Extent and Toxicity of Contaminated Marine Sediments in Southeastern Florida

NOAA Technical Memorandum NOS NCCOS 4

Cover photograph: Manatee Bay and the C-111 Canal, Florida. [5wl71646. 1994. Scale 1:48000; azimuth 248.7 25.254° N, 80.40517° W. (Coastal Aerial Photography, NOAA/ National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts.nos.noaa.gov/images/photos/5wl71646.gif>.]

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2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
<	Value below the limit of detection
AChE	Acetylcholinesterase
Ann	Annelida
Anop	Anopla
ANOVA	Analysis of variance
Anth	Anthozoa
Art	Arthropoda
ASTM	American Society for Testing and Materials
AVS	Acid volatile sulfides
B	Blank contamination greater than three times the detection limit
B-HCH	beta-Hexachlorohexane
Biva	Bivalvia
BVA	Barry A. Vittor & Associates, Inc.
B[*a*]P	Benzo[*a*]pyrene
B[*a*]PEq	Benzo[*a*]pyrene equivalents
C	Celsius
CAS	Chemical Abstract Service
CCD	Charged couple device
CCEHBR	Center for Coastal Environmental Health and Biomolecular Research
CEAT	2-Chloro-4-ethylamino-6-amino-*s*-triazine (atrazine metabolite)
Cho	Chordata
CIAT	6-Amino-2-chloro-4-isopropylamino-*s*-triazine (atrazine metabolite)
cm	Centimeter
Cni	Cnidaria
Comet assay	Same as single cell gel (SCG) electrophoresis
DDD	1,1-Dichloro-2,2-bis(*p*-chlorophenyl)ethane
DDE	1,1-Dichloro-2,2-bis(chlorophenyl)ethylene
DDT	1,1,1-Trichloro-2,2-bis(*p*-chlorophenyl)ethane
df	Dilution factor
DMSO	Dimethyl sulfoxide
DNA	Deoxyribonucleic acid
DO	Dissolved oxygen
EC50	Median effective concentration
Ech	Echinodermata
EDTA	Ethylenediaminetetraacetic acid
EEO	Electroendosmosis
EPA	Environmental Protection Agency
EtBr	Ethidium bromide
ft	Feet
g	Grams or gravity
Gast	Gastropoda
GC/MS	Gas chromotography/mass spectrometry
HCH	Hexachlorohexane
HPLC	High-performance liquid chromatography
hr	Hour
HRGS P450	P450 Human Reporter Gene System
I	Interference
J	Value below the limit of detection
L	Liter
LMA	Low melting agarose

LPIL	Lowest practical identification level of benthic organisms
LS	Laboratory standard
M	Molar
m	Meta
m/z	Mass to charge ratio
Mala	Malacostraca
mg	Milligram
min	Minute(s)
mm	Millimeter(s)
Mol	Mollusca
n	Number of data points (roughly equivalent to the number of sampling sites).
NBS	National Biological Service
NC	Not calculated
NCCOS	NOAA/NOS/National Centers for Coastal Ocean Science
NCI	Negative chemical ionization
ND	Not detected
NH_3-N	Ammonia nitrogen
NIOL	North Oyster Inlet Landing reference sample
nm, m	Not mutagenic, mutagenic
NOAA	National Oceanic and Atmospheric Administration
NOS	NOAA/National Ocean Service
np1eo	4-*n*-nonylphenolmonoethoxylate (isomeric mixture)
np2eo	4-*n*-nonylphenoldiethoxylate (isomeric mixture)
np3eo	4-*n*-nonylphenoltriethoxylate (isomeric mixture)
np4eo	4-*n*-nonylphenoltetraethoxylate (isomeric mixture)
np5eo	4-*n*-nonylphenolpentaethoxylate (isomeric mixture)
NS	Not significant
NS&T	National Status and Trends Program
o1eo	octylphenolmonoethoxylate (isomeric mixture)
o2eo	octylphenoldiethoxylate (isomeric mixture)
o3eo	octylphenoltriethoxylate (isomeric mixture)
o4eo	octylphenoltetraethoxylate (isomeric mixture)
o5eo	octylphenoltriethoxylate (isomeric mixture)
Olig	Oligochaeta
Ophi	Ophiuroidea
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyl congeners
pH	Measure of acidity. Defined as the logarithm of the reciprocal of hydrogen ion concentration in gram-atoms per liter
POE(3)	Octylphenylether (tertiary octylphenol), same as Triton X-100
Poly	Polychaeta
ppt	Parts per thousand
QA/QC	Quality control/quality assurance
Rhy	Rhynchocoela (now Nemertea)
RLU	Relative light units
SCG	Single cell gel (SCG) electrophoresis
SEM	Simultaneously extracted metal in 1N HCl
SIM	Selected ion mode
Sip	Sipunculida
SPE	Solid phase extraction
SSC-SD	US Navy Space and Naval Warfare Systems Center, San Diego, CA
TAE	TAE buffer is composed of Tris, EDTA-Na_2-salt and acetic acid.
TAN	Total ammonia nitrogen

TBTs	Tributyltins
TEQ	Toxic equivalents
TIC	Total inorganic carbon
TM	Tail moment
TOC	Total organic carbon
TotTM	Sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg, and Ag as measured by NS&T via hydrofluoric acid extraction
Tris	Tris(hydroxymethyl)aminomethane
UAN	Unionized ammonia nitrogen
USDA	US Department of Agriculture
USGS	US Geological Survey
V	Volt
μm	Micron
∑BTs	The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as ng Sn/g dry wt.).
∑Cdane	The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlorepoxide.
∑DDTs	The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑Dieldrin	The sum of dieldrin and aldrin.
∑PAHs	The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.
∑PCBs	The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.

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ABSTRACT

Thirty sites were sampled in southern Biscayne Bay and Manatee Bay in December 1999 to determine the extent of toxicity in sediments. Analyses and assays included: pesticides and phenols in seawater; chemical contaminants in sediment; amphipod mortality, HRGS P450, sea urchin sperm fertilization and embryology, Microtox™, Mutatox™, grass shrimp AChE and juvenile clam mortality assays; sea urchin sperm, amphipod and oyster DNA damage; and benthic community assessment. Sediment sites near the mouth of canals showed evidence of contamination. Contaminant plumes and associated toxicity do not appear to extend seaward of the mouth of the canals in an appreciable manner. Concentrations of contaminants in the sediments in open areas of Biscayne and Manatee Bays are generally low.

1. INTRODUCTION

The "Biological Effects" component of the National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends (NS&T) Program for Marine Environmental Quality conducts intensive regional surveys to describe the incidence, severity, and spatial extent of adverse biological effects associated with chemical contamination. These studies are conducted in specific coastal areas based on a number of considerations, including: high levels of contamination found in mussels and oyster tissues samples under the "Mussel Watch" component of NS&T program; likelihood or documentation of adverse biological effects of contamination based on state and local environmental data; and possible collaboration with other Federal, state and local agencies. Typically, the studies are designed to obtain data simultaneously on levels of chemical contaminants in sediment and biota, results of multiple toxicity tests, analysis of biomarker responses, and changes in benthic biological community structure. By combining and synthesizing data from field observations, chemical analyses, toxicity tests, and measures of benthic community structure, NOAA's "biological effects" studies provide a holistic understanding of regional environmental quality and the spatial extent of contamination-related adverse biological effects. To date, NOAA has performed "biological effects" studies in over 30 different estuaries and other coastal waters throughout the United States, often in close cooperation with coastal states. In Florida, NOAA has performed such studies in Tampa Bay, four bays of the Florida Panhandle (Pensacola, Choctawhatchee, St. Andrew and Apalachicola), and Biscayne Bay.

Comprehensive bay-wide sampling was conducted in Biscayne Bay over two years (1995 and 1996) to determine the incidence, severity and spatial extent of sediment toxicity. It was based on a stratified-random sampling design that comprised more than 200 sites covering an area of 484 sq km. As in previous NOAA studies, toxicity tests were selected to ensure different modes of contaminant exposure (i.e., bulk sediment, porewater, and chemical extracts of sediments) to a variety of test organisms (invertebrates, bacteria, and others) and to measure different assessment end-points (i.e., mortality, impaired reproduction, physiological stress, and enzyme induction).

The 1995 study results showed high levels of sediment contamination and severity of toxicity in several peripheral canals and tributaries, notably the lower Miami River. In terms of the areal extent, sediment toxicity as inferred from the amphipod mortality test was 13% of the total area, that inferred from the sea urchin fertilization test was about 47%, and that inferred from the Microtox^{TM} test was 51%. In comparison, a compilation of results of NOAA's sediment toxicity from 23 different coastal areas in 1999 showed that 7% of the total studied area was classified as toxic based on the amphipod mortality tests, 39% based on sea urchin fertilization test, and 66% based on the Microtox^{TM} test.

The 1995 data also showed an unexpectedly wide, but apparently sporadic, occurrence of sediment toxicity in southern Biscayne Bay. Although sediment toxicity was expected at sites located in or just outside Black Creek - Goulds Canal, Military Canal, and Mowry Canal, it was not expected in the open waters of the Bay extending eastward to Featherbed Banks and Elliott Key. Also, unlike other parts of the Bay, the observed toxicity in this area was not associated with high levels of contaminants; to the contrary, contaminant levels at those sites were generally very low, in some instances at or below method detection limits.

The 1999 NOAA follow-up study described here was intended to determine patterns of toxicity in southern Biscayne Bay and to define certain measures of environmental quality before major environmental restoration and mitigation activities are implemented in South Florida. Its initial objectives were to define the existence of toxicity associated with effluents from freshwater discharge canals in coastal waters of south Florida (including the C-111 canal), and to determine whether the pattern of sediment toxicity observed in southern Biscayne Bay was persistent. The study included a wider array of potential toxicants than before and a broader suite of toxicity tests, including tests for genotoxic effects. Samples were collected in November-December 1999 from 30 sites, most of which coincided with sites in the previous study conducted in 1995 and 1996.

2. METHODS

2.1. Sampling sites

Biscayne Bay is a shallow tropical saline lagoon located along the southeastern-most portion of the state of Florida (Figure 1). It is surrounded on the north by the growing urban areas of Dade County, which include Miami and Miami Beach, and on the south by the sparsely inhabited Homestead area and the northern Florida Keys. The eastern boundary of the Bay is composed of barrier islands which eventually become part of the Florida Keys. The western shore is the Florida mainland. Biscayne Bay can be divided into three major areas: North, Central and South. The southern portion of the Bay ranges from the Featherbed Bank to Card Bank. This section is undeveloped and fringed by mangrove wetlands. Benthic habitats are dense seagrass beds, large hard ground areas and algal communities. The main canals draining into the portion of the Bay are Black Creek, Princeton Canal, Military Canal, Mowry Canal and Model Land Canal. Ocean exchange is restricted to the tidal creeks between the islands of the northern portion of the Florida Keys. The southern portion of the Bay is connected to Card Sound, a small coastal lagoon. Restricted openings limit flushing and water exchange between Card Sound and Biscayne Bay. South of Card Sound is Barnes Sound, also a shallow lagoon with little water circulation. Manatee Bay is located off the western side of Barnes Sound. The C-111 Canal flows into this small coastal lagoon.

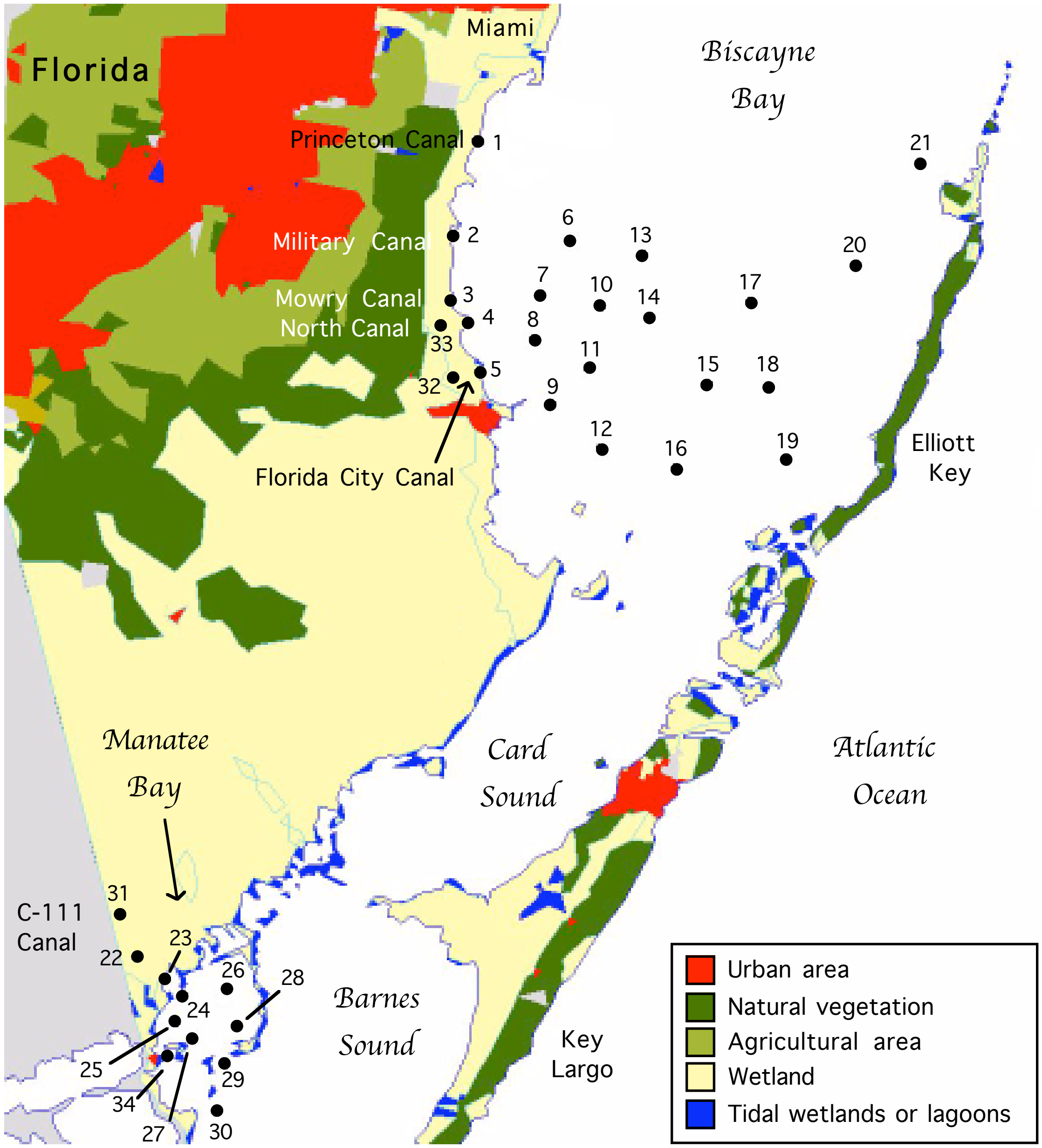

Figure 1. Sampling sites in Biscayne Bay and Manatee Bay, and land use pattern.

Thirty sites were sampled in southern Biscayne Bay and Manatee Bay in December 1999. Site locations are listed in Table 1 and shown in Figure 1. Additional sites were added for shrimp acetylcholinesterase assay tests. The type of analyses, number of samples and laboratory performing the collection and analyses are listed in Table 2. A schematic of the sample types and analyses is shown in Figure 2. Results are listed in Appendices I through V, and aerial photographs of the sampling area can be found in Appendix VI.

2.2. Sampling and processing methods

2.2.1. Seawater

The seawater samples were collected from a depth of one meter using a submersible marine pump. The pump was connected to a length of Teflon tubing connected to two in-line, stainless steel filter holders each housing a 1-μm pore size GF/F filter (Whatman no. 1825150). The particulate matter was discarded. The filtered water flowed into a pre-cleaned 20-L stainless steel canister and sealed with an airtight lid. A field blank was collected each sampling day by pumping 10 L of organic free water through the sampling and filtration system into a pre-cleaned stainless steel container.

The water samples were shipped in coolers with dry ice to the testing laboratory in Beltsville, MD within 24 hr of collection. The samples were stored in a 4 °C cooler at the laboratory and extracted within 7 days of collection.

Water samples were collected concurrently with grass shrimp samples (Section 2.2.4.5).

2.2.2. Sediment

Sediment samples were collected at 30 Biscayne Bay and Manatee Bay sites using a Kynar-coated 0.04-m^2 Young-modified van Veen grab sampler deployed by hand. Only the upper 2 - 3 cm of sediment were collected for chemical analyses and toxicity bioassays. Sediments were removed from the sampler with a plastic scoop and transferred to a lined, stainless steel container. Sediments were homogenized using a plastic paddle prior to distribution into individual containers for grain size, total organic carbon (TOC) and total inorganic carbon (TIC), chemistry, and bioassays.

2.2.2.1. Chemistry

The sample processing protocol is described in detail in Lauenstein and Cantillo (1993, 1998).

2.2.2.2. Bioassays

2.2.2.2.1. Microtox and Mutatox

Sediments were extracted using dichloromethane following the procedure in Long *et al.* (1998) by Columbia Analytical Services, Jacksonville, FL. This extract was used for Microtox™ and Mutatox™ assays.

2.2.3. Sediment pore water

Homogenized sediment samples were shipped chilled to USGS, Corpus Christi, TX, and received the following day. Samples were kept refrigerated and porewaters were extracted within 8 days of field sample collection and within 48 hours of arrival in Texas. The pore water was extracted using a pressurized pneumatic extraction device made of polyvinyl chloride and a

Table 1. Sampling site locations in Biscayne Bay and Manatee Bay.

Site	Latitude	Longitude	Location
Biscayne Bay			
1	25° 31' 15"	80° 19' 50"	Princeton Canal
2	25° 29' 22"	80° 20' 18"	Military Canal
3	25° 28' 12"	80° 20' 16"	Mowry Canal
4	25° 27' 46"	80° 20' 00"	North Canal
5	25° 26' 52"	80° 19' 45"	Florida City Canal
6	25° 29' 18"	80° 18' 13"	Biscayne Bay
7	25° 28' 20"	80° 18' 37"	Biscayne Bay
8	25° 27' 32"	80° 18' 50"	Biscayne Bay
9	25° 26' 13"	80° 18' 32"	Biscayne Bay
10	25° 28' 06"	80° 17' 37"	Biscayne Bay
11	25° 26' 56"	80° 17' 52"	Biscayne Bay
12	25° 25' 27"	80° 17' 38"	Biscayne Bay
13	25° 29' 00"	80° 16' 52"	Biscayne Bay
14	25° 27' 53"	80° 16' 43"	Biscayne Bay
15	25° 26' 37"	80° 15' 37"	Biscayne Bay
16	25° 25' 05"	80° 16' 13"	Biscayne Bay
17	25° 28' 10"	80° 14' 52"	Biscayne Bay
18	25° 26' 37"	80° 14' 33"	Biscayne Bay
19	25° 25' 13"	80° 14' 10"	Biscayne Bay
20	25° 28' 50"	80° 12' 52"	Biscayne Bay
21	25° 30' 42"	80° 11' 50"	Biscayne Bay
Manatee Bay			
22	25° 16' 15"	80° 26' 18"	C-111 Canal
23	25° 15' 45"	80° 25' 42"	C-111 Canal
24	25° 15' 18"	80° 25' 18"	Manatee Bay
25	25° 14' 48"	80° 25' 30"	Manatee Bay
26	25° 15' 15"	80° 24' 36"	Manatee Bay
27	25° 14' 30"	80° 25' 09"	Manatee Bay
28	25° 14' 45"	80° 24' 21"	Manatee Bay
29	25° 13' 54"	80° 24' 24"	Barnes Sound
30	25° 13' 12"	80° 24' 48"	Barnes Sound
Sites sampled only for shrimp acetylcholinesterase assay			
31*	25° 17' 11"	80° 26' 28"	C-111 Canal upstream
32*	25° 26' 54"	80° 20' 21"	Florida City Canal upstream
33*	25° 27' 47"	80° 20' 35"	North Canal upstream
34*	25° 14' 07"	80° 25' 53"	Manatee Marina

Table 2. Number of samples and type of analyses performed.

Analysis/assay	Number of samples	Laboratory
Seawater analyses for pesticides and phenols	30	USDA/Agricultural Research Service
Sediment analyses for NS&T analytes	30	Texas A&M University
Amphipod mortality assay	30	Environmental Science & Engineering, Inc.
Sea urchin sperm assay	30	US Geological Survey
HRGS P450 assay	30	Columbia Analytical Services
Microtox^{TM} and Mutatox^{TM} assays	30	NOAA/NOS/NCCOS/CCEHBR
Grass shrimp AChE assay	15	NOAA/NOS/NCCOS/CCEHBR
Juvenile clam mortality assay	15	NOAA/NOS/NCCOS/CCEHBR
Oyster DNA damage	10	US Navy
Sea urchin sperm DNA damage	10	US Navy
Amphipod DNA damage	10	US Navy
Benthos	30	Barry A. Vittor and Associates, Inc.

5-μm polyester filter. The apparatus and procedure are described in USGS (2000). After extraction, the porewaters were centrifuged at 1200 x g for 20 min to remove suspended material, and stored frozen in polycarbonate bottles.

2.2.4. Specimens for assays

2.2.4.1. Amphipods

Specimens of *Ampelisca abdita* were purchased from Eastern Aquatic Bio Supply, Inc., and held in the laboratory in pre-sieved uncontaminanted sediment until use (Environmental Science and Engineering, Inc., 2000). The Biscayne Bay sediment samples were homogenized within the original sample containers after large objects such as stones, plant debris and organisms were removed by hand.

Following completion of the amphipod sediment bioassays, the remaining live amphipods (*Ampelisca abdita*) from each replicate were pooled, placed in 1 mL of ice-cold cryopreservative mix, and frozen on dry ice. Amphipods used to test sediments from sites 1, 2, 3, 4, 5, 8, 9, 18, 21 and 23 were shipped frozen to the US Navy Space and Naval Warfare Systems Center (SSC-SD) Biomarker Lab, San Diego, CA, for DNA Damage analysis.

2.2.4.2. Clams

Specimens of the clam (*Mercenaria mercenaria*) were obtained from Sea Perfect, Charleston, NC, a hatchery located near the NOAA/NOS/NCCOS Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) facility.

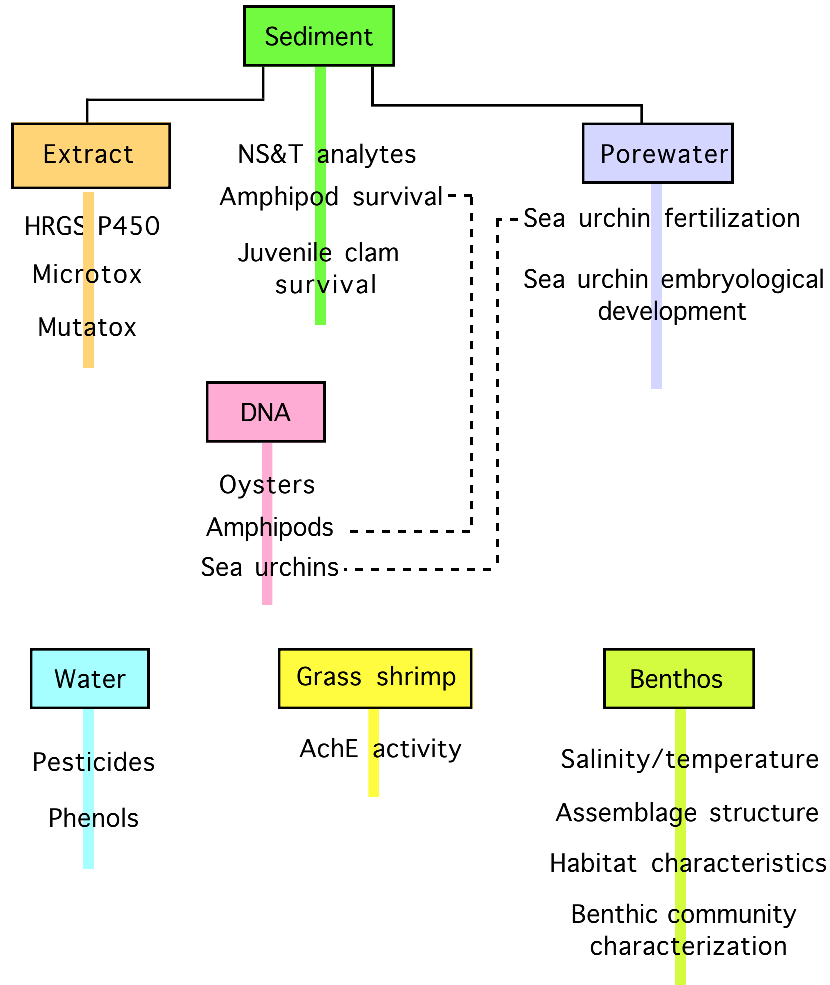

Figure 2. Schematic of samples and analyses.

2.2.4.3. Oysters

Oysters (*Crassostrea virginica*) were pried off rock or mangrove root substrates at the mouth of drainage control canals corresponding to sampling sites 1, 2, 4, 5, canal C-111 and at a reference site in Little Card Sound, without damaging the animals' shell. Oysters were placed in ice chests in clean zip-loc bags filled with site water and transported by boat back to the Biscayne National Park headquarters laboratory for processing. Physical/chemical data were collected at each site at the time of collection. Ten oysters were collected at each site with the exceptions of site 2 where only 6 were found, and site 3 where no oysters were found.

The resident oyster populations were not plentiful at any site except along the breakwater at site 4, North Canal. In most cases the oysters from any one site were of many varying sizes. The site 4 collection was during low tide but only submerged individuals were collected. The collection at site 5 was also close to low tide, oysters were attached to rocks and mangrove roots above the waterline at the time of collection. Collection at sites 1 through 3 coincided with high tide, and all collected individuals were submerged. No oysters were found at site 3.

Oyster collection at C-111 occurred near low tide, but the gathered oysters were all collected from submerged rocks. Oysters collected from the Little Card Sound reference site were all attached to submerged rocks or mangrove roots.

2.2.4.4. Sea urchins

Specimens of the sea urchin *Arbacia punctulata* used in this study were obtained from Gulf Specimen Company, Inc., Panacea, FL.

2.2.4.5. Grass shrimp

Approximately 20 grass shrimp were collected live from seven sites in Biscayne Bay and three sites in Manatee Bay using a dip net. The shrimp were placed in plastic bags and frozen immediately using dry ice. The samples were transported to NOAA/NOS/NCCOS/CCEHBR, Charleston, SC, sorted on ice and identified to species. All shrimp, with the exception of those collected from site 3, were identified as *Palaemonetes intermedius*. The shrimp collected at site 3 were not analyzed because they were determined to be *Palaemon floridanus*. The shrimp from each site were separated into 2-animal samples, wrapped in aluminum foil, and stored in a –70 °C freezer until analysis. In addition to the field-collected *P. intermedius*, laboratory-reared *P. intermedius* were used as a control. Previous work on acetylcholinesterase (AChE) in *Palaemonetes* has concentrated on the species *P. pugio*. Because no previous AChE work on *P. intermedius* has been published, a laboratory-reared population of *P. pugio* was also sampled for AChE analysis for comparative purposes.

2.2.5. Benthos

A Young-modified Van Veen grab (area = 0.04 m^2) was used to collect bottom samples at the 30 sites. Samples were prescreened through 0.5-mm mesh sieves in the field by NOAA personnel and fixed in a 10% formalin solution. The preserved sample fractions were transported to Barry A. Vittor & Associates, Inc. (BVA) laboratory in Mobile, AL.

2.3. Analyses and assays

2.3.1. Seawater analyses

2.3.1.1. Pesticides

Two 10-L aliquots of each seawater sample were measured into stainless steel canisters for duplicate processing. Field blanks were processed concurrently with the samples. Each sample canister was pressurized with high purity nitrogen forcing the water sample through a certified solid phase extraction (SPE) cartridge containing hyper-cross-linked styrene-divinylbenzene copolymer, ENV+ (Jones Chromatography) extraction resin. After extraction, the ENV+ cartridge was dried with nitrogen and eluted with certified high purity solvents (6 mL dichloromethane followed by 9 mL of 3:1 acetone:acetonitrile). This 15-mL extract was concentrated to a final volume of 0.5 mL under nitrogen and analyzed by two gas chromatograph-mass spectrometers.

2.3.1.2. Alkyl phenols

One liter of non-filtered seawater was extracted for each site. The liter of seawater was placed in a separatory funnel, and 100 mL dichloromethane and 40 g NaCl were added. The funnel was shaken for 3 minutes. The organic (dichloromethane) phase was separated and retained. Another aliquot of 100 mL of dichloromethane was added and the funnel again shaken and the organic phase added to the previous one. The collected organic phase was passed through a Na_2SO_4 column to remove any water present. The organic phase was placed in a Roto-evap and the solvent exchanged to hexane. The resulting solution was evaporated to 1 mL.

Dichloromethane extracts were prepared for GC/MS analysis by adding pentafluorobenzoyl chloride according to the method of Wahlberg *et al.* (1990). Briefly, the extracts were reduced in volume to approximately 0.2 mL, and diluted to 2 mL using toluene. To perform the derivatization, 10 μL of pentafluorobenzolyl chloride (Aldrich Chemical Co.), and 5 μL of low-water containing pyridine were mixed, heated to 60 °C, and maintained at 60 °C for 15 min. A basic solution, 10 mL of NaOH solution (4 g/100 mL), was added to neutralize excess acid. The mixture was placed in a 4 °C refrigerator overnight. The organic phase was removed and analyzed using negative chemical ionization gas chromatographic mass spectrometry. Prior to injection in the gas chromatograph (GC), the samples were passed through Na_2SO_4 cartridges to remove excess water and particulates.

The GC column used was a 30 m long DB-17MS column, 0.25 mm ID, and 0.25 μm support. Column flow was 1.13 mL/min of helium gas. The temperature program was: 130 °C for 4 minutes, up to 170 °C ramped at 20 °C/min, up to 250 °C at ramped 7 °C/min, up to 300 °C at ramped 10 °C/min, and ending with a 20-min hold, for a total run time of 42.43 min.

The mass spectrometer was a 5890A Hewlett Packard GC/MS operated in electron capture negative ionization mode. The reagent gas was methane at 2.0 torr and the source operated at 250 °C. The other heated zones were the injector at 250 °C and the transfer line, 280 °C. The halogenated derivative was selectively determined using electron capture negative chemical ionization (NCI) detection methods. The standard for the octylphenol analysis were provided by Aldrich Chemical Company as tetramethylbutylphenol. The other standards were combined as a mixture in POE(3) [same as Triton X-100] (Chem Services), which was analyzed and determined to have the following composition of octylphenol and octylphenol ethoxylates: 0.9% octylphenol, 24.5% octylphenolmonoethoxylate, 38.7% octylphenoldiethoxylate, 29.4% octylphenoltriethoxylate, 5.8% octyltetraethoxylate, 0.7% octylpentaethoxylate. This composition was determined by fluorescence after separation by HPLC using a Hypersil column. GC analysis confirmed this composition determination. However certain impurities, approximately 11%, were present and reduced the octylphenol ethoxylate composition slightly. The mass spectrometer was operated in SIM mode dwelling on the following ions: 400 - octylphenol, 444 - octylphenolmonoethoxylate (isomeric mixture), 488 - octylphenoldiethoxylate (isomeric mixture), 532 - octylphenoltriethoxylate (isomeric mixture), 576 - octylphenoltetraethoxylate (isomeric mixture) and 620 - octylphenoltriethoxylate (isomeric mixture). The retention time window was set into the quantitation program for the report generator for the Hewlett Packard system and the appropriate ions searched. Standard concentrations ranged from 0.005 to 1.3 μg/mL. Linearity was maintained over the low end for standards, the highest range being 1 μg/mL to 0.25 μg/mL. To quantitate the nonylphenol and nonylphenol ethoxylates, the instrument was calibrated using purified standards of the ethoxylates 1 through 5, and a standard of nonylphenol obtained from Schenectady International. The derivatives of these compounds form stable substitutions of 194 mass units with no apparent fragmentation, thus providing maximum sensitivity. These mixed standards each yield about 8 to 11 peaks on chromatography which are summed across each analyte group, i.e. nonylphenol 414 m/z, [4-*n*-nonylphenolmonoethoxylate (isomeric mixture)] (np1eo) 458 m/z, [4-*n*-nonylphenoldiethoxylate (isomeric mixture)] (np2eo) 502 m/z, [4-*n*-nonylphenoltriethoxylate (isomeric mixture)] (np3eo) 546 m/z, [4-*n*-nonylphenoltetraethoxylate (isomeric mixture)] (np4eo) 590 m/z and [4-*n*-nonylphenolpentaethoxylate (isomeric mixture)] (np5eo) 620 m/z. Each retains a characteristic pattern similar to the standard. However pattern variations do appear to occur in the field collected samples. These pattern shifts are also available for interpretation.

The recovery of the spiked sample was adequate: 120% nonylphenol, 149% np1eo, 169% np2eo, 159% np3eo, 97% np4eo and 43% np5eo. The precision was excellent, notice Princeton Canal Mouth samples A and B show an average relative percent difference of 20% (ranging from 3.2 to 45%). The percent differences were greatest with the 4 and 5 nonylphenolethoxylates, which are the more difficult to quantitate because the GC/MS loses sensitivity as the ethoxy substitution increases.

Results of analyses are listed in Tables I.1 and I.2.

2.3.2. Whole sediment

2.3.2.1. Chemical analyses

The analytical protocols for the determination of carbon content, solids, and particle size distribution, trace organic contaminants, and element analyses are described in detail in Lauenstein and Cantillo (1993, 1998). Results are listed in Appendix II: carbon content, solids, and particle size distribution (Table II.1); polycyclic aromatic hydrocarbons (PAHs) (Table II.2); pesticides (Table II.3); polychlorinated biphenyl congeners (PCBs) (Table II.4); major and trace elements, and acid volatile sulfides (AVS) (Table II.5); and tributyltins (TBTs) (Table II.6).

2.3.2.2. Juvenile clam assay

Sediments for the clam (*Mercenaria mercenaria*) bioassays were warmed to room temperature and press-sieved through a 212-µm mesh screen. Bioassays were done in pre-cleaned 16-oz glass jars containing 60 mL of sediment and 180 mL of 20 µm filtered seawater. There were five replicates for each sediment sample. Following the addition of the seawater, sediments were allowed to settle under active aeration in the bioassay beakers for 24-hr before the addition of the clams. After settling, thirty (212 to 350 µm in length) clams were added to each beaker. The bioassays were run at 30 ppt salinity, 20° C, and a 12-hr light: 12-hr dark cycle in environmental chambers. Clams in each beaker were fed 5 mL of the flagellate *Isochrysis galbana* every 48 hr. Temperature, dissolved oxygen, salinity, pH and ammonia were monitored during all bioassays. At the end of ten days, clams were retrieved by re-sieving the sediment through a 212-µm mesh sieve. Clam mortality in each replicate was determined using an Olympus SZH10 microscope under 7.0x magnification. Site-specific mortality was evaluated in comparison to a reference site (Folly River, SC) using ANOVA and Dunnett's Test (arcsin transformed percent mortality data). Due to the large number of sediment samples to be evaluated, sediments were tested in three separate 10-day assays. A reference sediment (Folly River, SC) sample was included in each of the assays. Results are listed in Table III.1.

2.3.2.3. Amphipod survival

Amphipods, *Ampelisca abdita*, were exposed to the test sediments for 10 days under static conditions following American Society for Testing and Materials (ASTM) procedures (ASTM, 1995). Two hundred mL of homogenized sediment were added to each of five replicate chambers per sample, and 800 mL of filtered seawater was added. The sediment and seawater were allowed to equilibrate for one day prior to introduction of the amphipods. The *Ampelisca* specimens were sieved from the holding chambers, and rinsed with seawater. Twenty sub-adult amphipods were randomly distributed into plastic weigh boats to determine average weight per specimen. Condition and number of organisms was noted prior to loading of the test chambers. Organism loading of 20 amphipods per test chamber was performed in random order. After one hour, the test chambers were examined for any amphipods that did not burrow into the sediment. The chambers were placed in random order within a water bath. Oil-free air was delivered into the water column of each test chamber to maintain acceptable oxygen levels. Ambient laboratory lighting was continuous to promote tube-dwelling activity by the amphipods. The amphipods were not fed during the test. The test chambers were examined daily and the number of animals found on the sediment surface, water column or water surface was recorded. Dead amphipods were removed and noted. Live amphipods trapped in the water surface were gently prodded with a stream of overlying water applied with a plastic pipette and allowed to descend and reburrow. Water quality parameters measured included temperature, salinity, dissolved oxygen, pH and ammonia.

The tests were terminated after 10 days. The sediments were washed with seawater and sieved. The material remaining on the screen was rinsed into a dish and labeled. The living organisms were removed to a plastic weigh boat, counted and weighed. All samples for which greater than 10% (2 out of 20) of the original organisms were unaccounted for were reexamined. Amphipods not accounted for at test termination were assumed dead and recorded as such. Results are listed in Table III.2.

Individuals from sites 1, 2, 3, 4, 5, 8, 9, 18, 21 and 23 were hand-picked and placed into glass vials, preserved with a cryopreservative and shipped on dry ice to another laboratory for genetic testing.

2.3.3. Bioassays using sediment extracts

2.3.3.1. HRGS P450 bioassay on sediment extracts

Sediment samples were extracted using EPA Method 3550 (Anderson and McCoy, 2000). Briefly, approximately 20 g of sediment were extracted with dichloromethane to yield 1 mL of extract. A separate sediment sample was used to determine percent solids. Extracts were exchanged into a 2:1:1:1 dimethyl sulfoxide (DMSO), toluene and isopropyl alcohol solution. The final extract volume was 2 mL. Two 1-mL vials were prepared from each sample. One was shipped to Columbia Analytical Services in Vista, CA, for P450 Human Reporter Gene System (HRGS) analysis (EPA Method 4425), and the other to CCEHBR in Charleston, NC.

For Tier I testing, 5 μL extract samples were applied to three replicate sample wells and incubated for 16 hours. Cells were then washed, lysed, and the solution centrifuged. Fifty μL were used if the supernatant was applied to a 96-well plate, followed by 100 μL of a co-factor solution and 100 μL of the enzyme substrate luciferin. Luminescence was measured as relative light units (RLU) using a ML 2250 Luminometer. A solvent blank and reference inducers {2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) and benzo[*a*]pyrene (B[*a*]P)} were also included for each sample test run.

Benzo[*a*]pyrene equivalents (B[*a*]PEq) were calculated for all sample extracts and duplicate extracts. The B[*a*]PEq is a measure of the CYP1A1-inducing PAHs, plus any coplanar PCBs, dioxins or furans that may be present in the sample and are calculated as follows:

$$B[a]PEq\ (\mu g/g) = \frac{\text{fold induction}}{60} \times \frac{\text{volume factor}}{\text{dry weight}} \times \text{df.}$$

Fold induction is calculated as the mean relative light units (RLU) produced by the sample divided by the mean RLU produced by the solvent blank. The factor of 60 represents the approximate fold induction produced by 1.0 μg of B[*a*]PEq/mL. The volume factor (400) represents the total extract volume (2 mL) divided by the volume extract applied to the cells (5 μL). Dividing by the dry weight of each sample, calculated using percent solids of the 20 g samples, yields B[*a*]PEq in μg/g dry weight. If a dilution is used, the B[*a*]PEq value is multiplied by the dilution factor (df).

A standard curve for dioxin/furan mixture demonstrated that fold induction per mL is equal to the dioxin Toxic Equivalents (TEQ_{HRGS}) in pg/g dry weight. Therefore, the equation to express the data as only chlorinated inducers (in ng/g) is as follows:

$$TEQ_{HRGS} = \text{fold induction} \times \frac{\text{volume factor}}{1000 \times \text{dry weight}} \times \text{df}.$$

Tier II testing was conducted on the three sample extracts producing the highest level of induction at 16 hours of exposure. Selected sample extracts (sites 2, 4 and 5) were used in the HRGS assay at 6 and 16 hours of exposure to evaluate the contribution from rapid-acting PAHs and the chlorinated inducing compounds (dioxins, furans, coplanar PCBs) which require 16 hours for maximum response.

The results are listed in Tables III.3 and III.4.

2.3.3.2. Microtox™

The Microtox™ assay was performed using dichloromethane extracts of sediments provided to NOAA/NOS/NCCOS/CCEHBR by Columbia Analytical Services.

A suspension of luminescent bacteria, *Vibrio fischeri*, was thawed and reconstituted with deionized water, covered and stored in a 4° C well on the Microtox™ analyzer. To assess toxicity, each sample was diluted into four test concentrations. A total of three replicate analyses were performed for each sediment sample. The percent decrease in luminescence in each concentration relative to the reagent blank was then calculated and used to calculate an EC50 (the sediment concentration causing a 50% reduction in luminescence). EC50 results are reported as mg/ml (corrected for dry wt.). Site-specific toxicity was evaluated by comparing to a reference site (North Inlet, SC) using ANOVA and Multiple Comparison Tests as well as a nonparametric Distribution Free approach. Results are listed in Table III.5

2.3.3.3. Mutatox™

The Mutatox™ genotoxicity bioassay was performed by NOAA/NOS/NCCOS/CCEHBR as described in Microbics Corporation's Mutatox™ manual using the same solvent extracts prepared for the Microtox™ organic extract assay (Microbics Corporation, 1993).

Two assay protocols were utilized. The first, the S-9 assay, utilizes media which contain mammalian hepatic enzymes which metabolize promutagenic compounds and thus can be used to screen sediments for mutagens which require metabolic activation. The second assay, the direct assay, uses media which contains no mammalian enzymes and thus can be used to screen for mutagens which do not require activation. The mutagenic potential of samples was evaluated using the criteria described in the Microbics Corporations' Mutatox™ Manual (Microbics Corporation, 1993). A total of three replicate analyses were performed for each sediment sample. A sediment was considered to be mutagenic only if all three replicates met the criteria for mutagenicity. Results are listed in Table III.6

2.3.4. Bioassay using sediment porewaters

2.3.4.1. Sea urchin fertilization

Sea urchin (*Arbacia punctulata*) fertilization pore-water toxicity tests were performed at the US Geological Survey National Biological Service (NBS), Texas Gulf Coast Field Station, Corpus Christi, TX.

Urchin sperm was exposed for 30 min to 100%, 50% and 25% dilutions of sediment porewater using 0.45 μm filtered seawater. The reference porewater sample used was collected from Redfish Bay, TX. Salinity of the porewaters was adjusted as needed using a brine prepared with Milli-Q deionized water. Subsamples of sperm exposed to porewater were removed for DNA damage assessment (see Section 2.3.6.3).

2.3.4.2. Sea urchin embryological development

After 30 min exposure, sea urchin eggs were added to the sperm to determine fertilization. The number of embroys is determined.

2.3.5. Grass shrimp acetylcholinesterase activity

Organophosphate and carbamate insecticides produce toxicity in vertebrates and invertebrates by inhibiting the nervous system enzyme acetylcholinesterase, AChE. The inhibition of this enzyme can be used as a biomarker of exposure and/or effects due to these classes of pesticides. The use of this biomarker offers several advantages over chemical contaminant monitoring alone. First, this indicator will respond to any chemical which produces toxicity through this mechanism. Additionally, the inhibition produced by many of these compounds persists long after waterborne chemical concentrations have decreased to nondetectable levels.

Previous work on whole body AChE activity was performed on *Palaemonetes pugio* to determine the presence of AChE (Key *et al.*, 1998). Each sample analyzed consisted of two adult shrimp. Depending on the number of shrimp that were collected from each of the sites, the number of samples ranged from 6 to 10. Each sample was homogenized (Pro Scientific model Pro 200 motor with a 20 mm x 150 mm stainless steel generator) on ice in 50 mM Tris-HCl buffer (pH = 8.1) at 20 mg/mL for 45 seconds. Next, 75 μL of each homogenate was added to a test tube containing 1.425 mL of Tris HCl buffer. After a 15 min incubation period at 30° C, 967 μL of the dilute homogenate was added to a cuvette containing 33 μL of 0.87% 5,5'-dithiobis-(2-nitrobenzoic acid), the color reagent. Finally, 10 μL of 75 mM acetylthiocholine, the substrate, was added to the cuvette then covered with parafilm, inverted to mix, and placed in a spectrophotometer to read continuously for 1 min at a wavelength of 412 nm. For each homogenate sample, three subsamples was assayed. A fourth subsample was incubated with 15 μL of 10 μM eserine to account for nonenzymatic hydrolysis of the substrate. The protein content of the homogenate was determined using the Sigma Assay Procedure, a modification of the original Lowry method (Lowry *et al.*, 1951). Whole body AChE activity was reported as nmol product formed/mg protein/min.

Statistical analysis of the results from the AChE analysis was evaluated using ANOVA and Dunnett's Multiple Comparison Test. All statistical analyses used the lab-reared *P. intermedius* as the control group. Results are listed in Table III.9.

2.3.6. DNA damage

Increased or higher incidence of DNA damage in fish or mussel tissue has previously been found to be correlated with contamination. In this study, testing with oysters and sea urchin sperm were carried out on an exploratory basis to further evaluate the applicability of the procedure as a biomarker.

2.3.6.1. Oysters

In the laboratory, a notch was filed in each oyster to allow the passage of a 25-gauge syringe needle that was inserted into the adductor muscle and 100 μL of hemolymph withdrawn. The hemolymph was placed in a 1.5 mL microcentrifuge tube and spun at 600 x g for 2 minutes to pellet hemocytes. The supernatant was discarded and cell pellets resuspended in 1 mL ice-cold cryopreservation solution, gently mixed, and frozen on dry ice. The samples were kept frozen, and shipped to the US Navy Space and Naval Warfare Systems Center (SSC-SD), San Diego, CA, Biomarker Lab for DNA damage analysis.

For SCG electrophoresis or Comet assay, frozen samples were thawed on ice, 200 μL of the sample were transferred to a fresh microcentrifuge tube on ice, and the cells pelleted by spinning at 600 x g for 2 min. Depending on the size of the pellet, which is proportional to the number of cells in the pellet, the pellet was re-suspended in anywhere from 50 to 200 μL of LMA/Kenny's solution (0.65% low melting point agarose in Kenny's salt solution, 0.4 M NaCl, 9 mM KCl, 0.7 mM K_2HPO_4, and 2 mM $NaNCO_3$, pH 7.5) at 30 °C, and 50 μL of the suspension was coated on a SCG/Comet slide. Results are listed in Table IV.2.

2.3.6.2. Amphipods

For SCG/Comet analysis frozen samples were thawed on ice and 3 - 4 amphipods (*Ampelisca abdita*) from each tube were transferred into a fresh microcentrifuge tube. All accompanying cryopreservative medium was discarded and the organisms suspended in 200 μL ice cold Kenny's salt solution. The organisms were homogenized briefly in the tube using a mini-pestle and 200 μL of the suspended cells transferred to a fresh microcentrifuge tube on ice. The cells were pelleted by spinning at 600 x g for 2 min and depending on the size of the pellet was re-suspended in anywhere from 100 to 200 μL LMA/Kenny's agarose at 30 °C. Fifty microliters were withdrawn and coated on a SCG/Comet slide. Results are listed in Table IV.3.

2.3.6.3. Sea urchin sperm

The LMA/Kenny's resuspended cells (mentioned in Section 2.3.4.1) were applied to slides previously coated with 0.65% agarose [Fisher Biotech, low electroendosmosis (EEO)* agarose] in 40 mM tris-acetate and 1 mM EDTA, at pH 7.5 (TAE buffer)Δ, or in the case of the urchin sperm samples applied to a GelBond sheet. A slide cover was placed over the sample which was then allowed to gel on an ice chilled stainless steel tray for 3 min. A top-coat of 50 μL agarose was applied over the sample, the coverslip replaced, and the gelling step repeated. After gelling, the coverslip was removed and the slides placed in a lysing solution of 2.5 M NaCl, 10

* Electroendosmosis (EEO) is a functional measure of the number of sulfate and pyruvate residues present on the agarose polysaccharide. This phenomenon occurs during electrophoresis when the anticonvective medium (the agarose) has a fixed negative charge. In an electric field, the hydrated positive ions associated with the fixed anionic groups in the agarose gel migrate toward the cathode. Water is thus pulled along with the positive ions, and migration of the negative molecules such as DNA is retarded.

Δ TAE buffer is composed of Tris, EDTA-Na_2-salt and acetic acid.

mM Tris [tris(hydroxymethyl)aminomethane], 0.1 M EDTA, 1% Triton X-100[◊], and 10% DMSO at pH 10.0 in a glass screw-top Coplin jar and incubated at 4 °C for at least 1 hr.

Between-batch variability of SCG/Comet slides was monitored by running laboratory standards prepared from bird blood cells of known damage levels.

Prior to unwinding and electrophoresis, the lysing solution was rinsed from the slides with three 2-min rinses of distilled water. The rinsed slides were placed in a submarine gel electrophoresis chamber filled with 300 mM NaOH and 1 mM EDTA, and the DNA allowed to unwind under alkaline conditions for 15 min. After unwinding, electrophoresis was performed at 300 mA, 25 V for 10 min. The slides were transferred to Coplin jars and neutralized with three 2-min rinses in 0.4 M Tris at pH 7.5. Excess solution was blotted away, and the neutralized slides fixed in ice cold ethanol for 5 minutes. The fixed slides were dried in an oven at 37 °C for 20 minutes and transferred to slide boxes for storage.

To determine the levels of DNA damage, the slides were stained with 35 μL of a 20 μg/mL solution of ethidium bromide[*] in distilled water (EtBr), and covered with a coverslip. Stained slides were analyzed by viewing at 200x with an epifluorescent microscope (excitation filter 510-560 nm green light, barrier filter 590 nm) with an attached CCD camera and image analysis software (Komet image analysis system, Kinetic Imaging, Ltd., UK).

For all Comet assays, the fluorescent "head" or nucleus diameter and the length (μm) of any accompanying trailing DNA "tails" resulting from strand breakage are measured for each nucleus analyzed. Measurements were made in five sectors on each slide, counting 5 nuclei in each sector randomly positioning the lens above each sector and counting left to right from the upper left-hand corner of the field of view. Overlapping nuclei or tails were not counted. For the oyster samples 25 nuclei from each individual were scored, 25 nuclei from each replicate of amphipods, and 3 subsamples were prepared and separately scored from each urchin sperm sample. The image system calculated a large number of quantitative parameters for each nuclei, the most important being the total intensity of each comet (comet optical intensity), the percentage of damaged DNA in the tail, and the tail moment (TM) which is the product of the percentage of DNA in the tail times the tail length divided by 100. Data was analyzed by ANOVA using InStat statistical software (GraphPad). Results are listed in Table IV.4.

2.3.7. Benthos

At the Barry A. Vittor & Associates, Inc. (BVA) laboratory, benthic sediment samples were inventoried, rinsed gently with tap water through a 0.5 mm mesh sieve to remove preservatives and sediment, stained with Rose Bengal, and stored in 70% isopropanol solution until processing. Sample material (sediment, detritus, organisms) was placed in white enamel trays for sorting under Wild M-5A dissecting microscopes. All macroinvertebrates were carefully removed with forceps and placed in labeled glass vials containing 70% isopropanol. Each vial represented a major taxonomic group (*e.g.* Polychaeta, Mollusca, Arthropoda). All sorted macroinvertebrates were identified to the lowest practical identification level (LPIL), which in most cases was to species level unless the specimen was a juvenile, damaged, or otherwise unidentifiable. The number of individuals of each taxon, excluding fragments, was recorded. A voucher collection was prepared, composed of representative individuals of each species not previously encountered in samples from the region.

[◊] Detergent, octylphenol ethylene oxide condensate.

[*] 3,8-diamino-5-ethyl-6-phenylphenanthridinium bromide, CAS number 1239-45-8.

All data generated as a result of laboratory analysis of macroinfaunal samples were first coded on data sheets. Enumeration data were entered for each species according to site and replicate. These data were reduced to a data summary report for each site, which included a taxonomic species list and benthic community parameters information. Archive data files of species identification and enumeration were prepared. The data and quality assurance/quality control (QA/QC) reports for the Biscayne and Manatee Bay samples are given in Appendix V. Quality control comments for common LPIL taxa are annotated in data tables. Summary of results are in Table V.6.

3. RESULTS

3.1. Seawater

3.1.1. Pesticides

The results of analyses of pesticides are listed in Table I.1. Eight of the 52 pesticides analyzed for were found in the seawater samples. These were two herbicides (atrazine and metolochor) and two herbicide metabolites (CEAT and CIAT), three organophosphate insecticides (chlorpyrifos, diazinon and malathion), and a DDT metabolite (4,4'-DDE) (Table I.1). The herbicides were the most prevalent compounds with metolochor present at all sites sampled. Organophosphates were detected at three sites including Military Canal and North Canal. Higher levels were found at the upstream sites than at the mouth of the canals.

3.1.2. Alkyl phenols

Most concentrations were below those of the blanks for these samples. This suggests that there was a background problem with the sample containers. Use of a larger volume of water would have lowered the limit of detection. In spite of the moderate blank levels, two sites did stand out as having moderate levels of the ethoxylates, especially nonylphenolethoxylate. The Florida City Mouth sample had moderate levels of nonylphenols and the Princeton Canal Mouth had rather high levels of the 3- and 4-ethoxylates and moderate levels of the 3- and 4-octylphenolethoxylates. These octylethoxylate compounds were unique because usually the tetramethylbutylphenol is the only alkyl chain component present, but in these samples there appears to be significant levels of the branched chain octylphenol forms which would easily double the amount at the Princeton Canal Mouth. Of the two, nonylphenol versus octylphenol, it is the octyl form which is the more potent endocrine disruptor. Therefore these results may signify problems for this area. It appears likely that there is some sewage treatment discharge at this site or perhaps an industrial discharge that may account for the presence of these compounds.

The results of water analyses for nonylphenols, nonylphenol ethoxylates, octylphenol, and octylphenol ethoxylates are listed in Table I.2. Concentrations were generally lower than the highest values measured in effluent-dominated rivers in the upper Midwest (Barber *et al.*, 1999; Snyder *et al.*, 1999). In the Des Plains, Illinois and Detroit Rivers, the concentrations of nonylphenol were about 0.5 μg/L and the total amount of ethoxy nonylphenols were often higher. None of these rivers had 3-, 4- and 5-ethoxy substituted nonylphenol concentrations as high as found in these samples. The octylphenols and ethoxylates concentrations in the rivers were comparable to those measured here.

3.2. Sediment

3.2.1. Chemistry

NOAA's National Status and Trends Program (NS&T) determines the status of, and detects changes in, the environmental quality of the nation's coastal waters. This program monitors levels of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCBs) congeners, several pesticides, butyltins, and selected trace elements in sediment and mollusk samples from U.S. coastal waters. Sediments collected at the 30 sites in Biscayne Bay were analyzed for the NS&T "suite" of analytes. Results of sediment analyses are listed in Tables II.1 (carbon content, percent moisture and grain size distribution), II.2 (PAHs), II.3 (pesticides, herbicides), II.4 (PCBs), II.5 (major and trace elements), and II.6 (tributyltins) in Appendix II. Results were compared to the nationwide NS&T median and 85th percentile values for sediment (Table II.7). Concentrations above the 85th percentile are in the highest 15% of the data set and are used to indicate "high" concentrations. Distribution of NS&T "high" and "median" concentrations at the sites sampled in this study is shown in Figure 2.

In general, mean analyte concentrations in sediment were below the NS&T "median" with the exception of sediment collected in or at the mouth of the canals. High levels of many NS&T analytes and aggregate[Δ] data in sediments have been found at Mussel Watch sites near high human population densities and in sediments with a high percentage of clay- and silt-sized particles nationwide. Sites 1 through 5 are south of Miami and drain urban and agricultural areas. Sites 22 through 23 are influenced by the C-111 canal which drains agricultural areas and portions of the Everglades National Park. Sediments from sites 2, 5, 22, 23 and 24 are composed of more than 60% clay- and silt-sized particles.

Shown graphically in Figures 3 and 4, are the results for the sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg, and Ag (TotTM) as measured by NS&T via hydrofluoric acid extraction. These are the metals whose toxicity is mitigated if the concentration of AVS (S volatized by 1N HCl) exceeds the sum of concentrations of the Simultaneously Extracted Metal (SEM) in 1N HCl. Since TotTM is greater than SEM, if AVS is greater than TotTM, then AVS is also greater than SEM and the metals cannot be toxic (assuming that the assumptions of the AVS/SEM guideline are acceptable) (O'Connor, 1993).[*] As shown in Figures 3 and 4, the five sites at the mouth of the canals (sites 1 - 5), have high TotTM relative to AVS concentrations, indicating that the sediments may be toxic. Sites 22 - 30 (Manatee) Bay have high AVS concentrations and low TotTM indicating that these sediments are probably not toxic. Site 23 located at the mouth of the C-111 canal has an AVS of 24 μg/g and a TotTM of 57 μg/g thus being potentially toxic. Curiously, site 22 located in the C-111 canal itself has slightly higher AVS, 54 μg/g, and lower TotTM, 41 μg/g. The salinity at site 22 is slightly lower than that at site 23 (Figure 5). The area between sites 22 and 23 may be a mixing zone where freshwater from the canal mixes with more saline water, resulting in possible deposition of sediment. Such depositional material is often high in Fe and Mn oxyhydroxides, and clay. The concentrations of Fe at sites 22 and 23 are 6360 and 9480 μg/g, and for Mn, 67 and 91 μg/g respectively, showing an increase between the two sites. The levels of Al, an indicator of the presence of clays, were 2310 and 6560 μg/g respectively. Sites 7 and 16 have high TotTM to AVS ratios but the TotTM and AVS values are low. Sediment from these sites have high percentages of sand-sized particles.

Δ Aggregates are sums of the concentrations of similar chemical compounds such as DDT and its metabolites. The aggregate definitions are found in Table II.7, Appendix II.

* AVS > TotM > SEM. Therefore if (totM/AVS) < 1, then metals are not considered toxic.

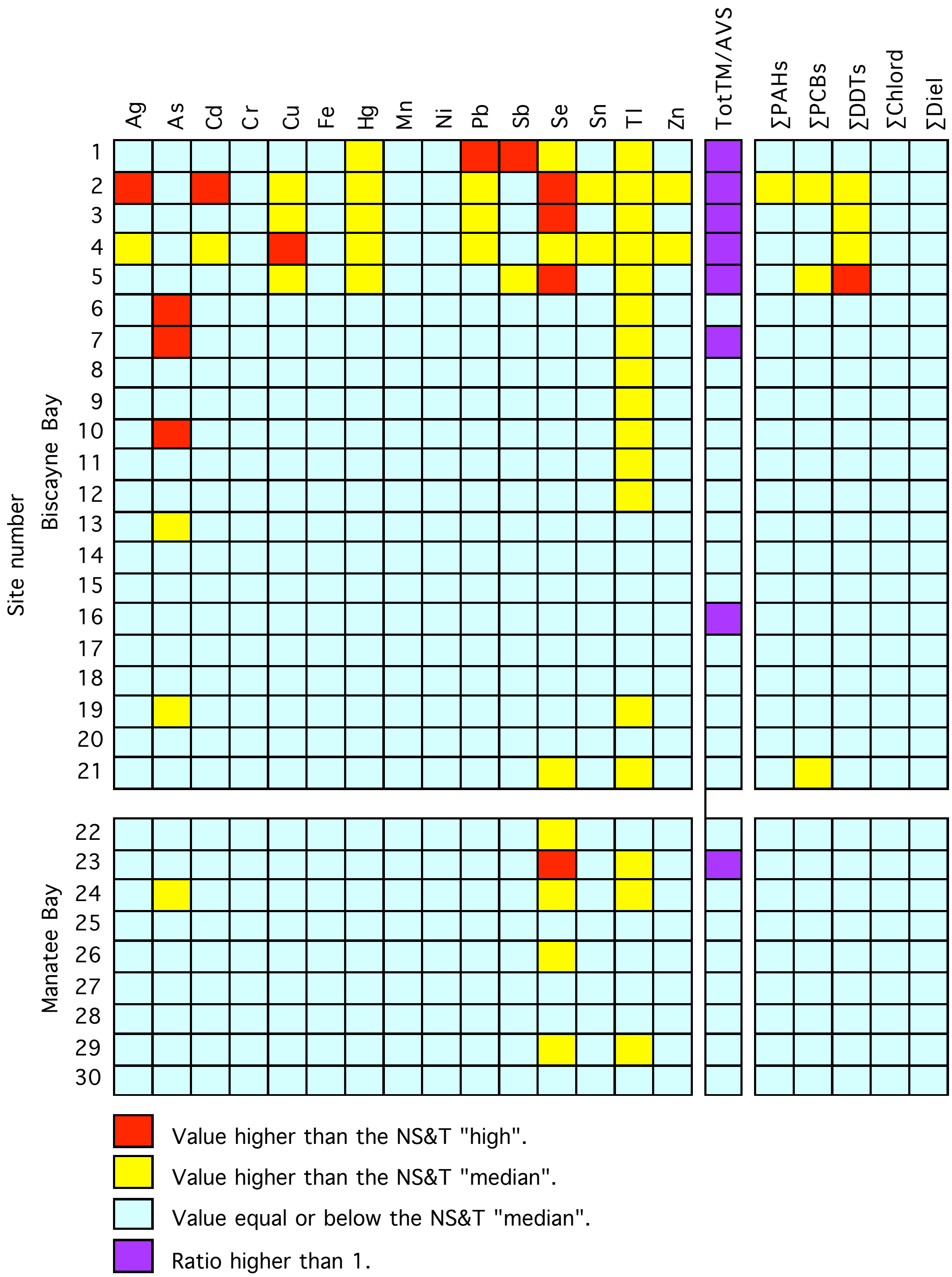

Figure 3. NS&T "median" and "high" concentrations in sediment collected in Biscayne Bay and Manatee Bay.

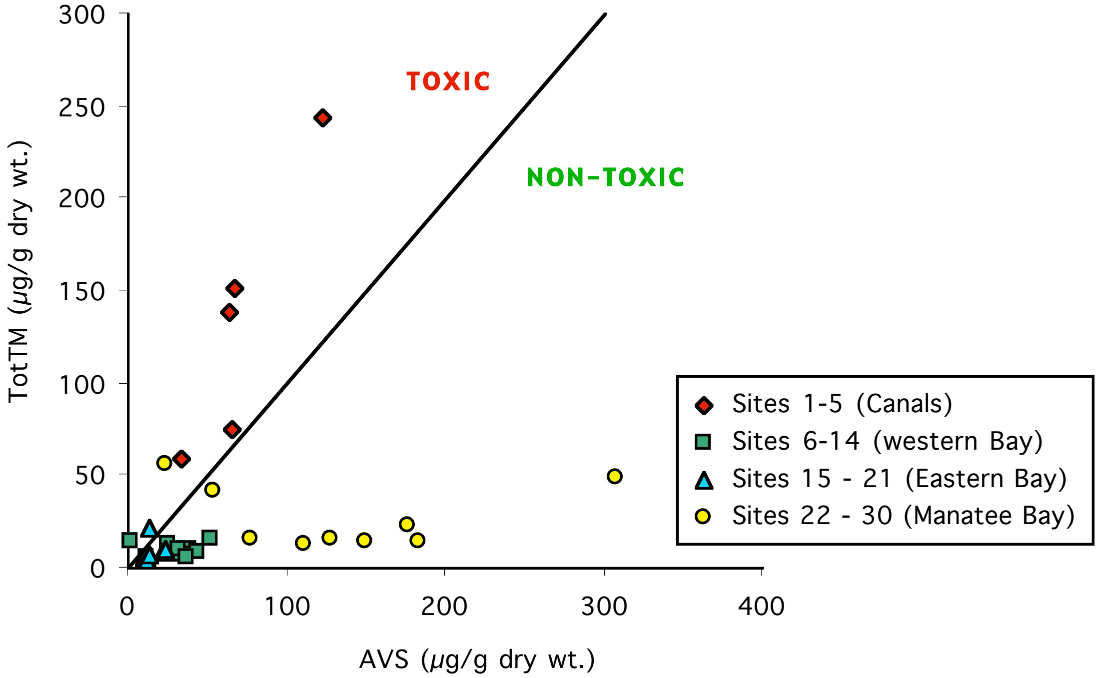

Figure 4. Sum of the concentrations of trace metals (TotTM = [Cu] + [Zn] + [Ni] + [Pb] + [Cd] + [Hg] + [Ag]) versus AVS concentration (µg/g dry wt.).

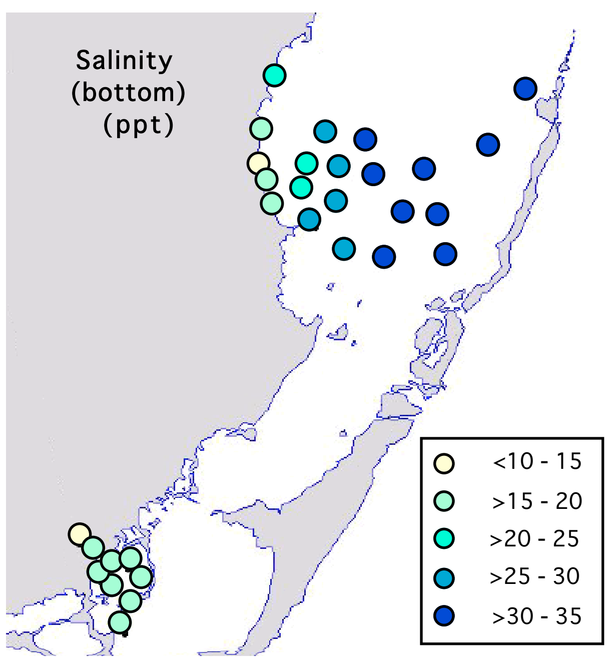

Figure 5. Spatial distribution of bottom salinity (ppt).

3.2.2. Bioassays

3.2.2.1. Juvenile clam assay

The results of the juvenile clam bioassay are shown in Figure 6 and the spatial distribution in Figure 7. Four sites in Biscayne Bay (sites 8, 9, 12, 20) and one site (site 30) in Manatee Bay had >15% mortality and were significantly different from the Folly River reference site. Highest mortality was observed in sediments from site 9 (47%) and site 30 (39%). Sediments from 11 sites (sites 2, 4, 10, 13, 15, 19, 21, 22, 23, 25, 28) were associated with less than 15% mortality, but had survival significantly depressed relative to reference site sediments. Sediments from two of the sites (sites 9 and 30) with the highest mortality also had elevated ammonia levels in the overlying water during the laboratory test. However, two other sites with high mortality (sites 4 and 20) had ammonia levels in the same range as the Folly River reference site, where the sediment bioassay resulted in no mortality. The role that ammonia may have played in the observed toxicity is unclear and should be considered along with other contaminant information.

3.2.2.3. Amphipod survival

Results of the amphipod survival assays are presented graphically in Figures 8 and 9. Results significantly different than controls using Dunnett's one-tailed t-test were found for sites 8, 12, 13, 14, 15, 20, 23 and 30. Site 20, which has the lowest percent survival (27%), was composed of approximately 81% sand. Amphipods do not thrive in sandy sediments. It can be seen in Figure 9 that the sites with low amphipod percent survival had high percentages of sand-sized particles. The sites showing significant amphipod mortality and high percent sand are located in the center of the Bay at some distance from known contamination sources. However, the area where site 20 is located is in a well-known boating recreation area (J. Craynock, NOAA/AOML, personal communication). Aerial reconnaissance of the site from a helicopter and observations from a sampling vessel were performed by NOAA/AOML/Ocean Chemistry Division (Appendix VI). No apparent contamination source, however, was found. No other apparent anthropogenic activity takes place at the sampling site, located west of Elliott Key, a mostly uninhabited key located between Biscayne Bay and the Atlantic Ocean.

3.2.2.4. HRGS P450 analysis

There appeared to be low levels of CYP1A1 inducing compounds in the sediment samples. The three sites (2, 4 and 5) that produced the highest responses tested at two time intervals, appear to contain mostly PAHs. Comparison of the Biscayne Bay results with those of other areas indicate that the sediment samples contain lower amounts of PAHs, coplanar PCBs, dioxins and furans than most previously studied areas. The 3.6 μg B[*a*]PEq/g mean and 6.1 upper 99% confidence interval observed in this study are the lowest of any region investigated by NOAA at the time of analysis using the P450 HRGS assay. The earlier Biscayne Bay study produced a mean and upper 99% confidence interval of 8.2 and 10.2 respectively. The two highest values observed in this study were at sites 2 and 4 and were above the 11 μg B[*a*]PEq/g that appears to be the level below which effects on the biota would not be expected (Figure 10). Only four sites exhibited concentrations above the upper 99% confidence interval (sites 2, 3, 4 and 5), but none reached the concentration of 32 μg B[*a*]PEq/g indicative of potential biological effects. Tier II testing of the samples from sites 2, 4 and 5 showed increases in response from 6 to 16 hours of exposure indicating that the only inducing compounds present in the sediment samples were likely rapid-acting high molecular weight PAHs.

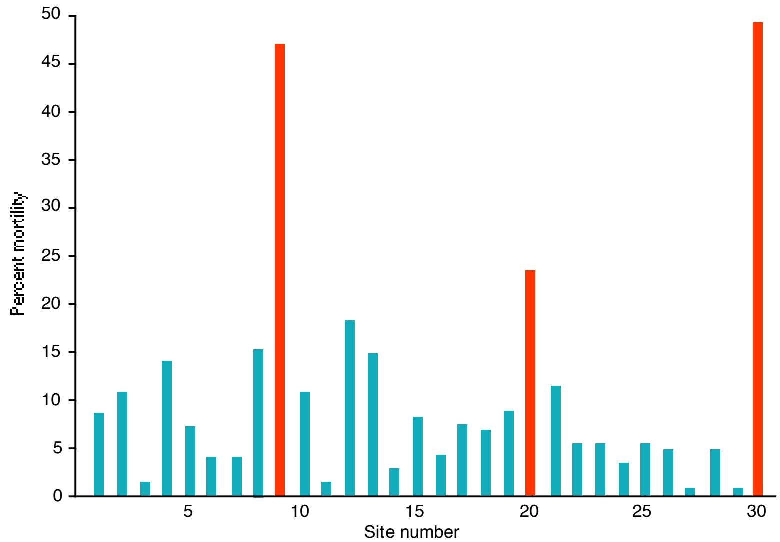

Figure 6. Mortality of juvenile *Mercenaria mercenaria* clams exposed to sediment. [Red bars indicate results significantly different from reference site (= 0.05) and higher than 15% mortality.]

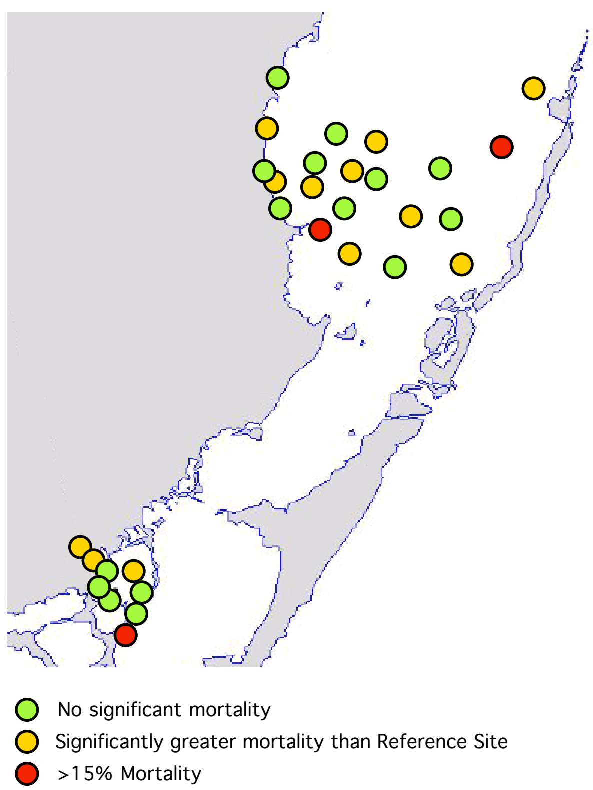

Figure 7. Spatial distribution of juvenile *Mercenaria mercenaria* clam survival assay of Biscayne Bay and Manatee Bay sediments.

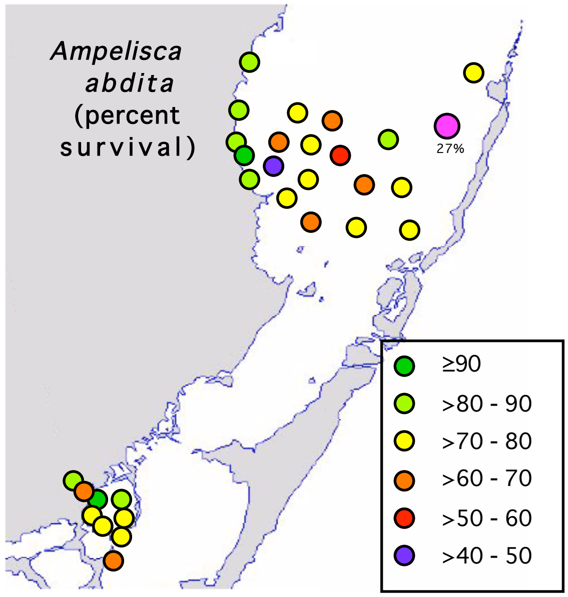

Figure 8. Survival of *Ampelisca abdita* exposed to whole sediment from Biscayne Bay during a 10-day toxicity test (percent survival).

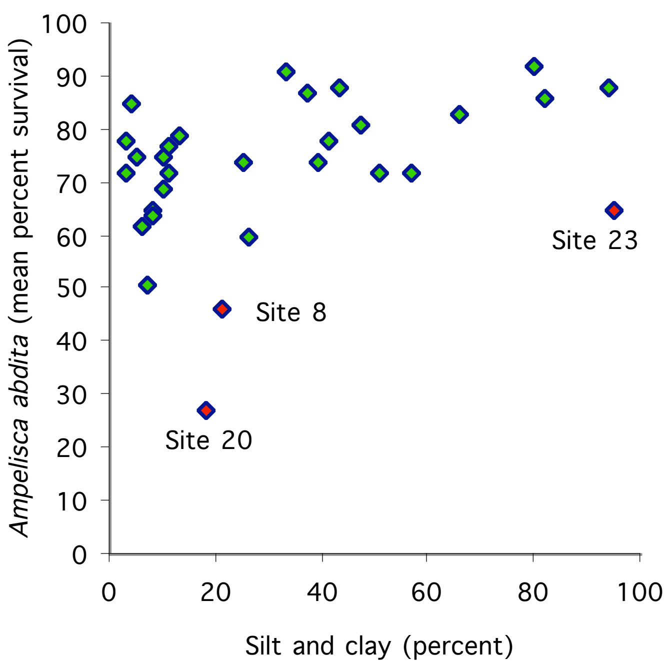

Figure 9. Survival of *Ampelisca abdita* and percent silt- and clay-sized particles in Biscayne Bay and Manatee Bay.

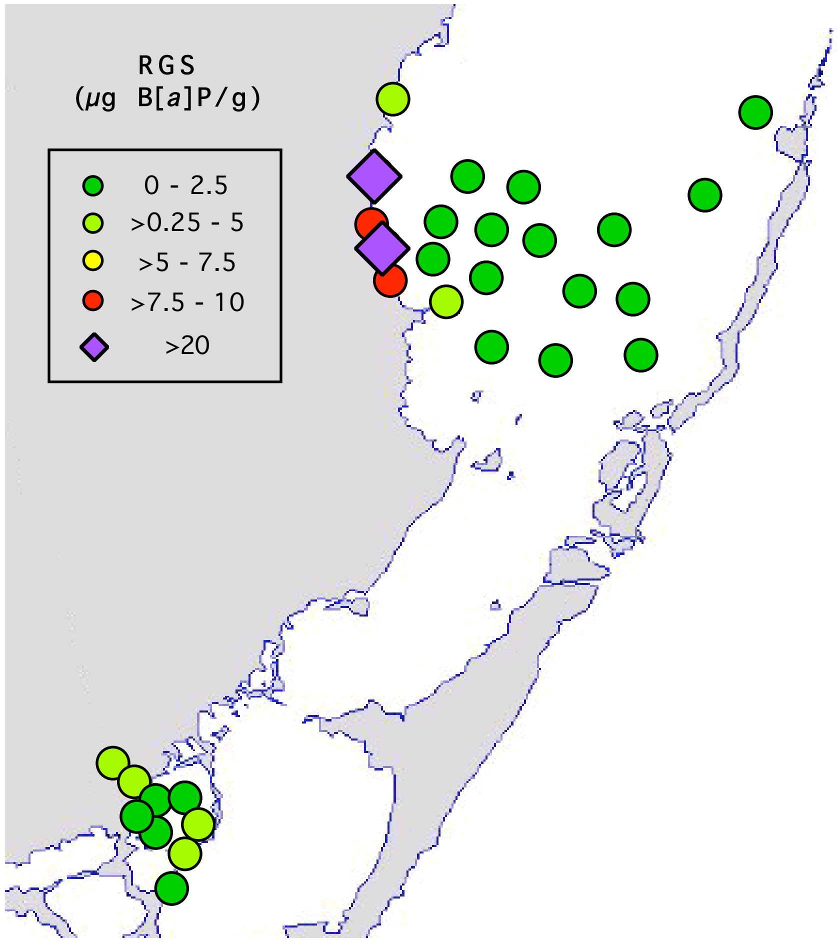

Figure 10. Distribution of HRGS P450 in benzo[*a*]pyrene equivalent units in Biscayne Bay sediments (µg B[*a*]PEq/g).

3.2.2.5. Microtox™

The Microtox™ results for the 5-min and 15-min assays were considered similar. For the 5-min assay, sites 1 - 15 were considered non toxic. For the 15-min awway, sites 1 - 18 were considered non toxic. These sites were all considered non-toxic and were not subjected to further statistical analysis. The toxicities of the remaining sites were compared to that in North Inlet sediments using both nonparametric (Distribution Free) and parametric (ANOVA; Dunnets) procedures. None of the sites were found to be significantly more toxic than North Inlet reference site using the nonparametric approach. Sites 21 - 30 were significantly more toxic than North Inlet sediments at both 5 and 15 minutes using the parametric procedures.

3.2.2.6. Mutatox™

Results of the Mutatox™ assay are listed in Table III.6. Only two of the sediment samples (sites 6 and 11) met the criteria for mutagenicity established in the Mutatox™ Manual for all replicates. The levels of chemical contaminants determined in the sediments from sites 6 and 11 were below the NS&T 85th percentile concentrations (Figure 2).

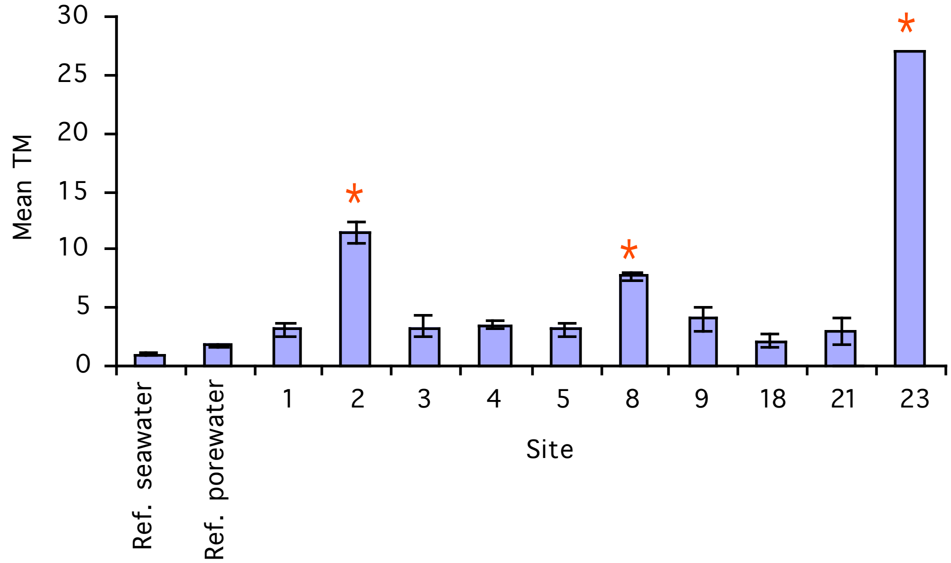

Figure 11. DNA damage in sea urchin sperm (mean tail moment). Error bar is the standard error of the mean.

3.2.2.7. Sea urchin sperm

DNA damage in sea urchin sperm after exposure to sediment porewater at 100%, 50% and 25% dilution was determined to be statistically significant at sites 5, 11, 21, 23 and 28 at 50% dilution, and significant only at site 23 at 25% dilution. In addition, sea urchin sperm was exposed to control seawater, control sediment porewater, and sediment porewater from sites 1, 2, 3, 4, 5, 8, 9, 18, 21 and 23. Results are presented in Figure 11. Site 23 (C-111 Canal) had damage levels so high that nuclei could not be identified by the image analysis software in 2 of the 3 replicates. A Dunnett's test comparison of all samples (except 23) to the control sediment porewater identified two sites, 2 and 8, as having statistically higher DNA damage than the control. Site 23 is considered to be significant since the damage to nuclei in those samples was many times greater than that observed in samples 2 and 8.

3.2.2.8. Grass shrimp

The results of the grass shrimp AChE assays are provided in Figures 12 and 13. Grass shrimp (*P. intermedius*) from three of the sites (site 4 [mouth of North Canal], site 33 [North Canal upstream] and site 2 [Military Canal]) had significantly reduced levels of AChE in comparison to a laboratory control population. AChE inhibition is often used as a biomarker of exposure to organophosphate and carbamate insecticides, however, other compounds such as cadmium, mercury and lead have been found to cause decreased levels of AChE activity in crustaceans (Reddy and Venugopal, 1993; Devi and Fingerman, 1995). Surface water analysis revealed two herbicides (atrazine and metolochor) and two atrazine metabolites 2-chloro-4-ethylamino-6-amino-*s*-triazine (CEAT) and 6-amino-2-chloro-4-isopropylamino-*s*-triazine (CIAT), three organophosphate insecticides (chlorpyrifos, diazonin and malathion), and an organochlorine metabolite (4,4'-DDE) in seawater collected at these sites (Table I.1).

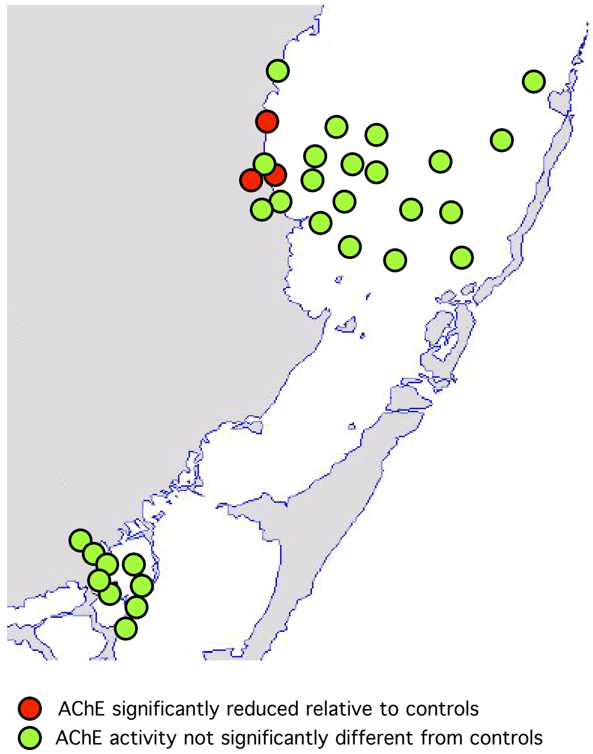

Figure 12. Statistical significance of grass shrimp AChE assay of Biscayne Bay and Manatee Bay sediment.

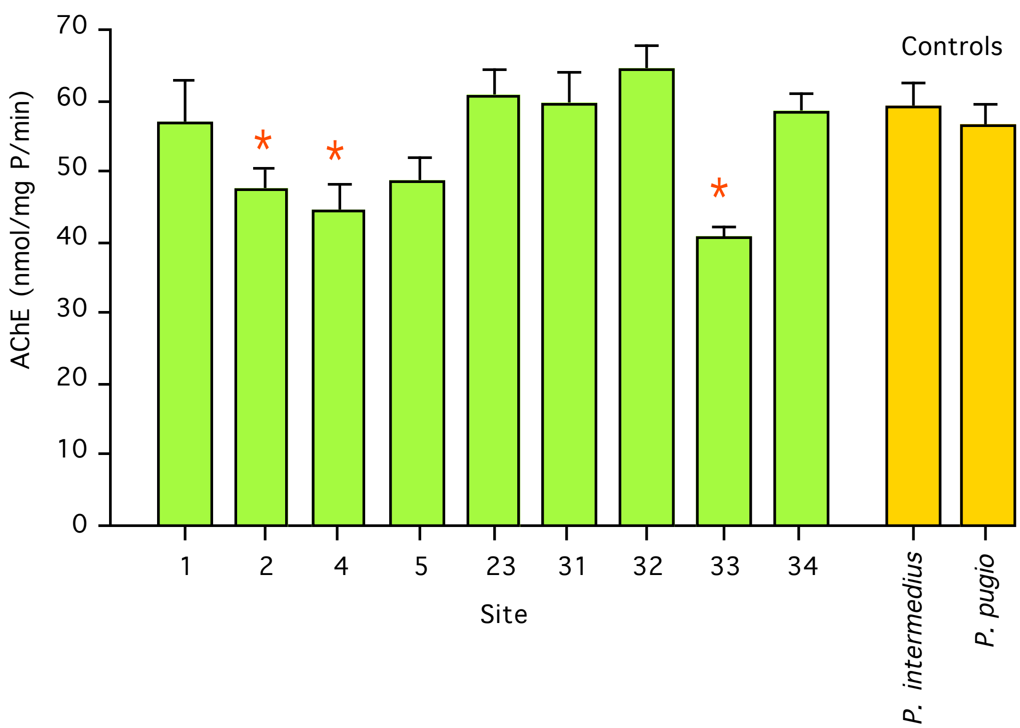

Figure 13. Whole body AChE activity in grass shrimp (*P. intermedius* and *P. pugio*). [* Significantly different from *P. intermedius* control.]

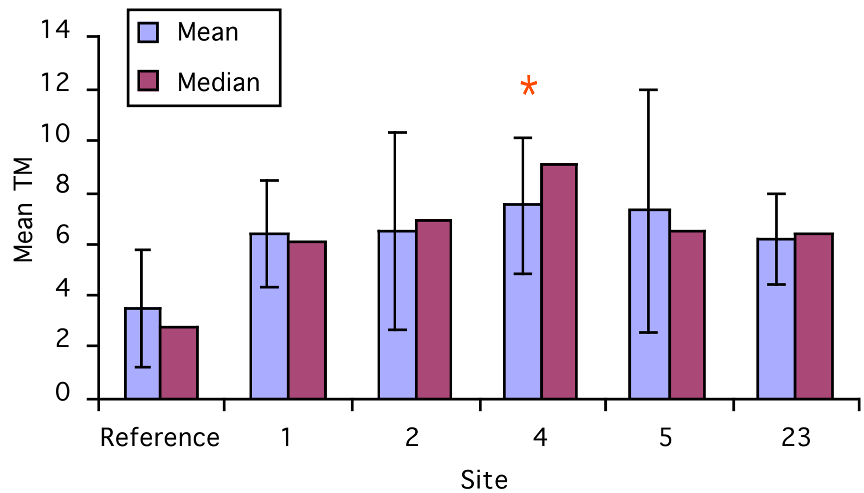

Figure 14. DNA damage in Biscayne Bay oysters (mean tail moment). Error bar is the standard error of the mean. [* Significantly different from control.]

3.3. DNA damage

3.3.1. Oysters

Oyster populations at the sampling sites were not large except at site 4. The oysters collected were of varying size and were found at different tidal exposure areas. The SCG/Comet results of DNA damage in the collected oysters are presented graphically in Figure 14. The variability in individual values in most cases can be attributed to a single high or low value outlier. Though normally distributed, the standard deviations were different enough to warrant using the non-parametric Kruskal-Wallis test. This comparison indicated that only the DNA damage from oysters collected at site 4 was significantly higher than those from the reference site. Though not of statistical significance, the mean TM values at all sites were higher than the reference site. Omission of the highest and lowest data points in each data set resulted in equal standard deviations which allowed parametric analysis using Dunnett's test comparing all sites to the reference value. All sites were identified as having mean TMs significantly higher than the reference even if the outliers in the reference data set were included.

3.3.2. Amphipod survival

The amphipods that survived exposure to Biscayne Bay sediments from sites 1, 2, 3, 4, 5, 8, 9, 18, 21 and 23 (see Section 2.3.2.3) were examined for DNA damage. The results are shown in Figure 15. No control samples were examined so statistical analysis was limited. The largest TM values were found at sites 1, 2, 3 and 23.

3.3.3. Sea urchin sperm

The sea urchin sperm exposed to control seawater, control porewater and sediment porewater from sites 1, 2, 3, 4, 5, 8, 9, 18, 21 and 23 (see Section 2.3.4.1) were examined for DNA damage. The results are shown in Figure 11. Damage to nuclei of sperm exposed to porewater

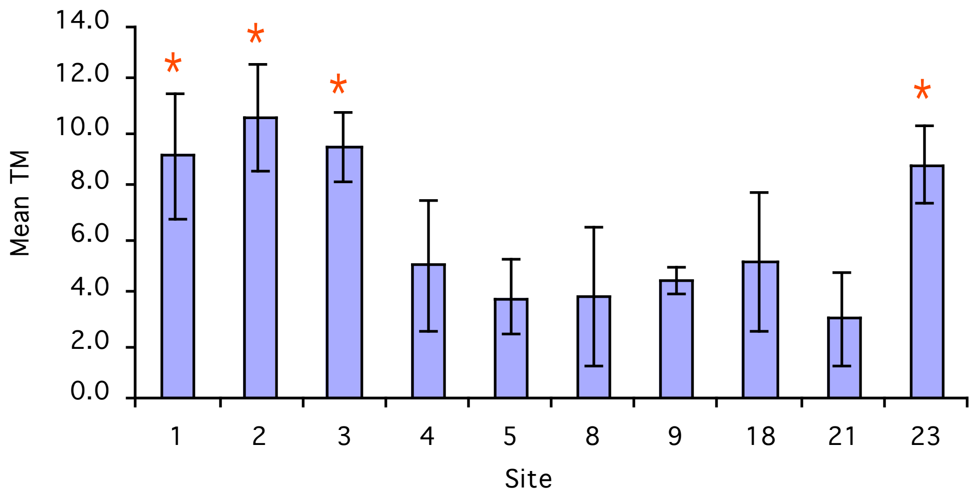

Figure 15. DNA damage in *Ampelisca abdita* exposed to Biscayne Bay and Manatee Bay sediments. [* Significantly different from control.]

from site 23 was so high that the image analysis software was unable to quantify the results. A Dunnett's test comparison of all the results except for those of site 23 to the control sediment porewater sample identified the results of samples from sites 2 and 8 and being statistically significant.

3.4. Benthos

3.4.1. Assemblage structure

Several numerical indices were chosen for analysis and interpretation of the macroinfaunal data. Infaunal abundance is reported as the total number of individuals per site and the total number of individuals per square meter (= density). Taxa richness is reported as the total number of taxa represented in a given site collection.

Taxa diversity, which is often related to the ecological stability and environmental "quality" of the benthos, was estimated by the Shannon-Wiener Index (Pielou, 1966), according to the following formula:

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

where, s is the number of taxa in the sample, i is the i'th taxon in the sample, and p_i is the number of individuals of the i'th taxon divided by the total number of individuals in the sample.

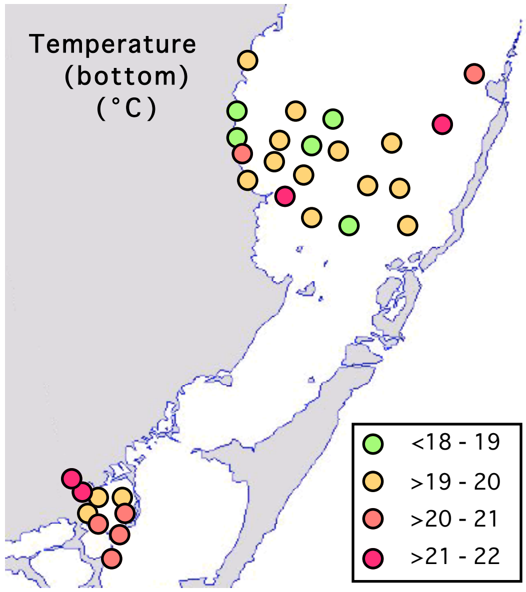

Figure 16. Bottom temperature (°C) in Biscayne Bay and Manatee Bay.

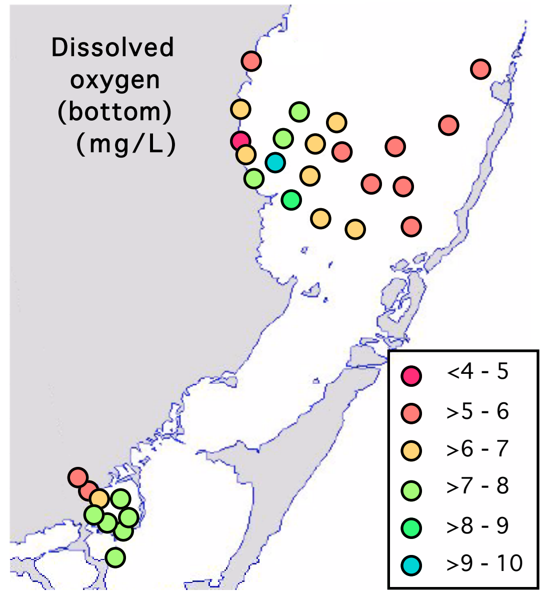

Figure 17. Bottom dissolved oxygen (mg/L) in Biscayne Bay and Manatee Bay.

3.4.2. Data analysis

Taxa diversity within a given community is dependent upon the number of taxa present (taxa richness) and the distribution of all individuals among those taxa (equitability or evenness). In order to quantify and compare faunal equitability to taxa diversity for a given area, Pielou's Evenness Index J' (Pielou, 1966) was calculated as $J' = H'/\ln S$, where $\ln S = H'_{max}$, or the maximum possible diversity, when all taxa are represented by the same number of individuals; thus, $J' = H'/H'_{max}$.

3.4.3. Habitat characteristics

Water quality data for the 30 sites are presented in Table V.1 and Figures 5, 16, and 17. Highest bottom water temperatures were found in Manatee Bay and at sites 4, 9, 20 and 21. Bottom salinity ranged from 7 ppt to 21 ppt for the shoreline sites 1 - 5 and between 12 ppt and 35 ppt for the remaining sites in Biscayne Bay. Salinity in Manatee Bay was 20 ppt or less for all sites. Bottom dissolved oxygen in Biscayne and Manatee Bay was below 7 mg/L at the sites close to the canals and at mid Bay. Higher dissolved oxygen levels were observed in a zone offshore from the canals and in Manatee Bay.

Particle clay- and silt-sized particle distribution is shown in Figure 18. Sediments with high percentages of fine particles were found in Manatee Bay, the canals and site 21. The highest percentages of sand-sized particles were found mid Bay.

3.4.4. Benthic community characterization

The complete phylogenetic listing for the Biscayne Bay and Manatee Bay sites as well as data on taxa abundance and strata occurrence is listed in Table V.2. A total of 14,051 organisms, representing 392 taxa, were identified from the 30 sites (Table V.3). The lowest numbers of

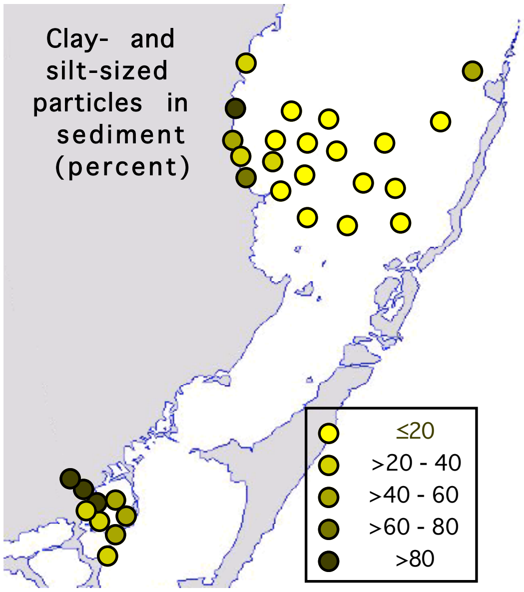

Figure 18. Clay- and silt-sized particles (percent) in sediments collected in Biscayne Bay and Manatee Bay.

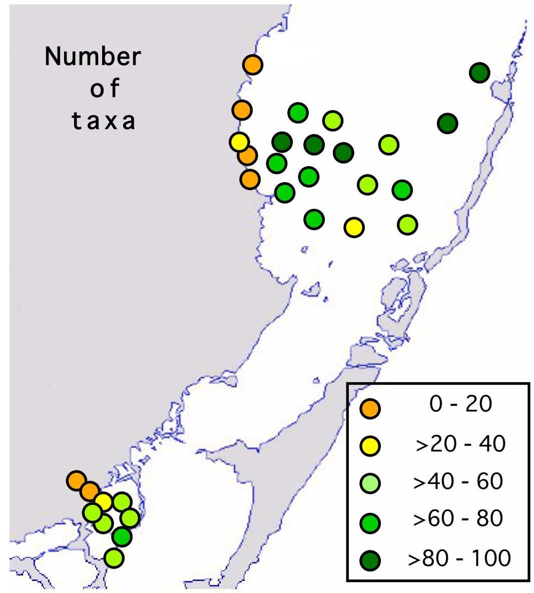

Figure 19. Number of taxa found in sediments collected in Biscayne Bay and Manatee Bay.

taxa were found in sites 1 - 5, 22 and 23 (Figure 19). These sites correspond to those with large percentages of clay- and silt-sized particles in sediment except for site 21. Polychaetes were the most numerous organisms present representing 41.3% of the total assemblage, followed in abundance by malacostracans (23.2%), gastropods (15.6%), and bivalves (11%). Polychaetes represented 31.8% of the total number of taxa followed by bivalves (21.4%), malacostracans (21.1%) and gastropods (15.2%) (Table V.3). The percentage abundance of the major taxa by site is given in Table V.4 and Figures 20 and 21.

The dominant taxa collected from the 21 Biscayne Bay sites were the gastropod, *Caecum pulchellum*, the malacostracan, *Hargeria rapax* and the polychaetes, *Exogone rolani* and *Fabricinuda trilobata*, representing 14.8%, 14.2%, 9.1%, and 5.3% of the total number of individuals, respectively (Table V.2). *Hargeria rapa* and the annelid family, Tubificidae (LPIL) were the most widely distributed taxa being found at 95% of the sites. The distribution of taxa representing less than 10% of the total assemblage at each site is given in Table V.5. Nearshore sites 1 - 5 in Biscayne Bay were dominated by a more estuarine fauna (Table V.5).

The dominant taxon collected from the nine Manatee Bay sites was the bivalve, *Brachidontes exustus*, representing 46.2% of the total number of individuals (Table V.2). Other common taxa included the gastropod, *Caecum pulchellum*, the arthropod, *Grandidierella bonnieroides*, and the annelid family, Tubificidae (LPIL), representing 7.6%, 5.3%, and 5.2% of the total number of individuals, respectively. Tubificids were the most widely distributed taxon being found at 100% of the sites. The sites in Manatee Bay were dominated by a more estuarine fauna than all but the most near shore sites in Biscayne Bay (Tables V.2 and V.5). For example, tubificid oligochaetes were the dominant taxa at 4 of the 9 sites, while the chironomid, *Clunio* (LPIL) was abundant at two of the nine sites in Manatee Bay.

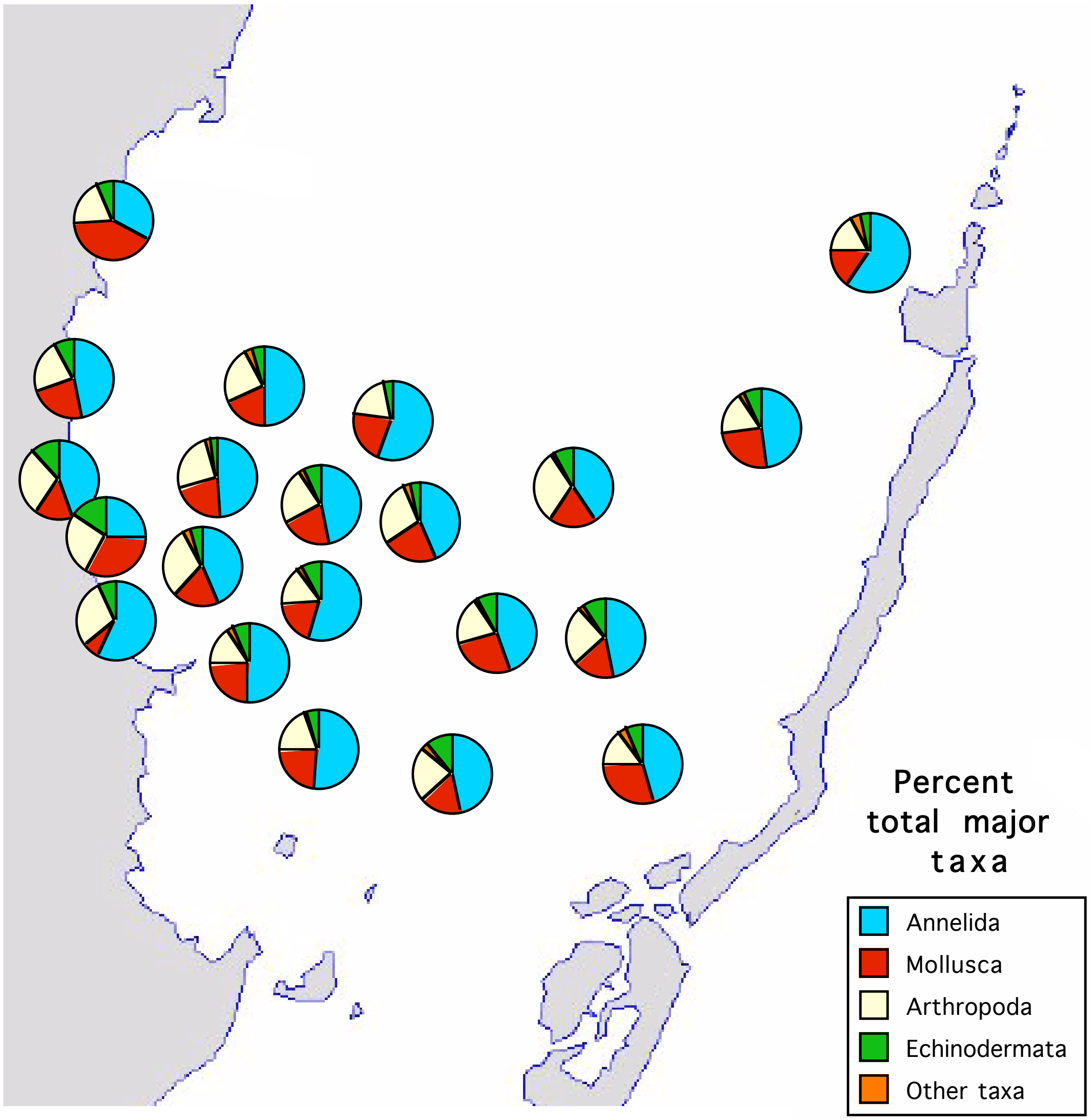

Figure 20. Percent abundance of major taxonomic groups for the Biscayne Bay sites.

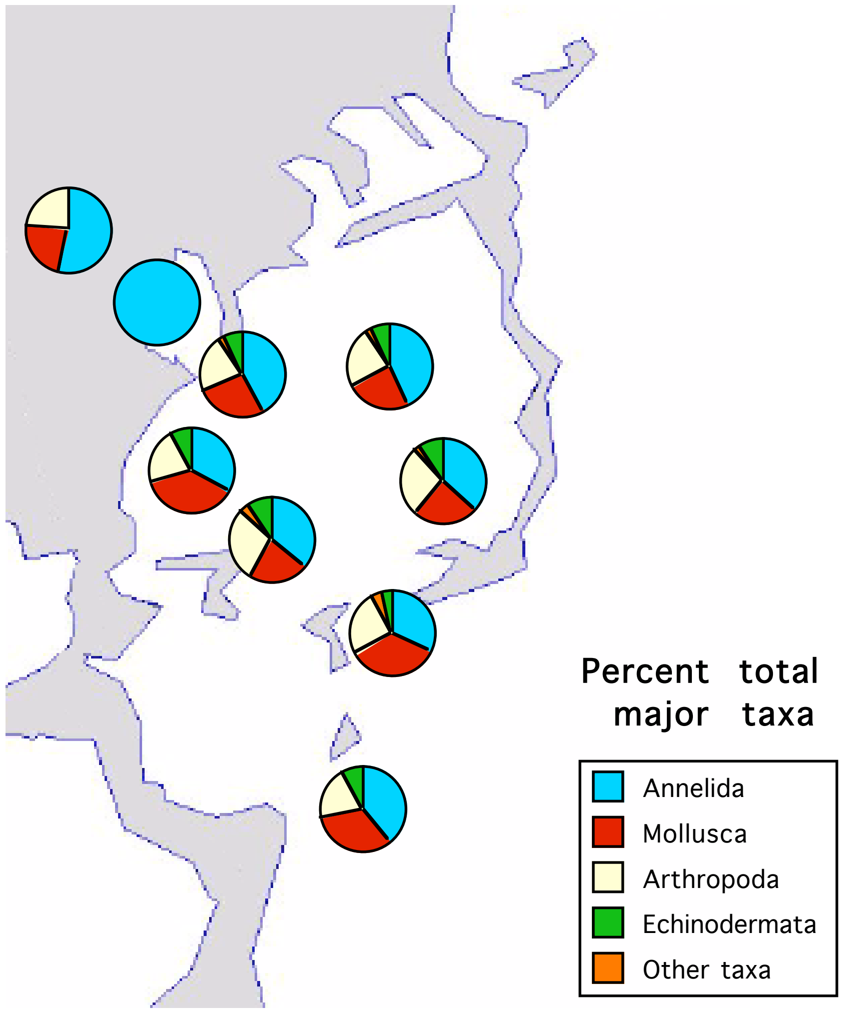

Figure 21. Spatial distribution of major taxonomic groups for the Manatee Bay sites.

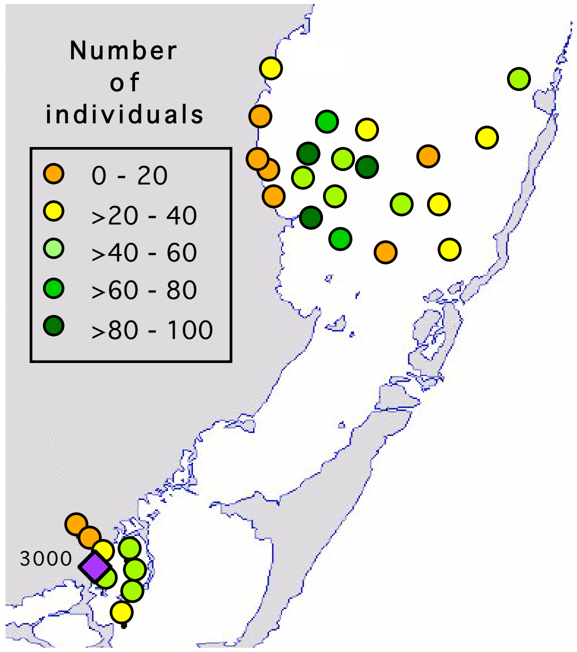

Figure 22. Spatial distribution of macroinvertebrate density in Biscayne Bay and Manatee Bay (number of individuals per square meter).

Site abundance and taxa data are summarized for the Biscayne Bay and Manatee Bay sites in Table V.6. In Biscayne Bay the number of taxa per site ranged from 13 at site 2 to 96 at site 7 (Table V.6; Figure 19). Near shore sites 1 through 5 had considerably lower taxa richness than the remaining sites in Biscayne Bay. In Manatee Bay the number of taxa per site ranged from 2 at site 23 to 74 at site 29.

Density per site in Biscayne Bay ranged from 1,075 organisms per square meter at site 2 to 24,725 organisms per square meter at site 7 (Table V.6; Figure 22). Densities were generally lower at the near shore sites 1 through 5. Density per site in Manatee Bay ranged from 150 organisms per square meter at site 23 to 74,050 organisms per square meter at site 25.

Taxa diversity (H') and evenness (J') for the Biscayne Bay and Manatee Bay sites are given in Table V.6 and Figures 23 and 24. Taxa diversity (H') in Biscayne Bay varied considerably and ranged from 1.62 at site 1 to 3.65 at site 20. Diversity was lowest at the near shore sites 1 through 5. Taxa evenness (J') in Biscayne Bay also exhibited considerable variation and ranged from 0.56 at site 15 to 0.88 at site 16. Taxa diversity (H') in Manatee Bay varied considerably and ranged from 0.64 at site 23 to 3.53 at site 29. Taxa evenness (J') in Manatee Bay exhibited variation and ranged from 0.24 at site 25 to 0.92 at site 23.

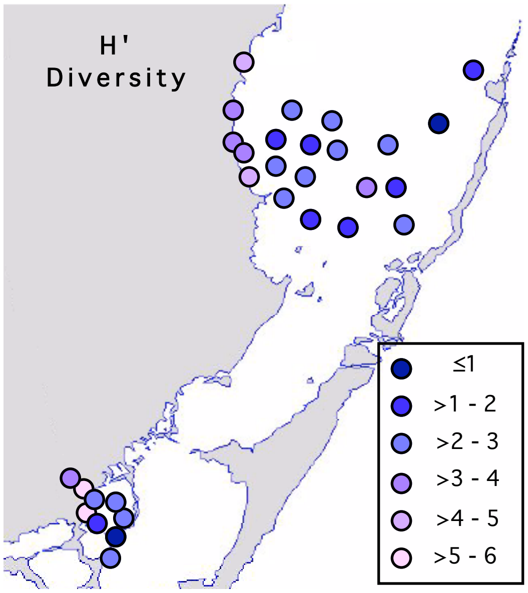

Figure 23. Taxa diversity, H', for Biscayne Bay and Manatee Bay.

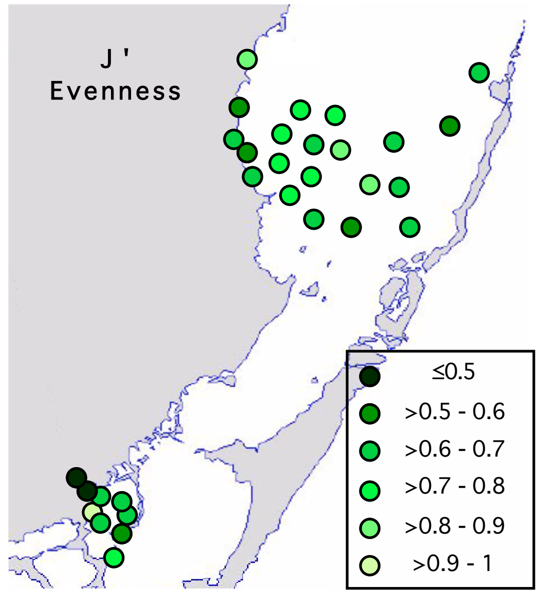

Figure 24. Taxa evenness, J', for Biscayne Bay and Manatee Bay.

4. SUMMARY OF RESULTS

A graphical summary of the assay tests responses for the sites evaluated in Biscayne Bay and Manatee Bay is shown in Figure 25. Not all tests were performed at each site so statistical analysis or calculation of toxicity indices is not warranted. In addition, the ecosystems of Biscayne Bay and Manatee Bay are different and insufficient numbers of samples were collected in Biscayne Bay to allow full characterization of its ecosystem.

- Benthic assessment results are summarized in Figure 26. The benthic summary indicates that the sites located near the canals had fewer species and larger number of individuals, i.e., diversity was low and evenness high, an indication of poor ecological conditions.

- Eight of the 52 pesticides analyzed for were found in the seawater samples. The herbicides were the most prevalent compounds with metolochor present at all sites sampled. Organophosphates were detected at three sites including Military Canal and North Canal. Higher levels were found at the upstream sites than at the mouth of the canals. Concentrations of alkyl phenols in seawater were generally low.

- Mean contaminant concentrations in sediment were below the NS&T "medians" with the exception of sediment collected in or at the mouth of the canals (sites 1 - 5), and at site 16. Sites 1 - 5 have high TotTM relative to AVS concentrations, indicating that the sediments may be toxic. Sites 22 - 30 (Manatee) Bay have high AVS concentrations and low TotTM indicating that these sediments are probably not toxic. Sediment from site 23 located at the mouth of the C-111 canal may be toxic. Site 22 located in the C-111 Canal itself has slightly higher AVS and lower TotTM than site 22. The salinity at site 22 is slightly lower than that at site 23 and the area between the two sampling sites may be the mixing zone.

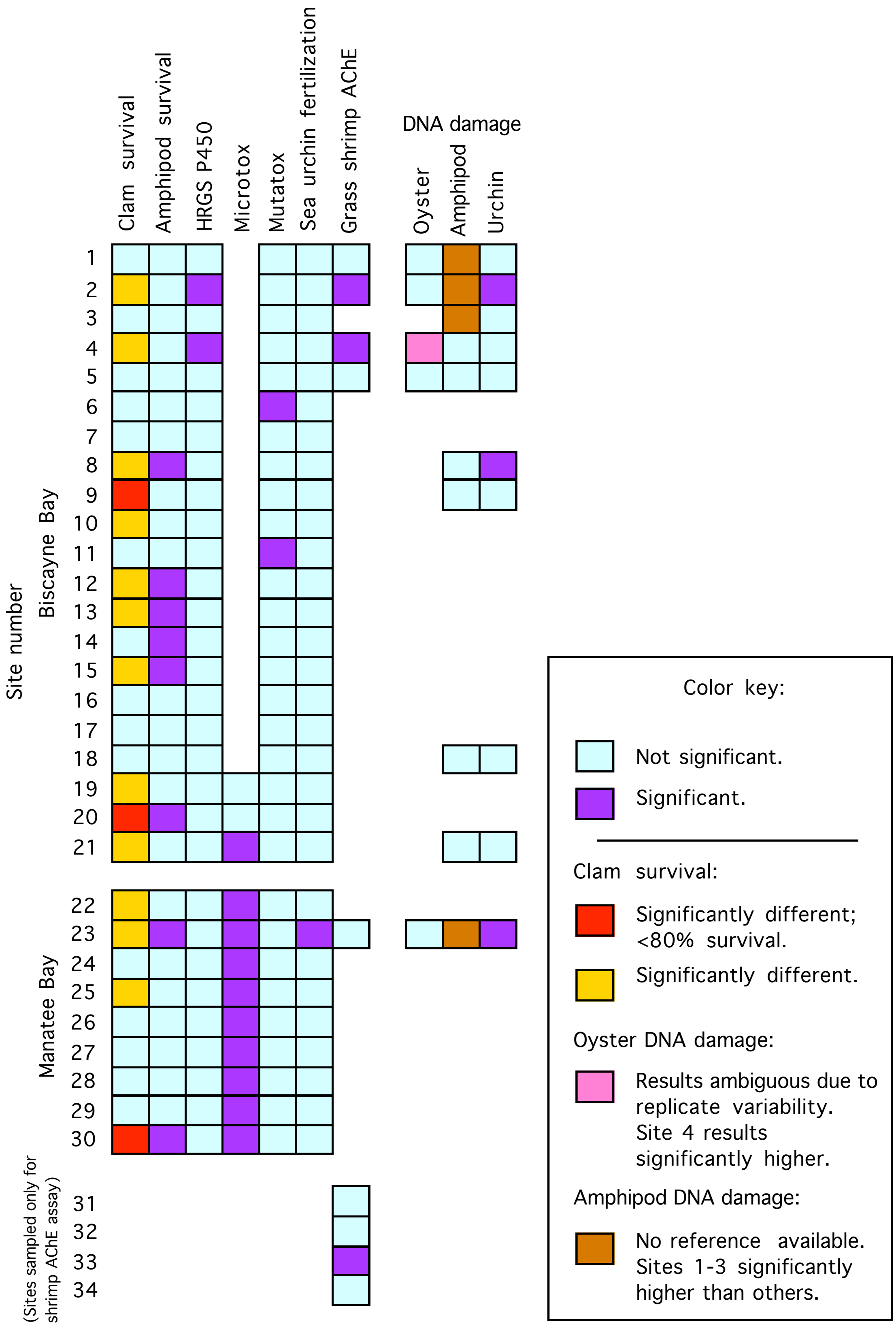

Figure 25. Summary of assay tests in Biscayne Bay and Manatee Bay.

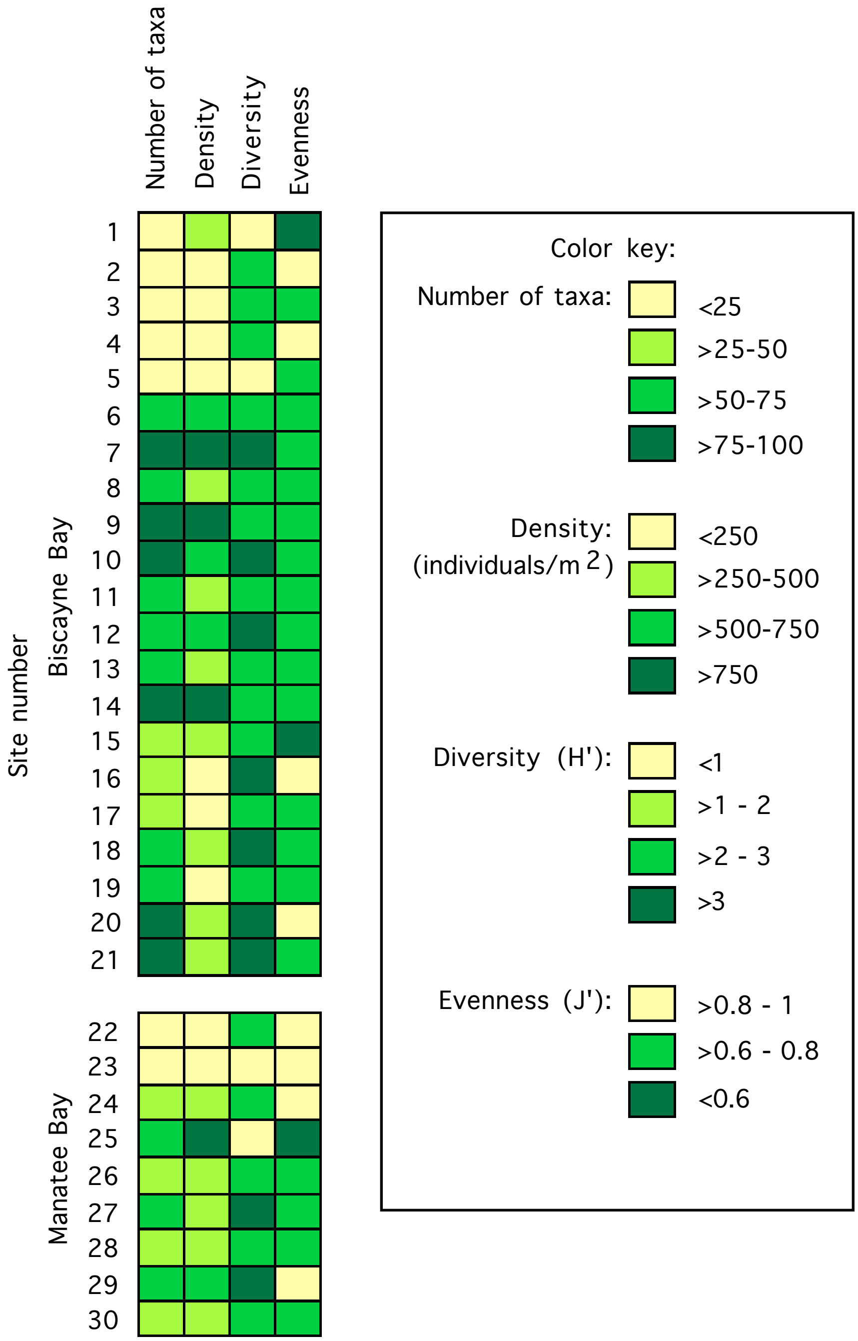

Figure 26. Summary of benthic assessment of Biscayne Bay and Manatee Bay. (In general, the lighter the colors, the lower the number of taxa, density, diversity and evenness.)

- Three sites had clam mortalities higher than 20%: sites 9, 20 and 30. Low contaminant concentrations were found when sediment chemistry analyses were performed.

- Results of the amphipod *Ampelisca* survival tests were significantly different than controls for sites 8, 12, 13, 14, 15, 20, 23 and 30. Site 20 has the lowest percent survival, 27%, and the sediment is approximately 81% sand. There are no marinas, canals or other sources of contaminants other than those from recreational boating activities. *Ampelisca* is known to be sensitive to sediment particle size and these results may reflect that.

- The two highest values observed for HRGS P450 in this study were at sites 2 and 4 and were above the level at which effects on the biota are detected.

- Microtox^{TM} tests were of limited use since only one sample from Biscayne Bay and nine samples from Manatee Bay were assayed and all were considered significantly more toxic than the sediment control. Samples from some of the sites were not expected to be statistically significant but all were found to be so.

- Only two of the sediment samples (sites 6 and 11) met the criteria for mutagenicity established in the Mutatox^{TM} Manual. These sites have low sediment contaminant concentrations.

- Sea urchin sperm tests identified three sites, sites 2, 8 and 23, as having statistically higher DNA damage than the control. Site 23 is considered to be significant since the damage to nuclei in those samples was many times greater than that observed in samples 2 and 8.

- Grass shrimp samples from only five of the 30 sites plus four additional sites higher up in the canals were assayed for AChE activity. Three of the sites (sites 2, 4 and 33) had reduced levels of AChE in comparison to a laboratory control population.

- Oyster DNA damage analyses was not performed on all samples and statistically significant damage was detected only in oysters collected at site 4.

- No control samples were examined so statistical analysis of the amphipod DNA assay was limited. The largest values were found at sites 1, 2, 3 and 23.

- Damage to nuclei of sea urchin sperm exposed to porewater from site 23 was so high that the image analysis software was unable to quantify the results. In addition, results of samples from sites 2 and 8 were found to be statistically significant.

In summary, consistent statistically and environmentally significant chemical analysis and assay responses were found at only a few sites: 1, 2, 3, 4, 5, and 23. This is not an unexpected result since the sites are located at the mouth of canals that are known to be contaminated.

5. CONCLUSIONS

This Biscayne bioeffects study used the triad approach to document the environmental health of the ecosystem. The legs of the triad consist of sediment chemistry, species numbers and richness, and bioassays. Viewing the results of the three legs, using the preponderance of evidence approach generally makes it possible to determine where the estuarine/coastal environment is degraded. Work by I. Hartwell and L. Claflin (NOAA/NOS/NCCOS, personal communication, 2003) indicate that the physical parameters of salinity and grain size are also important factors when determining species diversity and richness. For Biscayne Bay, the monitoring sites along the shore (sites 1-5) have the lowest salinity, the greatest amount of fine-sized particles (silt and clay fractions), the greatest number of elevated trace element and organic contaminant concentrations, the lowest number of different taxa, and the lowest species density. It is expected that sites 1-5 would have the highest amount of contamination because these are the Biscayne Bay sites closest to the urban centers and because high contaminants levels are commonly found in sediment with high percentages of fine-sized particles. If this bioeffects study were considered to consist of four components (physical parameters, chemistry, species information, and bioeffects results), the preponderance of evidence for the first three categories of derived information all indicate that shoreline sites (1-5) in Biscayne Bay, and to a lesser extent site 23 in Manatee Bay, are all degraded.

Because Biscayne and Manatee Bays were assessed in 1995, the expanded suite of bioeffects tests (Grass shrimp AchE; and DNA damage in oysters, amphipods and urchins) were only performed using sediments from sites that had previously indicated a potential environmental concern. For the most part, the expanded suite of bioassays bears out those concerns for sites 1-5 and 23. The open water Biscayne Bay site 18 exhibited low sediment contamination, no adverse effects on any of the seven bioeffects assays performed, no unusual results for the physical parameters (i.e. salinity or grain size) and good species density and diversity. While site 21 did exhibit some significant bioassay effects, like those found in the 1995 study (Long *et al.*, 1999) the current conclusion for the open water sites confirm the earlier conclusions: contaminant levels at those sites are generally low with no apparent reason for the few anomalous bioassay results apparent.

In conclusion:

(1) Sediment sites (1, 2, 3, 4, 5 and 23) near the mouth of canals show evidence of contamination ;

(2) Contaminant plumes and associated toxicity do not appear to appreciately extend seaward of the mouth of the canals;

(3) Concentrations of contaminants in the sediments in open areas of Biscayne and Manatee Bays are generally low.

6. ACKNOWLEDGMENTS

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8. APPENDIX I. Seawater

Table I.1. Pesticides in seawater samples collected in South Florida canals. (Zeros indicate concentrations below instrumental limit of dectection.)

	Mowry Canal Upstream	Mowry Canal Mouth	Military Canal Upstream	Military Canal Mouth	FL City Canal Upstream	FL City Canal Mouth	Princeton Canal Upstream	Princeton Canal Mouth
	Concentration (ng/L for 8 L sample)							
4,4'-DDD	0	0	0	0	0	0	0	0
4,4'-DDE	0	0	0	0	0	0	0	0
4,4'-DDT	0	0	0	0	0	0	0	0
4,4'-Dicofol	0	0	0	0	0	0	0	0
Acephate	0	0	0	0	0	0	0	0
Acetochlor	0	0	0	0	0	0	0	0
Alachlor	0	0	0	0	0	0	0	0
Aldrin	0	0	0	0	0	0	0	0
alpha-Chlordane	0	0	0	0	0	0	0	0
alpha-HCH	0	0	0	0	0	0	0	0
Ametryn	0	0	0	0	0	0	0	0
Atrazine	24.2	18.3	17.9	12.3	16.0	7.9	15.4	0
Azinphos-methyl	0	0	0	0	0	0	0	0
B-HCH	0	0	0	0	0	0	0	0
CEAT	0	0	0	0	0	0	12.7	0
Chlorothalonil	0	0	0	0	0	0	0	0
Chlorpyrifos	0	0	0	0	0	0	0	0
Chlorpyrifos-methyl	0	0	0	0	0	0	0	0
CIAT	34.3	24.9	35.3	24.4	11.1	14.3	28.8	0
cis-Permethrin	0	0	0	0	0	0	0	0
Cyanazine	0	0	0	0	0	0	0	0
d_{10}-Anthracene$^{\Delta}$	0	0	0	0	0	0	0	0
d_{10}-Diazinon$^{\Delta}$	0	0	0	0	0	0	0	0
delta-HCH	0	0	0	0	0	0	0	0
Diazinon	6.0	0	39.2	0	0	0	0	0
Dieldrin	0	0	0	0	0	0	0	0
Endosulfan I	0	0	0	0	0	0	0	0
Endosulfan II	0	0	0	0	0	0	0	0
Endosulfan sulfate	0	0	0	0	0	0	0	0
Ethion	0	0	0	0	0	0	0	0
Ethoprop	0	0	0	0	0	0	0	0
Fenamiphos	0	0	0	0	0	0	0	0
gamma-Chlordane	0	0	0	0	0	0	0	0
Heptachlor	0	0	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0	0	0
Lindane	0	0	0	0	0	0	0	0
Malathion	0	0	8.1	0	0	0	0	0
Metalaxyl	0	0	0	0	0	0	0	0
Methamidophos	0	0	0	0	0	0	0	0
Methoxychlor	0	0	0	0	0	0	0	0

$^{\Delta}$ Internal standard.

Table I.1 Pesticides in seawater samples collected in South Florida canals. (Zeros indicate concentrations below instrumental limit of dectection.) (cont.)

	Mowry Canal Upstream	Mowry Canal Mouth	Military Canal Upstream	Military Canal Mouth	FL City Canal Upstream	FL City Canal Mouth	Princeton Canal Upstream	Princeton Canal Mouth
	Concentration (ng/L for 8 L sample)							
Metolachlor	24.7	11.9	14.9	10.5	8.9	9.2	8.6	2.9
Metribuzin	0	0	0	0	0	0	0	0
Mirex	0	0	0	0	0	0	0	0
Naled	0	0	0	0	0	0	0	0
Norflurazon	0	0	0	0	0	0	0	0
Oxamyl	0	0	0	0	0	0	0	0
Pendamethalin	0	0	0	0	0	0	0	0
Phorate	0	0	0	0	0	0	0	0
Simazine	0	0	0	0	0	0	0	0
trans-Nonachlor	0	0	0	0	0	0	0	0
trans-Permethrin	0	0	0	0	0	0	0	0
Trifluralin	0	0	0	0	0	0	0	0

$^{\Delta}$ Internal standard.

Table I.1 Pesticides in seawater samples collected in South Florida canals. (Zeros indicate concentrations below instrumental limit of dectection.) (cont.)

	C-111 Upstream	C-111 Mouth	North Bridge	North Mouth	North Canal	Card Sound	Lab blank	Field blank
	Concentration (ng/L for 8 L sample)							
4,4'-DDD	0	0	0	0	0	0	0	0
4,4'-DDE	0	0	3.7	0	0	0	0	0
4,4'-DDT	0	0	0	0	0	0	0	0
4,4'-Dicofol	0	0	0	0	0	0	0	0
Acephate	0	0	0	0	0	0	0	0
Acetochlor	0	0	0	0	0	0	0	0
Alachlor	0	0	0	0	0	0	0	0
Aldrin	0	0	0	0	0	0	0	0
alpha-Chlordane	0	0	0	0	0	0	0	0
alpha-HCH	0	0	0	0	0	0	0	0
Ametryn	0	0	0	0	0	0	0	0
Atrazine	26.3	0	29.4	15.2	22.8	0	0	0
Azinphos-methyl	0	0	0	0	0	0	0	0
B-HCH	0	0	0	0	0	0	0	0
CEAT	0	0	0	0	0	0	0	0
Chlorothalonil	0	0	0	0	0	0	0	0
Chlorpyrifos	0	0	5.2	0	0	0	0	0
Chlorpyrifos-methyl	0	0	0	0	0	0	0	0
CIAT	0	0	27.9	12.2	35.4	0	0	0
cis-Permethrin	0	0	0	0	0	0	0	0
Cyanazine	0	0	0	0	0	0	0	0
d_{10}-Anthracene$^{\Delta}$	0	0	0	0	0	0	0	0
d_{10}-Diazinon$^{\Delta}$	0	0	0	0	0	0	0	0
delta-HCH	0	0	0	0	0	0	0	0
Diazinon	0	0	60.3	0	10.8	0	0	0
Dieldrin	0	0	0	0	0	0	0	0
Endosulfan I	0	0	0	0	0	0	0	0
Endosulfan II	0	0	0	0	0	0	0	0
Endosulfan sulfate	0	0	0	0	0	0	0	0
Ethion	0	0	0	0	0	0	0	0
Ethoprop	0	0	0	0	0	0	0	0
Fenamiphos	0	0	0	0	0	0	0	0
gamma-Chlordane	0	0	0	0	0	0	0	0
Heptachlor	0	0	0	0	0	0	0	0
Heptachlor epoxide	0	0	0	0	0	0	0	0
Lindane	0	0	0	0	0	0	0	0
Malathion	0	0	0	0	0	0	0	0
Metalaxyl	0	0	0	0	0	0	0	0
Methamidophos	0	0	0	0	0	0	0	0
Methoxychlor	0	0	0	0	0	0	0	0
Metolachlor	12.8	2.5	65.1	8.0	119.1	3.8	0	0.0
Metribuzin	0	0	0	0	0	0	0	0

$^{\Delta}$ Internal standard.

Table I.1 Pesticides in seawater samples collected in South Florida canals. (Zeros indicate concentrations below instrumental limit of dectection.) (cont.)

	C-111 Upstream	C-111 Mouth	North Bridge	North Mouth	North Canal	Card Sound	Lab blank	Field blank
	Concentration (ng/L for 8 L sample)							
Mirex	0	0	0	0	0	0	0	0
Naled	0	0	0	0	0	0	0	0
Norflurazon	0	0	0	0	0	0	0	0
Oxamyl	0	0	0	0	0	0	0	0
Pendamethalin	0	0	0	0	0	0	0	0
Phorate	0	0	0	0	0	0	0	0
Simazine	0	0	0	0	0	0	0	0
trans-Nonachlor	0	0	0	0	0	0	0	0
trans-Permethrin	0	0	0	0	0	0	0	0
Trifluralin	0	0	0	0	0	0	0	0

$^{\Delta}$ Internal standard.

Table I.2. Alkylphenol ethoxylates in seawater samples collected in South Florida canals. (Zeros indicate concentrations below the blank.)

	Mowry Mouth	Florida City Upstream	Florida City Mouth	North Mouth	Military A	Military B
	Concentration (ng/L)					
Octylphenol	0	0	0	0	0	0
o1eo	0	0	0	0	0	0
o2eo	0	0	0	0	0	0
o3eo	0	0	0	0	19.3	0
o4eo	0	0	0	0	3.35	0
o5eo	0	0	0	0	0	0
Nonylphenol	0	141	380	0	0	0
np1eo	0	0	0	0	0	0
np2eo	0	0	199	0	0	0
np3eo	0	0	2800	0	0	0
np4eo	0	0	594	0	0	0
np5eo	0	0	0	0	0	0

	Princeton Upstream	Princeton Mouth A	Princeton Mouth B	C-111 Mouth	C-111 Upstream	North Bridge (control)	Mowry Upstream	Card Sound
Octylphenol	0	0	0	0	0	0	0	0
o1eo	0	0	0	0	0	0	0	0
o2eo	0	0	0	0	0	0	0	0
o3eo	0	44.0	41.0	0	0	0	0	0
o4eo	0	24.2	29.2	0	0	0	0	0
o5eo	0	1.87	2.31	0	0	0	0	0
Nonylphenol	0	0	0	0	0	317	0	0
np1eo	0	0	0	0	0	0	0	0
np2eo	0	607	539	0	0	0	0	0
np3eo	0	11300	11700	0	0	0	0	0
np4eo	0	8440	11900	0	0	0	0	0
np5eo	0	1050	1660	1050	0	1070	0	0

9. APPENDIX II. Sediment chemistry

Table II.1. Carbon content, solids, and particle size distribution in Biscayne Bay sediments (percent).

Site	TOC	TIC	Solids	Sand	Silt	Clay	Fines (Silt + Clay)
1	1.75	8.08	39	63.4	25.1	11.5	37
2	4.47	6.95	12	17.6	53.0	29.4	82
3	2.12	8.83	30	53.4	34.5	12.1	47
4	2.84	8.91	27	67.4	25.1	7.5	33
5	3.25	9.97	26	33.8	51.5	14.7	66
6	0.30	10.42	59	87.4	3.9	8.7	13
7	0.48	10.51	59	89.8	4.1	6.1	10
8	0.59	9.12	59	79.4	9.2	11.5	21
9	0.39	7.67	61	89.0	4.4	6.6	11
10	0.42	10.66	61	90.0	4.2	5.7	10
11	0.36	7.08	69	90.4	3.1	6.5	10
12	0.27	5.35	68	92.5	1.3	6.2	8
13	0.43	10.43	60	91.5	6.1	2.3	8
14	0.26	7.88	66	93.0	4.6	2.3	7
15	0.25	3.74	72	94.3	2.5	3.3	6
16	0.14	1.22	74	96.8	1.9	1.3	3
17	0.19	2.47	73	95.6	2.6	1.8	4
18	0.15	1.09	75	97.4	2.0	0.6	3
19	0.22	1.56	72	95.3	3.4	1.3	5
20	1.01	5.45	54	81.1	10.2	8.8	19
21	2.04	8.62	33	59.1	20.8	20.1	41
22	2.45	7.92	35	6.1	48.5	45.5	94
23	2.47	6.93	27	5.1	64.2	30.8	95
24	1.62	7.74	31	19.9	31.8	48.4	80
25	0.89	9.53	41	61.3	17.2	21.5	39
26	2.25	8.64	35	57.3	25.0	17.7	43
27	1.15	8.34	44	75.2	11.2	13.7	25
28	1.33	9.01	34	49.1	30.0	21.0	51
29	2.60	6.03	31	42.8	30.6	26.6	57
30	1.26	8.25	30	73.4	13.0	13.7	27

Table II.2. Polycyclic aromatic hydrocarbons (PAHs) in Biscayne Bay sediments (ng/g dry weight).

Site	1	2	3	4	5
Total PAHs*	134.2	1633.2	484.3	565.4	454.1
Total NS&T PAHs$^{\Delta}$	30.9	660.7	271.0	262.6	164.1
Naphthalene	2.0 J	16.7 J	6.4 J	6.2 J	4.5 J
C1-Naphthalenes	2.1 J	17.8 J	19.4	8.7 J	5.2 J
C2-Naphthalenes	3.1 J	91.9	30.1	8.5 J	19.2
C3-Naphthalenes	3.1 J	29.1	11.1 J	9.9 J	6.8 J
C4-Naphthalenes	2.0 J	16.9 J	2.7 J	7.0 J	4.2 J
Biphenyl	0.7 J	3.2 J	2.4	2.0 J	1.7 J
Acenaphthylene	0.3 J	11.6	1.8	4.7	1.5 J
Acenaphthene	0.4 J	3.4	4.2	2.9	1.2
Fluorene	0.5 J	3.7 J	4.1	3.4	1.6 J
C1-Fluorenes	1.0 J	10.5	3.8	4.3 J	3.6
C2-Fluorenes	3.7	25.7	6.6	10.3	9.1
C3-Fluorenes	5.5	25.9	4.6	11.0	11.9
Phenanthrene	1.4 J	14.3 J	38.3	18.4	4.8 J
Anthracene	0.9 J	28.2	5.1	14.5	4.9
C1-Phenanthrenes/Anthracenes	2.4 J	18.6	9.4	12.8	9.8
C2-Phenanthrenes/Anthracenes	7.1	37.2	11.6	15.0	17.4
C3-Phenanthrenes/Anthracenes	9.5	67.9	8.6	11.6	20.7
C4-Phenanthrenes/Anthracenes	11.5	56.4	9.3	10.5	18.1
Dibenzothiophene	0.3 J	2.7 J	2.8	1.7 J	1.2 J
C1-Dibenzothiophenes	0.7 J	8.6	2.0 J	1.8 J	5.0
C2-Dibenzothiophenes	2.2 J	20.8	4.1	3.3 J	11.0
C3-Dibenzothiophenes	2.5	30.5	4.9	4.7	14.4
Fluoranthene	4.0	114.9	54.9	44.4	28.7
Pyrene	5.3	103.5	42.4	45.0	25.8
C1-Fluoranthenes/Pyrenes	24.8	98.3	16.7	34.4	37.9
Benzo[*a*]anthracene	2.0	40.0	12.8	27.9	12.1
Chrysene	2.4	59.2	21.0	23.1	12.1
C1-Chrysenes	2.6	42.0	9.8	14.8	14.9
C2-Chrysenes	5.8	30.7	14.3	15.1	18.3
C3-Chrysenes	6.4	9.7	2.8	3.2	6.8
C4-Chrysenes	0.8 J	10.7	2.8	3.2	8.2
Benzo[*b*]fluoranthene	3.4	147.1	30.8	44.0	25.7
Benzo[*k*]fluoranthene	1.1	50.1	10.1	19.9	8.0
Benzo[*e*]pyrene	1.7 J	73.3	13.6	20.3	11.3
Benzo[*a*]pyrene	2.4 J	78.4	19.1	28.6	17.9
Perylene	2.7 J	27.9	5.9	8.1	13.6
Indeno[1,2,3-*c,d*]pyrene	2.8	104.1	14.7	22.8	16.3
Dibenzo[*a,h*]anthracene	0.6 J	18.0	3.2	4.7	3.7
Benzo[*g,h,i*]perylene	2.8 J	83.9	16.3	33.2	14.9
2-Methylnaphthalene	1.4 J	10.9 J	11.3	5.8 J	3.3 J
1-Methylnaphthalene	0.8 J	6.8 J	8.0	2.9 J	1.9 J
2,6-Dimethylnaphthalene	1.0 J	55.2	15.9	2.6 J	12.8
1,6,7-Trimethylnaphthalene	0.5 J	3.0 J	1.2 J	1.6 J	1.2 J
1-Methylphenanthrene	0.8 J	3.2 J	2.5	2.0 J	2.2

* Total PAHs: The sum of concentrations of the PAH compounds determined.

$^{\Delta}$ Total NS&T PAHs: The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.

J - Value below the limit of detection.

ND - Not detected.

Table II.2. Polycyclic aromatic hydrocarbons (PAHs) in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	6	7	8	9	10
Total PAHs*	40.3	31.9	38.5	41.1	39.9
Total NS&T PAHs$^{\Delta}$	9.3	8.8	12.2	11.3	11.2
Naphthalene	1.3 J	0.9 J	1.6 J	2.2 J	2.0 J
C1-Naphthalenes	1.3 J	1.1 J	1.7 J	2.5 J	2.4 J
C2-Naphthalenes	2.2 J	1.7 J	2.9 J	5.0	3.5 J
C3-Naphthalenes	2.8 J	1.6 J	2.3 J	4.4 J	3.8 J
C4-Naphthalenes	0.3 J	0.5 J	2.5 J	3.0 J	3.2 J
Biphenyl	0.5 J	0.4 J	0.5 J	0.5 J	0.5 J
Acenaphthylene	0.1 J	0.1 J	0.1 J	0.1 J	0.1 J
Acenaphthene	0.7	0.4 J	1.0	0.7	0.4 J
Fluorene	0.2 J	0.2 J	0.4 J	0.2 J	0.3 J
C1-Fluorenes	1.1 J	0.7 J	1.2 J	1.0 J	0.8 J
C2-Fluorenes	2.2	1.7	1.6	2.0	1.5
C3-Fluorenes	3.0	2.6	1.4 J	2.3	1.7
Phenanthrene	0.6 J	0.5 J	0.7 J	0.6 J	0.6 J
Anthracene	0.1 J	0.1 J	0.2 J	0.2 J	0.2 J
C1-Phenanthrenes/Anthracenes	2.9	2.7	1.2 J	1.5	1.3 J
C2-Phenanthrenes/Anthracenes	2.0	1.1 J	1.6	0.9 J	1.1 J
C3-Phenanthrenes/Anthracenes	4.4	3.3	1.5	1.7	2.0
C4-Phenanthrenes/Anthracenes	1.8	0.7 J	0.8 J	1.6	1.6
Dibenzothiophene	0.1 J	0.1 J	0.1 J	0.1 J	0.2 J
C1-Dibenzothiophenes	0.3 J	0.3 J	0.4 J	0.3 J	0.4 J
C2-Dibenzothiophenes	0.6 J	0.7 J	0.6 J	0.4 J	0.9 J
C3-Dibenzothiophenes	1.4 J	0.8 J	0.8 J	1.2 J	1.4
Fluoranthene	0.8 J	1.0 J	1.2	0.6 J	0.8 J
Pyrene	0.6 J	0.8 J	1.1 J	0.6 J	0.7 J
C1-Fluoranthenes/Pyrenes	0.9 J	0.9 J	0.8 J	0.8 J	0.5 J
Benzo[*a*]anthracene	0.2 J	0.3 J	0.4 J	0.2 J	0.3 J
Chrysene	0.6	0.7	0.9	0.6	0.8
C1-Chrysenes	0.5 J	0.5 J	0.5 J	0.4 J	0.4 J
C2-Chrysenes	1.2	0.4 J	1.2	1.3	1.7
C3-Chrysenes	0.8	0.4 J	0.8	0.7	0.8
C4-Chrysenes	0.4 J	0.2 J	0.4 J	0.3 J	0.2 J
Benzo[*b*]fluoranthene	1.0 J	0.8 J	1.3	0.6 J	0.7 J
Benzo[*k*]fluoranthene	0.4 J	0.6	0.5	0.3 J	0.4 J
Benzo[*e*]pyrene	0.4 J	0.5 J	0.7 J	0.5 J	0.6 J
Benzo[*a*]pyrene	0.4 J	0.6 J	0.7 J	0.4 J	0.5 J
Perylene	0.5 J	0.2 J	0.4 J	0.4 J	0.4 J
Indeno[1,2,3-*c,d*]pyrene	0.7 J	0.6 J	1.2 J	0.4 J	0.6 J
Dibenzo[*a,h*]anthracene	0.1 J	0.1 J	0.1 J	0.1 J	0.2 J
Benzo[*g,h,i*]perylene	0.8 J	0.8 J	1.4 J	0.7 J	0.7 J
2-Methylnaphthalene	0.7 J	0.7 J	1.1 J	1.5 J	1.5 J
1-Methylnaphthalene	0.6 J	0.5 J	0.6 J	1.1 J	0.8 J
2,6-Dimethylnaphthalene	0.6 J	0.6 J	0.5 J	1.0 J	0.5 J
1,6,7-Trimethylnaphthalene	0.4 J	0.2 J	0.3 J	0.4 J	0.3 J
1-Methylphenanthrene	0.2 J	0.2 J	0.2 J	0.2 J	0.2 J

* Total PAHs: The sum of concentrations of the PAH compounds determined.

$^{\Delta}$ Total NS&T PAHs: The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.

J - Value below the limit of detection.

ND - Not detected.

Table II.2. Polycyclic aromatic hydrocarbons (PAHs) in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	11		12		13		14		15	
Total PAHs*	36.3		18.3		30.7		24.0		25.8	
Total NS&T PAHs$^{\Delta}$	8.2		6.2		10.4		8.4		7.0	
Naphthalene	1.9	J	1.5	J	2.0	J	1.2	J	2.0	J
C1-Naphthalenes	2.1	J	1.4	J	1.6	J	0.9	J	1.4	J
C2-Naphthalenes	4.0	J	1.3	J	1.9	J	1.4	J	2.1	J
C3-Naphthalenes	5.4		1.9	J	2.0	J	1.6	J	2.3	J
C4-Naphthalenes	4.6		0.3	J	0.7	J	0.5	J	1.9	J
Biphenyl	0.4	J	0.3	J	0.4	J	0.4	J	0.4	J
Acenaphthylene	0.1	J	0.0	J	0.1	J	0.1	J	0.1	J
Acenaphthene	0.6		0.4	J	0.4	J	0.4	J	0.3	J
Fluorene	0.2	J	0.2	J	0.2	J	0.2	J	0.1	J
C1-Fluorenes	0.9	J	0.5	J	0.8	J	0.7	J	0.6	J
C2-Fluorenes	1.9		0.8	J	1.7		0.8	J	1.4	
C3-Fluorenes	2.8		1.4		1.5	J	1.1	J	1.9	
Phenanthrene	0.4	J	0.4	J	0.6	J	0.6	J	0.3	J
Anthracene	0.1	J	0.1	J	0.1	J	0.1	J	0.1	J
C1-Phenanthrenes/Anthracenes	1.0	J	0.8	J	1.0	J	0.9	J	1.0	J
C2-Phenanthrenes/Anthracenes	0.9	J	0.6	J	1.9		1.3		1.1	J
C3-Phenanthrenes/Anthracenes	1.4		0.5	J	1.4	J	1.0	J	1.0	J
C4-Phenanthrenes/Anthracenes	0.9	J	0.5	J	0.8	J	0.6	J	0.9	J
Dibenzothiophene	0.1	J	0.1	J	0.1	J	0.1	J	0.1	J
C1-Dibenzothiophenes	0.2	J	0.2	J	0.3	J	0.3	J	0.2	J
C2-Dibenzothiophenes	0.6	J	0.3	J	0.7	J	0.7	J	0.9	J
C3-Dibenzothiophenes	0.9	J	0.8	J	1.3	J	0.6	J	1.2	
Fluoranthene	0.5	J	0.3	J	0.9	J	0.8	J	0.4	J
Pyrene	0.4	J	0.3	J	0.7	J	0.6	J	0.3	J
C1-Fluoranthenes/Pyrenes	0.4	J	0.3	J	0.6	J	0.5	J	0.4	J
Benzo[*a*]anthracene	0.1	J	0.1	J	0.3	J	0.3	J	0.1	J
Chrysene	0.3		0.3	J	0.7		0.7		0.3	
C1-Chrysenes	0.4	J	0.1	J	0.5	J	0.5	J	0.3	J
C2-Chrysenes	0.5	J	0.5	J	1.1		0.8		0.6	
C3-Chrysenes	0.3	J	0.6	J	0.3	J	0.7	J	0.4	J
C4-Chrysenes	0.2	J	0.2	J	0.2	J	0.2	J	0.1	J
Benzo[*b*]fluoranthene	0.4	J	0.3	J	0.7	J	0.7	J	0.4	J
Benzo[*k*]fluoranthene	0.2	J	0.2	J	0.3	J	0.3	J	0.2	J
Benzo[*e*]pyrene	0.2	J	0.2	J	0.5	J	0.4	J	0.2	J
Benzo[*a*]pyrene	0.2	J	0.2	J	0.5	J	0.4	J	0.2	J
Perylene	0.2	J	0.2	J	0.5	J	0.7	J	0.4	J
Indeno[1,2,3-*c,d*]pyrene	0.3	J	0.2	J	0.6	J	0.6	J	0.3	J
Dibenzo[*a,h*]anthracene	0.1	J	0.0	J	0.1	J	0.1	J	0.1	J
Benzo[*g,h,i*]perylene	0.4	J	0.2	J	0.8	J	0.6	J	0.3	J
2-Methylnaphthalene	1.3	J	0.8	J	1.0	J	0.6	J	0.8	J
1-Methylnaphthalene	0.8	J	0.5	J	0.7	J	0.4	J	0.5	J
2,6-Dimethylnaphthalene	0.4	J	0.3	J	0.5	J	0.4	J	0.3	J
1,6,7-Trimethylnaphthalene	0.3	J	0.2	J	0.3	J	0.3	J	0.2	J
1-Methylphenanthrene	0.1	J	0.1	J	0.2	J	0.2	J	0.1	J

* Total PAHs: The sum of concentrations of the PAH compounds determined.

$^{\Delta}$ Total NS&T PAHs: The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.

J - Value below the limit of detection.

ND - Not detected.

Table II.2. Polycyclic aromatic hydrocarbons (PAHs) in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	16		17		18		19		20	
Total PAHs*	12.6		48.9		38.1		19.4		36.8	
Total NS&T PAHs$^{\Delta}$	4.9		11.8		18.9		7.0		13.2	
Naphthalene	0.8	J	6.7		3.5		1.1	J	1.4	J
C1-Naphthalenes	0.8	J	1.2	J	10.7		2.3	J	3.1	J
C2-Naphthalenes	0.8	J	9.9		6.2		2.2	J	3.4	J
C3-Naphthalenes	1.0	J	13.9		4.4		2.3	J	3.7	J
C4-Naphthalenes	0.3	J	7.5		0.9	J	1.6	J	1.9	J
Biphenyl	0.2	J	0.5	J	0.6	J	0.5	J	0.5	J
Acenaphthylene	0.0	J	0.1	J	ND		0.0	J	0.1	J
Acenaphthene	0.1	J	0.3	J	0.2	J	0.3	J	0.4	J
Fluorene	0.1	J	0.2	J	0.2	J	0.2	J	0.4	J
C1-Fluorenes	0.2	J	0.4	J	0.5	J	0.5	J	1.1	J
C2-Fluorenes	0.2	J	0.6	J	0.8	J	0.7	J	1.6	J
C3-Fluorenes	0.6	J	0.8	J	0.8	J	0.9	J	1.1	J
Phenanthrene	0.3	J	0.4	J	0.5	J	0.4	J	1.0	J
Anthracene	0.0	J	0.1	J	0.1	J	0.1	J	0.3	J
C1-Phenanthrenes/Anthracenes	0.5	J	0.5	J	0.9	J	0.5	J	1.1	J
C2-Phenanthrenes/Anthracenes	0.7	J	0.6	J	0.8	J	0.6	J	0.9	J
C3-Phenanthrenes/Anthracenes	0.6	J	0.4	J	0.6	J	0.3	J	0.6	J
C4-Phenanthrenes/Anthracenes	0.5	J	0.2	J	0.3	J	0.2	J	1.0	J
Dibenzothiophene	0.1	J	0.1	J	0.2	J	0.1	J	0.2	J
C1-Dibenzothiophenes	0.2	J	0.2	J	0.5	J	0.2	J	0.5	J
C2-Dibenzothiophenes	0.3	J	0.3	J	0.9	J	0.2	J	1.0	J
C3-Dibenzothiophenes	0.4	J	0.3	J	0.8	J	0.3	J	1.4	J
Fluoranthene	0.2	J	0.4	J	0.3	J	0.4	J	1.2	J
Pyrene	0.2	J	0.4	J	0.2	J	0.3	J	1.0	J
C1-Fluoranthenes/Pyrenes	0.3	J	0.3	J	0.3	J	0.3	J	0.6	J
Benzo[*a*]anthracene	0.1	J	0.1	J	0.1	J	0.1	J	0.3	J
Chrysene	0.2	J	0.4		0.3	J	0.3	J	1.0	
C1-Chrysenes	0.3	J	0.2	J	0.3	J	0.2	J	0.5	J
C2-Chrysenes	0.4	J	0.4	J	0.6		0.3	J	0.9	
C3-Chrysenes	0.1	J	0.1	J	0.1	J	0.6		0.5	J
C4-Chrysenes	0.1	J	0.2	J	0.2	J	0.3	J	0.4	J
Benzo[*b*]fluoranthene	0.2	J	0.2	J	0.3	J	0.4	J	0.7	J
Benzo[*k*]fluoranthene	0.1	J	0.2	J	0.3	J	0.3	J	0.4	J
Benzo[*e*]pyrene	0.2	J	0.2	J	0.1	J	0.2	J	0.6	J
Benzo[*a*]pyrene	0.1	J	0.2	J	0.1	J	0.2	J	0.6	J
Perylene	1.1	J	0.2	J	0.5	J	0.2	J	0.5	J
Indeno[1,2,3-*c,d*]pyrene	0.1	J	0.2	J	0.1	J	0.1	J	0.8	J
Dibenzo[*a,h*]anthracene	0.0	J	0.0	J	0.0	J	0.0	J	0.1	J
Benzo[*g,h,i*]perylene	0.2	J	0.2	J	0.1	J	0.2	J	0.6	J
2-Methylnaphthalene	0.5	J	0.7	J	5.9		1.4	J	1.8	J
1-Methylnaphthalene	0.3	J	0.5	J	4.8		1.0	J	1.2	J
2,6-Dimethylnaphthalene	0.3	J	0.4	J	1.4	J	0.4	J	0.8	J
1,6,7-Trimethylnaphthalene	0.1	J	0.2	J	0.6	J	0.2	J	0.5	J
1-Methylphenanthrene	0.2	J	0.1	J	0.3	J	0.1	J	0.3	J

* Total PAHs: The sum of concentrations of the PAH compounds determined.

$^{\Delta}$ Total NS&T PAHs: The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.

J - Value below the limit of detection.

ND - Not detected.

Table II.2. Polycyclic aromatic hydrocarbons (PAHs) in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	21		22		23		24		25	
Total PAHs*	76.5		383.4		532.5		392.5		73.3	
Total NS&T PAHs$^{\Delta}$	28.9		190.1		250.2		198.7		27.8	
Naphthalene	3.2	J	3.8	J	6.0	J	4.0	J	3.0	J
C1-Naphthalenes	5.1	J	11.0		16.7		3.9	J	2.8	J
C2-Naphthalenes	7.2	J	22.0		74.4		7.2	J	3.0	J
C3-Naphthalenes	6.4	J	14.5		38.0		4.7	J	2.2	J
C4-Naphthalenes	2.7	J	5.5	J	10.3	J	2.3	J	1.1	J
Biphenyl	1.0	J	1.3		1.3	J	1.3	J	0.8	J
Acenaphthylene	0.4	J	3.8		3.6		6.6		0.3	J
Acenaphthene	0.6	J	1.0		3.3		1.2		0.7	
Fluorene	0.5	J	1.4		4.2		1.5		0.5	J
C1-Fluorenes	1.2	J	3.3		4.8		4.0		1.0	J
C2-Fluorenes	2.3	J	4.5		4.8		4.1		2.5	
C3-Fluorenes	1.4	J	4.5		8.3		5.0		3.5	
Phenanthrene	1.6	J	5.9		13.7		8.7		1.5	J
Anthracene	0.8	J	7.0		9.9		17.7		0.7	J
C1-Phenanthrenes/Anthracenes	1.9	J	5.2		10.0		9.1		1.7	J
C2-Phenanthrenes/Anthracenes	1.8	J	9.6		14.5		9.4		1.9	J
C3-Phenanthrenes/Anthracenes	1.3	J	4.4		9.1		6.2		2.6	
C4-Phenanthrenes/Anthracenes	1.7	J	4.1		3.7		4.3		0.9	J
Dibenzothiophene	0.3	J	0.7	J	1.7		0.6	J	0.3	J
C1-Dibenzothiophenes	0.7	J	1.5	J	1.7	J	1.4	J	0.5	J
C2-Dibenzothiophenes	0.7	J	2.4		2.4	J	1.9	J	0.8	J
C3-Dibenzothiophenes	1.2	J	1.8	J	2.0	J	2.5	J	0.8	J
Fluoranthene	2.9		29.5		59.6		22.9		3.8	
Pyrene	2.7	J	29.1		43.6		17.6		2.7	
C1-Fluoranthenes/Pyrenes	1.7	J	14.8		17.2		28.4		5.8	
Benzo[*a*]anthracene	0.9	J	41.8		18.6		28.8		1.3	
Chrysene	2.3		14.1		15.2		42.4		2.0	
C1-Chrysenes	1.6		5.8		12.3		14.1		2.0	
C2-Chrysenes	1.0	J	6.7		7.0		10.9		2.0	
C3-Chrysenes	2.2		2.4		5.0		5.5		2.7	
C4-Chrysenes	0.9	J	18.4		4.7		2.5		1.3	
Benzo[*b*]fluoranthene	2.4		32.1		30.7		30.6		4.4	
Benzo[*k*]fluoranthene	2.8		11.7		14.3		15.7		1.0	
Benzo[*e*]pyrene	2.2		13.4		12.5		13.8		1.8	
Benzo[*a*]pyrene	2.3	J	15.4		14.8		19.7		2.1	J
Perylene	1.0	J	6.3		5.4		6.2		1.3	J
Indeno[1,2,3-*c,d*]pyrene	1.9	J	12.9		13.9		13.5		3.0	
Dibenzo[*a,h*]anthracene	0.2	J	1.4	J	1.5	J	2.5		0.4	J
Benzo[*g,h,i*]perylene	3.8	J	8.3		12.0		10.4		2.7	J
2-Methylnaphthalene	3.2	J	6.5		9.7		2.4	J	1.8	J
1-Methylnaphthalene	1.9	J	4.6		7.0		1.4	J	1.0	J
2,6-Dimethylnaphthalene	1.1	J	6.1		22.2		5.3		2.0	J
1,6,7-Trimethylnaphthalene	0.6	J	1.6	J	2.7		1.2	J	0.5	J
1-Methylphenanthrene	0.5	J	1.4		1.8		1.6		0.5	J

* Total PAHs: The sum of concentrations of the PAH compounds determined.

$^{\Delta}$ Total NS&T PAHs: The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.

J - Value below the limit of detection.

ND - Not detected.

Table II.2. Polycyclic aromatic hydrocarbons (PAHs) in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	26		27		28		29		30	
Total PAHs*	89.1		66.8		126.0		105.5		55.2	
Total NS&T PAHs$^{\Delta}$	27.2		22.3		56.7		35.4		18.9	
Naphthalene	3.2	J	2.8	J	17.2		4.3	J	2.6	J
C1-Naphthalenes	3.6	J	3.5	J	17.5		5.5	J	3.1	J
C2-Naphthalenes	4.0	J	4.2	J	7.3	J	6.9	J	3.8	J
C3-Naphthalenes	3.3	J	2.8	J	3.2	J	4.1	J	2.8	J
C4-Naphthalenes	1.8	J	1.5	J	2.0	J	2.0	J	1.5	J
Biphenyl	0.9	J	0.9	J	1.1	J	1.2	J	0.6	J
Acenaphthylene	0.3	J	0.2	J	0.2	J	0.9	J	0.2	J
Acenaphthene	0.9		0.7		0.8		1.3		0.6	J
Fluorene	0.7	J	0.5	J	0.7	J	0.8	J	0.4	J
C1-Fluorenes	2.1	J	1.8	J	1.9	J	2.9	J	2.1	
C2-Fluorenes	4.3		2.4		4.8		6.4		2.3	
C3-Fluorenes	8.9		6.5		6.9		3.5		3.7	
Phenanthrene	2.0	J	1.2	J	1.5	J	2.1	J	1.3	J
Anthracene	1.0	J	0.5	J	0.8	J	1.8		0.6	J
C1-Phenanthrenes/Anthracenes	2.5		1.4	J	2.1	J	2.5	J	1.4	J
C2-Phenanthrenes/Anthracenes	3.2		1.8	J	4.6		2.9		2.3	
C3-Phenanthrenes/Anthracenes	4.5		2.3		5.9		4.0		2.6	
C4-Phenanthrenes/Anthracenes	3.0		2.6		5.1		3.4		1.6	J
Dibenzothiophene	0.3	J	0.2	J	0.3	J	0.4	J	0.2	J
C1-Dibenzothiophenes	0.9	J	0.6	J	1.1	J	0.8	J	0.6	J
C2-Dibenzothiophenes	1.5	J	0.9	J	2.7		1.7	J	0.9	J
C3-Dibenzothiophenes	1.8	J	1.0	J	4.4		2.7	J	1.4	J
Fluoranthene	2.8		2.0		2.4		3.3		1.6	
Pyrene	2.1	J	1.7	J	2.0	J	2.5	J	1.3	J
C1-Fluoranthenes/Pyrenes	3.0	J	2.8	J	4.2	J	5.0	J	1.4	J
Benzo[*a*]anthracene	0.8	J	0.7	J	0.5	J	1.0	J	0.6	J
Chrysene	1.9		1.3		1.9		2.0		1.1	
C1-Chrysenes	1.3		1.1		1.3		1.9		0.6	J
C2-Chrysenes	4.5		2.7		4.6		2.9		0.9	J
C3-Chrysenes	2.0		2.2		2.2		3.7		1.2	
C4-Chrysenes	1.7		0.9	J	1.0	J	1.0	J	0.6	J
Benzo[*b*]fluoranthene	3.3		2.6		2.7		4.8		2.3	
Benzo[*k*]fluoranthene	1.1		0.7		0.7	J	1.3		0.6	J
Benzo[*e*]pyrene	1.4	J	1.3	J	1.2	J	2.3	J	1.0	J
Benzo[*a*]pyrene	1.5	J	1.2	J	1.1	J	2.2	J	1.0	J
Perylene	1.2	J	1.4	J	3.3	J	1.8	J	1.0	J
Indeno[1,2,3-*c,d*]pyrene	2.8		1.8		2.2		3.5		1.6	
Dibenzo[*a,h*]anthracene	0.2	J	0.2	J	0.2	J	0.4	J	0.2	J
Benzo[*g,h,i*]perylene	2.8	J	1.9	J	2.3	J	4.0	J	1.7	J
2-Methylnaphthalene	2.4	J	2.3	J	11.4		3.7	J	2.0	J
1-Methylnaphthalene	1.3	J	1.2	J	6.1		1.9	J	1.1	J
2,6-Dimethylnaphthalene	2.5	J	1.9	J	3.9		2.5	J	1.6	J
1,6,7-Trimethylnaphthalene	0.8	J	0.6	J	0.8	J	0.9	J	0.5	J
1-Methylphenanthrene	0.5	J	0.4	J	0.7	J	0.7	J	0.4	J

* Total PAHs: The sum of concentrations of the PAH compounds determined.

$^{\Delta}$ Total NS&T PAHs: The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.

J - Value below the limit of detection.

ND - Not detected.

Table II.3. Pesticides in Biscayne Bay sediments (ng/g dry weight).

Site	1	2	3	4	5
Chlorinated Benzenes					
1,2,4,5-Tetrachlorobenzene	ND	1.28	0.68	0.40 J	ND
1,2,3,4-Tetrachlorobenzene	0.07 J	0.35 J	0.08 J	0.17 J	0.11 J
Pentachlorobenzene	ND	ND	0.06 J	0.02 J	ND
Hexachlorobenzene	ND	0.16 J	ND	0.18 J	0.00 J
Hexachlorocyclohexanes					
alpha-HCH	ND	ND	ND	0.11 J	0.11 J
beta-HCH	ND	ND	ND	0.01 J	0.09 J
gamma- HCH	0.70 B	8.73 I	1.60 B	1.49 B	1.99 B
delta-HCH	ND	0.27 J	0.05 J	ND	0.07 J
Chlordane-related Compounds					
Heptachlor	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	0.09 J	0.08 J	ND	0.08 J
Oxychlordane	ND	ND	ND	ND	ND
alpha-Chlordane	0.08 J	0.48 J	0.19 J	ND	0.16 J
gamma-Chlordane	0.03 J	0.20 J	0.16 J	0.05 J	0.10 J
cis-Nonachlor	0.06 J	0.60	0.35	0.05 J	0.13 J
trans-Nonachlor	ND	ND	0.22	ND	ND
Other Cyclodiene Pesticides					
Aldrin	ND	ND	0.05 J	ND	ND
Dieldrin	ND	ND	ND	ND	0.05 J
Endrin	0.16 J	ND	ND	ND	ND
Other Chlorinated Pesticides					
Pentachloroanisole	0.04 J	0.29 J	0.13 J	0.12 J	0.08 J
Chlorpyrifos	ND	0.57 J	0.15 J	ND	ND
Mirex	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND
DDTs and Related Compounds					
2,4'-DDE	0.11 J	2.75	0.31	0.19 J	0.93
4,4'-DDE	0.50	7.23	5.03	2.11	25.83
2,4'-DDD	0.07 J	0.50	0.21	0.39	1.12
4,4'-DDD	0.06 J	0.68 J	0.16 J	0.37 J	1.38
2,4'-DDT	ND	ND	0.03 J	0.06 J	ND
4,4'-DDT	0.48	0.47 J	0.13 J	0.35	0.18 J

B - Blank contamination greater than three times the limit of detection.
I - Interference.
J - Value below the limit of detection.
ND - Not detected.

Table II.3. Pesticides in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	6	7	8	9	10
Chlorinated Benzenes					
1,2,4,5-Tetrachlorobenzene	0.26	0.03 J	0.03 J	0.08 J	0.09 J
1,2,3,4-Tetrachlorobenzene	0.05 J	0.06 J	ND	ND	0.04 J
Pentachlorobenzene	ND	0.01 J	ND	ND	0.01 J
Hexachlorobenzene	0.06 J	0.00 J	0.03 J	ND	0.02 J
Hexachlorocyclohexanes					
alpha-HCH	0.05 J	ND	ND	ND	ND
beta-HCH	0.06 J	0.06 J	0.04 J	0.03 J	0.03 J
gamma-HCH	0.43 B	0.73 B	0.27 B	0.43 B	0.40 B
delta-HCH	0.04 J	0.03 J	0.01 J	0.04 J	0.06 J
Chlordane-related Compounds					
Heptachlor	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND
Oxychlordane	ND	0.09 J	0.12 J	0.15	ND
alpha-Chlordane	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
trans-Nonachlor	ND	ND	ND	ND	ND
Other Cyclodiene Pesticides					
Aldrin	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Other Chlorinated Pesticides					
Pentachloroanisole	0.02 J	0.04 J	0.03 J	0.03 J	0.03 J
Chlorpyrifos	0.06 J	0.08 J	0.02 J	ND	ND
Mirex	0.09	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND
DDTs and Related Compounds					
2,4'-DDE	0.16	0.35	0.35	0.31	0.14
4,4'-DDE	0.04 J	0.03 J	0.02 J	0.04 J	ND
2,4'-DDD	ND	0.09 J	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND
2,4'-DDT	ND	ND	ND	ND	ND
4,4'-DDT	0.02 J	0.03 J	0.01 J	0.02 J	0.02 J

B - Blank contamination greater than three times the limit of detection.
I - Interference.
J - Value below the limit of detection.
ND - Not detected.

Table II.3. Pesticides in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	11	12	13	14	15
Chlorinated Benzenes					
1,2,4,5-Tetrachlorobenzene	0.05 J	0.06 J	ND	0.08 J	ND
1,2,3,4-Tetrachlorobenzene	0.01 J	0.02 J	0.02 J	ND	0.01 J
Pentachlorobenzene	0.01 J	0.00 J	ND	ND	ND
Hexachlorobenzene	0.04 J	0.02 J	0.03 J	ND	ND
Hexachlorocyclohexanes					
alpha-HCH	ND	ND	ND	ND	ND
beta-HCH	0.01 J	ND	0.01 J	0.01 J	0.05 J
gamma-HCH	0.38 B	0.43 B	0.23 B	0.64 B	0.29 B
delta-HCH	0.02 J	0.01 J	0.01 J	0.02 J	0.04 J
Chlordane-related Compounds					
Heptachlor	ND	0.01 J	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND
alpha-Chlordane	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
Trans-Nonachlor	ND	ND	ND	ND	ND
Other Cyclodiene Pesticides					
Aldrin	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	0.01 J
Endrin	ND	ND	ND	ND	ND
Other Chlorinated Pesticides					
Pentachloroanisole	0.02 J	0.03 J	0.02 J	0.02 J	0.02 J
Chlorpyrifos	ND	0.02 J	0.01 J	ND	ND
Mirex	0.01 J	0.03 J	0.04 J	0.02 J	ND
Endosulfan II	ND	ND	ND	ND	ND
DDTs and Related Compounds					
2,4'-DDE	0.18	0.18	0.25	0.23	0.21
4,4'-DDE	ND	ND	0.01 J	0.00 J	ND
2,4'-DDD	ND	ND	ND	ND	0.04 J
4,4'-DDD	ND	ND	ND	ND	ND
2,4'-DDT	ND	ND	ND	ND	ND
4,4'-DDT	0.02 J	0.01 J	0.03 J	0.02 J	0.02 J

B - Blank contamination greater than three times the limit of detection.
I - Interference.
J - Value below the limit of detection.
ND - Not detected.

Table II.3. Pesticides in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	16	17	18	19	20
Chlorinated Benzenes					
1,2,4,5-Tetrachlorobenzene	0.10 J	0.07 J	0.11 J	0.15 J	0.12 J
1,2,3,4-Tetrachlorobenzene	0.02 J	0.02 J	0.01 J	0.04 J	0.04 J
Pentachlorobenzene	0.05 J	0.03 J	0.04 J	0.04 J	0.09 J
Hexachlorobenzene	ND	0.01 J	ND	ND	ND
Hexachlorocyclohexanes					
alpha-HCH	0.02 J	0.02 J	0.03 J	0.04 J	0.05 J
beta-HCH	ND	ND	0.02 J	ND	ND
gamma-HCH	0.41	0.62	0.37	0.40	0.67
delta-HCH	ND	ND	ND	ND	0.00 J
Chlordane-related Compounds					
Heptachlor	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND
alpha-Chlordane	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
Trans-Nonachlor	ND	ND	ND	ND	ND
Other Cyclodiene Pesticides					
Aldrin	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Other Chlorinated Pesticides					
Pentachloroanisole	0.02 J	0.03 J	0.02 J	0.02 J	0.04 J
Chlorpyrifos	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	0.05
Endosulfan II	ND	ND	ND	ND	ND
DDTs and Related Compounds					
2,4'-DDE	ND	ND	ND	ND	ND
4,4'-DDE	ND	ND	ND	ND	ND
2,4'-DDD	0.04 J	ND	ND	0.01 J	0.24
4,4'-DDD	ND	ND	ND	ND	ND
2,4'-DDT	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	ND

B - Blank contamination greater than three times the limit of detection.
I - Interference.
J - Value below the limit of detection.
ND - Not detected.

Table II.3. Pesticides in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	21	22	23	24	25
Chlorinated Benzenes					
1,2,4,5-Tetrachlorobenzene	0.30 J	0.54 J	2.90	0.38 J	0.02 J
1,2,3,4-Tetrachlorobenzene	0.16 J	0.04 J	0.13 J	0.08 J	0.08 J
Pentachlorobenzene	0.11 J	0.10 J	ND	ND	0.16
Hexachlorobenzene	ND	ND	ND	ND	ND
Hexachlorocyclohexanes					
alpha-HCH	0.07 J	0.06 J	0.11 J	0.06 J	0.03 J
beta-HCH	ND	ND	ND	ND	ND
gamma-HCH	1.65	1.00	1.51	2.84	1.20
delta-HCH	0.02 J	ND	ND	0.03 J	0.00 J
Chlordane-related Compounds					
Heptachlor	ND	0.07 J	0.20 J	0.05 J	0.04 J
Heptachlor epoxide	ND	0.03 J	ND	0.03 J	ND
Oxychlordane	ND	ND	ND	ND	ND
alpha-Chlordane	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
trans-Nonachlor	ND	ND	ND	ND	ND
Other Cyclodiene Pesticides					
Aldrin	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	0.04 J	ND
Endrin	ND	0.23 J	0.28 J	ND	ND
Other Chlorinated Pesticides					
Pentachloroanisole	0.06 J	0.18 J	0.21 J	0.16 J	0.05 J
Chlorpyrifos	ND	ND	ND	0.53 J	ND
Mirex	0.04 J	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND
DDTs and Related Compounds					
2,4'-DDE	ND	0.09 J	0.28	0.34	0.21
4,4'-DDE	0.14	0.65	1.12	0.76	0.18
2,4'-DDD	0.11 J	0.29	0.37	1.24	0.03 J
4,4'-DDD	ND	0.05 J	ND	ND	ND
2,4'-DDT	0.06	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	0.06 J	ND

B - Blank contamination greater than three times the limit of detection.
I - Interference.
J - Value below the limit of detection.
ND - Not detected.

Table II.3. Pesticides in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	26	27	28	29	30
Chlorinated Benzenes					
1,2,4,5-Tetrachlorobenzene	0.34 J	0.20 J	0.27 J	0.37 J	0.30 J
1,2,3,4-Tetrachlorobenzene	0.08 J	0.04 J	0.01 J	0.08 J	0.01 J
Pentachlorobenzene	ND	0.11 J	ND	ND	0.11 J
Hexachlorobenzene	ND	ND	ND	ND	ND
Hexachlorocyclohexanes					
alpha-HCH	0.07 J	0.06 J	0.06 J	0.08 J	0.07 J
beta-HCH	ND	ND	ND	ND	ND
gamma-HCH	2.34	0.97	1.68	2.45	1.07
delta-HCH	ND	0.01 J	0.01 J	0.02 J	0.01 J
Chlordane-related Compounds					
Heptachlor	ND	0.08 J	0.05 J	0.08 J	0.02 J
Heptachlor epoxide	ND	ND	ND	ND	ND
Oxychlordane	ND	ND	ND	ND	ND
alpha-Chlordane	ND	ND	ND	ND	ND
gamma-Chlordane	ND	ND	ND	ND	ND
cis-Nonachlor	ND	ND	ND	ND	ND
trans-Nonachlor	ND	ND	ND	ND	ND
Other Cyclodiene Pesticides					
Aldrin	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND
Other Chlorinated Pesticides					
Pentachloroanisole	0.09 J	0.18 J	0.08 J	0.08 J	0.06 J
Chlorpyrifos	0.18 J	ND	ND	ND	0.06 J
Mirex	0.15	0.13	0.12	0.16	0.15
Endosulfan II	ND	0.06 J	ND	ND	ND
DDTs and Related Compounds					
2,4'-DDE	0.60	0.33	0.24	0.41	0.20
4,4'-DDE	0.24	0.02 J	0.26	0.11	0.10
2,4'-DDD	ND	ND	ND	ND	ND
4,4'-DDD	ND	ND	ND	ND	ND
2,4'-DDT	ND	ND	ND	ND	ND
4,4'-DDT	0.11	ND	0.13	0.24	0.41

B - Blank contamination greater than three times the limit of detection.
I - Interference.
J - Value below the limit of detection.
ND - Not detected.

Table II.4. PCBs in Biscayne Bay sediments (ng/g dry weight).

Site	1	2	3	4	5
PCB 8/5	0.21 J	1.81	0.31 J	0.37 J	0.52
PCB 18/17	0.09 J	0.78	0.31	0.10 J	0.39
PCB 28	1.11	3.91	1.08	0.63	2.97
PCB 52	0.46	1.21	0.55	0.44 J	1.04
PCB 44	0.11 J	0.59	0.31	0.23	0.97
PCB 66	0.10 J	0.29 J	0.07 J	0.14 J	0.51
PCB 101/90	0.12	1.65	0.27	0.72	2.09
PCB 118	0.11 J	1.66	0.28	0.39	1.60
PCB 153/132	ND	4.91	1.05	1.28	2.58
PCB 105	ND	0.48	0.06 J	0.16 J	0.59
PCB 138 /160	0.27	4.69	0.64	0.78	2.08
PCB 187	ND	1.23	0.09 J	0.02 J	0.33
PCB 128	ND	0.65	0.07 J	0.04 J	0.27
PCB 180	0.35	3.09	0.69	0.49	1.20
PCB 170/190	0.11 J	4.98	0.96	0.56	0.70
PCB 195/208	ND	ND	0.02 J	ND	ND
PCB 206	ND	ND	ND	ND	0.01 J
PCB 209	0.11 J	0.51	ND	ND	0.23
Site 6	7	8	9	10	
PCB 8/5	0.26	0.51	0.12 J	0.18 J	0.29
PCB 18/17	0.12	0.17	0.07 J	0.12	0.10
PCB 28	0.17	ND	0.08	0.07	0.04 J
PCB 52	0.04 J	0.28	0.04 J	0.04 J	0.02 J
PCB 44	ND	0.02 J	0.04 J	0.02 J	0.02 J
PCB 66	ND	0.14	ND	ND	ND
PCB 101/90	0.23	0.35	0.29	0.41	0.31
PCB 118	ND	0.06 J	ND	ND	ND
PCB 153/132	ND	ND	ND	0.03 J	ND
PCB 105	ND	ND	ND	ND	ND
PCB 138 /160	0.08	0.06	0.04 J	0.06	0.06
PCB 187	ND	0.07	ND	ND	0.01 J
PCB 128	ND	ND	ND	ND	ND
PCB 180	0.07	0.10	0.02 J	0.03 J	0.07
PCB 170/190	ND	ND	ND	0.03 J	ND
PCB 195/208	ND	ND	ND	ND	ND
PCB 206	0.07 J	ND	0.01 J	ND	ND
PCB 209	ND	ND	ND	ND	ND

ND - Not detected.
J - Value below the defined limit of detection.

Table II.4. PCBs in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	11	12	13	14	15
PCB 8/5	0.09 J	0.29	0.13 J	0.11 J	0.07 J
PCB 18/17	0.04 J	0.04 J	0.04 J	0.09	0.09
PCB 28	ND	0.03 J	0.21	0.05 J	0.01 J
PCB 52	0.01 J	0.02 J	0.04 J	0.04 J	0.02 J
PCB 44	0.01 J	0.02 J	0.02 J	0.01 J	0.02 J
PCB 66	ND	ND	ND	ND	ND
PCB 101/90	0.29	0.20	0.30	0.30	0.13
PCB 118	ND	ND	ND	ND	0.01 J
PCB 153/132	ND	0.01 J	ND	ND	0.01 J
PCB 105	ND	ND	ND	ND	ND
PCB 138 /160	0.03 J	0.03 J	0.08	0.05	0.03 J
PCB 187	ND	ND	ND	ND	ND
PCB 128	ND	ND	ND	ND	ND
PCB 180	0.04 J	0.03 J	0.06 J	0.03 J	0.02 J
PCB 170/190	ND	ND	ND	ND	ND
PCB 195/208	ND	ND	ND	ND	ND
PCB 206	0.01 J	ND	0.08 J	ND	0.02 J
PCB 209	ND	0.03 J	ND	0.04 J	0.02 J
Site	16	17	18	19	20
PCB 8/5	0.11 J	0.13 J	0.08 J	0.05 J	0.09 J
PCB 18/17	ND	ND	ND	ND	ND
PCB 28	ND	ND	ND	0.02 J	0.02 J
PCB 52	ND	ND	ND	ND	ND
PCB 44	ND	ND	0.01 J	0.02 J	0.01 J
PCB 66	ND	ND	ND	0.01 J	0.05 J
PCB 101/90	ND	ND	ND	ND	ND
PCB 118	ND	ND	ND	ND	ND
PCB 153/132	0.06 J	0.05 J	0.07 J	0.03 J	0.03 J
PCB 105	ND	ND	ND	ND	ND
PCB 138 /160	0.03 J	0.03 J	0.03 J	0.04 J	0.07 J
PCB 187	ND	ND	ND	ND	0.04 J
PCB 128	ND	ND	ND	ND	ND
PCB 180	0.03	0.04	0.04	0.02	0.06
PCB 170/190	ND	ND	ND	ND	ND
PCB 195/208	ND	ND	ND	ND	ND
PCB 206	ND	ND	ND	0.04 J	ND
PCB 209	ND	ND	ND	ND	ND

ND - Not detected.
J - Value below the defined limit of detection.

Table II.4. PCBs in Biscayne Bay sediments (ng/g dry weight) (cont.).

Site	21	22	23	24	25
PCB 8/5	0.07 J	0.18 J	0.22 J	0.21 J	0.06 J
PCB 18/17	ND	0.16 J	ND	ND	ND
PCB 28	0.10 J	0.27 J	0.72	0.32 J	0.11 J
PCB 52	0.20 J	0.51	2.13	0.22 J	ND
PCB 44	ND	0.29 J	0.20 J	ND	ND
PCB 66	0.08 J	0.27	0.27 J	0.09 J	0.03 J
PCB 101/90	1.20	0.14	0.24	0.21	0.38
PCB 118	0.50	0.17 J	0.22 J	0.04 J	0.03 J
PCB 153/132	4.77	0.19 J	0.15 J	0.13 J	0.14 J
PCB 105	0.45 J	ND	ND	ND	ND
PCB 138 /160	3.53	0.55	0.63	0.23 J	0.09 J
PCB 187	1.80	ND	ND	ND	ND
PCB 128	0.23	0.35	ND	0.05 J	ND
PCB 180	3.69	ND	0.19	0.11	0.05
PCB 170/190	1.59 J	0.12 J	0.59 J	0.21 J	0.08 J
PCB 195/208	0.36	ND	ND	ND	ND
PCB 206	0.17 J	0.05 J	ND	ND	0.11 J
PCB 209	ND	ND	0.35	0.11 J	0.13 J
Site	26	27	28	29	30
PCB 8/5	0.04 J	0.21 J	0.10 J	0.56 J	0.28 J
PCB 18/17	ND	ND	ND	ND	ND
PCB 28	0.22 J	0.15 J	0.17 J	0.19 J	0.12 J
PCB 52	ND	ND	ND	ND	ND
PCB 44	ND	ND	ND	0.40	ND
PCB 66	0.04 J	ND	0.04 J	0.08 J	0.02 J
PCB 101/90	0.07	0.09	0.32	0.15	0.19
PCB 118	0.07 J	ND	0.12 J	0.13 J	0.10 J
PCB 153/132	ND	0.12 J	ND	ND	ND
PCB 105	ND	ND	ND	ND	ND
PCB 138 /160	ND	ND	ND	ND	0.11 J
PCB 187	ND	ND	ND	ND	ND
PCB 128	ND	ND	ND	ND	ND
PCB 180	0.40	ND	0.18	0.13	0.18
PCB 170/190	0.27 J	0.19 J	0.24 J	0.03 J	0.04 J
PCB 195/208	ND	ND	ND	ND	ND
PCB 206	0.26	0.10 J	0.12 J	0.07 J	ND
PCB 209	0.24	0.13 J	0.27	0.20 J	0.13

ND - Not detected.
J - Value below the defined limit of detection.

Table II.5. Major and trace elements, and acid volatile sulfides (AVS) in Biscayne Bay sediments (μg/g dry weight).

Site	1	2	3	4	5
Ag	0.0232	1.78	0.108	0.115	0.092
Al	3120	3880	3020	4080	7270
As	4.88	3.62	3.62	6.65	4.71
Cd	0.0433	0.609	0.194	0.195	0.180
Cr	12.9	14.3	14.0	20.1	21.8
Cu	5.67	34.5	19.8	140	18.2
Fe	2830	3520	2510	4100	5490
Hg	0.0985	0.179	0.0604	0.105	0.0711
Mn	20.5	52.4	35.9	50.2	45.5
Ni	4.01	6.03	4.04	6.66	9.09
Pb	116	19.3	24.3	26.0	5.82
Sb	4.38	0.344	0.297	0.417	0.567
Se	0.426	1.31	0.928	0.658	1.13
Sn	ND	1.44	ND	2.63	ND
Tl	0.117	0.287	0.168	0.167	0.179
Zn	12.5	89.6	26.6	71.0	25.8
TotTM*	138	152	75.1	244	59.3
AVS	63.6	68.0	65.0	122	33.8
TotTM/AVS	2.18	2.24	1.16	2.00	1.75

* TotTM = Sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg and Ag.
ND - Not detected.

Table II.5. Major and trace elements, and acid volatile sulfides (AVS) in Biscayne Bay sediments (μg/g dry weight).

Site	6	7	8	9	10
Ag	ND	ND	0.0153	ND	ND
Al	1220	575	1230	1100	1250
As	12.5	16.5	4.63	4.09	12.9
Cd	0.0300	0.0246	0.0262	0.0474	0.0223
Cr	8.94	9.42	6.19	5.37	8.70
Cu	1.51	0.936	1.85	1.58	1.05
Fe	2890	3900	1650	1390	2930
Hg	0.0224	0.0177	0.0232	0.0185	0.0327
Mn	49.0	48.6	34.8	21.4	41.0
Ni	1.63	1.12	1.45	1.63	1.29
Pb	ND	ND	ND	ND	ND
Sb	0.189	0.287	0.273	0.282	0.286
Se	0.248	0.183	0.207	0.186	0.228
Sn	ND	ND	ND	ND	0.201
Tl	0.293	0.224	0.197	0.111	0.306
Zn	9.40	12.2	6.62	4.49	6.30
TotTM*	12.6	14.3	9.98	7.77	8.70
AVS	24.6	2.32	38.3	33.6	43.5
TotTM/AVS	0.51	6.16	0.26	0.23	0.20

* TotTM = Sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg and Ag.
ND - Not detected.

Table II.5. Major and trace elements, and acid volatile sulfides (AVS) in Biscayne Bay sediments (μg/g dry weight).

Site	11	12	13	14	15
Ag	ND	ND	ND	0.0139	ND
Al	792	736	996	1010	750
As	5.33	3.26	9.00	3.44	2.82
Cd	0.0137	0.0107	0.0216	0.0150	0.0101
Cr	5.16	3.70	8.88	5.14	3.43
Cu	1.31	0.894	1.05	0.816	1.18
Fe	1330	717	2300	903	329
Hg	0.0172	ND	0.0254	0.0145	ND
Mn	19.9	8.67	46.5	20.2	6.45
Ni	1.42	2.68	1.19	1.47	2.29
Pb	ND	ND	ND	ND	ND
Sb	0.275	0.161	0.281	ND	ND
Se	0.196	0.139	0.269	0.191	0.132
Sn	ND	ND	ND	ND	ND
Tl	0.183	0.0783	ND	ND	ND
Zn	13.4	2.51	8.04	3.22	5.37
TotTM*	16.2	6.09	10.3	5.55	8.85
AVS	51.5	12	32.5	37.8	22.1
TotTM/AVS	0.31	0.51	0.32	0.15	0.40

* TotTM = Sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg and Ag.
ND - Not detected.

Table II.5. Major and trace elements, and acid volatile sulfides (AVS) in Biscayne Bay sediments (μg/g dry weight).

Site	16	17	18	19	20
Ag	ND	ND	ND	ND	ND
Al	707	537	507	591	794
As	0.842	0.931	0.712	10.2	1.99
Cd	0.00621	0.00512	0.00553	0.00534	0.0196
Cr	1.65	2.23	1.66	2.05	3.98
Cu	0.821	ND	1.03	1.06	1.47
Fe	227	225	178	159	390
Hg	ND	ND	ND	ND	ND
Mn	3.73	3.35	3.04	2.30	7.98
Ni	2.10	2.27	2.22	2.41	2.19
Pb	0.550	0.870	0.867	0.672	1.51
Sb	ND	ND	ND	ND	ND
Se	0.0994	0.121	0.104	0.122	0.241
Sn	ND	ND	ND	ND	ND
Tl	0.0639	0.0727	ND	0.148	0.0695
Zn	18.4	3.00	1.83	0.825	2.03
TotTM*	21.9	6.15	5.95	4.97	7.22
AVS	13.5	12.6	10.6	12.2	13.2
TotTM/AVS	1.62	0.49	0.56	0.41	0.55

* TotTM = Sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg and Ag.
ND - Not detected.

Table II.5. Major and trace elements, and acid volatile sulfides (AVS) in Biscayne Bay sediments (µg/g dry weight).

Site	21	22	23	24	25
Ag	ND	ND	ND	ND	ND
Al	5.11	2310	6560	6050	501
As	6.89	5.36	5.44	7.78	4.09
Cd	0.0285	0.0837	0.0950	0.0801	0.0246
Cr	2.58	21.7	19.2	18.6	11.9
Cu	2.11	7.35	12.6	8.87	2.82
Fe	7.14	6360	9480	9100	3960
Hg	0.0192	0.0412	0.0428	0.0445	0.0189
Mn	8.51	67.1	90.8	84.5	78.5
Ni	1.43	6.24	4.87	5.07	1.75
Pb	2.01	6.36	8.65	8.33	3.53
Sb	0.157	0.380	0.331	0.346	0.345
Se	0.505	0.540	0.830	0.634	0.365
Sn	ND	ND	ND	ND	ND
Tl	0.100	ND	0.0897	0.0952	0.0345
Zn	5.17	21.4	30.6	26.7	6.84
TotTM*	10.8	41.5	56.9	49.1	15.0
AVS	23.0	53.7	23.6	308	183
TotTM/AVS	0.47	0.77	2.41	0.16	0.08

* TotTM = Sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg and Ag.
ND - Not detected.

Table II.5. Major and trace elements, and acid volatile sulfides (AVS) in Biscayne Bay sediments (μg/g dry weight).

Site	26	27	28	29	30
Ag	ND	ND	ND	ND	ND
Al	4490	2260	8.40	3630	1950
As	4.91	4.38	3.25	5.91	4.78
Cd	0.0276	0.0244	0.0567	0.0441	0.0238
Cr	11.9	6.79	8.78	11.1	5.99
Cu	2.35	1.92	2.40	3.83	2.13
Fe	3800	2370	149	3400	1940
Hg	0.0165	0.0177	0.0184	0.0344	0.0215
Mn	78.2	50.6	62.2	87.3	53.7
Ni	2.41	1.41	1.77	2.47	1.12
Pb	3.40	3.01	3.42	7.93	2.85
Sb	0.298	0.180	0.144	0.176	0.205
Se	0.397	0.245	0.366	0.605	0.283
Sn	ND	ND	ND	ND	ND
Tl	0.0497	ND	0.0423	0.0870	ND
Zn	7.65	6.80	6.99	8.12	9.53
TotTM*	15.9	13.2	14.7	22.4	15.7
AVS	127	111	150	176	76.8
TotTM/AVS	0.12	0.12	0.10	0.13	0.20

* TotTM = Sum of concentrations of Cu, Zn, Ni, Pb, Cd, Hg and Ag.
ND - Not detected.

Table II.6. TBTs in Biscayne Bay sediments (ng Sn/g dry weight).

Site	1	2	3	4	5
Tetrabutyltin	ND	ND	ND	ND	ND
Tributyltin	ND	1.27	1.14	22.10	1.57
Dibutyltin	0.75	1.30	1.56	13.35	1.90
Monobutyltin	1.15	3.10	1.49	14.11	3.29
Site	6	7	8	9	10
Tetrabutyltin	ND	ND	ND	ND	ND
Tributyltin	0.25	0.21	0.14 J	0.23	0.25
Dibutyltin	0.22 J	0.32 J	0.78	0.33	0.37
Monobutyltin	0.53	0.62	1.66	0.74	0.77
Site	11	12	13	14	15
Tetrabutyltin	ND	ND	ND	ND	ND
Tributyltin	0.18 J	0.47	0.34	0.26	0.37
Dibutyltin	0.35 J	0.40	0.44	0.62	0.31 J
Monobutyltin	0.71	0.86	1.55	1.56	1.23
Site	16	17	18	19	20
Tetrabutyltin	ND	ND	ND	ND	ND
Tributyltin	ND	ND	ND	ND	ND
Dibutyltin	0.79	0.12 J	0.29 J	ND	0.17 J
Monobutyltin	1.40	0.34	1.14	0.46	0.79
Site	21	22	23	24	25
Tetrabutyltin	ND	ND	ND	ND	ND
Tributyltin	ND	0.27 J	0.74	0.10 J	ND
Dibutyltin	0.97	0.50 J	2.25	0.33 J	0.23 J
Monobutyltin	2.44	1.61	4.48	0.66	0.85
Site	26	27	28	29	30
Tetrabutyltin	ND	ND	ND	ND	ND
Tributyltin	0.09 J	ND	0.12 J	0.10 J	ND
Dibutyltin	0.17 J	0.10 J	0.42 J	0.54	0.58
Monobutyltin	0.65	0.84	1.29	2.09	1.97

ND - Not detected.
J - Value below the limit of detection.

Table II.7. NS&T Mussel Watch sediment data medians and 85th percentile values (1986 - 1993). (Medians and percentiles were determined using the average at each site across all sampled years. Element data in μg/g dry wt. unless noted, and organic data in ng/g dry wt.).

	Al (%)	Si (%)	Cr	Mn	Fe (%)
n	223	178	222	199	223
Median	2.4	3.0	54	370	2.1
85th percentile	4.8	36	120	740	3.7

	Ni	Cu	Zn	As	Se
n	223	223	223	223	207
Median	17	14	67	6.9	0.38
85th percentile	36	47	130	12	0.74

	Ag	Cd	Sn	Sb	Hg
n	223	223	223	178	223
Median	0.11	0.19	1.3	0.47	0.057
85th percentile	0.59	0.56	3.1	1.8	0.22

	Tl	Pb	TOC (%)	∑DDTs	∑PCBs
n	145	223	220	224	224
Median	0.073	18	1.0	2.9	15
85th percentile	0.56	40	2.4	18	80

	∑PAHs	∑Cdane	∑Dieldrin	Mirex
n	224	224	224	224
Median	380	0.51	0.30	0.002
85th percentile	2300	3.1	1.9	0.36

	Hexachloro-benzene	Lindane
n	223	224
Median	0.14	0.04
85th percentile	0.92	0.47

∑DDTs: The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑PCBs: The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.
∑PAHs: The sum of concentrations of the 18 PAH compounds determined on a long term basis as part of the NS&T Program.
∑Cdane: The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlorepoxide.
∑Dieldrin: The sum of dieldrin and aldrin.
∑BTs: The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as ng Sn/g dry wt.).
n: Number of data points (roughly equivalent to the number of sampling sites).

10. APPENDIX III. Sediment bioassay

Table III.1. Survival of *Mercenaria mercenaria* exposed to whole sediment from Biscayne Bay during a 10-day toxicity test.

Site	*Mercenaria mercenaria* percent survival	Percent of control	Significance
1	91.3	91.3	ns
2	89.3	89.3	*
3	98.7	98.7	ns
4	86.0	86.0	*
5	92.7	92.7	ns
6	96.0	96.0	ns
7	96.0	96.0	ns
8	84.7	84.7	*
9	53.3	53.3	*
10	89.1	89.1	*
11	98.7	98.7	ns
12	81.8	81.8	*
13	85.3	85.3	*
14	97.3	97.3	ns
15	91.8	91.8	*
16	96.0	96.0	ns
17	92.7	92.7	ns
18	93.3	93.3	ns
19	91.3	91.3	*
20	76.7	76.7	*
21	88.7	88.7	*
22	94.7	94.7	*
23	94.7	94.7	*
24	96.7	96.7	ns
25	94.7	94.7	*
26	95.3	95.3	ns
27	99.3	99.3	ns
28	95.3	95.3	ns
29	100.0	100.0	ns
30	60.7	60.7	*

ns - Not significant.
* - results significantly different than controls, □ < 0.05.

Table III.2. Survival of *Ampelisca abdita* exposed to whole sediment from Biscayne Bay during a 10-day toxicity test.

Site	*Ampelisca abdita* mean percent survival◊	Percent of control	Significance
1	87	96	ns
2	86	95	ns
3	81	89	ns
4	91	100	ns
5	83	91	ns
6	79	87	ns
7	69	76	ns
8	46	51	* *
9	77	85	ns
10	72	79	ns
11	75	82	ns
12	65	71	* *
13	64	70	* *
14	51	56	* *
15	62	68	* *
16	78	86	ns
17	85	93	ns
18	72	79	ns
19	75	82	ns
20	27	30	* *
21	78	85	ns
22	88	97	ns
23	65	71	* *
24	92	101	ns
25	74	81	ns
26	88	97	ns
27	74	81	ns
28	72	79	ns
29	72	79	ns
30	60	66	* *

◊ - Percent survival based on 100 organisms per sample except for site 21 which is based on 80 organisms per sample.
ns - Not significant.
** - Results significantly different than controls using Dunnett's one-tailed t-test and differences exceed minimum detectable significance, □ < 0.01.

Table III.3. HRGS P450 and toxic equivalent results for Biscayne Bay sediments.

Site	B[*a*]PEq (μg/g)	TEQ (ng/g dry wt.)
1	2.74	0.16
2	20.63	1.24
3	8.53	0.51
4	22.08	1.32
5	9.53	0.57
6	1.53	0.09
7	1.78	0.11
8	0.98	0.06
9	3.38	0.20
10	1.21	0.07
11	1.09	0.07
12	1.06	0.06
13	1.65	0.10
14	2.35	0.14
15	1.72	0.10
16	1.14	0.07
17	0.65	0.04
18	0.81	0.05
19	0.78	0.05
20	1.05	0.06
21	1.83	0.11
22	3.35	0.20
23	3.53	0.21
24	2.14	0.13
25	0.87	0.05
26	1.75	0.10
27	1.42	0.09
28	3.19	0.19
29	3.69	0.22
30	1.92	0.12
NIOL*	3.89	0.23

* NIOL. North Oyster Inlet Landing reference sample.

Table III.4. HRGS P450 of Tier II testing of selected Biscayne Bay sediments.

Site	RGS (μg B[*a*]P/g) 6 hour exposure	RGS (μg B[*a*]P/g) 16 hour exposure
2	214.8	37.7
4	111.1	25.8
5	56.3	4.3

Table III.5. Microtox^{TM} tests using dichloromethane extracts of Biscayne Bay sediments.

Site	Microtox^{TM} EC50 (5 min) Mean (mg/mL)	Percent of control	Sign.	Microtox^{TM} EC50 (15 min) Mean (mg/mL)	Percent of control	Sign.
1	>2.05	NC	NC	>2.05	NC	NC
2	>0.68	NC	NC	>0.68	NC	NC
3	>2.15	NC	NC	>2.15	NC	NC
4	>1.39	NC	NC	>1.39	NC	NC
5	>1.22	NC	NC	>1.22	NC	NC
6	>3.09	NC	NC	>3.09	NC	NC
7	>3.19	NC	NC	>3.19	NC	NC
8	>3.11	NC	NC	>3.11	NC	NC
9	>3.29	NC	NC	>3.29	NC	NC
10	>3.28	NC	NC	>3.28	NC	NC
11	>3.59	NC	NC	>3.59	NC	NC
12	>3.59	NC	NC	>3.59	NC	NC
13	>3.27	NC	NC	>3.27	NC	NC
14	>3.47	NC	NC	>3.47	NC	NC
15	>3.68	NC	NC	>3.68	NC	NC
16	>3.90	NC	NC	>3.90	NC	NC
17	3.29	152	<	>3.79	NC	NC
18	2.82	131	<	>3.91	NC	NC
19	2.57	119	<	3.06	146	<
20	1.78	82	>	1.98	95	NS
21	0.19	8.8	>	0.20	9.6	>
22	0.68	31	>	0.71	34	>
23	0.38	18	>	0.41	20	>
24	0.30	14	>	0.32	15	>
25	0.44	20	>	0.50	24	>
26	0.23	11	>	0.25	12	>
27	0.12	5.6	>	0.13	6.2	>
28	0.14	6.5	>	0.13	6.2	>
29	1.03	48	>	0.79	38	>
30	0.14	6.5	>	0.14	6.7	>
Control	2.16	100	NC	2.09	100	NC

< - Significantly less toxic than North Inlet (ANOVA; Dunnet's test).
> - Significantly more toxic than North Inlet (ANOVA; Dunnet's test).
NC - Not calculated.
NS - Not significantly different from North Inlet (ANOVA; Dunnet's test).

Table III.6. Mutatox^{TM} tests using dichloromethane extracts of Biscayne Bay sediments.

Site	Mutatox^{TM} mutagenicity
1	nm
2	nm
3	nm
4	nm
5	nm
6	m
7	nm
8	nm
9	nm
10	nm
11	m
12	nm
13	nm
14	nm
15	nm
16	nm
17	nm
18	nm
19	nm
20	nm
21	nm
22	nm
23	nm
24	nm
25	nm
26	nm
27	nm
28	nm
29	nm
30	nm
Control	nm

nm - Sample did not meet criteria for mutagenicity.
m - Sample met criteria for mutagenicity.

Table III.7. Sea urchin fertilization bioassay data for Biscayne Bay sediments.

Site	Urchin Fertilization at 100% Mean	Percent of control	Sign.	Urchin Fertilization at 50% Mean	Percent of control	Sign.
1	99.0	101	ns	99.8	101	ns
2	98.0	99	ns	98.8	100	ns
3	93.4	95	++	98.6	100	ns
4	98.4	100	ns	99.2	101	ns
5	66.0	67	* *	96.2	98	ns
6	98.4	100	ns	99.0	101	ns
7	97.8	99	ns	99.2	101	ns
8	98.6	100	ns	98.4	100	ns
9	98.2	100	ns	99.4	101	ns
10	89.0	90	++	99.0	101	ns
11	77.4	79	* *	97.6	99	ns
12	98.0	99	ns	99.0	101	ns
13	83.6	85	++	98.0	99	ns
14	95.6	97	ns	99.2	101	ns
15	94.2	96	++	97.2	99	ns
16	88.0	89	++	96.4	98	ns
17	98.2	100	ns	98.4	100	ns
18	99.2	101	ns	99.8	101	ns
19	98.4	100	ns	98.8	100	ns
20	99.4	101	ns	99.0	101	ns
21	11.4	12	* *	73.0	74	* *
22	99.4	101	ns	99.0	101	ns
23	54.8	56	* *	86.0	87	++
24	98.2	100	ns	98.8	100	ns
25	96.0	97	ns	99.2	101	ns
26	92.2	94	++	98.4	100	ns
27	98.6	100	ns	99.2	101	ns
28	70.0	71	* *	98.4	100	ns
29	94.4	96	++	99.2	101	ns
30	98.0	99	ns	99.4	101	ns

Table III.7. Sea urchin fertilization bioassay data for Biscayne Bay sediments (cont.).

Site	Urchin Fertilization at 25% Mean	Percent of control	Sign.
1	99.4	100	ns
2	99.2	100	ns
3	99.4	100	ns
4	99.0	99	ns
5	98.4	99	ns
6	98.8	99	ns
7	98.8	99	ns
8	99.4	100	ns
9	98.8	99	ns
10	99.2	100	ns
11	98.4	99	ns
12	98.8	99	ns
13	98.4	99	ns
14	99.4	100	ns
15	98.8	99	ns
16	99.2	100	ns
17	99.4	100	ns
18	99.2	100	ns
19	99.2	100	ns
20	98.6	99	ns
21	99.4	100	ns
22	98.6	99	ns
23	96.4	97	+
24	99.4	100	ns
25	98.2	99	ns
26	99.2	100	ns
27	99.8	100	ns
28	98.8	99	ns
29	99.0	99	ns
30	99.0	99	ns

ns - Not significant.
** - Results significantly different than controls using Dunnett's one-tailed t-test and differences exceed minimum detectable significance, □ < 0.01.
++ - Results significantly different than controls using Dunnett's one-tailed t-test, □ < 0.01.
+ - Results significantly different than controls using Dunnett's one-tailed t-test, □ < 0.05.

Table III.8. Urchin development bioassay data for Biscayne Bay sediments.

	Urchin Development at 100%			Urchin Development at 50%		
Site	Mean	Percent of control	Sign.	Mean	Percent of control	Sign.
1	98	102	ns	98.6	102	ns
2	0.2	0	* *	75.3	78	* *
3	6.8	7	* *	97.6	101	ns
4	0	0	* *	0.0	0	* *
5	7.5	8	* *	96.8	100	ns
6	0	0	* *	3.0	3	* *
7	0	0	* *	62.0	64	* *
8	0	0	* *	76.2	78	* *
9	72	75	* *	97.8	101	ns
10	0	0	* *	88.0	91	ns
11	0	0	* *	98.0	101	ns
12	0	0	* *	96.0	99	ns
13	49	52	* *	96.2	99	ns
14	0	0	* *	96.4	99	ns
15	90	94	ns	97.2	100	ns
16	4.2	4	* *	98.6	102	ns
17	0	0	* *	97.8	101	ns
18	83	86	++	98.2	101	ns
19	69	72	* *	98.8	102	ns
20	0	0	* *	69.8	72	* *
21	0	0	* *	86.0	89	++
22	98	103	ns	98.0	101	ns
23	0.2	0	* *	0.0	0	* *
24	97	101	ns	98.2	101	ns
25	96	100	ns	98.2	101	ns
26	97	101	ns	97.8	101	ns
27	95	100	ns	98.6	102	ns
28	97	101	ns	99.0	102	ns
29	52	54	* *	97.2	100	ns
30	2.8	3	* *	98.4	101	ns

Table III.8. Urchin development bioassay data for Biscayne Bay sediments (cont.).

	Urchin Development at 25%		
Site	Mean	Percent of control	Sign.
1	97.4	100	ns
2	95.6	98	ns
3	96.2	99	ns
4	98.0	101	ns
5	97.6	100	ns
6	98.4	101	ns
7	98.0	101	ns
8	98.8	102	ns
9	98.4	101	ns
10	99.2	102	ns
11	98.4	101	ns
12	98.6	101	ns
13	97.2	100	ns
14	99.2	102	ns
15	97.2	100	ns
16	99.0	102	ns
17	98.6	101	ns
18	98.6	101	ns
19	96.8	100	ns
20	98.0	101	ns
21	98.6	101	ns
22	99.0	102	ns
23	73.5	76	* *
24	98.2	101	ns
25	98.2	101	ns
26	97.4	100	ns
27	97.6	100	ns
28	98.8	102	ns
29	97.8	101	ns
30	97.0	100	ns

ns - Not significant.
** - Results significantly different than controls using Dunnett's one-tailed t-test and differences exceed minimum detectable significance, $\alpha < 0.01$.
++ - Results significantly different than controls using Dunnett's one-tailed t-test, $\alpha < 0.01$.
+ - Results significantly different than controls using Dunnett's one-tailed t-test, $\alpha < 0.05$.

Table III.9. Grass shrimp acetylcholinesterase activity (nmol/mg P/min).

Site	Count	Mean	Std. Dev.	Std. Err.	
1	7	57.5	14.7	5.56	
2	12	47.9	7.19	2.07	Significant
4	10	45.0	9.6	3.04	Significant
5	10	49.2	8.24	2.61	
23	10	60.9	10.2	3.22	
31*	6	59.9	10.2	4.16	
32*	6	64.4	8.11	3.31	
33*	12	40.9	4.11	1.19	Significant
34*	10	58.9	7.05	2.23	
Control *P. intermedius*	10	59.2	11.2	3.55	
Control *P. pugio*	10	56.5	9.04	2.86	

* Sampled only for shrimp AChE assay.

11. APPENDIX IV. DNA damage

Table IV.1. Physical and chemical data collected December 1, 1999 during oyster field sampling.

Site number	Name/Description	Number collected	Depth (ft)	Temp. (°C)	Salinity	DO (mg/L)	pH
Reference	Little Card Sound, Refer.	10	3.5	19	24.5	5.4	8.2
1	Princeton Canal, mouth	2	3.5	22.2	3.5	▯	7.7
1	Princeton, Canal, spoil tip	8	1.5	21.4	18.9	4.8	7.7
2	Military Canal	6	1.5	21.8	14.3	5.7	7.8
4	North Canal	10	1.5	21.3	18.3	9.3	8.1
5	Florida City Canal	10	1.5	19.9	18.4	5.3	8.2
23	C-111 Canal, Manatee Bay	10	1.5	18.9	15.9	8.1	8.4

* Samples collected December 2, 1999.

Table IV.2. Oyster DNA damage results.

Test number	▯ Reference*	1 Princeton Canal	2 Military Canal	4 North Canal	5 Florida Canal	▯ C-111 Canal
			Mean Tail Moment			
1	1.3	6.1	0.2	3.6	18.9	6.3
2	2.8	9.3	8.5	9.2	5.8	8.7
3	1.9	5.2	5.2	4.5	4.0	5.4
4	2.9	6.1	10.1	9.1	3.3	6.5
5	1.7	7.6	4.7	5.8	5.8	6.1
6	9.0	4.0	10.0	9.0	8.1	3.6
7	5.7	2.9	▯	9.1	7.2	7.4
8	2.8	7.1	▯	4.5	2.3	6.6
9	3.7	6.0	▯	10.3	7.4	3.3
10	2.8	9.6	▯	9.7	9.8	8.4
Mean	3.5	6.4	6.5	7.5	7.3	6.2
Stand. error of the mean	2.3	2.1	3.8	2.6	4.7	1.8

* Reference sample collected in Little Card Sound.

Table IV.3. Amphipod DNA damage results.

Site		Tail Moment	Mean (Stand. error of the mean)	Site		Tail Moment	Mean (Stand. error of the mean)
1	A	9.1	9.1	8	A	3.0	3.9
	B	8.7	(1.1)		B	3.4	(1.2)
	C	12.3			C	2.7	
	D	9.7			D	8.5	
	E	5.7			E	1.7	
2	A	8.9	10.6	9	A	3.9	4.4
	B	10.9	(0.9)		B	4.6	(0.2)
	C	11.0			C	4.4	
	D	8.6			D	5.2	
	E	13.6			E	4.0	
3	A	9.5	9.5	18	A	2.8	5.1
	B	10.7	(0.6)		B	3.8	(1.2)
	C	10.1			C	4.2	
	D	9.8			D	9.6	
	E	7.3			E	5.3	
4	A	6.6	5.0	21	A	4.8	3.0
	B	3.3	(1.1)		B	3.7	(0.9)
	C	8.5			C	0.7	
	D	3.5			D	2.7	
	E	3.1			E		
5	A	5.9	3.8	23	A	--	8.8
	B	4.1	(0.6)		B	--	(0.8)
	C	2.9			C	7.7	
	D	3.8			D	10.4	
	E	2.2			E	8.2	

Table IV.4. Sea urchin sperm DNA damage results.

Site		Tail Moment	Mean (Stand. error of the mean)	Site		Tail Moment	Mean (Stand. error of the mean)
1	A	2.4	3.1	9	A	5.9	3.9
	B	2.6	(0.6)		B	3.5	(1.0)
	C	4.2			C	2.4	
2	A	9.7	11.4	18	A	3.0	2.0
	B	12.5	(0.9)		B	1.7	(0.5)
	C	11.9			C	1.4	
3	A	1.9	3.3	21	A	5.0	2.9
	B	5.0	(0.9)		B	1.8	(1.1)
	C	3.0			C	1.8	
4	A	3.9	3.4	23	A	27.0	
	B	2.5	(0.5)		B	too high	
	C	3.8			C	too high	
5	A	4.2	3.0	Porewater			
	B	2.4	(0.6)	Ref.	A	1.6	1.7
	C	2.5			B	1.9	(0.1)
					C	1.7	
8	A	7.4	7.6				
	B	8.2	(0.3)	Seawater			
	C	7.2		Ref.	A	0.9	0.8
					B	0.6	(0.1)
					C	1.0	

Table V.1. Summary of site location and water quality data for the Biscayne Bay and Manatee Bay sites.

Site	Depth (m)	Sample depth	Temp. (°C)	Salinity (ppt)	Dissolved oxygen (mg/L)
1	1.83	surface	21.5	7.1	4.61
1	1.83	bottom	19.1	21.0	6.00
2	3.66	surface	19.2	16.7	6.09
2	3.66	bottom	18.4	17.9	6.23
3	3.66	surface	18.6	17.6	5.01
3	3.66	bottom	18.2	12.6	4.44
4	2.29	surface	20.4	16.5	7.09
4	2.29	bottom	20.3	19.3	6.11
5	3.66	surface	20.0	17.9	7.60
5	3.66	bottom	19.8	17.9	7.46
6	1.83	surface	19.0	28.1	7.29
6	1.83	bottom	19.1	28.3	7.41
7	1.83	surface	19.3	24.3	7.81
7	1.83	bottom	19.3	24.6	7.93
8	1.52	surface	19.3	19.3	6.40
8	1.52	bottom	19.5	23.9	9.42
9	1.83	surface	22.1	23.9	8.05
9	1.83	bottom	21.1	28.1	8.02
10	2.13	surface	18.9	29.2	6.16
10	2.13	bottom	18.8	29.7	6.22
11	1.68	surface	19.4	29.6	6.50
11	1.68	bottom	19.3	29.7	6.44
12	1.37	surface	20.0	27.7	6.53
12	1.37	bottom	19.8	27.9	6.82
13	2.44	surface	18.8	31.8	5.93
13	2.44	bottom	18.8	31.8	6.02
14	2.44	surface	19.3	31.8	5.93
14	2.44	bottom	19.2	31.9	5.90
15	2.29	surface	19.1	32.8	6.05
15	2.29	bottom	19.1	33.0	5.78
16	2.13	surface	18.8	30.9	5.94
16	2.13	bottom	18.8	31.3	6.41
17	2.44	surface	19.4	34.3	6.02
17	2.44	bottom	19.5	34.3	5.88
18	2.44	surface	20.0	33.1	6.06
18	2.44	bottom	19.9	33.2	5.97
19	2.74	surface	19.2	34.8	6.08
19	2.74	bottom	19.1	34.8	5.85
20	3.35	surface	21.5	34.4	5.81
20	3.35	bottom	21.5	34.4	5.55
21	2.13	surface	20.5	33.1	5.59
21	2.13	bottom	20.5	33.1	5.53

Table V.1. Summary of site location and water quality data for the Biscayne Bay and Manatee Bay sites (cont.).

Site	Depth (m)	Sample depth	Temp. (°C)	Salinity (ppt)	Dissolved oxygen (mg/L)
22	3.66	surface	21.3	12.5	5.57
22	3.66	bottom	21.1	14.7	5.51
23	3.66	surface	21.3	13.7	5.11
23	3.66	bottom	21.0	16.1	5.10
24	1.52	surface	20.0	16.8	7.20
24	1.52	bottom	19.9	16.9	6.16
25	1.52	surface	19.8	17.8	7.52
25	1.52	bottom	19.8	18.3	7.39
26	1.83	surface	20.0	19.0	7.56
26	1.83	bottom	19.7	19.1	7.35
27	1.22	surface	20.2	18.7	7.74
27	1.22	bottom	20.1	18.8	7.16
28	1.83	surface	20.8	19.1	7.29
28	1.83	bottom	20.3	19.2	7.32
29	1.52	surface	21.0	20.0	7.92
29	1.52	bottom	20.7	20.0	7.02
30	2.44	surface	21.5	19.3	7.68
30	2.44	bottom	20.8	19.7	7.53

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites.

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Caecum pulchellum	Mol	Gast	1253	14.8	14.8	16	76
Hargeria rapax	Art	Mala	1198	14.2	29.0	20	95
Exogone rolani	Ann	Poly	769	9.1	38.1	15	71
Fabricinuda trilobata	Ann	Poly	449	5.3	43.4	13	62
Tubificidae (LPIL)	Ann	Olig	364	4.3	47.7	20	95
Exogone lourei	Ann	Poly	320	3.8	51.5	13	62
Sabellidae (LPIL)	Ann	Poly	250	3.0	54.5	11	52
Grandidierella bonnieroides	Art	Mala	225	2.7	57.2	12	57
Polycirrus (LPIL)	Ann	Poly	190	2.2	59.4	1	5
Serpulidae (LPIL)	Ann	Poly	119	1.4	60.8	12	57
Polydora cornuta	Ann	Poly	109	1.3	62.1	2	10
Ampharetidae (LPIL)	Ann	Poly	99	1.2	63.3	5	24
Taylorpholoe hirsuta	Ann	Poly	87	1.0	64.3	9	43
Cumella garrityi	Art	Mala	81	1.0	65.3	15	71
Erichthonius brasiliensis	Art	Mala	81	1.0	66.2	8	38
Syllis cornuta	Ann	Poly	80	0.9	67.2	9	43
Tubulanus (LPIL)	Rhy	Anop	73	0.9	68.0	12	57
Streblospio benedicti	Ann	Poly	68	0.8	68.8	4	19
Laevicardium laevigatum	Mol	Biva	66	0.8	69.6	9	43
Capitellidae (LPIL)	Ann	Poly	64	0.8	70.4	11	52
Kalliapseudes sp. C	Art	Mala	63	0.7	71.1	5	24
Nematonereis hebes	Ann	Poly	63	0.7	71.9	12	57
Sphaerosyllis piriferopsis	Ann	Poly	61	0.7	72.6	11	52
Spio pettiboneae	Ann	Poly	54	0.6	73.2	7	33
Ophiuroidea (LPIL)	Ech	Ophi	53	0.6	73.9	12	57
Caecum imbricatum	Mol	Gast	44	0.5	74.4	7	33
Caecum floridanum	Mol	Gast	42	0.5	74.9	10	48
Ehlersia ferrugina	Ann	Poly	41	0.5	75.4	8	38
Rhynchocoela (LPIL)	Rhy	–	40	0.5	75.8	13	62
Caecum nitidium	Mol	Gast	38	0.4	76.3	11	52
Sipuncula (LPIL)	Sip	–	38	0.4	76.7	7	33
Schistomeringos pectinata	Ann	Poly	36	0.4	77.2	7	33
Haplosyllis spongicola	Ann	Poly	34	0.4	77.6	1	5
Nereididae (LPIL)	Ann	Poly	34	0.4	78.0	8	38
Pettibonella multiuncinata	Ann	Poly	34	0.4	78.4	9	43
Polyplacophora (LPIL)	Mol	Polyp	34	0.4	78.8	9	43
Protodorvillea kefersteini	Ann	Poly	33	0.4	79.2	8	38
Amphiuridae (LPIL)	Ech	Ophi	31	0.4	79.5	8	38
Golfingiidae (LPIL)	Sip	–	31	0.4	79.9	7	33
Lembos (LPIL)	Art	Mala	31	0.4	80.3	8	38
Halmyrapseudes bahamensis	Art	Mala	30	0.4	80.6	3	14

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Pagurolangis largoensis	Art	Mala	30	0.4	81.0	7	33
Laeonereis culveri	Ann	Poly	29	0.3	81.3	9	43
Pseudoleptochelia sp. A	Art	Mala	29	0.3	81.7	6	29
Isolda pulchella	Ann	Poly	28	0.3	82.0	11	52
Prionospio (LPIL)	Ann	Poly	28	0.3	82.3	12	57
Monticellina dorsobranchialis	Ann	Poly	25	0.3	82.6	8	38
Mesanthura floridensis	Art	Mala	24	0.3	82.9	5	24
Ampelisca vadorum	Art	Mala	23	0.3	83.2	10	48
Chone (LPIL)	Ann	Poly	23	0.3	83.4	12	57
Nototanais (LPIL)	Art	Mala	23	0.3	83.7	3	14
Cymadusa compta	Art	Mala	22	0.3	84.0	6	29
Glycymeris pectinata	Mol	Biva	22	0.3	84.2	7	33
Oligochaeta (LPIL)	Ann	Olig	22	0.3	84.5	3	14
Syllis (LPIL)	Ann	Poly	21	0.3	84.8	5	24
Cirrophorus lyra	Ann	Poly	20	0.2	85.0	9	43
Lineidae (LPIL)	Rhy	Anop	20	0.2	85.2	10	48
Armandia maculata	Ann	Poly	18	0.2	85.4	7	33
Phascolion strombi	Sip	–	18	0.2	85.7	9	43
Amakusanthura magnifica	Art	Mala	17	0.2	85.9	7	33
Anomalocardia auberiana	Mol	Biva	17	0.2	86.1	4	19
Chione cancellata	Mol	Biva	17	0.2	86.3	10	48
Paramicrodeutopus myersi	Art	Mala	17	0.2	86.5	6	29
Cyclaspis pustulata	Art	Mala	16	0.2	86.6	7	33
Exogone atlantica	Ann	Poly	16	0.2	86.8	7	33
Laevicardium (LPIL)	Mol	Biva	16	0.2	87.0	5	24
Laonice cirrata	Ann	Poly	16	0.2	87.2	5	24
Nereis pelagica	Ann	Poly	16	0.2	87.4	7	33
Tellina iris	Mol	Biva	16	0.2	87.6	9	43
Accalathura crenulata	Art	Mala	15	0.2	87.8	7	33
Actiniaria (LPIL)	Cni	Anth	15	0.2	87.9	8	38
Brachidontes exustus	Mol	Biva	15	0.2	88.1	5	24
Maldanidae (LPIL)	Ann	Poly	15	0.2	88.3	7	33
Paramphinome sp. B	Ann	Poly	14	0.2	88.5	7	33
Cirratulidae (LPIL)	Ann	Poly	13	0.2	88.6	10	48
Leitoscoloplos robustus	Ann	Poly	13	0.2	88.8	2	10
Lioberus castaneus	Mol	Biva	13	0.2	88.9	3	14
Montacutidae (LPIL)	Mol	Biva	13	0.2	89.1	7	33
Syllidae (LPIL)	Ann	Poly	13	0.2	89.2	5	24
Aricidea philbinae	Ann	Poly	12	0.1	89.4	5	24
Elasmopus sp. C	Art	Mala	12	0.1	89.5	5	24
Glycera americana	Ann	Poly	12	0.1	89.7	3	14
Odostomia laevigata	Mol	Gast	12	0.1	89.8	7	33
Oxyurostylis smithi	Art	Mala	12	0.1	89.9	5	24
Terebellidae (LPIL)	Ann	Poly	12	0.1	90.1	7	33
Nereis panamensis	Ann	Poly	11	0.1	90.2	3	14

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Oxyurostylis (LPIL)	Art	Mala	11	0.1	90.4	8	38
Syllis broomensis	Ann	Poly	11	0.1	90.5	5	24
Axiothella sp. A	Ann	Poly	10	0.1	90.6	2	10
Scoletoma impatiens	Ann	Poly	10	0.1	90.7	6	29
Carpias algicola	Art	Mala	9	0.1	90.8	4	19
Deutella incerta	Art	Mala	9	0.1	90.9	4	19
Photis (LPIL)	Art	Mala	9	0.1	91.0	4	19
Pitar fulminatus	Mol	Biva	9	0.1	91.1	7	33
Plesiolembos rectangulatus	Art	Mala	9	0.1	91.3	4	19
Pleuromeris tridentata	Mol	Biva	9	0.1	91.4	3	14
Rictaxis punctostriatus	Mol	Gast	9	0.1	91.5	6	29
Spionidae (LPIL)	Ann	Poly	9	0.1	91.6	7	33
Caulleriella cf. alata	Ann	Poly	8	0.1	91.7	5	24
Cingula floridana	Mol	Gast	8	0.1	91.8	1	5
Corophium sp. Q	Art	Mala	8	0.1	91.9	3	14
Cyclaspis sp. N	Art	Mala	8	0.1	91.9	4	19
Dasybranchus lunulatus	Ann	Poly	8	0.1	92.0	4	19
Exogone (LPIL)	Ann	Poly	8	0.1	92.1	2	10
Fimbriosthenelais minor	Ann	Poly	8	0.1	92.2	7	33
Hydroides dianthus	Ann	Poly	8	0.1	92.3	3	14
Nucula aegeenis	Mol	Biva	8	0.1	92.4	2	10
Paracerceis caudata	Art	Mala	8	0.1	92.5	4	19
Platynereis dumerilli	Ann	Poly	8	0.1	92.6	3	14
Vermiliopsis annulata	Ann	Poly	8	0.1	92.7	4	19
Xenanthura brevitelson	Art	Mala	8	0.1	92.8	3	14
Capitella capitata	Ann	Poly	7	0.1	92.9	3	14
Caulleriella sp. K	Ann	Poly	7	0.1	93.0	5	24
Ceratonereis versipedata	Ann	Poly	7	0.1	93.1	3	14
Cylindrobulla beauii	Mol	Gast	7	0.1	93.1	3	14
Erichsonella attenuata	Art	Mala	7	0.1	93.2	1	5
Limnoria (LPIL)	Art	Mala	7	0.1	93.3	2	10
Lysidice notata	Ann	Poly	7	0.1	93.4	6	29
Marginella lavalleeana	Mol	Gast	7	0.1	93.5	6	29
Mediomastus (LPIL)	Ann	Poly	7	0.1	93.5	7	33
Nereis (LPIL)	Ann	Poly	7	0.1	93.6	3	14
Spirorbidae (LPIL)	Ann	Poly	7	0.1	93.7	1	5
Varohios sp. A	Art	Mala	7	0.1	93.8	3	14
Veneridae (LPIL)	Mol	Biva	7	0.1	93.9	6	29
Aricidea (LPIL)	Ann	Poly	6	0.1	94.0	4	19
Ascidiacea (LPIL)	Cho	Asci	6	0.1	94.0	2	10
Branchiomma nigromaculata	Ann	Poly	6	0.1	94.1	3	14
Capitella jonesi	Ann	Poly	6	0.1	94.2	2	10
Dentimargo aureocincta	Mol	Gast	6	0.1	94.2	4	19
Dulichiella appendiculata	Art	Mala	6	0.1	94.3	2	10
Glans dominguensis	Mol	Biva	6	0.1	94.4	1	5

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Grubeosyllis rugulosa	Ann	Poly	6	0.1	94.4	3	14
Horoloanthura irpex	Art	Mala	6	0.1	94.5	1	5
Mysella planulata	Mol	Biva	6	0.1	94.6	1	5
Nassarius albus	Mol	Gast	6	0.1	94.7	5	24
Podarkeopsis levifuscina	Ann	Poly	6	0.1	94.7	2	10
Streblosoma hartmanae	Ann	Poly	6	0.1	94.8	4	19
Tellinidae (LPIL)	Mol	Biva	6	0.1	94.9	5	24
Amygdalum sagittatum	Mol	Biva	5	0.1	94.9	3	14
Batea carinata	Art	Mala	5	0.1	95.0	3	14
Gastropoda (LPIL)	Mol	Gast	5	0.1	95.1	2	10
Granulina ovuliformis	Mol	Gast	5	0.1	95.1	3	14
Lumbrineridae (LPIL)	Ann	Poly	5	0.1	95.2	3	14
Olivella dealbata	Mol	Gast	5	0.1	95.2	2	10
Owenia fusiformis	Ann	Poly	5	0.1	95.3	4	19
Parapionosyllis uebelackerae	Ann	Poly	5	0.1	95.3	5	24
Prionospio cristata	Ann	Poly	5	0.1	95.4	3	14
Scoloplos rubra	Ann	Poly	5	0.1	95.5	5	24
Stenoninereis martini	Ann	Poly	5	0.1	95.5	1	5
Syllis danieli	Ann	Poly	5	0.1	95.6	3	14
Turbonilla (LPIL)	Mol	Gast	5	0.1	95.6	2	10
Amphilochidae (LPIL)	Art	Mala	4	0.0	95.7	4	19
Aoridae (LPIL)	Art	Mala	4	0.0	95.7	2	10
Apseudidae (LPIL)	Art	Mala	4	0.0	95.8	2	10
Campylaspis sp. U	Art	Mala	4	0.0	95.8	4	19
Corophium (LPIL)	Art	Mala	4	0.0	95.9	2	10
Cyclaspis varians	Art	Mala	4	0.0	95.9	2	10
Demonax microphthalmus	Ann	Poly	4	0.0	96.0	1	5
Dorvilleidae (LPIL)	Ann	Poly	4	0.0	96.0	3	14
Eunicidae (LPIL)	Ann	Poly	4	0.0	96.1	1	5
Glyceridae (LPIL)	Ann	Poly	4	0.0	96.1	3	14
Glycinde solitaria	Ann	Poly	4	0.0	96.2	3	14
Golfingia (LPIL)	Sip	–	4	0.0	96.2	2	10
Leitoscoloplos (LPIL)	Ann	Poly	4	0.0	96.3	4	19
Lucina radians	Mol	Biva	4	0.0	96.3	2	10
Paguridae (LPIL)	Art	Mala	4	0.0	96.4	4	19
Podarke obscura	Ann	Poly	4	0.0	96.4	2	10
Polypedilum scalaenum group	Art	Inse	4	0.0	96.4	1	5
Schwartziella catesbyana	Mol	Gast	4	0.0	96.5	2	10
Syllides bansei	Ann	Poly	4	0.0	96.5	3	14
Tagelus (LPIL)	Mol	Biva	4	0.0	96.6	2	10
Tellina (LPIL)	Mol	Biva	4	0.0	96.6	3	14
Aclididae (LPIL)	Mol	Gast	3	0.0	96.7	2	10
Acmaea (LPIL)	Mol	Gast	3	0.0	96.7	1	5
Arabella multidentata	Ann	Poly	3	0.0	96.7	3	14
Aricidea cerrutii	Ann	Poly	3	0.0	96.8	3	14

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Aricidea finitima	Ann	Poly	3	0.0	96.8	2	10
Bhawania goodei	Ann	Poly	3	0.0	96.9	2	10
Bulla striata	Mol	Gast	3	0.0	96.9	1	5
Cerithiidae (LPIL)	Mol	Gast	3	0.0	96.9	3	14
Cerithium muscarum	Mol	Gast	3	0.0	97.0	2	10
Codakia costata	Mol	Biva	3	0.0	97.0	1	5
Crepidula maculosa	Mol	Gast	3	0.0	97.0	1	5
Crepidula plana	Mol	Gast	3	0.0	97.1	3	14
Glycera sp. D	Ann	Poly	3	0.0	97.1	2	10
Hydroides bispinosa	Ann	Poly	3	0.0	97.1	3	14
Hypereteone heteropoda	Ann	Poly	3	0.0	97.2	2	10
Leucothoe spinicarpa	Art	Mala	3	0.0	97.2	3	14
Lightiella floridana	Art	Ceph	3	0.0	97.2	1	5
Mediomastus californiensis	Ann	Poly	3	0.0	97.3	2	10
Mesanthura (LPIL)	Art	Mala	3	0.0	97.3	2	10
Metharpinia floridana	Art	Mala	3	0.0	97.3	1	5
Nereiphylla fragilis	Ann	Poly	3	0.0	97.4	2	10
Notomastus latericeus	Ann	Poly	3	0.0	97.4	2	10
Notomastus tenuis	Ann	Poly	3	0.0	97.5	3	14
Odostomia (LPIL)	Mol	Gast	3	0.0	97.5	1	5
Paracaprella tenuis	Art	Mala	3	0.0	97.5	2	10
Pectinidae (LPIL)	Mol	Biva	3	0.0	97.6	2	10
Polynoidae (LPIL)	Ann	Poly	3	0.0	97.6	2	10
Prionospio heterobranchia	Ann	Poly	3	0.0	97.6	3	14
Pseudovermilia occidentalis	Ann	Poly	3	0.0	97.7	1	5
Pyramidella crenulata	Mol	Gast	3	0.0	97.7	2	10
Strombiformis (LPIL)	Mol	Gast	3	0.0	97.7	3	14
Syllis beneliahui	Ann	Poly	3	0.0	97.8	2	10
Syllis lutea	Ann	Poly	3	0.0	97.8	3	14
Turbellaria (LPIL)	Pla	Turb	3	0.0	97.8	2	10
Ampelisca (LPIL)	Art	Mala	2	0.0	97.9	2	10
Amphiodia planispina	Ech	Ophi	2	0.0	97.9	1	5
Ampithoe (LPIL)	Art	Mala	2	0.0	97.9	1	5
Aricidea sp. X	Ann	Poly	2	0.0	97.9	1	5
Aricidea taylori	Ann	Poly	2	0.0	98.0	2	10
Axiothella mucosa	Ann	Poly	2	0.0	98.0	2	10
Bivalvia (LPIL)	Mol	Biva	2	0.0	98.0	2	10
Cerapus benthophilus	Art	Mala	2	0.0	98.0	1	5
Chrysopetalum hernancortezae	Ann	Poly	2	0.0	98.1	2	10
Cirrophorus furcatus	Ann	Poly	2	0.0	98.1	2	10
Crassinella lunulata	Mol	Biva	2	0.0	98.1	1	5
Cubanocuma gutzui	Art	Mala	2	0.0	98.1	2	10
Cyclaspis (LPIL)	Art	Mala	2	0.0	98.2	2	10
Dorvillea sociablis	Ann	Poly	2	0.0	98.2	1	5
Gammaridae (LPIL)	Art	Mala	2	0.0	98.2	1	5

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Hypereteone lighti	Ann	Poly	2	0.0	98.2	1	5
Lepidonotus variabilis	Ann	Poly	2	0.0	98.2	2	10
Leptosynapta (LPIL)	Ech	Holo	2	0.0	98.3	2	10
Listriella sp. G	Art	Mala	2	0.0	98.3	1	5
Loimia medusa	Ann	Poly	2	0.0	98.3	1	5
Lucina (LPIL)	Mol	Biva	2	0.0	98.3	1	5
Lucinidae (LPIL)	Mol	Biva	2	0.0	98.4	1	5
Lysianassa (LPIL)	Art	Mala	2	0.0	98.4	1	5
Malmgreniella maccraryae	Ann	Poly	2	0.0	98.4	1	5
Marginella (LPIL)	Mol	Gast	2	0.0	98.4	2	10
Mytilidae (LPIL)	Mol	Biva	2	0.0	98.5	2	10
Niso (LPIL)	Mol	Gast	2	0.0	98.5	1	5
Odontosyllis enopla	Ann	Poly	2	0.0	98.5	1	5
Olivella (LPIL)	Mol	Gast	2	0.0	98.5	1	5
Olivella bullula	Mol	Gast	2	0.0	98.6	2	10
Ophiactis savignyi	Ech	Ophi	2	0.0	98.6	2	10
Opisthodonta sp. B	Ann	Poly	2	0.0	98.6	1	5
Orbiniidae (LPIL)	Ann	Poly	2	0.0	98.6	2	10
Paratanaidae (LPIL)	Art	Mala	2	0.0	98.7	1	5
Pectinaria gouldii	Ann	Poly	2	0.0	98.7	2	10
Photis sp. J	Art	Mala	2	0.0	98.7	2	10
Phoxocephalidae (LPIL)	Art	Mala	2	0.0	98.7	1	5
Porifera (LPIL)	Por	–	2	0.0	98.7	1	5
Prionospio steenstrupi	Ann	Poly	2	0.0	98.8	2	10
Pusia gemmata	Mol	Gast	2	0.0	98.8	1	5
Scoletoma candida	Ann	Poly	2	0.0	98.8	1	5
Scoloplos (LPIL)	Ann	Poly	2	0.0	98.8	1	5
Semelidae (LPIL)	Mol	Biva	2	0.0	98.9	1	5
Sphaeromatidae (LPIL)	Art	Mala	2	0.0	98.9	2	10
Sphaerosyllis (LPIL)	Ann	Poly	2	0.0	98.9	2	10
Sphaerosyllis aciculata	Ann	Poly	2	0.0	98.9	1	5
Syllis gracilis	Ann	Poly	2	0.0	99.0	1	5
Transennella conradina	Mol	Biva	2	0.0	99.0	2	10
Uromunna reynoldsi	Art	Mala	2	0.0	99.0	1	5
Acmaeidae (LPIL)	Mol	Gast	1	0.0	99.0	1	5
Acteocina candei	Mol	Gast	1	0.0	99.0	1	5
Alpheus (LPIL)	Art	Mala	1	0.0	99.0	1	5
Alvania auberiana	Mol	Gast	1	0.0	99.1	1	5
Americardia media	Mol	Biva	1	0.0	99.1	1	5
Americhelidium americanum	Art	Mala	1	0.0	99.1	1	5
Ampelisca schellenbergi	Art	Mala	1	0.0	99.1	1	5
Amygdalum (LPIL)	Mol	Biva	1	0.0	99.1	1	5
Antalis antillarum	Mol	Scap	1	0.0	99.1	1	5
Bhawania heteroseta	Ann	Poly	1	0.0	99.1	1	5

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Branchiostoma (LPIL)	Cho	Lept	1	0.0	99.1	1	5
Branchiosyllis oculata	Ann	Poly	1	0.0	99.1	1	5
Bryozoa (LPIL)	Bry	–	1	0.0	99.2	1	5
Calyptraeidae (LPIL)	Mol	Gast	1	0.0	99.2	1	5
Cardiidae (LPIL)	Mol	Biva	1	0.0	99.2	1	5
Caulleriella (LPIL)	Ann	Poly	1	0.0	99.2	1	5
Ceratonereis (LPIL)	Ann	Poly	1	0.0	99.2	1	5
Cnidaria (LPIL)	Cni	–	1	0.0	99.2	1	5
Conus jaspideus	Mol	Gast	1	0.0	99.2	1	5
Craspedochiton hemphilli	Mol	Polyp	1	0.0	99.2	1	5
Cumella (LPIL)	Art	Mala	1	0.0	99.3	1	5
Cyclaspis unicornis	Art	Mala	1	0.0	99.3	1	5
Dentatisyllis carolinae	Ann	Poly	1	0.0	99.3	1	5
Diplodonta (LPIL)	Mol	Biva	1	0.0	99.3	1	5
Edotia lyonsi	Art	Mala	1	0.0	99.3	1	5
Eunice unifrons	Ann	Poly	1	0.0	99.3	1	5
Glycera (LPIL)	Ann	Poly	1	0.0	99.3	1	5
Goniada teres	Ann	Poly	1	0.0	99.3	1	5
Grubeosyllis clavata	Ann	Poly	1	0.0	99.3	1	5
Harmothoe imbricata	Ann	Poly	1	0.0	99.4	1	5
Hemitoma emarginata	Mol	Gast	1	0.0	99.4	1	5
Hesionidae (LPIL)	Ann	Poly	1	0.0	99.4	1	5
Latreutes fucorum	Art	Mala	1	0.0	99.4	1	5
Leptochelia (LPIL)	Art	Mala	1	0.0	99.4	1	5
Leptochelia forresti	Art	Mala	1	0.0	99.4	1	5
Lumbrineris coccinea	Ann	Poly	1	0.0	99.4	1	5
Lysidice (LPIL)	Ann	Poly	1	0.0	99.4	1	5
Maera sp. C	Art	Mala	1	0.0	99.5	1	5
Marginella apicina	Mol	Gast	1	0.0	99.5	1	5
Melinna cristata	Ann	Poly	1	0.0	99.5	1	5
Musculus lateralis	Mol	Biva	1	0.0	99.5	1	5
Nannodiella oxia	Mol	Gast	1	0.0	99.5	1	5
Nematoda (LPIL)	Nem	–	1	0.0	99.5	1	5
Neomegamphopus kalanii	Art	Mala	1	0.0	99.5	1	5
Neritina virginea	Mol	Gast	1	0.0	99.5	1	5
Notomastus (LPIL)	Ann	Poly	1	0.0	99.6	1	5
Notomastus sp. A	Ann	Poly	1	0.0	99.6	1	5
Oenonidae (LPIL)	Ann	Poly	1	0.0	99.6	1	5
Olividae (LPIL)	Mol	Gast	1	0.0	99.6	1	5
Ophiuridae (LPIL)	Ech	Ophi	1	0.0	99.6	1	5
Opisthodonta sp. A	Ann	Poly	1	0.0	99.6	1	5
Ougia tenuidentis	Ann	Poly	1	0.0	99.6	1	5
Oxyurostylis lecroyae	Art	Mala	1	0.0	99.6	1	5
Paguristes (LPIL)	Art	Mala	1	0.0	99.6	1	5

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Biscayne Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Pagurus (LPIL)	Art	Mala	1	0.0	99.7	1	5
Palaemonidae (LPIL)	Art	Mala	1	0.0	99.7	1	5
Paranebalia belizensis	Art	Mala	1	0.0	99.7	1	5
Phoronis (LPIL)	Pho	–	1	0.0	99.7	1	5
Photis pugnator	Art	Mala	1	0.0	99.7	1	5
Phyllodoce arenae	Ann	Poly	1	0.0	99.7	1	5
Phyllodocidae (LPIL)	Ann	Poly	1	0.0	99.7	1	5
Pionosyllis spinisetosa	Ann	Poly	1	0.0	99.7	1	5
Piromis roberti	Ann	Poly	1	0.0	99.8	1	5
Pitar (LPIL)	Mol	Biva	1	0.0	99.8	1	5
Plakosyllis quadrioculata	Ann	Poly	1	0.0	99.8	1	5
Polycirrus plumosus	Ann	Poly	1	0.0	99.8	1	5
Potamethus sp. A	Ann	Poly	1	0.0	99.8	1	5
Prionospio multibranchiata	Ann	Poly	1	0.0	99.8	1	5
Protohadzia schoenerae	Art	Mala	1	0.0	99.8	1	5
Pyramidellidae (LPIL)	Mol	Gast	1	0.0	99.8	1	5
Saltipedis (LPIL)	Art	Mala	1	0.0	99.8	1	5
Schistomeringos rudolphi	Ann	Poly	1	0.0	99.9	1	5
Scyphoproctus platyproctus	Ann	Poly	1	0.0	99.9	1	5
Serolis mgrayi	Art	Mala	1	0.0	99.9	1	5
Sphaerosyllis perkinsi	Ann	Poly	1	0.0	99.9	1	5
Synalpheus (LPIL)	Art	Mala	1	0.0	99.9	1	5
Tegula fasciata	Mol	Gast	1	0.0	99.9	1	5
Terebellides parvus	Ann	Poly	1	0.0	99.9	1	5
Terebridae (LPIL)	Mol	Gast	1	0.0	99.9	1	5
Trichobranchidae (LPIL)	Ann	Poly	1	0.0	100.0	1	5
Trochidae (LPIL)	Mol	Gast	1	0.0	100.0	1	5
Turridae (LPIL)	Mol	Gast	1	0.0	100.0	1	5
Volvarina avenacea	Mol	Gast	1	0.0	100.0	1	5
Zebina browniana	Mol	Gast	1	0.0	100.0	1	5

Manatee Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Brachidontes exustus	Mol	Biva	2586	46.2	46.2	7	78
Caecum pulchellum	Mol	Gast	426	7.6	53.7	7	78
Grandidierella bonnieroides	Art	Mala	299	5.3	59.1	8	89
Tubificidae (LPIL)	Ann	Olig	290	5.2	64.3	9	100
Clunio (LPIL)	Art	Inse	214	3.8	68.1	4	44
Syllis broomensis	Ann	Poly	178	3.2	71.3	7	78
Elasmopus sp. C	Art	Mala	163	2.9	74.2	4	44
Exogone rolani	Ann	Poly	131	2.3	76.5	7	78
Fabricinuda trilobata	Ann	Poly	100	1.8	78.3	5	56
Cymadusa compta	Art	Mala	96	1.7	80.0	7	78
Shoemakerella cubensis	Art	Mala	83	1.5	81.5	5	56

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Manatee Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Polyplacophora (LPIL)	Mol	Polyp	76	1.4	82.8	4	44
Acteocina canaliculata	Mol	Gast	51	0.9	83.7	5	56
Laevicardium laevigatum	Mol	Biva	42	0.7	84.5	6	67
Rhynchocoela (LPIL)	Rhy	–	38	0.7	85.2	7	78
Elasmopus pocillimanus	Art	Mala	29	0.5	85.7	3	33
Tubulanus (LPIL)	Rhy	Anop	28	0.5	86.2	4	44
Cirratulidae (LPIL)	Ann	Poly	26	0.5	86.7	5	56
Cirrophorus lyra	Ann	Poly	26	0.5	87.1	5	56
Amphiuridae (LPIL)	Ech	Ophi	24	0.4	87.5	4	44
Aricidea philbinae	Ann	Poly	24	0.4	88.0	4	44
Schwartziella catesbyana	Mol	Gast	24	0.4	88.4	1	11
Pectinaria gouldii	Ann	Poly	23	0.4	88.8	5	56
Acuminodeutopus naglei	Art	Mala	22	0.4	89.2	2	22
Ampelisca vadorum	Art	Mala	22	0.4	89.6	5	56
Aricidea sp. X	Ann	Poly	22	0.4	90.0	3	33
Podarke obscura	Ann	Poly	22	0.4	90.4	6	67
Bulla striata	Mol	Gast	21	0.4	90.8	7	78
Actiniaria (LPIL)	Cni	Anth	19	0.3	91.1	5	56
Sabellidae (LPIL)	Ann	Poly	19	0.3	91.4	4	44
Pectinidae (LPIL)	Mol	Biva	18	0.3	91.8	1	11
Batea carinata	Art	Mala	17	0.3	92.1	3	33
Fimbriosthenelais minor	Ann	Poly	17	0.3	92.4	1	11
Taylorpholoe hirsuta	Ann	Poly	17	0.3	92.7	2	22
Hydroides dianthus	Ann	Poly	16	0.3	93.0	3	33
Acteocina candei	Mol	Gast	15	0.3	93.2	2	22
Crepidula maculosa	Mol	Gast	13	0.2	93.5	4	44
Hargeria rapax	Art	Mala	12	0.2	93.7	6	67
Lucina radians	Mol	Biva	12	0.2	93.9	5	56
Nereididae (LPIL)	Ann	Poly	12	0.2	94.1	4	44
Chione cancellata	Mol	Biva	11	0.2	94.3	3	33
Chone (LPIL)	Ann	Poly	10	0.2	94.5	3	33
Lembos (LPIL)	Art	Mala	10	0.2	94.6	3	33
Lyonsia hyalina	Mol	Biva	10	0.2	94.8	4	44
Paracerceis caudata	Art	Mala	10	0.2	95.0	4	44
Exogone lourei	Ann	Poly	9	0.2	95.2	1	11
Glycinde solitaria	Ann	Poly	9	0.2	95.3	4	44
Caecum nitidium	Mol	Gast	8	0.1	95.5	3	33
Chione (LPIL)	Mol	Biva	8	0.1	95.6	1	11
Pleurobranchus (LPIL)	Mol	Gast	8	0.1	95.8	1	11
Montacutidae (LPIL)	Mol	Biva	7	0.1	95.9	2	22
Prionospio heterobranchia	Ann	Poly	7	0.1	96.0	4	44
Syllis beneliahui	Ann	Poly	7	0.1	96.1	1	11
Aricidea taylori	Ann	Poly	6	0.1	96.2	1	11
Dulichiella appendiculata	Art	Mala	6	0.1	96.3	1	11

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Manatee Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Ehlersia ferrugina	Ann	Poly	6	0.1	96.4	1	11
Ceratonereis singularis	Ann	Poly	5	0.1	96.5	3	33
Cylindrobulla beauii	Mol	Gast	5	0.1	96.6	3	33
Marginella lavalleeana	Mol	Gast	5	0.1	96.7	2	22
Podarkeopsis levifuscina	Ann	Poly	5	0.1	96.8	2	22
Serpulidae (LPIL)	Ann	Poly	5	0.1	96.9	3	33
Ceratonereis longicirrata	Ann	Poly	4	0.1	97.0	2	22
Cerithiidae (LPIL)	Mol	Gast	4	0.1	97.0	1	11
Cerithium muscarum	Mol	Gast	4	0.1	97.1	1	11
Haliotinella patinaria	Mol	Gast	4	0.1	97.2	1	11
Leitoscoloplos robustus	Ann	Poly	4	0.1	97.3	3	33
Nereis pelagica	Ann	Poly	4	0.1	97.3	2	22
Oxyurostylis smithi	Art	Mala	4	0.1	97.4	3	33
Tellinidae (LPIL)	Mol	Biva	4	0.1	97.5	1	11
Turbellaria (LPIL)	Pla	Turb	4	0.1	97.5	4	44
Calyptraeidae (LPIL)	Mol	Gast	3	0.1	97.6	1	11
Dentimargo aureocincta	Mol	Gast	3	0.1	97.6	3	33
Diptera (LPIL)	Art	Inse	3	0.1	97.7	1	11
Halmyrapseudes bahamensis	Art	Mala	3	0.1	97.8	2	22
Hydrozoa (LPIL)	Cni	Hydr	3	0.1	97.8	2	22
Laevicardium (LPIL)	Mol	Biva	3	0.1	97.9	1	11
Leitoscoloplos (LPIL)	Ann	Poly	3	0.1	97.9	3	33
Melitidae (LPIL)	Art	Mala	3	0.1	98.0	1	11
Monticellina dorsobranchialis	Ann	Poly	3	0.1	98.0	2	22
Nereis acuminata	Ann	Poly	3	0.1	98.1	2	22
Schistomeringos pectinata	Ann	Poly	3	0.1	98.1	3	33
Teinostoma biscaynense	Mol	Gast	3	0.1	98.2	1	11
Amakusanthura magnifica	Art	Mala	2	0.0	98.2	1	11
Cerapus benthophilus	Art	Mala	2	0.0	98.3	2	22
Cerithium atratum	Mol	Gast	2	0.0	98.3	1	11
Dipolydora socialis	Ann	Poly	2	0.0	98.3	1	11
Erichthonius brasiliensis	Art	Mala	2	0.0	98.4	1	11
Granulina ovuliformis	Mol	Gast	2	0.0	98.4	1	11
Hesionidae (LPIL)	Ann	Poly	2	0.0	98.4	1	11
Leptosynapta (LPIL)	Ech	Holo	2	0.0	98.5	1	11
Lima pellucida	Mol	Biva	2	0.0	98.5	2	22
Lucina multilineata	Mol	Biva	2	0.0	98.5	1	11
Nassarius albus	Mol	Gast	2	0.0	98.6	1	11
Nematonereis hebes	Ann	Poly	2	0.0	98.6	1	11
Nucula aegeenis	Mol	Biva	2	0.0	98.6	1	11
Oxyurostylis (LPIL)	Art	Mala	2	0.0	98.7	1	11
Pagurus (LPIL)	Art	Mala	2	0.0	98.7	1	11
Parahesione luteola	Ann	Poly	2	0.0	98.8	1	11
Prionospio (LPIL)	Ann	Poly	2	0.0	98.8	2	22

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Manatee Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Sipuncula (LPIL)	Sip	–	2	0.0	98.8	2	22
Strombiformis (LPIL)	Mol	Gast	2	0.0	98.9	2	22
Xenanthura brevitelson	Art	Mala	2	0.0	98.9	1	11
Accalathura crenulata	Art	Mala	1	0.0	98.9	1	11
Ampharetidae (LPIL)	Ann	Poly	1	0.0	98.9	1	11
Amphilochidae (LPIL)	Art	Mala	1	0.0	98.9	1	11
Amphipoda (LPIL)	Art	Mala	1	0.0	99.0	1	11
Ampithoidae (LPIL)	Art	Mala	1	0.0	99.0	1	11
Aoridae (LPIL)	Art	Mala	1	0.0	99.0	1	11
Aricidea catherinae	Ann	Poly	1	0.0	99.0	1	11
Aricidea cerrutii	Ann	Poly	1	0.0	99.0	1	11
Armandia (LPIL)	Ann	Poly	1	0.0	99.1	1	11
Batea catharinensis	Art	Mala	1	0.0	99.1	1	11
Bullidae (LPIL)	Mol	Gast	1	0.0	99.1	1	11
Caecum (LPIL)	Mol	Gast	1	0.0	99.1	1	11
Cardiomya (LPIL)	Mol	Biva	1	0.0	99.1	1	11
Ceradocus (LPIL)	Art	Mala	1	0.0	99.1	1	11
Cerapus (LPIL)	Art	Mala	1	0.0	99.2	1	11
Ceratonereis (LPIL)	Ann	Poly	1	0.0	99.2	1	11
Corophium (LPIL)	Art	Mala	1	0.0	99.2	1	11
Cumingia tellinoides	Mol	Biva	1	0.0	99.2	1	11
Elasmopus (LPIL)	Art	Mala	1	0.0	99.2	1	11
Elysia evelinae	Mol	Gast	1	0.0	99.3	1	11
Epitonium echinaticostum	Mol	Gast	1	0.0	99.3	1	11
Erichsonella attenuata	Art	Mala	1	0.0	99.3	1	11
Eupolymnia nebulosa	Ann	Poly	1	0.0	99.3	1	11
Gnathia (LPIL)	Art	Mala	1	0.0	99.3	1	11
Goniadidae (LPIL)	Ann	Poly	1	0.0	99.3	1	11
Haminoea succinea	Mol	Gast	1	0.0	99.4	1	11
Hypereteone heteropoda	Ann	Poly	1	0.0	99.4	1	11
Kalliapseudes sp. C	Art	Mala	1	0.0	99.4	1	11
Laeonereis culveri	Ann	Poly	1	0.0	99.4	1	11
Leptosynapta multigranula	Ech	Holo	1	0.0	99.4	1	11
Maldanidae (LPIL)	Ann	Poly	1	0.0	99.4	1	11
Marphysa (LPIL)	Ann	Poly	1	0.0	99.5	1	11
Melinna maculata	Ann	Poly	1	0.0	99.5	1	11
Microspio maori	Ann	Poly	1	0.0	99.5	1	11
Mytilidae (LPIL)	Mol	Biva	1	0.0	99.5	1	11
Nereis (LPIL)	Ann	Poly	1	0.0	99.5	1	11
Olivella dealbata	Mol	Gast	1	0.0	99.6	1	11
Ophiuroidea (LPIL)	Ech	Ophi	1	0.0	99.6	1	11
Ostracoda (LPIL)	Art	Ostr	1	0.0	99.6	1	11
Paguridae (LPIL)	Art	Mala	1	0.0	99.6	1	11
Pandoridae (LPIL)	Mol	Biva	1	0.0	99.6	1	11

Table V.2. Abundance and distribution of taxa for the Biscayne Bay and Manatee Bay sites (cont.).

Manatee Bay:

Taxon Name	Phylum	Class	Number of Individuals	Percent total	Cumulative percent	Site occurrence	Site percent occurrence
Paraonidae (LPIL)	Ann	Poly	1	0.0	99.6	1	11
Phascolion strombi	Sip	–	1	0.0	99.7	1	11
Philinidae (LPIL)	Mol	Gast	1	0.0	99.7	1	11
Phoxocephalidae (LPIL)	Art	Mala	1	0.0	99.7	1	11
Platynereis dumerilli	Ann	Poly	1	0.0	99.7	1	11
Plesiolembos rectangulatus	Art	Mala	1	0.0	99.7	1	11
Polycirrus (LPIL)	Ann	Poly	1	0.0	99.8	1	11
Porifera (LPIL)	Por	–	1	0.0	99.8	1	11
Psammobiidae (LPIL)	Mol	Biva	1	0.0	99.8	1	11
Rictaxis punctostriatus	Mol	Gast	1	0.0	99.8	1	11
Rissoidae (LPIL)	Mol	Gast	1	0.0	99.8	1	11
Scaphandridae (LPIL)	Mol	Gast	1	0.0	99.8	1	11
Sphaeromatidae (LPIL)	Art	Mala	1	0.0	99.9	1	11
Sphaerosyllis taylori	Ann	Poly	1	0.0	99.9	1	11
Stenothoe gallensis	Art	Mala	1	0.0	99.9	1	11
Streblospio benedicti	Ann	Poly	1	0.0	99.9	1	11
Syllides bansei	Ann	Poly	1	0.0	99.9	1	11
Synaptula hydriformis	Ech	Holo	1	0.0	99.9	1	11
Turbonilla (LPIL)	Mol	Gast	1	0.0	100.0	1	11
Turridae (LPIL)	Mol	Gast	1	0.0	100.0	1	11
Veneridae (LPIL)	Mol	Biva	1	0.0	100.0	1	11

Taxa Key

Ann = Annelida
- Olig = Oligochaeta
- Poly = Polychaeta

Art = Arthropoda
- Ceph = Cephalocarida
- Inse = Insecta
- Mala = Malacostraca
- Ostr = Ostracoda

Bry = Bryozoa

Cho = Chordata
- Asci = Ascidiacea
- Lept = Leptocardia

Cni = Cnidaria
- Anth = Anthozoa
- Hydr = Hydrozoa

Ech = Echinodermata
- Holo = Holothuroidea
- Ophi = Ophiuroidea

Mol = Mollusca
- Biva = Bivalvia
- Gast = Gastropoda
- Polyp = Polyplacophora
- Scap = Scaphopoda

Nem = Nematoda

Pho = Phoronida

Pla = Platyhelminthes
- Turb = Turbellaria

Por = Porifera

Rhy = Rhynchocoela
- Anop = Anopla

Sip = Sipuncula

Table V.3. Summary of overall abundance of major benthic macroinfaunal taxonomic groups for the Biscayne Bay and Manatee Bay sites.

Total No.		Total No.		
Taxa	Taxa	% Total	Individuals	% Total
Annelida				
Oligochaeta	2	0.5	676	4.8
Polychaeta	162	41.3	4,473	31.8
Mollusca				
Bivalvia	43	11.0	3,002	21.4
Gastropoda	61	15.6	2,130	15.2
Polyplacophora	2	0.5	111	0.8
Scaphopoda	1	0.3	1	0.0
Arthropoda				
Cephalocarida	1	0.3	3	0.0
Insecta	3	0.8	221	1.6
Malacostraca	91	23.2	2,962	21.1
Ostracoda	1	0.3	1	0.0
Echinodermata				
Holothuroidea	3	0.8	6	0.0
Ophiuroidea	5	1.3	114	0.8
Other Taxa	17	4.3	351	2.5
Total	392		14,051	

Table V.4. Summary of abundance of major benthic macroinfaunal taxonomic groups by site for the Biscayne Bay and Manatee Bay sites.

Site	Taxa	Total No. Taxa	Percent of Total	Total No. Individuals (per 0.04 m^2)	Percent of Total
1	Annelida	5	33.3	93	29.2
	Mollusca	6	40.0	14	4.4
	Arthropoda	3	20.0	201	63.0
	Other Taxa	1	6.7	11	3.4
	Total	15		319	
2	Annelida	6	46.2	28	65.1
	Mollusca	3	23.1	6	14.0
	Arthropoda	3	23.1	8	18.6
	Other Taxa	1	7.7	1	2.3
	Total	13		43	
3	Annelida	11	44.0	110	65.1
	Mollusca	4	16.0	13	7.7
	Arthropoda	7	28.0	40	23.7
	Other Taxa	3	12.0	6	3.6
	Total	25		169	
4	Annelida	5	26.3	26	36.1
	Mollusca	6	31.6	17	23.6
	Arthropoda	5	26.3	11	15.3
	Other Taxa	3	15.8	18	25.0
	Total	19		72	
5	Annelida	8	57.1	44	45.8
	Mollusca	1	7.1	2	2.1
	Arthropoda	4	28.6	28	29.2
	Other Taxa	1	7.1	22	22.9
	Total	14		96	
6	Annelida	32	49.2	313	47.9
	Mollusca	12	18.5	77	11.8
	Arthropoda	16	24.6	245	37.5
	Echinodermata	2	3.1	8	1.2
	Other Taxa	3	4.6	10	1.5
	Total	65		653	
7	Annelida	46	48.4	493	49.8
	Mollusca	20	21.1	159	16.1
	Arthropoda	24	25.3	330	33.4
	Echinodermata	2	2.1	2	0.2
	Other Taxa	3	3.2	5	0.5
	Total	95		989	

Table V.4. Summary of abundance of major benthic macroinfaunal taxonomic groups by site for the Biscayne Bay and Manatee Bay sites (cont.).

Site	Taxa	Total No. Taxa	Percent of Total	Total No. Individuals (per 0.04 m^2)	Percent of Total
8	Annelida	32	43.2	155	33.1
	Mollusca	14	18.9	105	22.4
	Arthropoda	22	29.7	196	41.9
	Echinodermata	2	2.7	2	0.4
	Other Taxa	4	5.4	10	2.1
	Total	74		468	
9	Annelida	39	51.3	501	64.8
	Mollusca	17	22.4	125	16.2
	Arthropoda	13	17.1	125	16.2
	Echinodermata	2	2.6	9	1.2
	Other Taxa	5	6.6	13	1.7
	Total	76		773	
10	Annelida	39	46.4	325	64.9
	Mollusca	17	20.2	47	9.4
	Arthropoda	20	23.8	116	23.2
	Echinodermata	2	2.4	2	0.4
	Other Taxa	6	7.1	11	2.2
	Total	84		501	
11	Annelida	37	55.2	274	55.7
	Mollusca	12	17.9	134	27.2
	Arthropoda	11	16.4	70	14.2
	Echinodermata	1	1.5	3	0.6
	Other Taxa	6	9.0	11	2.2
	Total	67		492	
12	Annelida	40	51.9	239	38.5
	Mollusca	17	22.1	273	44.0
	Arthropoda	15	19.5	100	16.1
	Echinodermata	1	1.3	1	0.2
	Other Taxa	4	5.2	7	1.1
	Total	77		620	
13	Annelida	31	56.4	213	72.9
	Mollusca	12	21.8	50	17.1
	Arthropoda	10	18.2	14	4.8
	Other Taxa	2	3.6	15	5.1
	Total	55		292	

Table V.4. Summary of abundance of major benthic macroinfaunal taxonomic groups by site for the Biscayne Bay and Manatee Bay sites (cont.).

Site	Taxa	Total No. Taxa	Percent of Total	Total No. Individuals (per 0.04 m^2)	Percent of Total
14	Annelida	38	43.2	523	53.8
	Mollusca	20	22.7	315	32.4
	Arthropoda	24	27.3	103	10.6
	Echinodermata	2	2.3	16	1.6
	Other Taxa	4	4.5	16	1.6
	Total	88		973	
15	Annelida	22	44.0	69	16.6
	Mollusca	13	26.0	128	30.8
	Arthropoda	10	20.0	199	48.0
	Echinodermata	1	2.0	7	1.7
	Other Taxa	4	8.0	12	2.9
	Total	50		415	
16	Annelida	16	45.7	66	69.5
	Mollusca	6	17.1	9	9.5
	Arthropoda	8	22.9	14	14.7
	Echinodermata	1	2.9	2	2.1
	Other Taxa	4	11.4	4	4.2
	Total	35		95	
17	Annelida	20	40.0	30	15.8
	Mollusca	10	20.0	80	42.1
	Arthropoda	15	30.0	59	31.1
	Echinodermata	1	2.0	7	3.7
	Other Taxa	4	8.0	14	7.4
	Total	50		190	
18	Annelida	30	46.2	102	30.2
	Mollusca	11	16.9	79	23.4
	Arthropoda	16	24.6	112	33.1
	Echinodermata	2	3.1	10	3.0
	Other Taxa	6	9.2	35	10.4
	Total	65		338	
19	Annelida	26	44.8	97	39.1
	Mollusca	17	29.3	108	43.5
	Arthropoda	9	15.5	30	12.1
	Echinodermata	2	3.4	3	1.2
	Other Taxa	4	6.9	10	4.0
	Total	58		248	

Table V.4. Summary of abundance of major benthic macroinfaunal taxonomic groups by site for the Biscayne Bay and Manatee Bay sites (cont.).

Site	Taxa	Total No. Taxa	Percent of Total	Total No. Individuals (per 0.04 m^2)	Percent of Total
20	Annelida	40	47.6	162	61.6
	Mollusca	21	25.0	62	23.6
	Arthropoda	15	17.9	26	9.9
	Echinodermata	2	2.4	2	0.8
	Other Taxa	6	7.1	11	4.2
	Total	84		263	
21	Annelida	53	59.6	240	54.8
	Mollusca	15	16.9	35	8.0
	Arthropoda	14	15.7	133	30.4
	Echinodermata	3	3.4	17	3.9
	Other Taxa	4	4.5	13	3.0
	Total	89		438	
22	Annelida	7	53.8	11	50.0
	Mollusca	3	23.1	5	22.7
	Arthropoda	3	23.1	6	27.3
	Total	13		22	
23	Annelida	2	100.0	5	100.0
	Total	2		5	
24	Annelida	17	41.5	126	47.7
	Mollusca	11	26.8	87	33.0
	Arthropoda	9	22.0	34	12.9
	Echinodermata	1	2.4	1	0.4
	Other Taxa	3	7.3	16	6.1
	Total	41		264	
25	Annelida	17	34.0	199	6.7
	Mollusca	18	36.0	2673	90.2
	Arthropoda	11	22.0	79	2.7
	Other Taxa	4	8.0	11	0.4
	Total	50		2962	
26	Annelida	18	42.9	129	26.5
	Mollusca	10	23.8	81	16.7
	Arthropoda	10	23.8	265	54.5
	Echinodermata	1	2.4	3	0.6
	Other Taxa	3	7.1	8	1.6
	Total	42		486	

Table V.4. Summary of abundance of major benthic macroinfaunal taxonomic groups by site for the Biscayne Bay and Manatee Bay sites (cont.).

Site	Taxa	Total No. Taxa	Percent of Total	Total No. Individuals (per 0.04 m^2)	Percent of Total
27	Annelida	19	35.8	171	37.5
	Mollusca	12	22.6	121	26.5
	Arthropoda	15	28.3	128	28.1
	Echinodermata	2	3.8	4	0.9
	Other Taxa	5	9.4	32	7.0
	Total	53		456	
28	Annelida	15	36.6	99	20.9
	Mollusca	10	24.4	50	10.6
	Arthropoda	11	26.8	317	67.0
	Echinodermata	1	2.4	1	0.2
	Other Taxa	4	9.8	6	1.3
	Total	41		473	
29	Annelida	24	32.4	172	30.9
	Mollusca	25	33.8	222	39.9
	Arthropoda	19	25.7	130	23.4
	Echinodermata	3	4.1	20	3.6
	Other Taxa	3	4.1	12	2.2
	Total	74		556	
30	Annelida	19	38.8	139	36.1
	Mollusca	16	32.7	167	43.4
	Arthropoda	10	20.4	68	17.7
	Other Taxa	4	8.2	11	2.9
	Total	49		385	

Table V.5. Percentage abundance of dominant benthic macroinfaunal taxa (>10% of the total) for the Biscayne Bay and Manatee Bay sites.

Taxa	Sites 1	2	3	4	5	6	7	8	9	10
Annelida										
Oligochaeta										
Tubificidae (LPIL)			29	14	16					
Polychaeta										
Ampharetidae (LPIL)	20	16	15							
Exogone lourei									10	
Exogone rolani						25				22
Fabricinuda trilobata							17			
Haplosyllis spongicola										
Leitoscoloplos robustus		27.9								
Polycirrus (LPIL)									25	
Polydora cornuta									14	
Sabellidae (LPIL)										
Serpulidae (LPIL)										
Stenoninereis martini		12								
Streblospio benedicti			11	18	22					
Syllis broomensis										
Arthropoda										
Insecta										
Clunio (LPIL)										
Malacostraca										
Elasmopus sp. C										
Grandidierella bonnieroides	49.8				24					
Halmyrapseudes bahamensis			15							
Hargeria rapax	12					30	19	31		12
Shoemakerella cubensis										
Mollusca										
Bivalvia										
Brachidontes exustus										
Laevicardium (LPIL)										
Gastropoda										
Caecum pulchellum								12		
Polyplacophora										
Polyplacophora (LPIL)										
Rhynchocoela										
Anopla										
Tubulanus (LPIL)				21	23					

Table V.5. Percentage abundance of dominant benthic macroinfaunal taxa (>10% of the total) for the Biscayne Bay and Manatee Bay sites (cont.).

	Sites									
Taxa	11	12	13	14	15	16	17	18	19	20
Annelida										
Oligochaeta										
Tubificidae (LPIL)						17				
Polychaeta										
Ampharetidae (LPIL)										
Exogone lourei										
Exogone rolani	13		31	18						
Fabricinuda trilobata	23									
Haplosyllis spongicola										13
Leitoscoloplos robustus										
Polycirrus (LPIL)										
Polydora cornuta										
Sabellidae (LPIL)				15						
Serpulidae (LPIL)										
Stenoninereis martini										
Streblospio benedicti										
Syllis broomensis										
Arthropoda										
Insecta										
Clunio (LPIL)										
Malacostraca										
Elasmopus sp. C										
Grandidierella bonnieroides										
Halmyrapseudes bahamensis										
Hargeria rapax					38		15	26		
Shoemakerella cubensis										
Mollusca										
Bivalvia										
Brachidontes exustus										
Laevicardium (LPIL)										
Gastropoda										
Caecum pulchellum	21	31	13	29	27		36	17	35	11
Polyplacophora										
Polyplacophora (LPIL)										
Rhynchocoela										
Anopla										
Tubulanus (LPIL)										

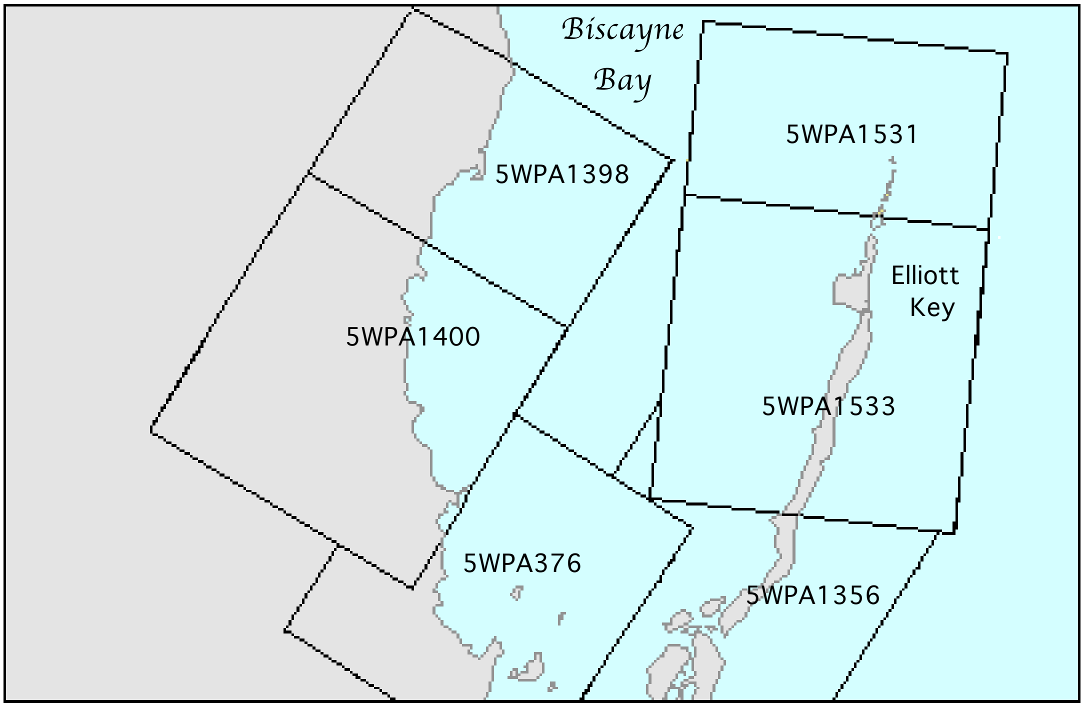
Table V.5. Percentage abundance of dominant benthic macroinfaunal taxa (>10% of the total) for the Biscayne Bay and Manatee Bay sites (cont.).

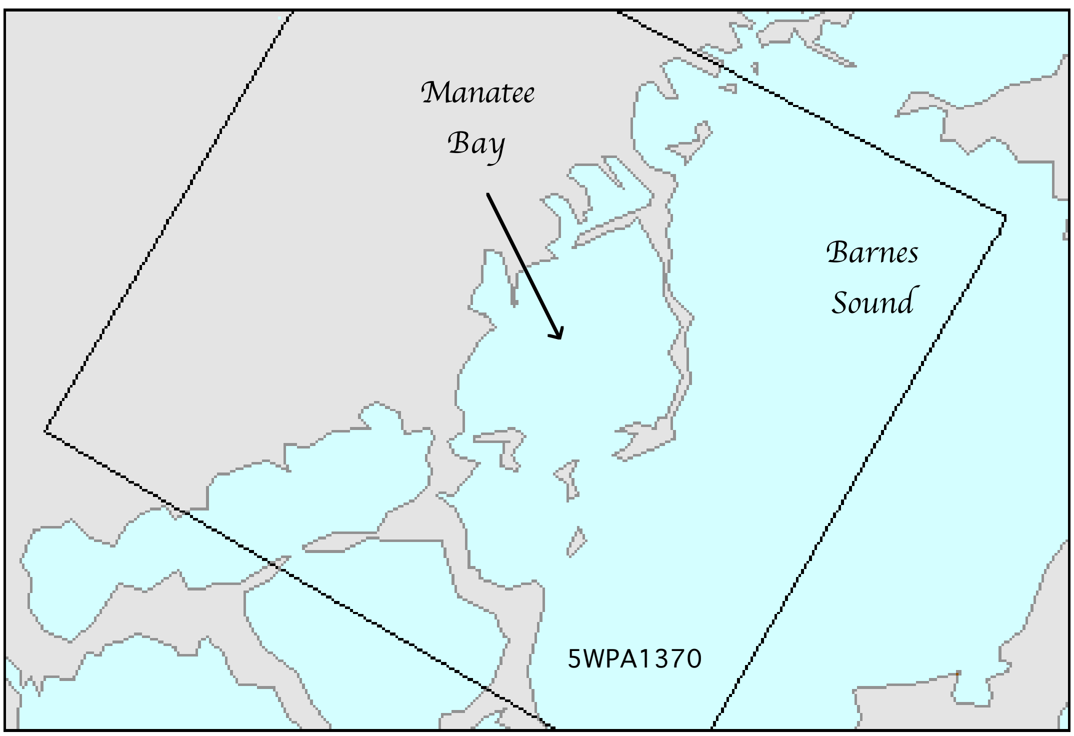
	Sites									
Taxa	21	22	23	24	25	26	27	28	29	30
Annelida										
Oligochaeta										
Tubificidae (LPIL)		23	67	19			16			
Polychaeta										
Ampharetidae (LPIL)										
Exogone lourei										
Exogone rolani									10	
Fabricinuda trilobata										
Haplosyllis spongicola										
Leitoscoloplos robustus			33							
Polycirrus (LPIL)										
Polydora cornuta										
Sabellidae (LPIL)										
Serpulidae (LPIL)	16									
Stenoninereis martini										
Streblospio benedicti										
Syllis broomensis										12
Arthropoda										
Insecta										
Clunio (LPIL)						15		21		
Malacostraca										
Elasmopus sp. C						14		14		
Grandidierella bonnieroides		18				15		23		
Halmyrapseudes bahamensis										
Hargeria rapax	23									
Shoemakerella cubensis										10
Mollusca										
Bivalvia										
Brachidontes exustus					82		11			
Laevicardium (LPIL)		14								
Gastropoda										
Caecum pulchellum				15			10			33
Polyplacophora										
Polyplacophora (LPIL)									12	
Rhynchocoela										
Anopla										
Tubulanus (LPIL)										

Table V.6. Summary of benthic macroinfaunal data for the Biscayne Bay and Manatee Bay sites.

Site	Number of taxa	Number of individuals	Density (number of individuals/m^2)	H' Diversity	J' Evenness
Biscayne Bay					
1	15	319	7975	1.62	0.60
2	13	43	1075	2.20	0.86
3	25	169	4225	2.37	0.73
4	19	72	1800	2.43	0.83
5	14	96	2400	1.94	0.73
6	65	653	16325	2.63	0.63
7	96	989	24725	3.19	0.70
8	74	468	11700	2.93	0.68
9	76	773	19325	2.93	0.68
10	84	501	12525	3.26	0.73
11	67	492	12300	2.80	0.67
12	77	620	15500	3.12	0.72
13	55	292	7300	2.78	0.69
14	88	973	24325	2.68	0.60
15	50	415	10375	2.21	0.56
16	35	95	2375	3.13	0.88
17	50	190	4750	2.77	0.71
18	66	338	8450	3.04	0.73
19	58	248	6200	2.97	0.73
20	85	263	6575	3.65	0.82
21	89	438	10950	3.40	0.76
Manatee Bay					
22	13	22	550	2.32	0.91
23	2	6	150	0.64	0.92
24	39	258	6450	2.92	0.80
25	51	2962	74050	0.94	0.24
26	42	486	12150	2.85	0.76
27	53	456	11400	3.12	0.78
28	41	473	11825	2.63	0.71
29	74	556	13900	3.53	0.82
30	49	385	9625	2.68	0.69

13. APPENDIX VI. Aerial photography





Location of aerial images in the NOAA/NOS Coastal Photography website.

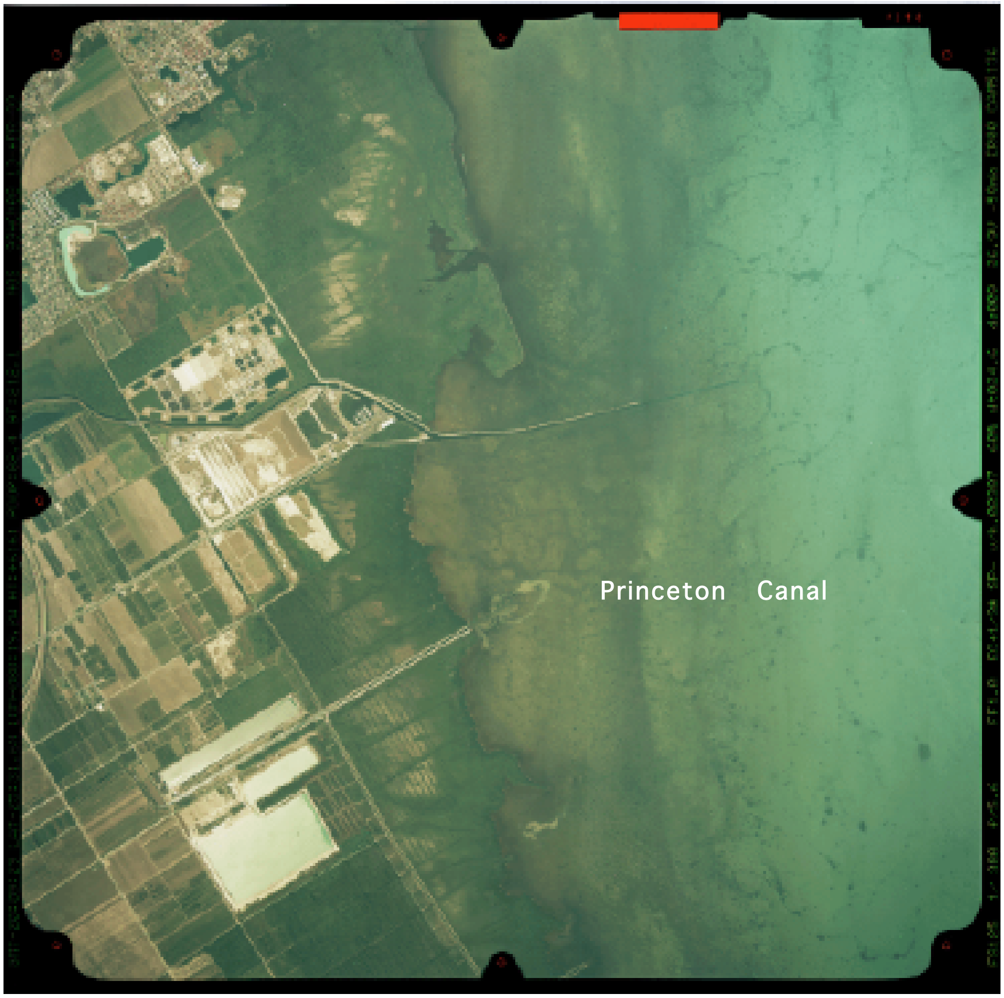


Plate VI.1. Princeton Canal.
[5WPA1398. 1999. Scale 1:40000; azimuth 211.4; 25.526° N, 80.320° W. (Coastal Aerial Photography, NOAA/National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts.nos.noaa.gov/images/photos/5wpa 1398.gif>.]

Plate VI.2. Military, Mowry Canals, North and Florida City Canals.
[5WPA1400. 1999. Scale 1:40000; azimuth 211.2; 25.472° N, 80.356° W. (Coastal Aerial Photography, NOAA/National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts.nos.noaa.gov/images/photos/5wpa1400.gif>.]

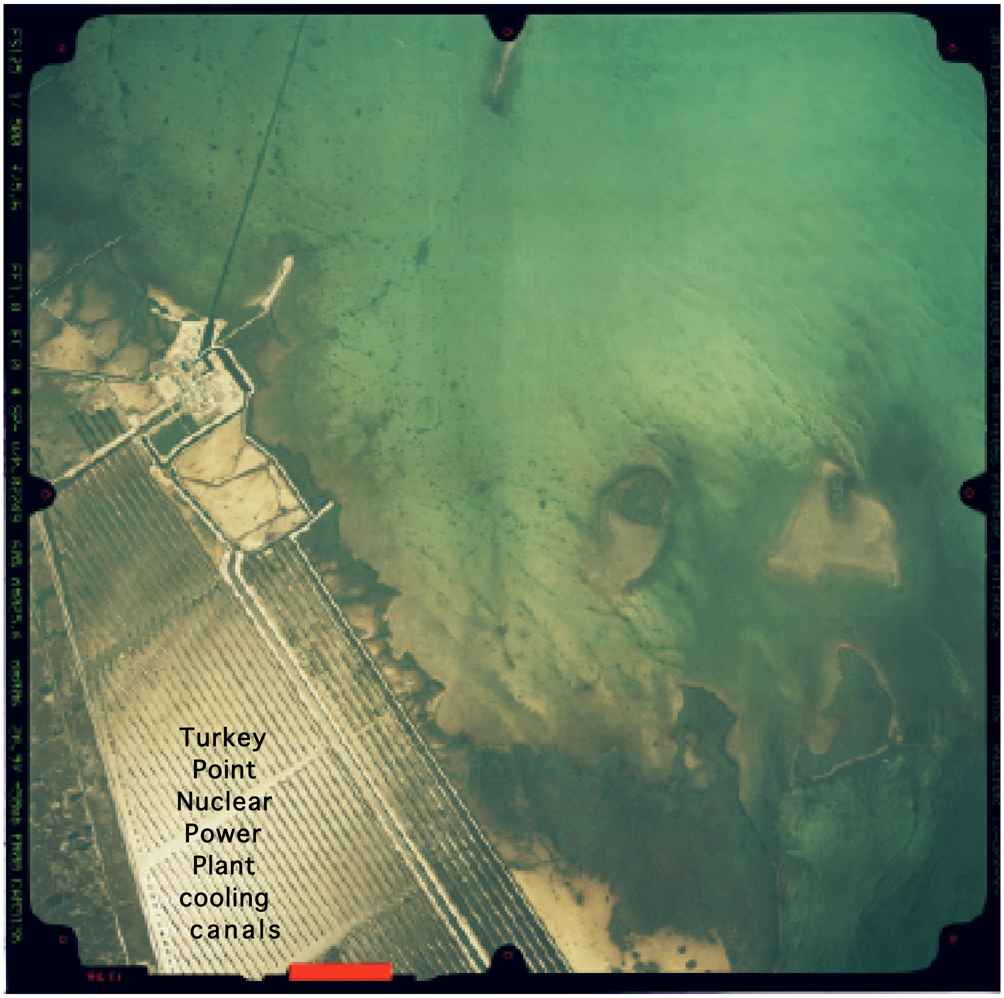


Plate VI.3. Turkey Point.
[5WPA1376. 1999. Scale 1:40000; azimuth 32.9; 25.411° N, 80.313° W. (Coastal Aerial Photography, NOAA/National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts. nos.noaa.gov/images/photos/5wpa 1376.gif>.]

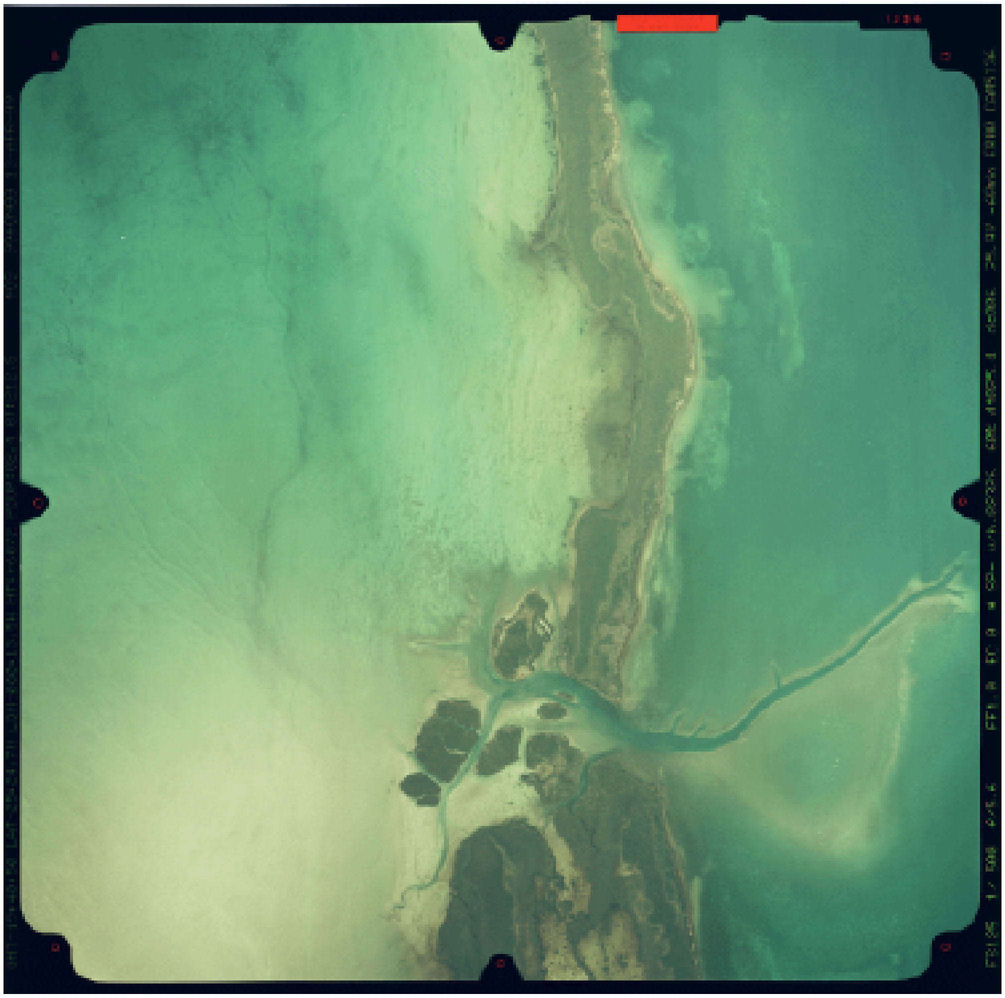


Plate VI.4. Elliott Key, Caesar's Creek and Old Rhodes Key.
[5WPA1356. 1999. Scale 1:40000; azimuth 212.4; 25.412° N, 80.225° W. (Coastal Aerial Photography, NOAA/ National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts.nos. noaa.gov/images/photos/5wpa1356.gif>.]

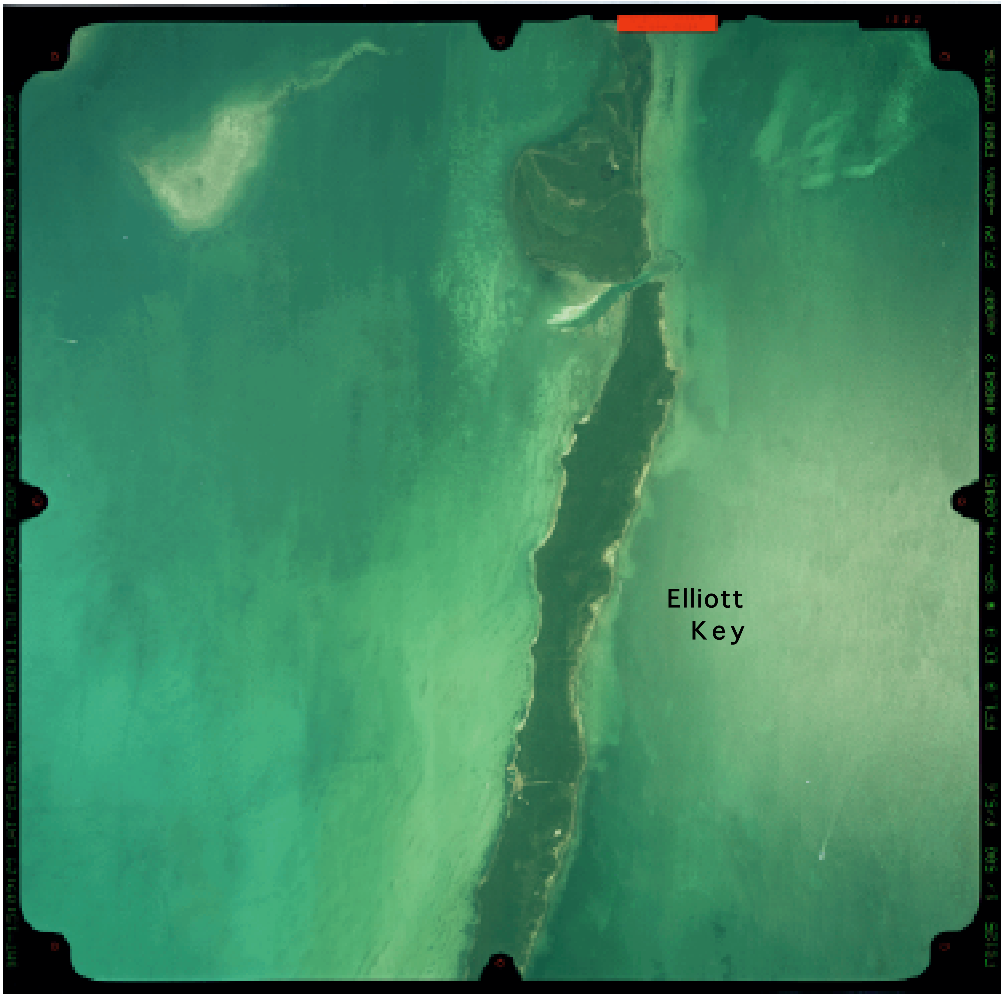


Plate VI.5. Sands Key and Elliott Key.
[5WPA1533. 1999. Scale 1:40000; azimuth 186.5; 25.478° N, 80.194° W. (Coastal Aerial Photography, NOAA/National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts.nos.noaa.gov/images/photos/5wpa 1533.gif>.]

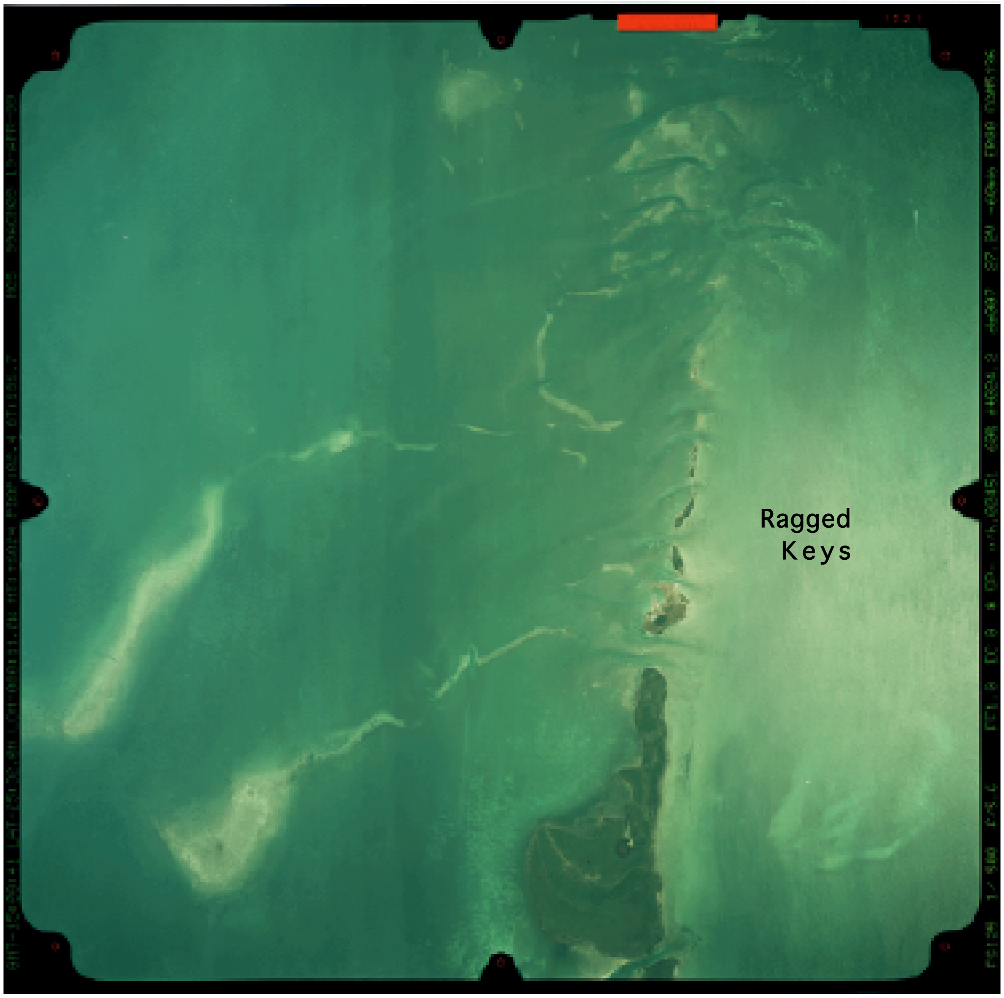


Plate VI.6. Sands Key and Ragged Keys.
[5WPA1531. 1999. Scale 1:40000; azimuth 186.2; 25.533° N, 80.187° W. (Coastal Aerial Photography, NOAA/National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts.nos.noaa.gov/images/photos/ 5wpa1531.gif>.]

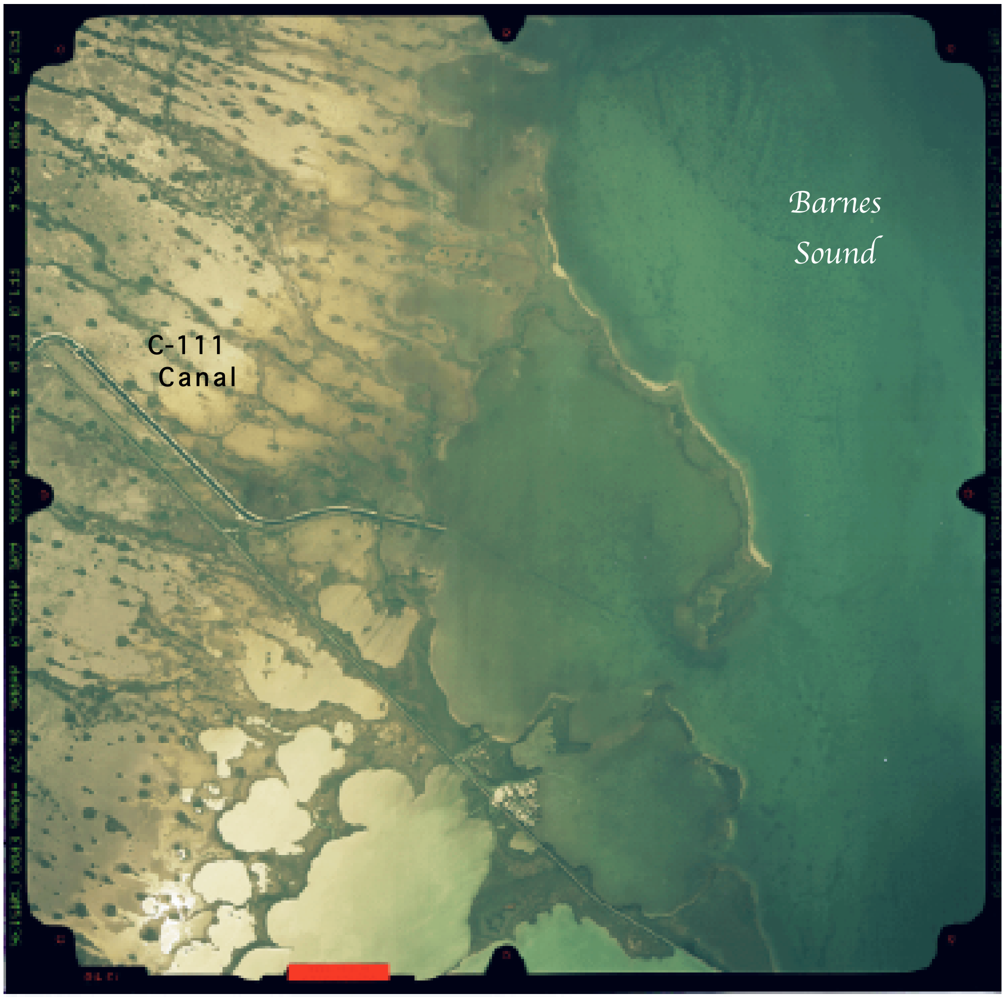


Plate VI.7. Manatee Bay and the C-111 Canal.
[5WPA1370. 1999. Scale 1:40000; azimuth 30.2; 25.258° N, 80.419° W. (Coastal Aerial Photography, NOAA/National Ocean Service, <http://mapfinder.nos.noaa.gov:80/>, <http://mfproducts.nos.noaa.gov/images/photos/5wpa 1370.gif>.]

Plate VI.8. Recreational boat mooring site east of Elliott Key. [Photographed by J. Craynock (NOAA/AOML), on December 19, 2001 from an R-22 Helicopter (Wilderness Air and Land, Miami, FL) at an altitude of 600 ft.]

Plate VI.9. Recreational boat mooring site east of Elliott Key. [Photographed by J. Craynock (NOAA/AOML), on December 19, 2001 from an R-22 Helicopter (Wilderness Air and Land, Miami, FL) at an altitude of 600 ft.]

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