

[1] BVA 1985

Community indices for the Port Everglades ODMDS CS4 and CS7 sites were generally similar. The higher D richness value for the CS4 site indicates a high total taxa found at CS4. Again, the larger number of rarer (low numerical abundance) species found in the 1984 survey may account for the somewhat lower H' diversity value. The lower Si dominance value at the CS4 site corresponds to the somewhat higher H' diversity estimated for the CS4 site.

Overall, infaunal communities at both the CS4 and CS7 sites are represented by most of the same families within the major taxonomic groups. The shift in numerical dominance between the ampeliscid amphipods (arthropods) in CS4 and polychaets (annelids) in CS7 is most easily explained by natural community variation rather than true community differences.

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Additionally, a limestone outcropping was discovered at the CS7 during the May 18-20 survey. Limestone was encountered at stations 17, 18 and 19 during box coring and a small rock sample was collected at each station and brought to the surface. No attempt was made to quantify the assemblages of epifaunal organisms on the rock fragments though visual examination determined that the outcropping contained a number of sessile and free living invertebrates. The limestone outcropping was later examined by sidescan sonar and was shown to dominate the southern half of the candidate site (south of 26º 7.8'). The outcropping extended beyond the survey area and had little to no relief.

Comparisons between Palm Beach and Port Everglades Infauna

Overall the Port Everglades ODMDS and Palm Beach ODMDS infaunal communities share a number of similarities with regard to structure. Both locales had a similar number of taxa dominated by the same major taxonomic groups. As the dominant group, annelids were represented at Palm Beach by 36 families and at Port Everglades by 31 families. Fully 100% of the Port Everglades annelid families were represented in the Palm Beach infauna. At Port Everglades 58.33% of its most important (numerically abundant) 24 arthropod families were shared at Palm Beach. Environmental factors that affect benthic community structure e.g., temperature, DO, sediment grain size distribution etc., were not shown to be significantly different between Palm Beach and Port Everglades.

Sites among locales were examined to determine whether infaunal communities were effected by depth or distance from shore (table 6). When grouped by distance from shore, sites do not appear to be more similar than sites grouped by locale with regard to community parameters. Environmental factors that affect benthic community structure were not shown to be significantly different between the nearshore and farshore sites.

Table 6: Dominant infaunal groups and community indices for the Palm Beach Harbor and Port Everglades Candidate sites.

Candidate Site	Annelida % of Total	Arthropoda % of Total	Diversity (H')	Evenness (J')	Richness (D)	Dominance (Si)
Near Shore						
Palm Beach 4.5 Mile Candidate Site	42.03	13.24	4.70	0.857	9.08	0.055
Port Everglades 4 Mile Candidate Site	36.86	52.71	4.92	0.789	12.28	0.077
Far Shore						
Palm Beach 9 Mile Candidate Site	80.42	5.29	5.26	0.886	11.37	0.036
Port Everglades 7 Mile Candidate Site	62.49	22.87	4.45	0.756	10.73	0.133

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4.0 SUMMARY

The objective of this project was to collect data to characterize the candidate ODMDSs offshore Port Everglades and Palm Beach, Florida. Data collected included water column profiles, water quality samples, bottom sediment chemistry, bottom sediment granulometry and benthic biota.

Salinity, dissolved oxygen, and transmissivity data indicated water masses over the candidate sites were similar to open ocean waters and deviated little between candidate sites. Water quality analyses for trace metals, PCB's and pesticides showed very low levels for these parameters. Total petroleum hydrocarbons were higher than expected for the offshore candidate sites.

Grain size distributions at the candidate sites were similar with the offshore Port Everglades candidate sites having a slightly coarser distribution. Oil and grease, total petroleum hydrocarbons, pesticides and PCBs were generally below detection limits in the sediments. For metals, only copper and lead were detected in significant amounts in the sediments. Copper and Lead were detected at similar amounts for all candidate sites except the Palm Beach 9 Mile Candidate Site which had higher copper and lower lead amounts.

Macroinfaunal samples were dominated in numbers by annelids and arthropods. All candidate sites were similar in that they had a similar number of taxa dominated by the same major taxonomic groups.

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