Initial Assessment of Sediment Quality and Benthic Condition within the Lower St. John's River Estuary

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Abstract

A large, multi-disciplinary research 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 within the Lower St. John's River estuary (LSJR), Florida. One aspect of the overall program is the monitoring of benthic macroinfaunal communities and associated analysis of chemical contaminants and other stressors (e.g., ammonia, sulfide) in sediments, thereby providing the overall program with a basis for interpreting potential biological impacts in the LSJR in relation to multiple stressor inputs. Potential pollution inputs include shipping, marinas, commercial shipbuilding and repair, military bases, pulp and paper manufacturing, petroleum storage facilities, power generation, urban and high-density residential development, and water-based recreation. The river also supports commercial and recreational fishing, a wide variety of agricultural activities, and includes several superfund sites. Reported here are the results from the initial sampling event of July 2000. Benthic macroinfaunal communities at five of the seven sites sampled in the LSJR show indications of stress that could be associated with anthropogenic activities. Four sites are dominated by species indicative of polluted environments and one additional site shows degraded condition based on values of several benthic community measures. Chemical contamination of sediments likely to have adverse effects on benthic fauna was observed at three stations. However, concentrations of man-made pesticides or other chemical substances typically associated with human activities (e.g., PCBs) were detectable at all stations.

Introduction

An overall objective of the *M*onitoring and *E*vent *R*esponse for *HAB*s (*MERHAB*) Florida Monitoring Program, established in October 1999, is provide a comprehensive estuarine monitoring program that will 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 Lower St. John's River (LSJR) estuary. The MERHAB Florida Monitoring program can be divided into two main groups of monitoring activities, continuous and seasonal. Continuous monitoring of a suite of physical, chemical, and biological variables at multiple water depths is conducted from an autonomous instrumented platform located within the LSJR. Further information on this aspect of the program and 24-hour data can be found at www.MERHABFL.org. Seasonal intensive monitoring is conducted at six fixed stations and one reference station. This intensive monitoring can be broken down into the following major components each with objectives designed to address the overall goal of the MERHAB Florida project: phytoplankton monitoring; bacterial monitoring; and benthic monitoring. Reported here are the results of the benthic monitoring component from the first round of seasonal monitoring activities in July 2000.

The benthic component of this program is designed to address the following 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 a basis for examining potential relationships between HAB events and processes occurring in bottom substrates; and (3) 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 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 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.

Methods

Seasonal monitoring is being conducted over a two-year period (July 2000 to July 2002) and includes seasonal sampling (July, November/December, March) of biotic and environmental variables in both sediments and the water column at seven fixed stations (Fig. 1). Benthic samples are being collected at each of the seven fixed monitoring stations during each monitoring event. 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.

Three replicate macroinfaunal samples were collected from each station with a 0.04m^2 Young grab sampler. Samples were collected to a maximum sediment depth of 10 cm and were rejected if <5 cm. Contents of grabs were live sieved in the field with a 0.5 mm mesh screen, fixed in 10% buffered formalin with rose Bengal, and transferred to the laboratory for further processing. Animals were sorted from sample debris and identified to the lowest practical taxon. Total Organic Carbon (TOC) and sediment grain-size characteristics were measured at each station in subsamples of composited surface sediment (upper 2-3 cm) collected with a Young grab sampler. Subsamples were obtained from the same composite source used for analysis of chemical contaminants. A single composite sediment sample was analyzed for chemical contaminants at each station; duplicates were run at ~10% of the stations for quality control purposes. A total of 12 inorganic metals, 25 polynuclear aromatic hydrocarbons (PAHs), 26 polychlorinated biphenyls (PCBs), and 21 pesticides were measured at each station.

Biological significance of contaminant levels was evaluated in relation to two types of numerical sediment quality guidelines: Effects Range-Low (ERL) and Effects Range-Median (ERM) values (Long et al., 1995; Long and Morgan, 1990); and Threshold Effects Level (TEL) and Probable Effects Level (PEL) values (MacDonald et al., 1996).

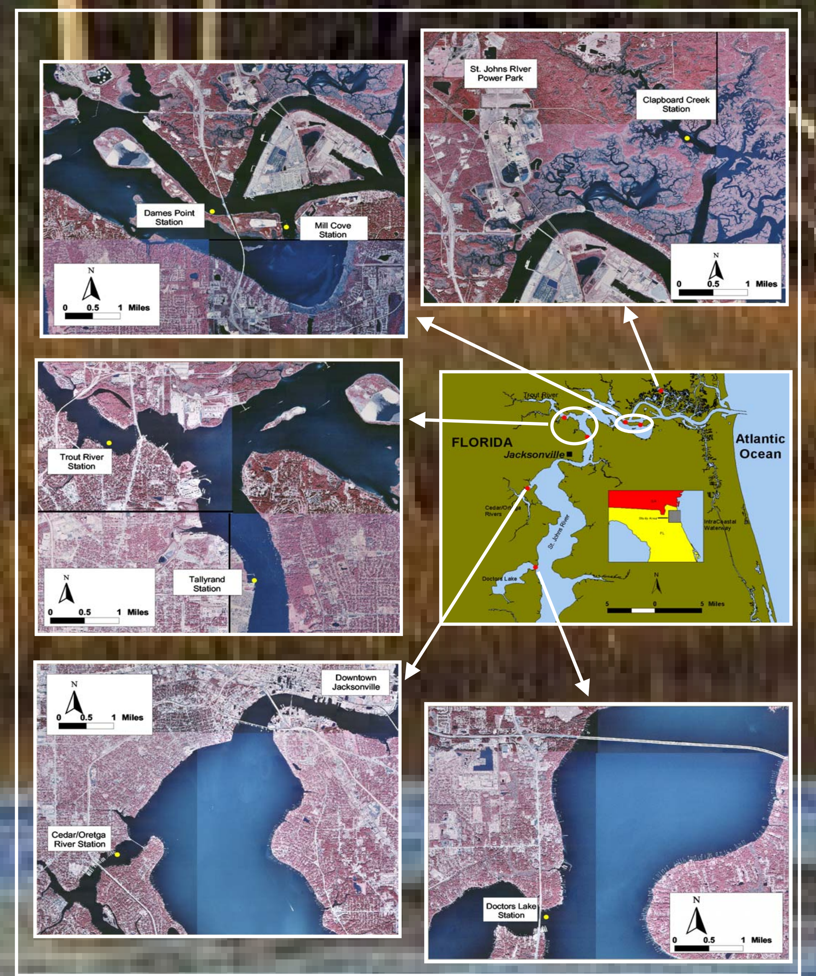

Figure 1. Locations for MERHAB Florida Monitoring stations in the Lower St. John's River estuary.

Results

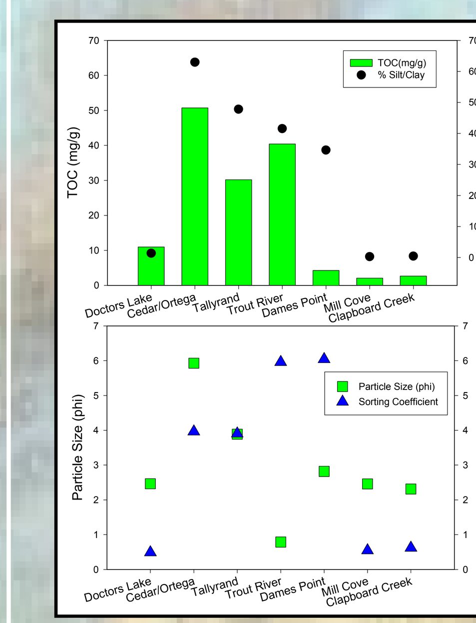

Figure 2. Sediment characteristics at MERHAB Florida stations in July 2000.

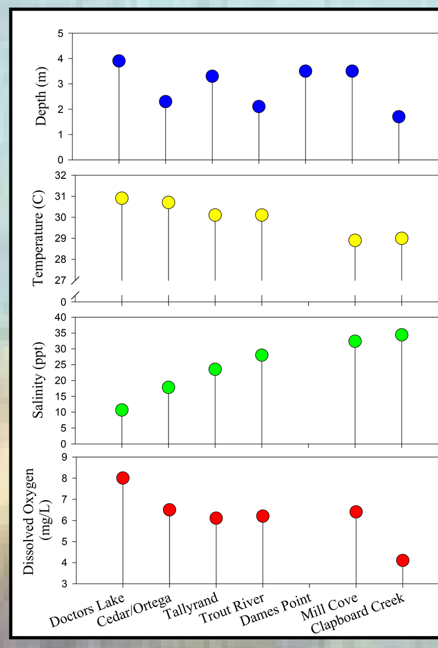

Figure 3. Bottom water quality characteristics for July 2000. Due to strong currents bottom water quality measurements were not taken at the Dames Point station.

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.

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	*Streblospio benedicti* (P)	27	29.03
	Macoma mitchelli (B)	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

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

❖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 exceedances, 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 exceedances and only 4.8% of EMAP stations had 8 or more ERL/TEL exceedances. (J. Hyland, unpublished data).

❖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).

Conclusions

➢Chemical contamination of sediment at levels likely to have 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 multiple pollutant inputs.

➢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.

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