MERHAB Florida Monitoring Program

(FY01 Annual Report for the CCMA – Charleston Team's Component of the MERHAB Florida Monitoring Program: Benthic Monitoring and System-Wide Data Management)

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Submitted by

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1. Introduction

Harmful Algal Blooms (HABs) have become an issue of national concern. Significant environmental and economic impacts due to HABs have occurred in coastal regions across the United States. Virtually every coastal state is threatened by HABs, often by more than one harmful or toxic species. Impacts of HABs include mass mortalities of fish and shellfish, human illness or even death from consumption of contaminated shellfish or fish, death of marine mammals, seabirds and sea turtles, and chronic/sublethal effects on marine fish and shellfish. A HAB may consist of a massive bloom of cells that discolor the water or a dilute concentration of cells that produce highly potent toxins. The only factor common to all HABs is that harmful effects are produced; HABs are not characterized by the number, abundance, or size of the causal organisms (Smayda 1997). Multiple environmental and physical factors may influence HAB population dynamics, including nutrient enrichment, seasonal temperature and salinity changes, storm events, physical transport, chemical loading, and watershed land use (Anderson 1995; NOAA 1999).

Of particular concern on the Atlantic coast of the U.S. is the toxic dinoflagellate *Pfiesteria piscicida* (Steidinger & Burkholder) and related *Pfiesteria*-like organisms (PLOs). *Pfiesteria* has a complex life cycle including multiple flagellated and amoeboid stages, and occurs in both toxic and non-toxic forms (Burkholder et al. 1995; Burkholder and Glasgow 1997). *Pfiesteria piscicida* has been observed in coastal waters of North Carolina, Maryland, Delaware, and South Carolina. PLOs have been found in Florida waters as well. This species has been linked to fish kills and fish lesions in mid-Atlantic estuaries where it captured major media attention (Burkholder et al. 1992; Burkholder et al. 1995; Lewitus et al. 1995; Noga et al. 1996; Burkholder et al. 1999). Of particular concern when dealing with this species is its potential for human health impacts. Human cognitive impairments have been seen in laboratory personnel exposed to *Pfiesteria* and learning deficits have been observed in rats exposed to *Pfiesteria* (Burkholder et al. 1992; Burkholder et al. 1995; Levin 2001; Schmechel and Koltai 2001). Numerous unanswered questions exist with respect to the ecology of these organisms, their impact on pelagic and benthic fauna, and their relationship to anthropogenic activities.

The lower St. Johns River (LSJR) has been an historical hot spot for fish lesions, is known to harbor PLOs, and supports populations of schooling planktivorous fish often associated with lesions and HAB events elsewhere along the eastern seaboard. Thus, the LSJR was a logical system in which to establish an intensive HAB monitoring program for Florida waters (Fig. 1). Also, due to concerns over deteriorating water quality as a result of a variety of human activities in the area, the St. Johns River is recognized by the State of Florida as a priority area in need of surface-water protection and restoration. Accordingly, a comprehensive three-year monitoring study (MERHAB Florida Monitoring Program) was initiated in October 1999 to evaluate potential relationships between water- and sediment-quality variables, occurrences of harmful algal blooms, and the incidence of fish diseases and other biological impacts in this important estuarine system.

The study is being conducted by teams of scientists from the NOAA/NCCOS Center for Coastal Monitoring and Assessment (CCMA) in Charleston, SC (supported by internal NOAA funding) and from several other partnering institutions supported through a cooperative agreement

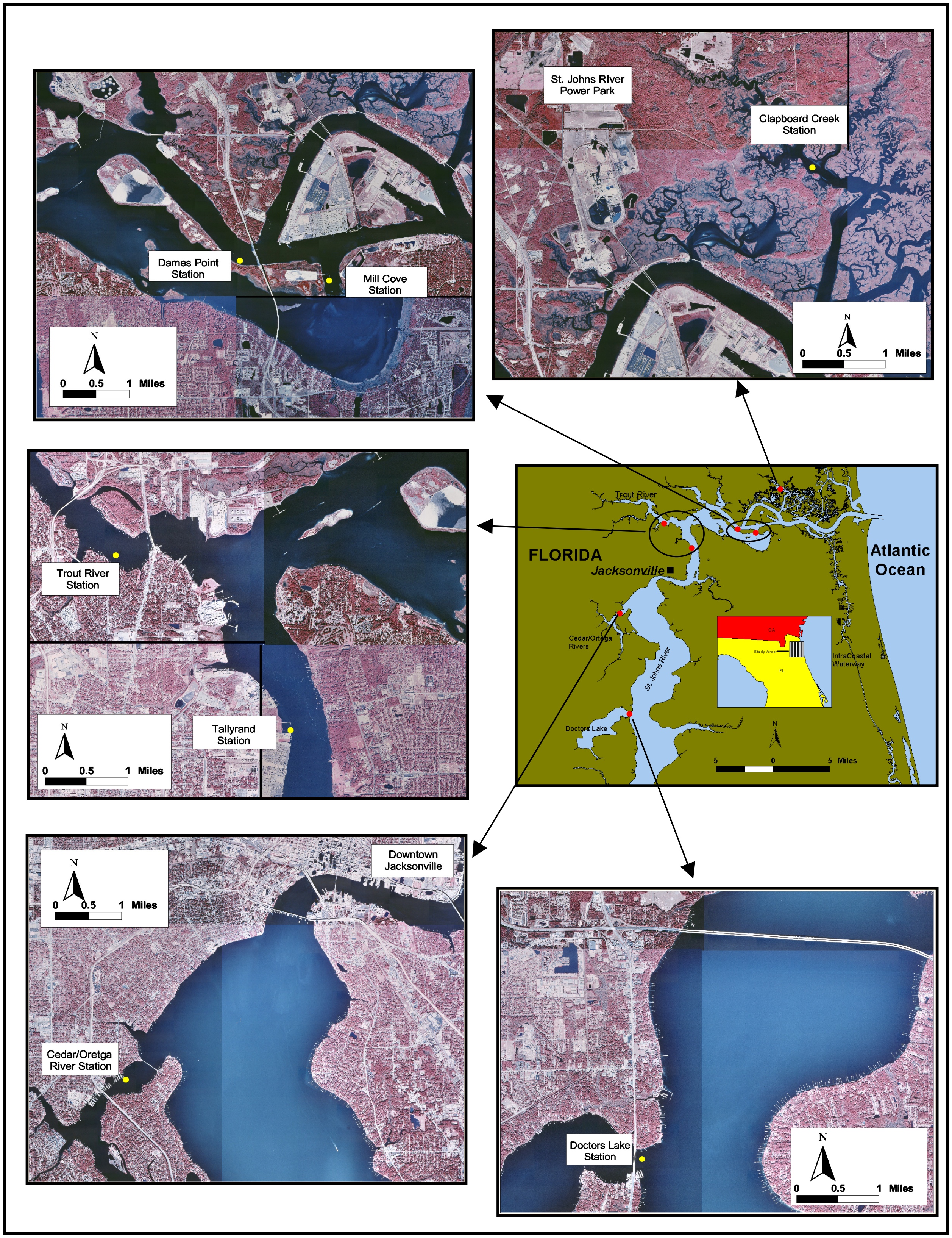

Figure 1. Station locations for MERHAB Florida monitoring in the St. Johns River, Florida.

(#NA97OA0361) between NOAA and the Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute. In addition to the CCMA-Charleston lab, partnering institutions include the Florida Marine Research Institute, NOAA/NCCOS Center for Coastal Fisheries and Habitat Research, USDA/Agricultural Research Service/Southern Regional Research Center, Rutgers University, University of North Carolina (UNC) at Wilmington, UNC at Chapel Hill, University of South Florida, and the St. Johns River Water Management District. Each partner brings to the project a wealth of experience critical to addressing the overall goal of determining ecological symptoms and consequences of HABs in the LSJR basin.

The CCMA-Charleston team has been actively involved in the project since its beginning, with key responsibilities in system-wide data management and implementation of a benthic monitoring component. The soft-bottom benthos is a key component of coastal ecosystems, playing vital roles in detrital decomposition, nutrient cycling, and energy flow to higher trophic levels. Moreover, because of their relatively stationary existence within the sediments, benthic infauna can serve as reliable indicators of potential environmental disturbances. The benthic monitoring component also includes the analysis of chemical contaminants and other stressors (e.g., ammonia, sulfide) in sediments. These analyses are important in providing the program with a basis for interpreting potential biological impacts in the LSJR in relation to multiple stressor inputs.

This annual report provides a summary of activities and accomplishments, through December 2001, of the CCMA-Charleston team's component of the MERHAB Florida Monitoring Program.

2. Objectives and Scope

An overall objective of the MERHAB Florida Monitoring Program is to evaluate potential relationships between water- and sediment-quality variables, occurrences of harmful algal blooms, and the incidence of fish diseases and other biological impacts in the LSJR estuary. The benthic component of this program is designed to address the following additional supporting objectives: (1) to evaluate potential effects of HABs and associated environmental changes (e.g., nutrient enrichment, organic loading, oxygen depletion) on the composition and structure of benthic assemblages; (2) to provide information on effects of catastrophic HAB events on economically valuable species of benthic molluscs and crustaceans; (3) to provide an opportunity for monitoring the incidence of HAB cysts in sediments; (4) to provide a basis for examining potential relationships between HAB events and processes occurring in bottom substrates; and (5) to provide a basis for comparing the relative contributions of HABs and other symptoms of eutrophication versus chemical contamination of sediments as potential sources of impacts in the benthos. The latter objective is especially important to address given the proximity to a major metropolitan area with potential pollutant inputs from a variety of sources including shipping, marinas, commercial shipbuilding and repair, military bases, pulp and paper manufacturing, petroleum storage facilities, power generation, commercial and recreational fishing, urban and high-density residential development, and water-based recreation. The river also supports a wide variety of agricultural activities throughout its watershed and includes several Superfund sites.

Field sampling is being conducted over a two-year period (July 2000 to July 2002) and includes:

(1) seasonal sampling (July, November/December, March) of biotic and environmental variables in both sediments and the water column at seven fixed stations (Fig. 1), and (2) continuous (time-series) monitoring of a suite of physical, chemical, and biological variables at multiple water depths from an instrumented platform at one of the fixed stations. The instrumented platform is connected to a HDR GOES satellite transmitter that provides real-time, remotely accessed data to the CCMA-Charleston lab. The CCMA-Charleston team is responsible for maintaining these data as part of their data management role and developing an associated web site.

As mentioned above, the CCMA-Charleston team also is leading the benthic monitoring component. Benthic samples are being collected three times a year over a two-year period at each of the seven fixed monitoring stations. Sampling occasions to date are as follows: July 2000, December 2000, March 2001, July 2001, and November 2001. Samples are collected for the analysis of benthic community structure and composition (macroinfauna > 0.5 mm), porewater un-ionized ammonia and sulfide, and basic habitat parameters (depth, sediment grain size and TOC, dissolved oxygen, salinity, temperature, and pH). Sediment samples earmarked for contaminant analysis (metals, pesticides, PCBs, and PAHs) also are being collected at each station and sampling occasion; however, only one of the collections in each year will be processed initially and the rest will be archived for possible subsequent analysis pending results of other monitoring activities.

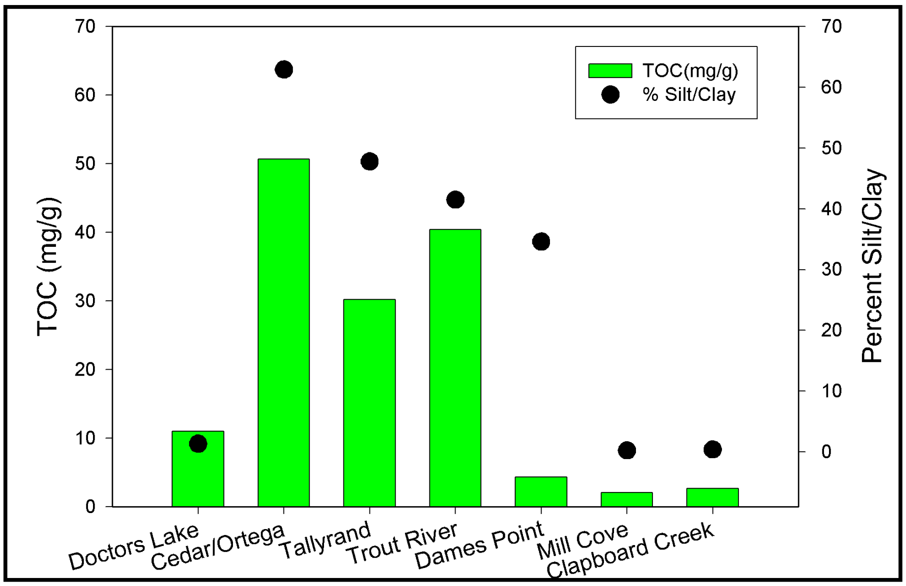

Figure 2. Sediment characteristics at MERHAB Florida stations in July 2000. Solid green bars indicate Total Organic Carbon (mg/g) and black circles indicate Percent Silt/Clay of the sediments.

3. Current Progress and Preliminary Findings

3A. Benthic Monitoring Component

Five sampling trips have been completed to date. Processing has been completed on benthic infaunal and sediment contaminant samples collected during the July 2000 cruise. Benthic infaunal processing is underway for samples collected during the November 2000, March 2001 and July 2001 cruises.

Key habitat characteristics of the seven sampling sites (Figs. 2 and 3, and Appendix A) can be summarized as follows: (1) relatively shallow water depths of 1.6 m to 6.4 m; (2) a wide range in salinity (oligohaline to euhaline salinities); (3) dissolved oxygen levels averaging 6.7 mg/L,

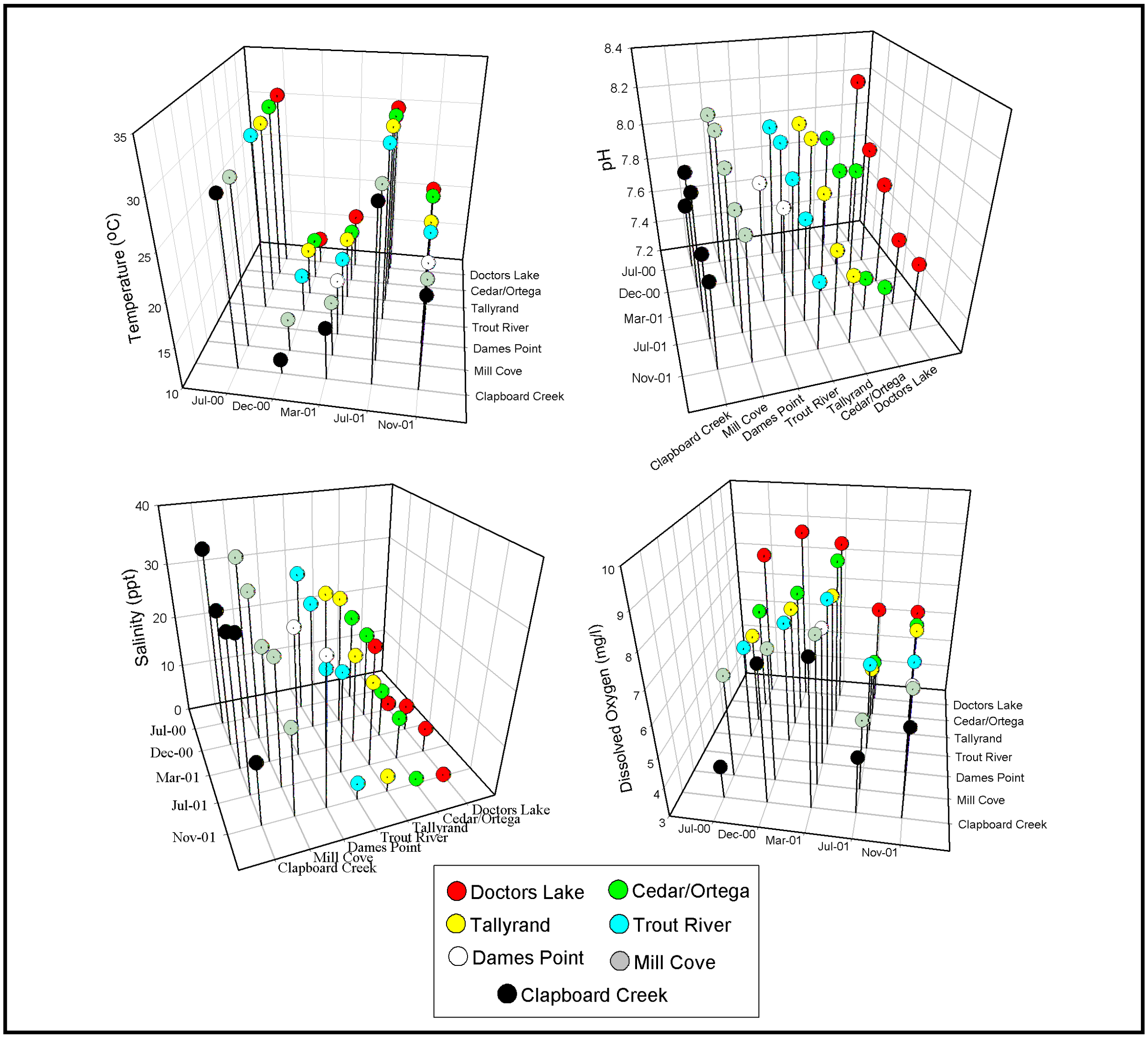

Figure 3. Bottom water quality characteristics at MERHAB Florida stations in July 2000, December 2000, March 2001, July 2001 and November 2001. Due to strong currents water quality measurements were made at the Dames Point station (white circle) only in March 2001, and November 2001.

which is above a reported benthic hypoxic effect threshold of 1.4 mg/L (Diaz and Rosenberg 1995); (4) total organic carbon in sediments ranging from low (Mill Cove – 2.1 mg/g) to very high (Cedar/Ortega River – 50.7 mg/g); and (5) sediment texture ranging from fine (Cedar/Ortega River – 62.9% Silt-Clay) to coarse (Mill Cove – 0.3% Silt-Clay). Seasonal variation is evident in the measured water quality parameters including temperature, salinity, pH, and dissolved oxygen (Fig. 3). Porewater hydrogen sulfide and un-ionized ammonia were measured at each station and showed a high degree of variation both by station and sampling cruise (Fig. 4).

Appendix B lists means and ranges in concentrations of various chemical contaminants measured in this study (i.e., pesticides, PAHs, PCBs, and metals) and, where available, corresponding sediment quality guidelines (SQG) for interpreting the biological significance of the observed contaminant levels. Two types of SQGs are included: 1) Effects Range-Low (ERL) and Effects

Range-Median (ERM) values of Long et al. (1995, updated from Long and Morgan 1990); and 2) Threshold Effects Level (TEL) and Probable Effects Level (PEL) values of MacDonald et al. (1996). ERL and TEL values are both lower-threshold bioeffect limits, below which adverse effects of the contaminants on sediment-dwelling organisms are not expected to occur. In contrast, ERM and PEL values both represent midrange concentrations of chemicals above which adverse effects are more likely to occur. Concentration-to-SQG comparisons were based on the lower ERL and upper ERM values for most chemicals (see appendix); in some cases, however (e.g., where updated ERL and ERM values were not available), the alternative TEL and PEL values were used.

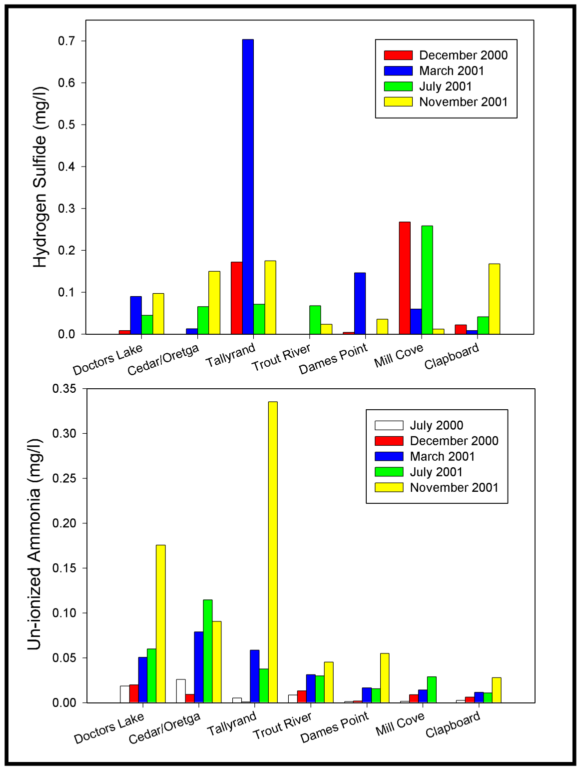

Figure 4. Porewater un-ionized ammonia and sulfide concentrations at MERHAB Florida sites in July 2000, December 2000, March 2001, July 2001, and November 2001. No sulfide measurements are reported for July 2000 because readings were not corrected for turbidity.

Sediments exhibited varying degrees of chemical contamination. Four of the sites, including the reference station Clapboard Creek, had sediments with all measured contaminants below corresponding, lower-threshold ERL/TEL guidelines. Three stations, Cedar/Ortega, Tallyrand and Trout River, exhibited "high" levels of contamination — defined here as one or more contaminants present at concentrations above upper-threshold ERM/PEL guideline values, or multiple (three or more) contaminants present at moderate concentrations between these lower and upper bioeffect thresholds (Table 1). Of particular note are the levels of sediment contamination at the Cedar/Ortega River and Tallyrand stations with 8 and 13 lower-threshold ERL/TEL guideline exceedences, respectively. This amount of contamination is exceptionally high in comparison to conditions throughout southeastern estuaries. Only 1.2% of stations sampled randomly in 1994 and 1995 as part of the Environmental Monitoring and Assessment Program (EMAP) had 13 or more ERL/TEL exceedences and only 4.8% of EMAP stations had 8 or more ERL/TEL

Table 1. MERHAB Florida stations with sediment contaminant concentrations exceeding ERL/TEL or ERM/PEL sediment quality guidelines in July 2000.

Station	Analyte	Concentration	ERL/TEL[a]	ERM/PEL[b]
Cedar/ Ortega	Acenaphthene (ng/g)	26.70	16.00	500.00
	Copper (µg/g)	109.00	34.00	270.00
	4′,4'-DDE (ng/g)	3.50	2.20	27.00
	Fluorene (ng/g)	39.00	19.00	540.00
	Mercury (µg/g)	0.50	0.15	0.71
	Lead (µg/g)	99.20	46.70	218.00
	Total DDTs[c] (ng/g)	4.96	1.58	46.10
	Total PCBs (ng/g)	125.41	22.70	180.00
Tallyrand	Acenaphthene (ng/g)	503.00	16.00	500.00
	Acenaphthylene (ng/g)	46.60	44.00	640.00
	Anthracene (ng/g)	542.00	85.30	1100.00
	Benzo(a)anthracene (ng/g)	723.00	261.00	1600.00
	Benzo(a)pyrene (ng/g)	435.00	430.00	1600.00
	Fluoranthene (ng/g)	2740.00	600.00	5100.00
	Fluorene (ng/g)	444.00	19.00	540.00
	2-Methylnaphthalene (ng/g)	281.00	70.00	670.00
	Naphthalene (ng/g)	676.00	160.00	2100.00
	Phenanthrene (ng/g)	1920.00	240.00	1500.00
	Pyrene (ng/g)	1550.00	665.00	2600.00
	Total PAHs[d] (ng/g)	12791.00	4022.00	44792.00
	Total PCBs (ng/g)	37.84	22.70	180.00
Trout River	Mercury (µg/g)	0.29	0.15	0.71
	Total DDTs[c] (ng/g)	1.80	1.58	46.10
	Total PCBs (ng/g)	66.78	22.70	180.00

[a] SQG value is the ERL value from Long et al. (1995), unless noted otherwise; [b] SQG value is the ERM value from Long et al. (1995), unless noted otherwise; [c]Total DDTs = 2´4´-DDD + 4´4´-DDD + 2´4´-DDE + 4´4´-DDE + 2´4´-DDT + 4´4´-DDT; [d]Without Perylene.

exceedences. (J. Hyland, unpublished data). At the Tallyrand station, two of the 13 chemicals in excess of ERL/TEL guidelines, Acenaphthene and Phenanthrene, also exceeded the higher ERM/PEL guidelines. At levels above ERM/PEL values adverse bioeffects on sediment-dwelling organisms are likely to occur.

Table 2. Top five numerically dominant species collected at each MERHAB Florida sampling station, July 2000. A = Anthozoa. An = Anopla. B = Bivalvia. G = Gastropoda. M = Malacostraca. P = Polychaeta. Po = Porifera. R = Rhynchocoela.

Station	Taxon	Abundance	% Abundance
Doctors Lake	*Streblospio benedicti* (P)	304	37.16
	Mytilopsis leucophaeata (B)	277	33.86
	Melitidae (M)	56	6.85
	Nereis succinea (P)	43	5.26
	Rhynchocoela (R)	36	4.40
Cedar/Ortega	*Macoma mitchelli* (B)	27	29.03
	Streblospio benedicti (P)	27	29.03
	Tellinidae (B)	10	10.75
	Hypereteone spp. (P)	8	8.60
	Rangia cuneata (B)	7	7.53
Tallyrand	*Streblospio benedicti* (P)	147	53.07
	Mediomastus ambiseta (P)	35	12.64
	Cyclaspis varians (M)	19	6.86
	Leucon americanus (M)	12	4.33
	Tubulanus spp. (An)	7	2.53
Trout River	*Odostomia impressa* (G)	88	42.11
	Nereis succinea (P)	24	11.48
	Grandidierella bonnieroides (M)	14	6.70
	Melita spp. (M)	12	5.74
	Dipolydora socialis (P)	6	2.87
Dames Point	*Sabellaria vulgaris* (P)	208	25.97
	Paracaprella pusilla (M)	125	15.61
	Actiniaria (A)	105	13.11
	Batea catharinensis (M)	69	8.61
	Tubulanus spp. (An)	34	4.24
Mill Cove	*Paraonis fulgens* (P)	29	58.00
	Americhelidium americanum (M)	3	6.00
	Batea catharinensis (M)	2	4.00
	Mediomastus spp. (P)	2	4.00
	Nephtys picta (P)	2	4.00
Clapboard Creek	*Gemma gemma* (B)	292	53.48
	Porifera (Po)	56	10.26
	Dipolydora socialis (P)	30	5.49
	Ampelisca spp. (M)	24	4.40
	Mediomastus spp. (P)	22	4.03

Appendix C provides a list of the benthic infaunal species collected in July 2000 at the MERHAB Florida sampling stations. Polychaete worms and molluscs dominated these benthic fauna. The polychaete, *Streblospio benedicti*, the most abundant species collected in all samples combined, is a species indicative of polluted environments (Pearson and Rosenberg 1978, Hyland et al. 1985). Dominant species, however, varied among sampling stations. Doctors Lake, Cedar/Ortega, Tallyrand and Trout River were dominated by species indicative of polluted environments (*Streblospio benedicti*, *Macoma sp.*, and *Nereis succinea*) while the remaining stations, inclusive of the reference station Clapboard Creek, were not (Table 2). Recall that three of these stations that were dominated by pollution indicators (Cedar/Ortega, Tallyrand, and Trout River) were also highly contaminated by chemicals (Table 1).

Table 3. Characteristics of benthic macroinfaunal (> 0.5mm) at stations sampled for the MERHAB Florida Program, July 2000. Three replicate grabs ($0.04\ m^2$) were taken at each station. H′ was calculated using base-2 logarithms.

Station	Mean Abundance (No./grab)	Mean Density (No./m^2)	Mean No. Taxa (per grab)	Mean Diversity (H′)
Doctors Lake	273	6817	16	2.37
Cedar/Ortega	31	775	7	2.24
Tallyrand	92	2308	16	2.74
Trout River	70	1742	17	3.05
Dames Point	267	6675	42	3.84
Mill Cove	17	417	7	2.06
Clapboard Creek	182	4550	24	2.39

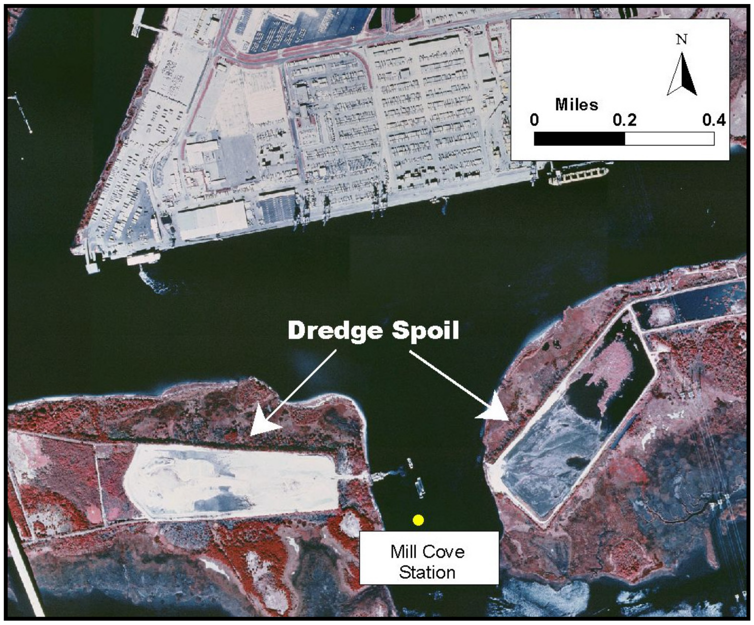

Figure 5. MERHAB Florida Mill Cove Station, Lower St. Johns River, Florida.

The macroinfaunal assemblages in the St. Johns River displayed a wide range in measures of diversity and abundance (Table 3). Dames Point had the highest species richness and diversity while Cedar/Ortega and Mill Cove tied for the lowest mean species richness with an average of 7 species per sample. Mill Cove also had the lowest mean H' diversity and density. The low values of these various measures support that Mill Cove (in addition to Doctors Lake, Cedar/Ortega, Tallyrand and Trout River) also exhibits evidence of impaired benthic condition. The degraded benthos at Mill Cove may be explained by its close proximity to dredge spoil sites (Fig. 5). Chemical contaminants at Mill Cove were at relatively low levels below ERL/TEL SQGs (Appendix B). However, porewater sulfide concentrations (though variable) were among the highest at this site (Fig. 4).

3B. System-Wide Data Management and the Continuous Water-Quality Monitoring Component

System-wide data management activities have focused on development of the framework for capturing and disseminating continuous monitoring data from the instrumented platform located at the Trout River station. These data are being transferred via the GOES satellite system every

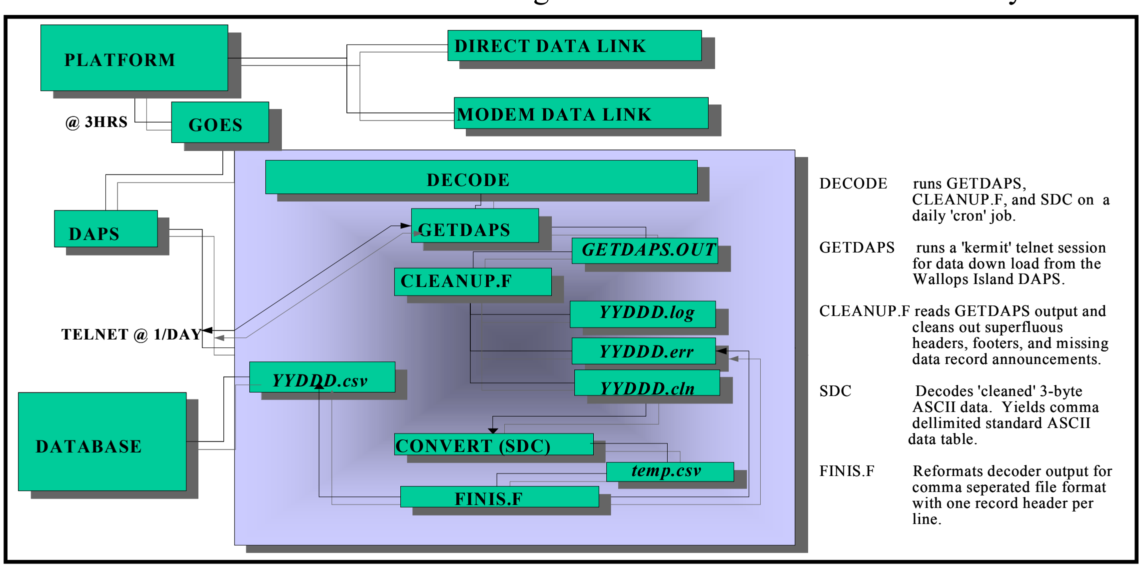

Figure 6. Schematic diagram of near-real time data retrieval from the autonomous instrumented platform.

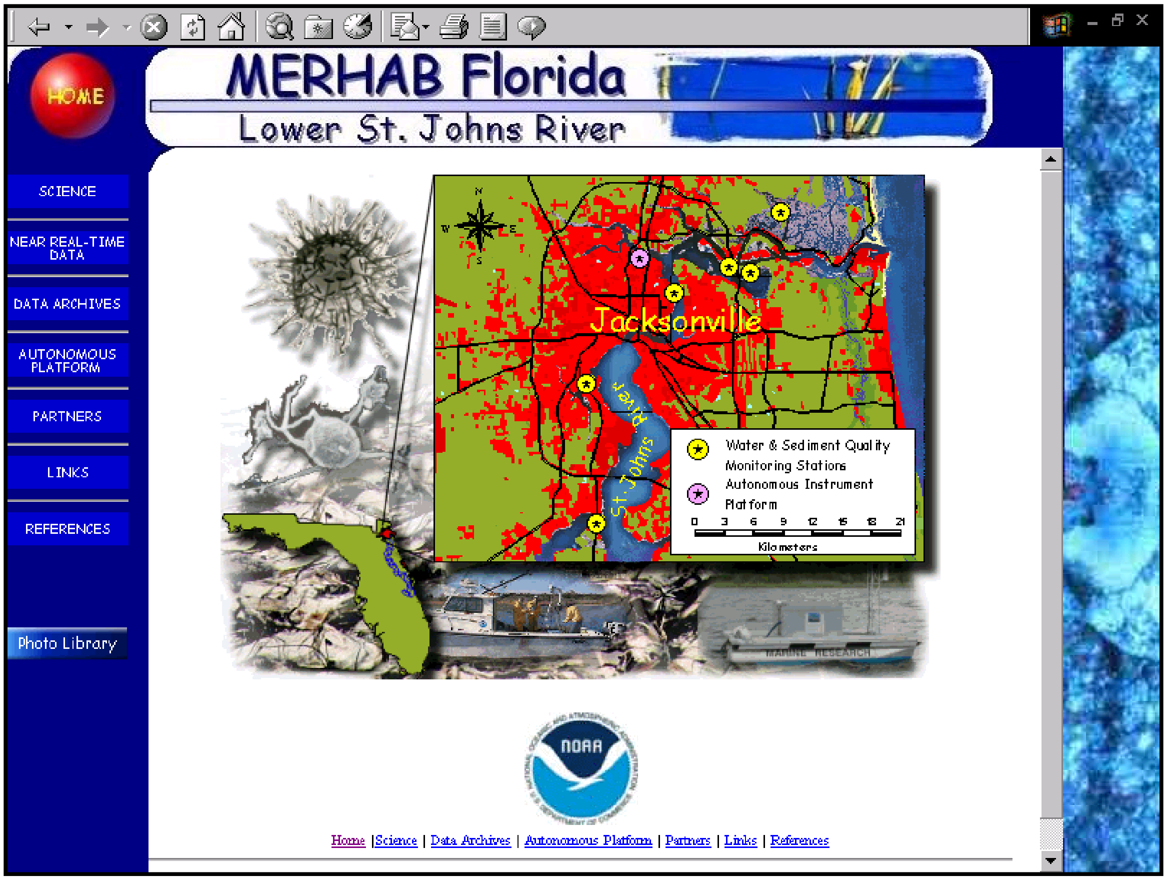

Figure 7. View of the front-page of new MERHAB Florida website, currently under review.

three hours and are currently being retrieved by the CCMA – Charleston Team using an automated process (Fig. 6). The near real-time data on a suite of chemical, physical and biological variables are then being processed and stored in an Oracle Database for subsequent use by research partners and all other interested users.

A MERHAB Florida website also has been developed to facilitate the dissemination of this information to as wide a user audience as possible (Fig. 7). This website is currently under review and will be made available to the public in January 2002. The website will provide direct access to various types of information including the near-real time data on water-quality variables measured by the platform; data archives associated with the additional seasonal intensive monitoring at the various fixed stations; and general information on scientific approaches, significant developments and products.

4. Conclusions

- Chemical contamination of sediment at levels likely of having adverse effects on benthic fauna was observed at three stations nearest the center of Jacksonville (Cedar/Ortega, Tallyrand, and Trout River). Concentrations of man-made pesticides or other chemical substances typically associated with human activities (e.g., PCBs) were detectable at all stations, though not always present at concentrations likely of causing significant bioeffects. The widespread distribution of these contaminants is most likely attributable to the proximity to a major metropolitan area with potential pollutant inputs from shipping, marinas, commercial shipbuilding and repair, military bases, pulp and paper manufacturing, petroleum storage facilities, power generation, fishing, urban and high-density residential development, and recreation. Other sources include a wide variety of agricultural activities throughout the LSJR watershed and several Superfund sites.

- Variable and often high levels of porewater un-ionized ammonia and hydrogen sulfide were detected at the MERHAB Florida sampling stations and indicate the potential for problems associated with eutrophication. High concentrations of H_2S, for example, may explain the incidence of impaired benthic condition at Mill Cove, where there were low levels of chemical contaminants in sediments.
- Benthic macroinfaunal communities at five of the seven sites sampled in the lower St. Johns River show indication of stress that could be associated with anthropogenic activities. Four sites (Doctors Lake, Cedar/Ortega, Tallyrand, and Trout River) are dominated by species indicative of polluted environments. One additional site (Mill Cove) shows degraded condition based on values of several benthic community measures.
- In a heavily developed system such as the St. Johns River any evaluation of the impacts of Harmful Algal Blooms on benthic communities would have to take into account the relative contributions of impacts resulting from multiple stressors.
- Data are being remotely retrieved from the autonomous instrumented platform via the GOES satellite system. A MERHAB Florida website for disseminating this and related monitoring data has been developed and is currently under review.

5. Acknowledgments

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Appendix A. Summary of station location and water quality data for stations sampled in the St. Johns River in July 2000, December 2000, March 2001, July 2001 and November 2001.

Station	Latitude	Longitude	Bottom Water				
			Depth (m) Average (min. – max.)	Temperature (°C) Average (min. – max.)	Salinity (ppt) Average (min. – max.)	Dissolved Oxygen (mg/L) Average (min. – max.)	pH Average (min. – max.)
Doctors Lake	30.1495°	81.6992°	4.3 (3.5 – 5.0)	22.5 (13.3 – 30.9)	4.6 (0.4 – 10.7)	7.6 (6.4 – 8.8)	7.8 (7.6 – 8.2)
Cedar/Ortega River	30.2768°	81.7113°	2.0 (1.6 – 2.3)	23.0 (15.1 – 30.7)	11.0 (1.1 – 17.8)	6.7 (5.0 – 8.3)	7.7 (7.4 – 7.9)
Tallyrand	30.3598°	81.6195°	3.7 (1.7 – 5.3)	22.9 (15.8 – 30.6)	17.4 (3.2 – 25.4)	6.56 (5.3 – 7.6)	7.8 (7.6 – 8.0)
Trout River	30.3913°	81.6550°	2.8 (2.1 – 3.1)	22.7 (14.6 – 30.2)	18.6 (3.4 – 28.0)	6.7 (6.0 – 7.9)	7.7 (7.6 – 8.0)
Dames Point*	30.3831°	81.5613°	6.4 (3.5 – 9.2)	18.35 (16.8 – 19.9)	26.3 (25.1 – 27.5)	6.8 (6.0 – 7.5)	8.0 (7.9 – 8.0)
Mill Cove	30.3792°	81.5388°	3.2 (1.8 – 4.0)	21.8 (14.0 – 29.3)	25.2 (17.0 – 32.4)	6.7 (5.4 – 7.8)	8.0 (7.9 – 8.1)
Clapboard Creek	30.4342°	81.5075°	1.6 (1.4 – 1.9)	21.5 (11.8 – 29.4)	25.8 (12.3 – 34.4)	6.0 (4.1 – 7.7)	7.8 (7.6 – 7.9)

* At Dames Point bottom water quality measured only in March 2001 and November 2001 due to strong currents during other sampling events.

Appendix B. Summary of contaminant concentrations and sediment quality guideline (SQG) exceedences at St. Johns River MERHAB sites in July 2000 (n = 7 sites). Concentrations of analytes below method detection limits are reported as < MDL. SQG exceedences are bolded.

Analyte	Station							SQG	
	Doctors Lake	Cedar/ Ortega	Tallyrand	Trout River	Dames Point	Mill Cove	Clapboard Creek	ER-L/TEL[a]	ER-M/PEL[b]
Metals (µg/g dry wt., unless otherwise indicated)									
Aluminum (%)	0.29	1.69	1.44	2.32	1.30	0.02	0.11	--	--
Arsenic	0.35	5.00	4.99	6.96	1.44	<MDL	0.18	8.2	70
Cadmium	0.02	0.74	0.18	0.33	0.06	<MDL	<MDL	1.2	9.6
Chromium	<MDL	37.80	30.90	47.50	7.60	<MDL	<MDL	81	370
Copper	1.38	**109.00**	16.20	27.20	0.53	0.21	<MDL	34	270
Iron (%)	0.29	2.72	1.98	3.11	0.78	0.04	0.12	--	--
Lead	5.25	**99.20**	44.50	43.60	6.61	0.54	0.88	46.7	218
Manganese	32.00	157.00	180.00	208.00	30.10	8.42	4.89	--	--
Mercury	0.02	**0.50**	0.07	**0.29**	0.01	<MDL	<MDL	0.15	0.71
Nickel	2.21	14.00	11.80	17.20	3.36	0.40	0.74	20.9	51.6
Selenium	0.09	0.65	0.32	0.07	<MDL	<MDL	<MDL	--	--
Silver	<MDL	0.47	0.18	0.26	<MDL	<MDL	<MDL	1.0	3.7
Tin	<MDL	4.93	1.88	4.35	<MDL	<MDL	<MDL	--	--
Zinc	<MDL	124.00	42.60	126.00	<MDL	19.70	<MDL	150	410
PAHs (ng/g dry wt.)									
Acenaphthene	<MDL	**26.70**	**503.00**	<MDL	<MDL	<MDL	<MDL	16	500
Acenaphthylene	<MDL	16.50	**46.60**	12.10	<MDL	<MDL	<MDL	44	640
Anthracene	<MDL	41.90	**542.00**	17.10	<MDL	<MDL	<MDL	85.3	1100
Benzo(a)anthracene	<MDL	151.00	**723.00**	71.60	<MDL	<MDL	<MDL	261	1600
Benzo(a)pyrene	<MDL	195.00	435.00	112.00	<MDL	<MDL	<MDL	430	1600
Benzo(b)fluoranthene	11.80	255.00	495.00	123.00	<MDL	<MDL	<MDL	--	--
Benzo(e)pyrene	9.90	167.00	**296.00**	103.00	<MDL	<MDL	<MDL	--	--
Benzo(g,h,i)perylene	11.70	147.00	201.00	95.10	<MDL	<MDL	<MDL	--	--
Benzo(j+k)fluoranthene	12.10	193.00	417.00	132.00	<MDL	<MDL	<MDL	--	--
Biphenyl	<MDL	25.40	95.70	<MDL	10.60	<MDL	<MDL	--	--
Chrysene+Triphenylene	10.20	216.00	712.00	89.10	3.75	<MDL	<MDL	--	--
Dibenz(a,h+a,c)anthracene	2.04	23.50	38.60	23.00	1.94	<MDL	<MDL	63.4	260
Dibenzothiophene	<MDL	15.20	181.00	<MDL	<MDL	<MDL	<MDL	--	--
2,6 Dimethylnaphthalene	<MDL	11.20	102.00	<MDL	<MDL	<MDL	<MDL	--	--
Fluoranthene	20.80	468.00	**2740.00**	151.00	9.16	<MDL	<MDL	600	5100
Fluorene	<MDL	**39.00**	**444.00**	10.20	<MDL	<MDL	<MDL	19	540
Indeno(1,2,3-cd)pyrene	12.40	162.00	246.00	91.00	<MDL	<MDL	<MDL	--	--
1-Methylnaphthalene	<MDL	19.90	138.00	15.90	<MDL	<MDL	<MDL	--	--
2-Methylnaphthalene	<MDL	33.70	**281.00**	19.90	<MDL	<MDL	<MDL	70	670

Appendix B. Continued

Analyte	Station							SQG	
	Doctors Lake	Cedar/ Ortega	Tallyrand	Trout River	Dames Point	Mill Cove	Clapboard Creek	ER-L/TEL[a]	ER-M/PEL[b]
1-Methylphenanthrene	<MDL	24.10	136.00	11.90	<MDL	<MDL	<MDL	--	--
Naphthalene	<MDL	131.00	**676.00**	60.00	<MDL	<MDL	<MDL	160	2100
Perylene	28.20	173.00	141.00	55.20	5.21	<MDL	<MDL	240	1500
Phenanthrene	6.76	157.00	**1920.00**	49.30	<MDL	<MDL	<MDL	--	--
Pyrene	20.70	454.00	**1550.00**	187.00	8.73	<MDL	<MDL	665	2600
1,6,7 Trimethylnaphthalene	<MDL	16.20	53.10	<MDL	<MDL	<MDL	<MDL	--	--
Total PAHs[c]	118.40	2974.10	**12791.00**	1374.20	34.18	<MDL	<MDL	4022	44792
PCBs (ng/g dry wt.)									
Total PCBs	17.15	**125.40**	**37.86**	**66.77**	7.29	4.95	4.66	22.7	180
Pesticides (ng/g dry wt.)									
Aldrin	<MDL	<MDL	0.02	<MDL	<MDL	<MDL	<MDL	--	--
Alpha-chlordane	<MDL	0.25	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Chlorpyrifos	<MDL	<MDL	<MDL	1.40	0.21	<MDL	<MDL	--	--
Dieldrin	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	15.2[d]	0.715[e]
Endosulfan ether	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Endosulfan I	<MDL	<MDL	0.24	0.21	<MDL	<MDL	<MDL	--	--
Endosulfan II	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Endosulfan lactone	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Endosulfan Sulfate	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Heptachlor	<MDL	0.04	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Heptachlor epoxide	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Hexachlorobenzene	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Lindane[f]	<MDL	<MDL	<MDL	0.08	<MDL	<MDL	<MDL	0.32[d]	0.99[e]
Mirex	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
Trans-nonachlor	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	--	--
4'4'-DDD	<MDL	1.21	<MDL	0.43	<MDL	<MDL	<MDL	1.22[d]	7.81[e]
4'4'-DDE	0.29	**3.50**	0.81	1.31	0.05	<MDL	<MDL	2.20	27.00
4'4'-DDT	0.16	0.14	0.10	0.06	0.04	<MDL	<MDL	1.19[d]	4.77[e]
DDD[g]	<MDL	1.33	0.17	0.43	<MDL	<MDL	<MDL	--	--
DDE[g]	0.29	3.50	0.81	1.31	0.05	<MDL	<MDL	--	--
DDT[g]	0.16	0.14	0.10	0.06	0.04	<MDL	<MDL	--	--
Total DDTs[h]	0.45	**4.97**	1.08	**1.80**	0.09	<MDL	<MDL	1.58[d]	46.1[e]

[a] SQG value is the ERL value from Long et al. (1995), unless noted otherwise; [b] SQG value is the ERM value from Long et al. (1995), unless noted otherwise; [c]Without Perylene; [d]TEL value from MacDonald et al. (1996); [e]PEL value from MacDonald et al. (1996); [f]Gamma BHC; [g]DDD = 2´4´-DDD + 4´4´-DDD; DDE = 2´4´-DDE + 4´4´-DDE; DDT = 2´4´-DDT + 4´4´-DDT; [h]Total DDTs = 2´4´-DDD + 4´4´-DDD + 2´4´-DDE + 4´4´-DDE + 2´4´-DDT + 4´4´-DDT.

Appendix C. List of macrobenthic species collected at MERHAB Florida sampling sites, July 2000. Specimens were identified to the lowest possible identification level (LPIL).

Taxon Name	Abundance	% Abundance	Cumulative Abundance	% Cumulative Abundance
Streblospio benedicti	499	17.86	499	17.86
Gemma gemma	292	10.45	791	28.31
Mytilopsis leucophaeata	277	9.91	1068	38.22
Sabellaria vulgaris	209	7.48	1277	45.71
Paracaprella pusilla	127	4.55	1404	50.25
Actiniaria (LPIL)	120	4.29	1524	54.55
Odostomia impressa	88	3.15	1612	57.70
Batea catharinensis	72	2.58	1684	60.27
Nereis succinea	72	2.58	1756	62.85
Melitidae (LPIL)	60	2.15	1816	65.00
Porifera (LPIL)	56	2.00	1872	67.00
Dipolydora socialis	54	1.93	1926	68.93
Rhynchocoela (LPIL)	49	1.75	1975	70.69
Mediomastus (LPIL)	47	1.68	2022	72.37
Tubulanus (LPIL)	47	1.68	2069	74.05
Mediomastus ambiseta	38	1.36	2107	75.41
Ampelisca (LPIL)	29	1.04	2136	76.45
Macoma mitchelli	29	1.04	2165	77.49
Paraonis fulgens	29	1.04	2194	78.53
Eusarsiella zostericola	28	1.00	2222	79.53
Ischadium recurvum	27	0.97	2249	80.49
Rangia cuneata	26	0.93	2275	81.42
Cyclaspis varians	21	0.75	2296	82.18
Diopatra cuprea	21	0.75	2317	82.93
Melita (LPIL)	19	0.68	2336	83.61
Xanthidae (LPIL)	19	0.68	2355	84.29
Tellinidae (LPIL)	18	0.64	2373	84.93
Grandidierella bonnieroides	15	0.54	2388	85.47
Leucon americanus	13	0.47	2401	85.93
Pista quadrilobata	13	0.47	2414	86.40
Ascidiacea (LPIL)	12	0.43	2426	86.83
Hypereteone (LPIL)	12	0.43	2438	87.26
Lucina multilineata	12	0.43	2450	87.69
Marenzellaria viridis	12	0.43	2462	88.12

Appendix C. Continued

Taxon Name	Abundance	% Abundance	Cumulative Abundance	% Cumulative Abundance
Assiminea succinea	11	0.39	2473	88.51
Polydora cornuta	11	0.39	2484	88.90
Sigambra tentaculata	11	0.39	2495	89.30
Aeginellidae (LPIL)	10	0.36	2505	89.66
Nereis lamellosa	10	0.36	2515	90.01
Sphenia antillensis	9	0.32	2524	90.34
Corophium (LPIL)	8	0.29	2532	90.62
Mactridae (LPIL)	7	0.25	2539	90.87
Nucula proxima	7	0.25	2546	91.12
Anadara transversa	6	0.21	2552	91.34
Exogone (LPIL)	6	0.21	2558	91.55
Hydroides dianthus	6	0.21	2564	91.77
Leitoscoloplos robustus	6	0.21	2570	91.98
Nereis micromma	6	0.21	2576	92.20
Paraprionospio pinnata	6	0.21	2582	92.41
Podarkeopsis levifuscina	6	0.21	2588	92.63
Ampelisca abdita	5	0.18	2593	92.81
Amphilochidae (LPIL)	5	0.18	2598	92.98
Cyathura polita	5	0.18	2603	93.16
Heteromastus filiformis	5	0.18	2608	93.34
Aoridae (LPIL)	4	0.14	2612	93.49
Bivalvia (LPIL)	4	0.14	2616	93.63
Cirrophorus (LPIL)	4	0.14	2620	93.77
Demonax (LPIL)	4	0.14	2624	93.92
Edotia triloba	4	0.14	2628	94.06
Magelona sp. H	4	0.14	2632	94.20
Nereis (LPIL)	4	0.14	2636	94.35
Ophiuroidea (LPIL)	4	0.14	2640	94.49
Podarke obscura	4	0.14	2644	94.63
Prionospio (LPIL)	4	0.14	2648	94.77
Tubificoides heterochaetus	4	0.14	2652	94.92
Abra aequalis	3	0.11	2655	95.03
Aglaophamus verrilli	3	0.11	2658	95.13
Americhelidium americanum	3	0.11	2661	95.24
Armandia maculata	3	0.11	2664	95.35
Capitella capitata	3	0.11	2667	95.45
Cerapus benthophilus	3	0.11	2670	95.56
Clinotanypus (LPIL)	3	0.11	2673	95.67

Appendix C. Continued

Taxon Name	Abundance	% Abundance	Cumulative Abundance	% Cumulative Abundance
Corbulidae (LPIL)	3	0.11	2676	95.78
Corophium lacustre	3	0.11	2679	95.88
Crassostrea virginica	3	0.11	2682	95.99
Gyptis pluriseta	3	0.11	2685	96.10
Latreutes parvulus	3	0.11	2688	96.21
Leitoscoloplos (LPIL)	3	0.11	2691	96.31
Leptosynapta tenuis	3	0.11	2694	96.42
Mytilidae (LPIL)	3	0.11	2697	96.53
Nereiphylla fragilis	3	0.11	2700	96.64
Ogyrides alphaerostris	3	0.11	2703	96.74
Panopeus herbstii	3	0.11	2706	96.85
Serpulidae (LPIL)	3	0.11	2709	96.96
Tubificidae (LPIL)	3	0.11	2712	97.07
Ampelisca vadorum	2	0.07	2714	97.14
Bateidae (LPIL)	2	0.07	2716	97.21
Ceratonereis irritabilis	2	0.07	2718	97.28
Cryptochironomus (LPIL)	2	0.07	2720	97.35
Eobrolgus spinosus	2	0.07	2722	97.42
Euceramus praelongus	2	0.07	2724	97.49
Gastropoda (LPIL)	2	0.07	2726	97.57
Lepidonotus sublevis	2	0.07	2728	97.64
Lepidonotus variabilis	2	0.07	2730	97.71
Melita longisetosa	2	0.07	2732	97.78
Mitrella lunata	2	0.07	2734	97.85
Nephtys picta	2	0.07	2736	97.92
Nereis riisei	2	0.07	2738	98.00
Notomastus hemipodus	2	0.07	2740	98.07
Paraeupolymnia sp. A	2	0.07	2742	98.14
Phyllodoce arenae	2	0.07	2744	98.21
Piromis roberti	2	0.07	2746	98.28
Sabaco americanus	2	0.07	2748	98.35
Sabellidae (LPIL)	2	0.07	2750	98.43
Scoloplos rubra	2	0.07	2752	98.50
Tellina (LPIL)	2	0.07	2754	98.57
Terebellidae (LPIL)	2	0.07	2756	98.64
Tharyx acutus	2	0.07	2758	98.71
Vitrinellidae (LPIL)	2	0.07	2760	98.78
Acteocina canaliculata	1	0.04	2761	98.82

Appendix C. Continued

Taxon Name	Abundance	% Abundance	Cumulative Abundance	% Cumulative Abundance
Ampharetidae (LPIL)	1	0.04	2762	98.85
Amygdalum papyria	1	0.04	2763	98.89
Anachis lafresnayi	1	0.04	2764	98.93
Capitellidae (LPIL)	1	0.04	2765	98.96
Cerapus (LPIL)	1	0.04	2766	99.00
Chione intapurpurea	1	0.04	2767	99.03
Cirratulidae (LPIL)	1	0.04	2768	99.07
Columbellidae (LPIL)	1	0.04	2769	99.11
Corbula (LPIL)	1	0.04	2770	99.14
Diplodonta (LPIL)	1	0.04	2771	99.18
Epitonium (LPIL)	1	0.04	2772	99.21
Epitonium multistriatum	1	0.04	2773	99.25
Glycinde solitaria	1	0.04	2774	99.28
Hydrobiidae (LPIL)	1	0.04	2775	99.32
Ilyanassa trivittata	1	0.04	2776	99.36
Mediomastus californiensis	1	0.04	2777	99.39
Monoculodes (LPIL)	1	0.04	2778	99.43
Nassarius vibex	1	0.04	2779	99.46
Odostomia (LPIL)	1	0.04	2780	99.50
Owenia fusiformis	1	0.04	2781	99.53
Phoronis (LPIL)	1	0.04	2782	99.57
Pinnotheridae (LPIL)	1	0.04	2783	99.61
Polypedilum scalaenum group	1	0.04	2784	99.64
Porcellanidae (LPIL)	1	0.04	2785	99.68
Spiochaetopterus oculatus	1	0.04	2786	99.71
Spionidae (LPIL)	1	0.04	2787	99.75
Streblosoma hartmanae	1	0.04	2788	99.79
Streptosyllis pettiboneae	1	0.04	2789	99.82
Syllis (LPIL)	1	0.04	2790	99.86
Synidotea (LPIL)	1	0.04	2791	99.89
Ungulinidae (LPIL)	1	0.04	2792	99.93
Veneridae (LPIL)	1	0.04	2793	99.96
Vitrinella floridana	1	0.04	2794	100.00