The Hart-Miller Island Exterior Monitoring Program

Year 16 **Draft** Technical Report for COC Review

Compiled by Matthew Rowe
5/12/00

DRAFT TECHNICAL

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CONVERSIONS[2]

WEIGHT:

1Kg = 1000g = 2.205 lbs.
1g = 1000mg = 2.205 x 10^{-3}lbs
1mg = 1000μg = 2.205 x 10^{-3}lbs

1 lb = 16oz = 0.454Kg

LENGTH:

1m = 100cm = 3.281ft = 39.370in
1cm = 10mm = 0.394in
1mm = 1000μm = 0.039in

1ft = 12in = 0.348m

CONCENTRATION:

1ppm = 1mg/L = 1mg/Kg = 1μg/g = 1mL/m^3
1g/cc = 1Kg/L = 8.345 lbs/gallon
1g/m^3 = 1mg/L = 6.243 x 10^{-5}lbs/ft^3

1 lb/gal = 7.481 lbs/ft^3 = 0.120g/cc = 119.826g/L = 119.826Kg/m^3
1oz/gal = 7.489Kg/m^3

VOLUME:

1L = 1000mL
1mL = 1000μL
1cc = 10^{-6} m^3

1yd^3 = 27ft^3 = 764.560L = 0.764m^3
1acre-ft = 1233.482m^3
1 gallon = 3785cc
1ft^3 = 0.028m^3 = 28.317L

FLOW:

1m/s = 196.850ft/min = 3.281ft/s
1m^3/s = 35.320ft^3/s

1ft^3/s = 1699.011L/min = 28.317L/s
1ft^2/hr = 2.778 x 10^{-4}ft^2/s = 2.581 x 10^{-5}m^2/s
1ft/s = 0.031m/s
1yd^3/min = 0.45ft^3/s
1yd^3/s = 202gal/s = 764.560L/s

AREA:

1m^2 = 10.764ft^2
1hectare = 10000m^2 = 2.471acres

1ft^2 = 0.093m^2
1acre = 4046.856m^2 = 0.405 hectares

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[2] Modified from the June 1994 Draft "Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual" published by the U.S. Environmental Protection Agency and the U.S. Army Corp of Engineers.

MS - Mass Spectrometry

NBS - National Bureau of Standards

NIST - National Institute of Standards and Technology

NOAA - National Oceanic and Atmospheric Administration

NRC - National Research Council of Canada

PAH - Polynuclear Aromatic Hydrocarbons

PCB - Polychlorinated Biphenyl

ppb - Parts per billion

ppm - Parts per million

ppt - Parts per thousand

QA - Quality Assurance

QC - Quality Control

SOP - Standard Operating Procedure

SRM - Standard Reference Material

TARSA - Technical and Regulatory Services Administration

TBP - Theoretical Bioaccumulation Potential

TDL - Target Detection Limit

TOC - Total Organic Carbon

TRC - Technical Review Committee

UMCES - University of Maryland Center for Environmental Science

USACE - U.S. Army Corps of Engineers

EPA - United States Environmental Protection Agency

WQC - Water Quality Certification

CHAPTER 1: PROJECT MANAGEMENT AND TECHNICAL/SCIENTIFIC COORDINATION (PROJECT I)

Hart-Miller Island Exterior Monitoring Program

July 1997 - April 1999

Prepared for

Maryland Port Administration
Maryland Department of Transportation

By

Visty P. Dalal, Chairman, Exterior Monitoring Program
Matthew Rowe, Technical Coordinator, Exterior Monitoring Program

Dredging Coordination and Assessment Division
Technical and Regulatory Services Administration
Maryland Department of the Environment
2500 Broening Highway
Baltimore, Maryland 21224

INTRODUCTION

With a 64,000 square mile watershed and 2,300 square miles of tidal surface waters, Chesapeake Bay is the nation's largest estuary. Chesapeake Bay is a valuable natural resource and ranks third, behind only the Atlantic and Pacific oceans, among the United States' most productive fisheries. Over half of the nation's catch of blue crabs (*Callinectes sapidus*) and 70-90% of the Atlantic Coast stock of striped bass (*Morone saxatilis*) come from the Chesapeake.

As a highway for shipping, the Bay is also an important center of commerce for the Mid-Atlantic states. Two major ports are found on the Bay: the Hampton Roads Complex near the mouth of the Bay in Virginia and the Port of Baltimore located on the Upper Bay in Maryland. The Hampton Roads complex ranks third in the nation and Baltimore ninth in foreign water-born commerce. Baltimore is the nation's leading exporter of cars and trucks.

The Port of Baltimore's geographic location, 120 miles from the mouth of the Bay, requires a long network of commercial shipping channels. Tributaries contribute vast quantities of sediment to the mainstem Bay, creating a complex of shoals and shallows which shift with tidal currents, freshwater inflow and storm events. These dynamic sediment transport processes operating in the Bay watershed require annual maintenance dredging of the approach channels to the port of Baltimore.

Site Background

Finding placement sites for the material dredged from the approach channels to Baltimore Harbor is an ongoing concern. Moreover, sediments dredged from Baltimore's Inner Harbor are contaminated and require placement in specially designed disposal facilities. In 1981, construction of the Hart-Miller Island Confined Disposal Facility (HMI) was initiated to provide storage capacity for the Port of Baltimore's dredging projects. A 29,000-foot long dike covering an 1,100-acre area was constructed along the historical footprints of Hart and Miller Islands at the mouth of Back River. The eastern or Bay side of the dike was reinforced with filter cloth and rip-rap to protect the dike from wave and storm-induced erosion. A 4,300-foot long cross-dike was also constructed across the interior of the facility, dividing HMI into a 300-acre South Cell and an 800-acre North Cell. A series of five spillways are located on the perimeter dike, with spillways 1, 2 and 4 located in the North Cell and spillways 3 and 5 located in the South Cell. The spillways are designed to release supernatant water from dredged material deposited at HMI.

Dikes around the six-mile perimeter were raised from +18 feet above mean low water (MLW) to +28 feet in 1988, to provide sufficient capacity for the 50-foot channel deepening project. The site was filled to capacity in June 1996. Raising the dikes around the North Cell by an additional 16 feet (to +44 feet MLW) increased the placement capacity by 30 million cubic yards, giving the site an additional 12 years of operational life, beginning 10/01/96. Volumes and project names for dredged materials placed at HMI during monitoring Year 16 are provided in Table 1-1.

sediment geochemistry, and tissue toxicological analyses. Some of these projects were discontinued over the years as their effectiveness as monitoring tools became questionable. The following four projects, which have been consistently monitored from the beginning of the program to the present day, are: (1) Project Management and Scientific/Technical Coordination, (2) Sedimentary Environment, (3) Benthic Community Studies, and (4) Analytical Services.

Project I: ***Project Management and Scientific/Technical Coordination*** - Maryland Department of the Environment (MDE)

During the baseline monitoring years (1981-1983), the Chesapeake Research Consortium was responsible for project management, followed by the Maryland Department of Natural Resources (DNR) from 1984 to 1995. In 1995, part way through the Year 15 monitoring effort, project management was transferred from the Maryland DNR to the Maryland Department of the Environment (MDE). The Dredging Coordination and Assessment Division (DCAD) within the Technical and Regulatory Services Administration (TARSA) of MDE presently coordinates the Hart-Miller Island Exterior Monitoring Program.

Project management entails comprehensive oversight of the HMI Exterior Monitoring Program (EMP) to ensure coordination between the different projects and principal investigators (PIs). Before a monitoring year begins, DCAD reviews draft monitoring proposals for the upcoming year and consults with the PIs concerning sampling stations and analyses. Following approval of the proposals by the Maryland Port Administration (MPA), DCAD develops formats and timeframes for receipt of deliverables from the PIs, including seasonal reports, draft technical and data reports, invoices and attendance at quarterly meetings. Budgets for each of the PIs are tracked by MDE and portfolios are distributed to each PI during quarterly meetings.

Upon receipt of the draft data and technical reports, DCAD initiates a three-tiered peer review process to address the technical and editorial issues. The first level of review is conducted internally by MDE staff knowledgeable in the fields of dredging and environmental risk assessment, including toxicologists, engineers, benthic and aquatic ecologists. The next level of review is performed by the HMI Technical Review Committee (TRC) consisting of researchers/staff from the University of Maryland, and State and Federal agencies, who have backgrounds in estuarine ecology and processes. The final tier in the review process is the HMI Citizens' Oversight Committee (COC), a group of stakeholders from the public, watermen's associations and environmental groups, who bring the cares and concerns of Maryland's citizens to bear on the monitoring effort. DCAD compiles and organizes the comments received and submits them to the PIs for response. This process promotes quality control and assurance in the final HMI reports.

Lastly, DCAD conducts database management, production and standardization of the data and technical reports, and holds quarterly and special meetings among the PIs and the TRC. Project I is a constantly evolving, dynamic project which strives to constantly improve the scientific merit of the EMP and the presentation of the data and technical reports.

Project III: ***Benthic Community Studies*** – University of Maryland Center for Environmental Studies

For the sixteenth consecutive year, CBL was responsible for describing the benthic community surrounding HMI. Sampling was only conducted once this year, during August 1997. In addition to the same 17 stations sampled last year, another nearfield station (S1) and the Back River transect stations (BSM75, M1-M5), were sampled in Year 16. As in years past, a small number of species were the dominant members of the benthic community.

The most abundant species in Year 16 were the annelid worms *Scolecolepides viridis*, *Streblospio benedicti*, and *Tubificoides heterochaetus*; the crustaceans *Leptocheirus plumulosus* and *Cyathura polita*; and the clam *Rangia cuneata*. A total of 29 species were collected in the quantitative infaunal samples (compared to 26, 31, 30, 30, 35, 32, 34, 31, 35, 30 and 26 for the 15th through 5th years, respectively). The major differences in the dominant or most abundant species among stations were primarily a result of differences in bottom-type (e.g., silt/clay, shell or sand). Cluster analysis showed no unusual groupings of stations due to factors other than bottom-type.

The benthic index of biotic integrity (B-IBI) was used for the second consecutive year. Based on this index, none of the eighteen regular benthic stations sampled showed any signs of being stressed. Only one of the Back River transect stations, BSM75, was shown to be stressed based on the B-IBI. Overall, no adverse impacts on the benthic community from the operation and maintenance of HMI were observed.

CHAPTER 2: ANALYSIS OF CONTAMINANTS IN BENTHIC ORGANISMS AND SEDIMENTS COLLECTED NEAR HART-MILLER ISLAND (PROJECT II/IV)

SUBMITTED TO:

Dredging Coordination and Assessment Division
Technical and Regulatory Services Administration
Maryland Department of the Environment
2500 Broening Highway
Baltimore, MD 21224

PREPARED BY:

Robert Mason, Principal Investigator
Jean-Michel Laporte, Assistant Research Scientist
Angie Lawrence, Graduate Research Assistant

Coastal Chemistry Laboratory
Chesapeake Biological Laboratory
Center for Environmental Sciences
University of Maryland System
P.O. Box 38, 1 Williams Street
Solomons, Maryland 20688

UNDER CONTRACT TO:

Maryland Environmental Service
2011 Commerce Park Drive

drain. The spatula was acid rinsed between samples at each site to avoid cross contamination. The clam bodies were homogenized in a plastic blender with a stainless steel blade. Unused samples were returned to their respective bags and stored in the freezer until further analysis.

Sediment samples were taken at all sites using a Ponar grab sampler. Surficial sediments were collected from each Ponar grab. A single composite sample for each site was stored in a pre-acid-cleaned plastic jar and transported on ice back to the laboratory.

Analytical Procedures for Metals and Ancillary Parameters

Methods used for metals are similar to those described in detail in Dalal et al. (1999) and in Baker et al. (1997). For metals, a subsample of each trace metal sample (sediments and clams) was used for dry weight determination. Weighed samples were placed in a VWR Scientific Forced Air Oven at 60^0C and left overnight. The next day, samples were reweighed and a dry/wet ratio was calculated. After determining the water content of the sediment, the samples were heated to 550^0 C overnight. The samples were then reweighed and the percent organic matter (TOM in Table 2/4-2) in the sediment was determined by the percent loss on ignition (LOI).

Another subsample of clam tissue (5 g wet weight) was placed in acid-cleaned flasks for further digestion, using U.S. EPA Methods (Keith 1991). Ten mL of 1:1 HNO_3 was added and the slurry was mixed and covered with a watch glass. The sample was heated to 95^0C and allowed to reflux for 15 minutes without boiling. The samples were cooled, 5 mL of concentrated HNO_3 was added, and then they were allowed to reflux for another 30 minutes. This step was repeated to ensure complete oxidation. The watch glasses were removed and the resulting solution was allowed to evaporate to 5 mL without boiling. When evaporation was complete and the samples cooled, 2 mL of 30% H_2O_2 were added. The flasks were then covered and returned to the hot plate for warming. The samples were heated until effervescence subsided. We continually added 30% H_2O_2 in 1 mL aliquots with warming until the effervescence was minimal. No more than a total of 10 mL of H_2O_2 was added to each sample. Lastly, 5 mL of concentrated HCl and 10 mL of deionized water were added and the samples refluxed for 15 minutes. The samples were then cooled and filtered through Whatman No. 41 filter paper by suction filtration and diluted to 100 mL with deionized water. Sediments were digested in a similar fashion.

The clam and sediment homogenates were then analyzed using a Perkin-Elmer Zeeman 5000 HGA-400 Graphite Furnace Atomic Absorption Spectrophometer (GF-AAS) for Cu, Cd, Pb, Cr, Ni, Zn and Ag concentrations (U.S. EPA Methods, 7000 Series). Standards were prepared according to the Perkin-Elmer Analytical Methods manual. Spectral interferences, associated with lead, were minimized using a $Mg(NO_3)_2$ and PO_4 matrix. Matrix modifiers were not needed for Cu and Cd analysis. For enhanced sensitivity, pyrolytically coated graphite tubes

RESULTS AND DISCUSSION

Sediments

The concentrations of metals in the sediments are compared to the values obtained by the CBL for HMI in 1996, to those found during the Baltimore Harbor Mapping Study (Baker et al. 1997), and to the averages for Chesapeake Bay in general (MDE 1991, Table 2/4-1). For some of the metals, the relationship between the data collected in 1996 and 1997, for comparable stations, is shown in Figure 2/4-2. Considering the fact that some samples collected in 1997 were from the contaminated Back River region, the ranges in values obtained for HMI are comparable over the two years. Values for Pb, Cu, Ni and As are comparable between years, but higher in 1996 for Zn and higher in 1997 for Cd, Cr, Ag and Hg. Differences noted in all cases are within a factor of two and are not considered to be significant given longer term variability. These results are similar to findings in the "*Comprehensive Zinc Study for Hart-Miller Island Contained Disposal Site*" (UTI 1999). For some of the metals, sites appear to fall into two groups of samples: one set which is comparable across years and one that is not - see, for example, Cd, Hg and Zn. The data for Zn and Cr particularly stand out. Why the Zn values are low in 1997, and Cr higher, is not known. Both metals are sensitive to changes in sediment redox, and thus these differences could reflect differences in the depth of sediment collection or a difference in surface redox status.

A matrix correlating data for metals against acid volatile sulfide (AVS), total organic matter (TOM), %Carbon and %Nitrogen shows that for the 1997 data, Zn and Cu concentrations correlate well with all parameters. Nickel correlates with most parameters, but not AVS. Lead, Cd, Hg and MMHg all show a strong correlation with AVS, which is expected because they form strong sulfide bonds and bond, to some extent, with carbon (Table 2/4-2). Chromium does not strongly correlate with any of the variables. Thus, changes in sediment chemistry, as monitored by AVS and organic constituents, cannot help explain Cr variability. Overall, the differences in the results of the inter-annual comparison are likely explained in terms of the differences in the %C, AVS and other parameters across years.

Even given these variations, metal concentrations around HMI are not elevated compared to the Bay in general and are significantly lower than those found in Baltimore Harbor (Table 2/4-1). Most metals have values that fit the lower end of the Chesapeake Bay range and all are significantly lower than Baltimore Harbor. Thus, it is difficult to conclude that metals are specifically coming from HMI sources rather than more generic Bay-wide inputs.

To investigate possible metal sources, samples were collected in 1997 on a transect from the north end of HMI to the lower reaches of the Back River (see Figure 2/4- 1 - sites BSM 75 to HM7). Two sites that overlap with the Baltimore Sediment Mapping Study were also sampled to give continuity between the data sets (Compare site locations on figs. 2/4-1a and 1b). The results

sites. However, it should be noted that because clams were not found at all sites, and are not likely to be at the sites with the highest sediment metal loads, the information on clams should not be over-interpreted as indicating no impact. Alternatively, a lack of clams does not necessarily indicate a more contaminated site, as clams were not generally found at sites south of HMI during this sampling and these sites have overall lower sediment burdens than sites closer to HMI or to the Back River.

Clams were divided into large and small clams where possible and analyzed independently. The results are shown in Figure 2/4- 4. Most of the samples with enough clams for analysis were from the north end of HMI and thus the results are somewhat skewed in this regard. Contrary to the initial expectation, clam metal concentrations were often higher in small clams compared to large clams. This trend is strong for Cd, Pb, Cr, and to a lesser extent, As, Ag, Zn and Hg. No strong trends were seen for Ni and Cu. Further examination of the data shows that there are three stations where higher metal concentrations in small clams are particularly the case: BC6, M4 and M2. These sites are all very close together, suggesting that the smaller clams may have been impacted by a transient high pulse of metals to the sediment, or some other factor which is not reflected in the longer-lived large clams. Such a transient insult would not be reflected in the sediment data as the sampling methods sample more than one year of sediment accumulation (i.e. the sediment sample is a more integrated long-term measure and the clam data are more transient indicators). It should also be noted that because *Rangia* is a filter-feeding organism, it does not directly reflect sediment contamination. Rather, as there is some linkage in shallow, disturbed systems between the sediment and water column, there is an indirect coupling between sediment metal concentrations and clam metal concentrations. Thus, the trends between small and large clams are likely indicative of short-term fluctuations in surface sediment (floc) or suspended sediment particulate loads.

Bioaccumulation factors [(BAFs) a ratio of contaminant concentrations in organisms to concentrations in sediment] were estimated from the average data and compared between years (1996 vs 1997; Figure 2/4-5). Overall, values are similar across years, except perhaps for Pb. However, Pb is very poorly assimilated (log BAF 0.1 or less) and this could account for the lack of correlation. Also, as stated above, these BAFs are limited in the context that the clams are suspension feeders. Inorganic Hg and MMHg show some trend with organic matter of sediments, as we found in Baltimore Harbor (Mason and Lawrence in press). Some of the other metals (Ag and Cu) also show a trend with organic content but this is not strongly shown for Pb or Cd. Overall, MMHg is the most highly bioaccumulated metal (log BAFs all >1) and Pb is the least. These results are comparable to those found by others in other estuarine environments (Morse et al. 1993; NOAA 1996).

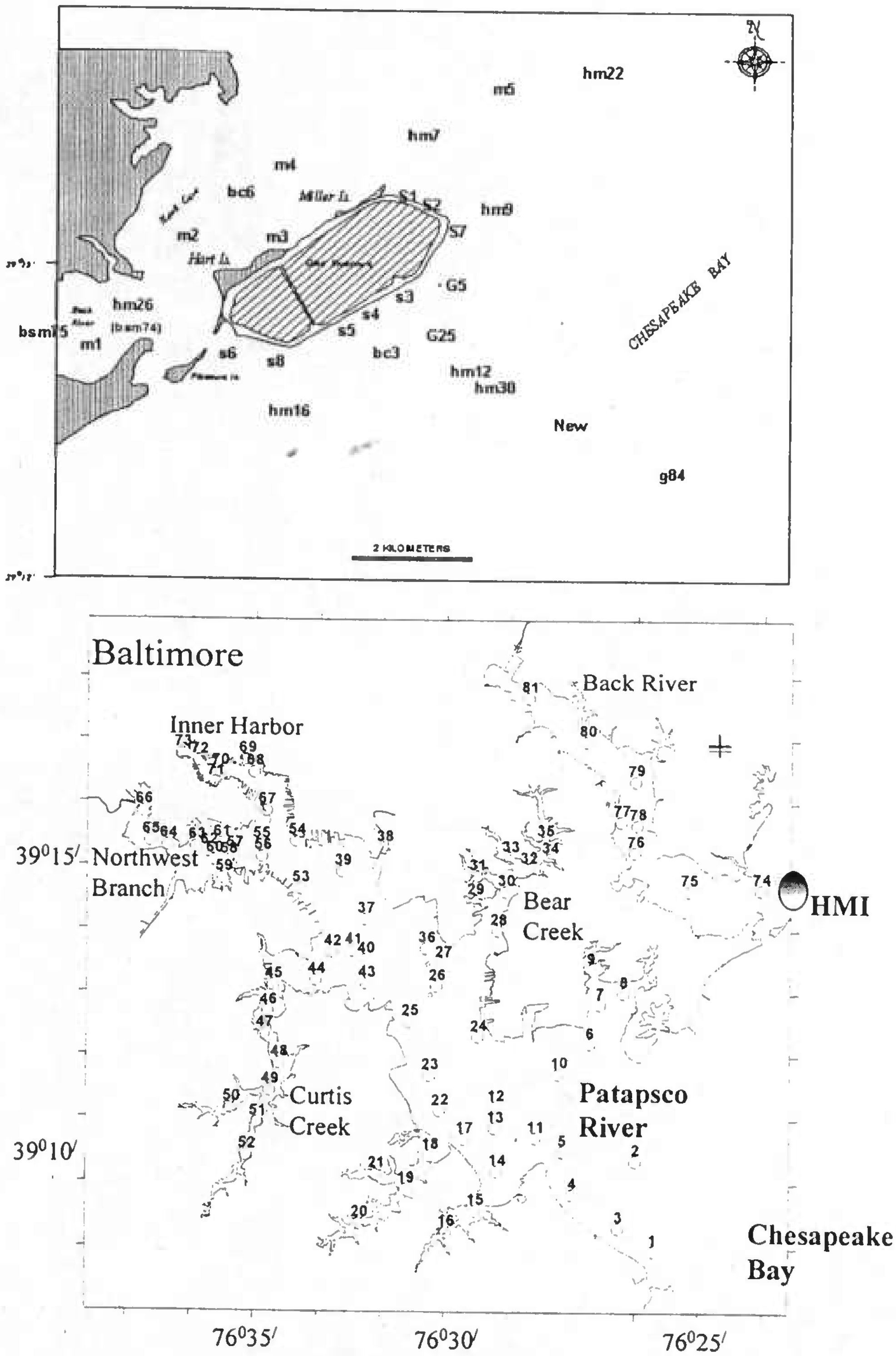

Figure 2/4-1: (a) Site map of Hart-Miller Island showing the sampling locations; (b) Accompanying map showing the stations from the Baltimore Mapping Study.

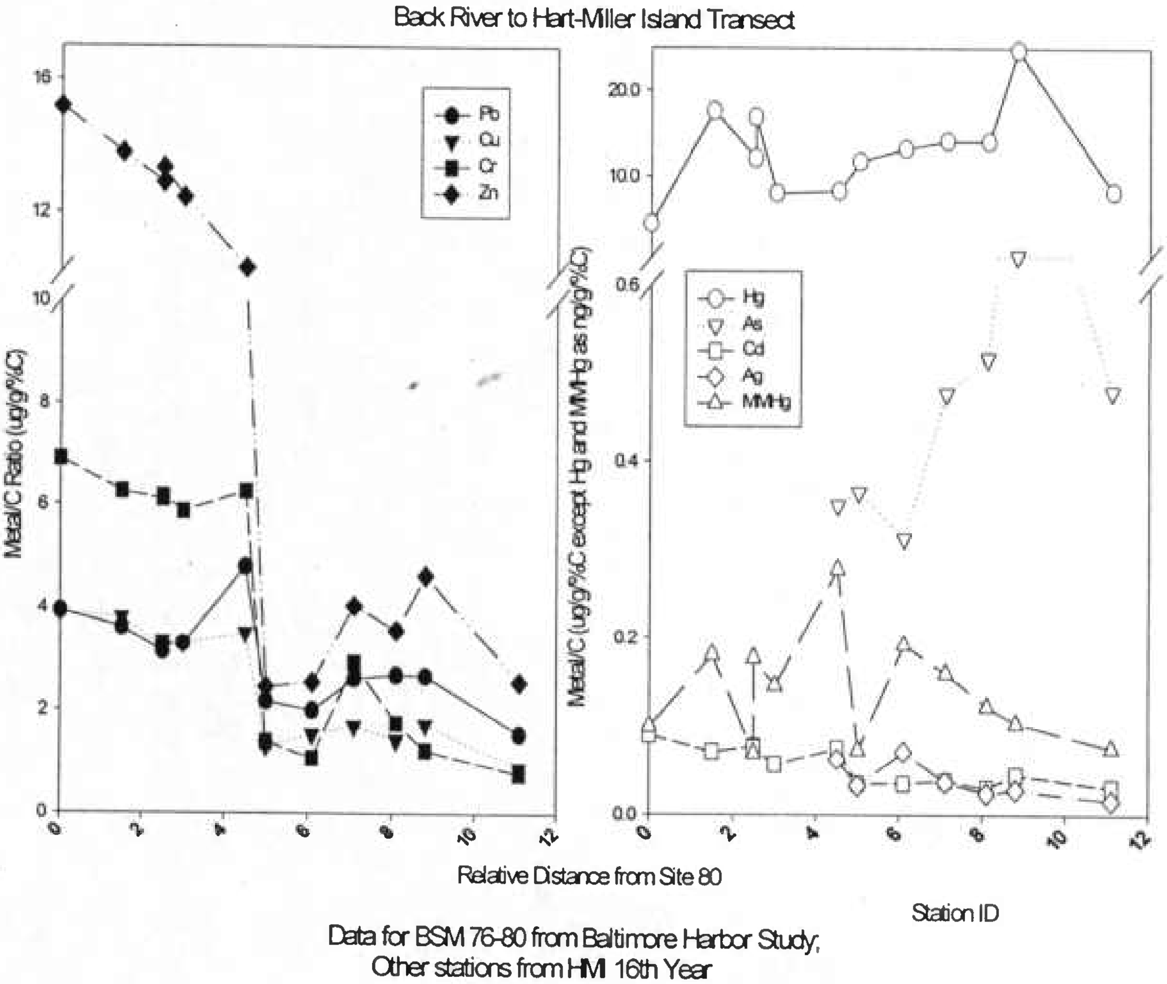

Figure2/4-3: Concentrations of metals in sediments on a transect from the Back River to Hart-Miller Island. See Figure 1 for site details.

Figure 4 continued...

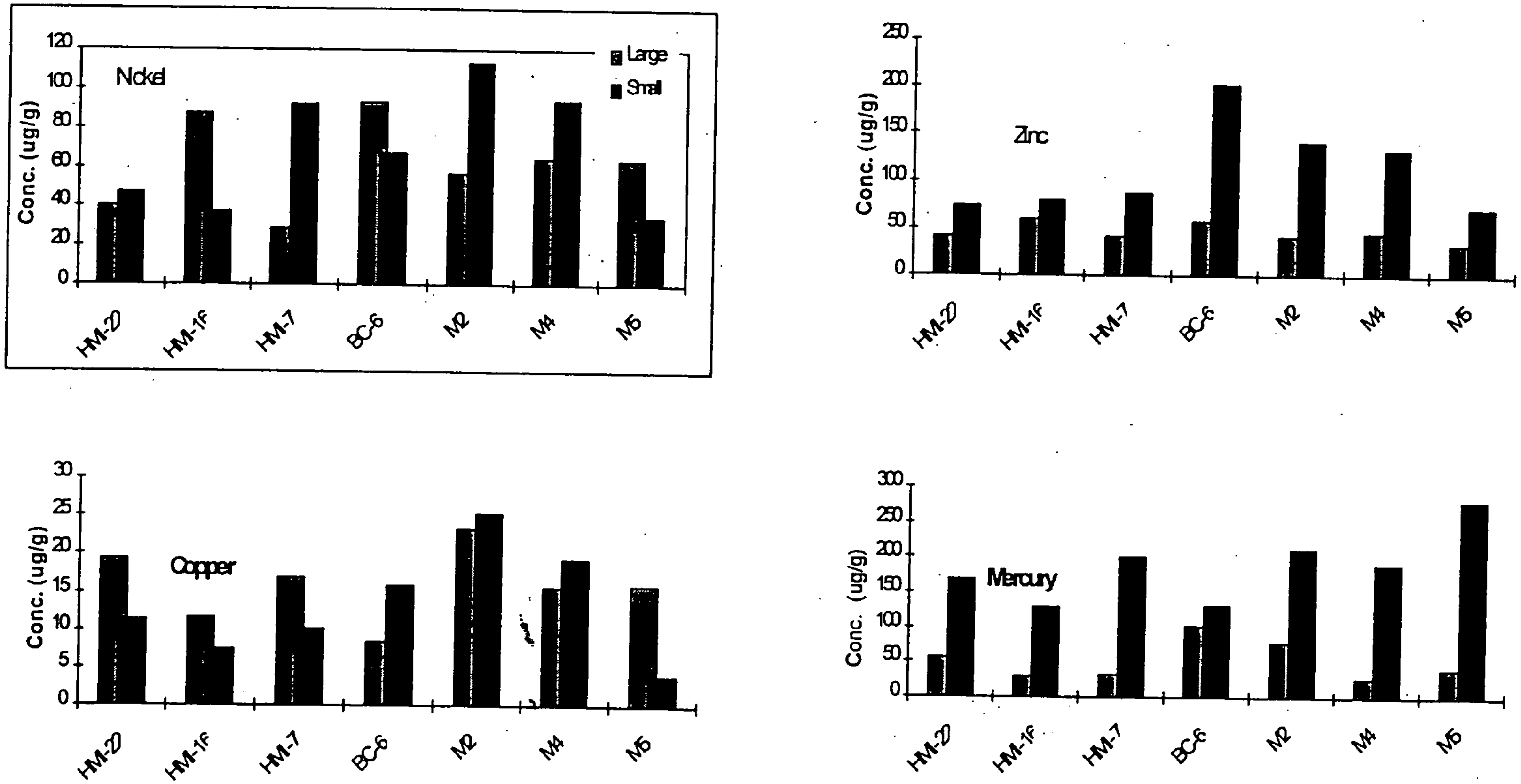

Table 2/4-1: Concentrations of metals in HMI sediments collected in 1996 and 1997 with comparison with baywide average values and values for Baltimore Harbor. Comparison is made on a dry weight basis.

Metal (μg/g dry wt.)	1996	1997*	BH Study**	MDE 91**
Cd	0.18-0.63	0.13-1.5	0.01-17.6	0.7-4
Pb	13.8-58.5	11.7-86.3	1-1014	78-194
Ni	19.2-97.7	3.6-80.6	3-157	42-113
Cr	14.0-60.7	6.8-172.7	6-1830	162-520
Cu	9.6-51.8	2.0-59.0	5-532	65-191
Zn	86.5-298.9	7-140.7	40-2580	353-681
Ag	0.2-0.9	0.04-2.5	-	-
As	4.6-25.9	0.5-25.4	-	-
Hg	0.057-0.35	0.083-0.70	0.004-3.13	0.3-0.6

Notes: * 1997 data excludes site BSM 75
** Data from Baltimore Harbor Mapping and the Chesapeake Bay Toxics Reduction Re-evaluation Report.

CHAPTER 3: BENTHIC COMMUNITY STUDIES (PROJECT III)

SUBMITTED TO:

Dredging Coordination and Assessment Division
Technical and Regulatory Services Administration
Maryland Department of the Environment

PREPARED BY:

Dr. Linda E. Duguay, Principal Investigator
Cynthia A. Shoemaker and Steven G. Smith

The University of Maryland System
Center for Environmental and Estuarine Studies
Chesapeake Biological Laboratory
Post Office Box 38
Solomons, MD 20688-0038

ABSTRACT

Benthic invertebrate populations surrounding the Hart-Miller Island Confined Disposal Facility (HMI) in the Upper Chesapeake Bay were monitored for the sixteenth consecutive year in order to examine any potential effects from the operation of HMI. In August 1997, bottom-dwelling organisms living within (infaunal) sediments both close to HMI (referred to as the nearfield stations) and at some distance from the facility (referred to as reference stations) were collected. The seventeen stations sampled during Year 15, plus the additional nearfield station S1, were sampled this year. Also sampled were a series of Back River Stations (M1-M5, BSM75) which were being examined by Dr. Rob Mason (University of Maryland Principal Investigator for Project II/IV) to determine what contribution the Back River might have on metal concentrations in the HMI area. All stations were only sampled once this year. Sampling for all projects (benthic, sediments, and metals) was conducted at a single time at each station over a two day period (August 18 and 19, 1997).

The infaunal samples were collected with a 0.05 m^2 Ponar grab and washed on a 0.7 mm mesh screen in the field. Twenty-four stations were sampled during the two day cruise: six nearfield stations S1, S2, S3, S5, S6, and BC3; eight reference stations HM7, HM9, HM16, HM22, HM26, BC6, 30, and NEW; four zinc stations G5, G25, G84, and HM12; and six Back River Transect stations M1, M2, M3, M4, M5, and BSM75. The various infaunal stations have sediments of varying compositions and include silt-clay stations, oyster-shell stations and sand stations. A total of 29 species were collected from the eighteen standard infaunal stations. The most abundant species were the worms *Scolecolepides viridis*, *Streblospio benedicti* and *Tubificoides heterochaetus*; the crustaceans *Leptocheirus plumulosus* and *Cyathura polita*; and the clam *Rangia cuneata*. Species diversity (H') values were evaluated at each of the eighteen standard infaunal stations. The highest diversity value (2.901) was obtained for the reference station HM16. The lowest diversity value (0.447) occurred at reference station HM7.

The length-frequency distributions of the clams *Rangia cuneata*, *Macoma balthica* and *Macoma mitchelli* were examined at the nearfield, reference, and zinc stations. There was fairly good correspondence in terms of numbers of clams present and the relative size groupings for the August sampling dates; the only exception to this was for the 10mm *Rangia*. In the 10mm size class there were 143 *Rangia* at the zinc stations, 1,422 at the nearfield stations and 5,455 at the reference stations. *Rangia cuneata* continues to be the most abundant clam species for all three groups of stations, followed by *Macoma mitchelli*, and then *Macoma balthica*.

For the second year in a row, the Chesapeake Bay Benthic Index of Biotic Integrity (B-IBI, Weisberg et al. 1997) was used to score all the benthic stations. This multimetric index of biotic integrity was developed using data from five Chesapeake Bay sampling programs. Assemblages with an average score of less than 3.0 are considered stressed because they have metric values that are less than the values at the poorest reference sites. None of the sites had an average score of less than 3.0 for the standard eighteen stations. Only one station, in the Back River Transect, had an average score of less than 3.0. That was station BSM75 with an average score of 1.5; this station was the farthest upriver of the Back River transect stations. It had the

INTRODUCTION

The results of the benthic population studies conducted during Year 16 of the Exterior Monitoring Program in and around the vicinity of HMI are presented in this report. HMI lies within the estuarine portion of Chesapeake Bay and experiences seasonal salinity and temperature fluctuations. This region of Chesapeake Bay encompasses vast soft-bottom shoals, which are important to protect since they function as critical breeding and nursery grounds for many commercial and non-commercial species of invertebrates and migratory fish. Because it is an area that is environmentally unpredictable from year to year, it is important to maintain as complete a record as possible on all facets of the ecosystem. Holland (1985, 1987) completed long-term studies of more stable mesohaline [5-18 parts per thousand salinity (Weisberg et al. 1997)] areas further south of HMI and found that most macrobenthic species showed significant year-to-year fluctuations in abundance. These fluctuations were primarily a result of slight salinity changes and the fact that the spring season was a period critical to juvenile recruitment and to the establishment of both regional and long-term distribution patterns. One would expect even greater fluctuations in the benthic organisms inhabiting the region of HMI which is located in the highly variable oligohaline [0.5-5 parts per thousand salinity (Weisberg et al. 1997)] portion of Chesapeake Bay. Indeed past studies (Pfitzenmeyer and Tenore 1987; Duguay, Tenore, and Pfitzenmeyer 1989; Duguay 1989, 1990, 1992, 1993, 1995, 1997, 1998) indicate that the benthic invertebrate populations in this region are predominantly opportunistic or r-selected species with short life spans, small body size and often high numerical densities. These opportunistic species are characteristic of disturbed or environmentally variable regions (Beukema 1988).

The major objectives of the Year 16 benthic monitoring studies were:

1. To monitor the nearfield benthic populations for possible effects of discharged effluent or seepage of dredge materials from HMI by following changes in benthic population size and species composition;

2. Continued monitoring of benthic populations at established reference stations for comparison with the nearfield stations surrounding the facility;

3. Continued monitoring of benthic populations at four stations where elevated levels of zinc were found in Year 9;

4. To provide *Rangia cuneata* to research groups at the Chesapeake Biological Laboratory (CBL) for chemical analyses of trace metal concentrations in order to ascertain various contaminant levels in benthic organisms and to determine whether there is any bioaccumulation; and

5. To monitor benthic populations at six stations along a transect from Back River. These stations were being examined by Dr. Rob Mason of CBL for their possible contribution to metal levels in the HMI area.

RESULTS AND DISCUSSION

Since the beginning of the benthic survey studies in 1981, a small number of species have been the dominant members of the benthic invertebrates collected in the vicinity of HMI. The most abundant species this year were the annelid worms *Scolecolepides viridis*, *Streblospio benedicti* and *Tubificoides heterochaetus*; the crustaceans *Leptocheirus plumulosus* and *Cyathura polita*; and the clam *Rangia cuneata* (Tables 3-3, 3-4, and 3-5). Variations in the range and average number of *S. viridis, L. plumulosus*, and *R. cuneata* at the reference stations since the initial sampling in August 1981 are presented in Table 3-1. The populations of these three species have remained relatively stable over the monitoring period. Overall the results of this year appear to be similar to previous years, except for the record numbers of *Rangia* in the 10mm size class (Figure 3-2). The number of *S.viridis* and *L. plumulosus* have decreased somewhat from last year, but they are similar to the numbers found in the earlier years of the project. The species found at the Back River Transect stations are shown in Table 3-6.

The major variations observed in dominant or most abundant species for a station occur primarily as a result of the different bottom types (Table 3-2). Soft bottoms are preferred by the annelid worms *S. viridis*, *Tubificoides sp.*, and *S. benedicti*, as well as the crustaceans *L. plumulosus* and *C. polita*. The most common inhabitants of the predominately old oyster shell substrates are more variable. The barnacle *Balanus improvisus*, the worm *Nereis succinea*, or the encrusting bryozoan *Membranipora tenuis* are often the dominant organisms. This year, the most common organisms found at the soft bottom stations were the clam *Rangia* and the worm *S. viridis*. *S. viridis* was also the most common organism found at the shell bottom stations.

Station HM26, at the mouth of the Back River, has in past years usually had the most diverse annelid worm fauna. However, this year, reference station HM9 was the most diverse station, having 8 species of worms in the August sampling period. A diverse annelid fauna was also recorded this year at the reference stations HM26 and 30 and the nearfield station, S6. All had 7 species of worms (Tables 3-3, 3-4, 3-5, and 3-6). This year, as in previous years, the most abundant worm species at the nearfield, reference, and zinc stations was *S. viridis*. It was also the most abundant worm at three of the six Back River stations.

The clam *R. cuneata,* the worm *S. viridis*, and the crustaceans *C. polita* and *L. plumulosus* occurred frequently at all three sets of our standard stations (nearfield, reference, and zinc) and also at the Back River stations. Over the course of the benthic monitoring studies, the worm *S. viridis* has frequently alternated with the crustaceans *C. polita* and *L. plumulosus* as the foremost dominant species. It appears that slight modifications in the salinity patterns during the important seasonal recruitment period in late spring play an important role in determining the dominance of these species. The crustaceans *C. polita* and *L. plumulosus* become more abundant during low salinity years while the worm *S. viridis* prefers slightly higher salinities. This year, *Rangia cuneata* was the most abundant species, followed by *S. viridis.*

This year, *C. polita* was more abundant than *L. plumulosus* at all three sets of standard stations (Tables 3-3, 3-4, 3-5). However, for the Back River stations *Leptocheirus* was

The largest number of species recorded for any of the stations was 19 at stations HM9 (reference) and BC3 (nearfield). The lowest number of species, 4, was recorded at nearfield station S1. Back River station BSM75 had the second lowest number of species, 7, with reference station BC6 being third with 9 species.

Three species of clams (*Rangia cuneata*, *Macoma balthica*, and *Macoma mitchelli*) were measured to the nearest millimeter in shell length to determine if any size/growth differences were noticeable between the reference, nearfield, and zinc stations (Figure 3-2). The clam numbers for *Macoma balthica* and *Macoma mitchelli* were similar to last year's numbers, but the *Rangia cuneata* numbers were higher than they have ever been. Overall, the nearfield, zinc and reference stations had similar numbers of *R. cuneata* except for the 10mm size range (Figure 3-2). This year, in the 10mm *Rangia* size class, there were 143 individuals at the zinc stations, 1,422 individuals at the nearfield stations and 5,455 at the reference stations. *Macoma balthica* was the least abundant of the three clams species recorded in the vicinity of HMI.

We again employed cluster analysis in this year's study to examine relationships among the different groups of stations based upon the numerical distribution of species and individuals of a species. In Figure 3-3, the stations with faunal similarity (based on chi-square statistics derived from the differences between the values of the variables for the stations) are linked by vertical connections in the dendrogram. Essentially, each station was considered to be a cluster of its own and at each step (amalgamated distances) the clusters with the shortest distance between them were combined (amalgamated) and treated as one cluster. Cluster analysis in past studies at HMI has clearly indicated a faunal response to bottom type (Pfitzenmeyer 1985). Thus, any unusual grouping of stations tends to suggest changes are occurring due to factors other than bottom type and further examinations of these stations may be warranted. Most of the time experience and familiarity with the area under study can help to explain the differences. When differences cannot be explained, however, other potential outside factors must be considered.

The August or summer sampling period represents a season of continued recruitment for the majority of benthic species, as well as a period of heavy stress from predatory activities, higher salinity, and higher water temperatures. These stresses exert a moderating effect on the benthic community which holds the various populations in check. This year, the first four stations to join the dendrogram consisted of 3 silt/clay stations and 1 sand station. The first pair to join the dendrogram was HM22 (a reference station) and S1 (a nearfield station). The second pair included 30 (a reference station) and HM12 (a zinc station). The clusters that formed during the August sampling period represented previously observed normal groupings for the reference and nearfield stations with no unusually isolated stations. These clusters were consistent with earlier studies and often grouped stations according to bottom type and general location within the study area. The zinc stations clustered along with the nearfield and reference stations and indicated no unusually isolated stations. If the benthic invertebrates in this region were being affected by some adverse or outside force it would appear in the groupings. No such indications were found during the August sampling period reported in this study.

The Ryan-Einot-Gabriel-Welsch Multiple Comparison test was used to determine if a

CONCLUSIONS AND RECOMMENDATIONS

During Year 16 of monitoring the benthic populations around HMI, the sampling locations, sampling techniques and analyses of the data were maintained as close as possible to that of previous years in order to limit variation. Maintenance of sampling locations, techniques and analyses should render differences due to effects of HMI more readily apparent. The same 17 benthic stations that were sampled last year were again sampled this year; nearfield station S1 was also sampled. We also sampled a Back River Transect in conjunction with Dr. Rob Mason (BSM75, M1, M2, M3, M4, and M5). The Back River transect was examined as a potential source of metals to the HMI region. We have continued to monitor all four infaunal sampling stations (HM12, G5, G25, and G84) which were established over the course of Year 9 in response to the findings of the sedimentary group of an observable enrichment of zinc in the sediments at these stations.

The results presented in this report are similar to those presented in the reports of the last eleven years. A total of 29 species (compared with 26, 30, 35, 31, 34, 32, 35, 30, 30, 31, and 26 for Years 5 through 15, respectively) were collected in the quantitative infaunal grab samples. Two species were numerically dominant on soft bottoms; these were the clam *R. cuneata* and the worm *S. viridis.* The oyster shell substrate stations had one numerically dominant species, the worm *S. viridis.* Salinity fluctuations on yearly and seasonal time scales appear to be important in regulating the position of dominance of the major species in this low and variable salinity region of the Bay. The average number of individuals per square meter (#/m^2) per station was highest for the reference stations (7,129) with decreasing values observed for the Back River stations (6,974), nearfield stations (4,106) and the zinc stations (2,581) during the August sampling period. The highest average species diversity value this year was found at reference station HM16; the lowest diversity value was also recorded at reference station HM7.

As has been the case in previous years, cluster analysis grouped stations of similar faunal composition in response to sediment type and general location within the HMI study area. There were no incidences of individual stations being isolated from common groupings during the August sampling period. The Ryan-Einot-Gabriel-Welsch multiple range test resulted in subsets of stations which contained a mix of nearfield, reference, and zinc stations. Friedman's non-parametric test indicated no significant differences among any of the station types (reference stations, nearfield stations, zinc stations or any combination thereof). According to the Chesapeake Bay B-IBI, the area surrounding the HMI is not considered stressed and only one station (BSM75) in the Back River transect was considered stressed with a average B-IBI score of 1.5. At present, there do not appear to be any discernable differences in the populations of benthic organisms at the nearfield, reference and zinc stations resulting directly from HMI.

The Hart-Miller Island Confined Disposal Facility will continue to operate well beyond the year 2000. It is strongly recommended that the infaunal populations continue to be sampled at the established locations during the period of active operation of HMI in order to ascertain any possible effects. Historical station looations and sampling techniques should be maintained to

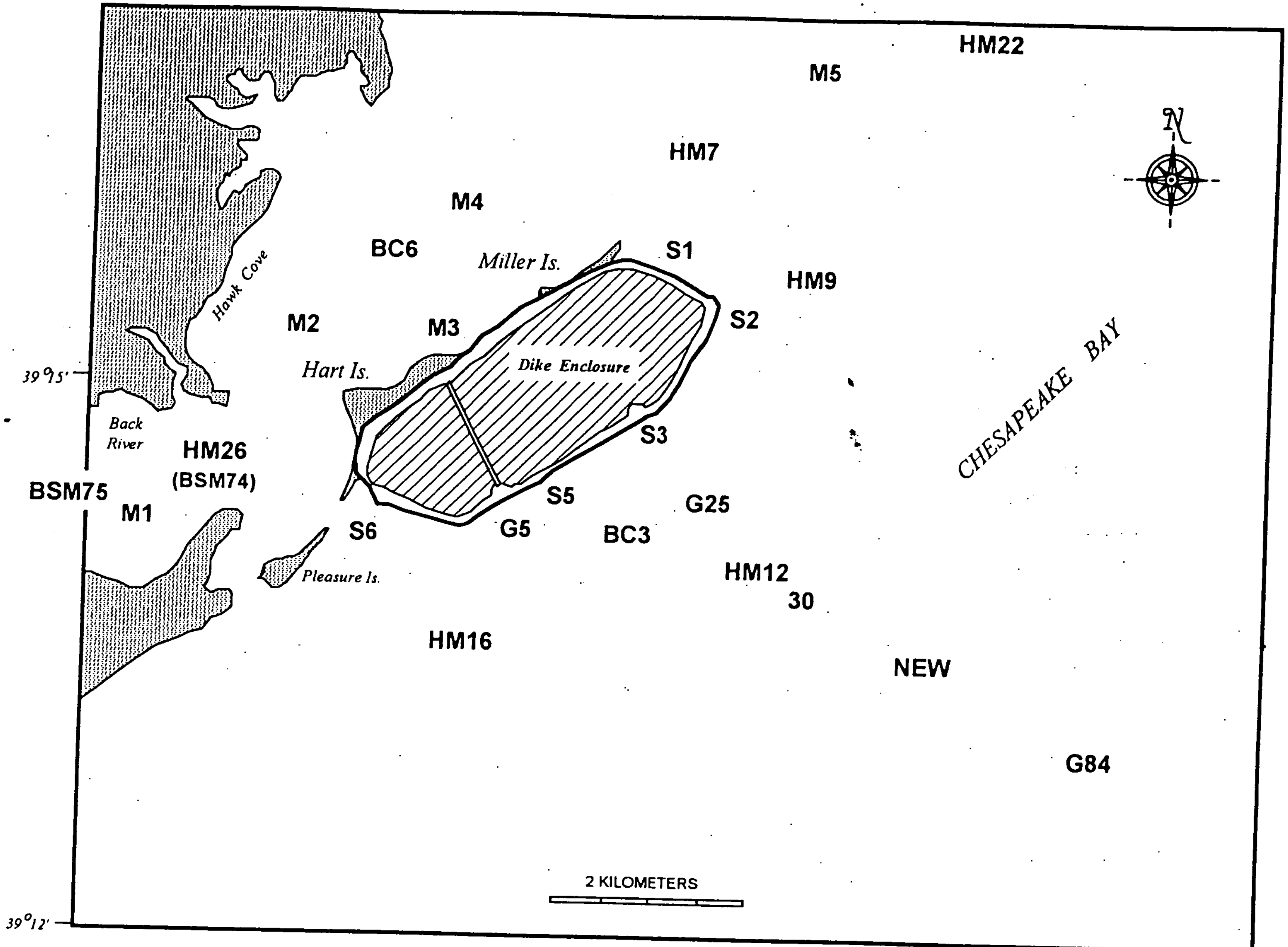

Figure 3-1. Benthic sampling station locations for the 16th year of benthic monitoring at HMI. University of Maryland, Chesapeake Biological Laboratory designations.

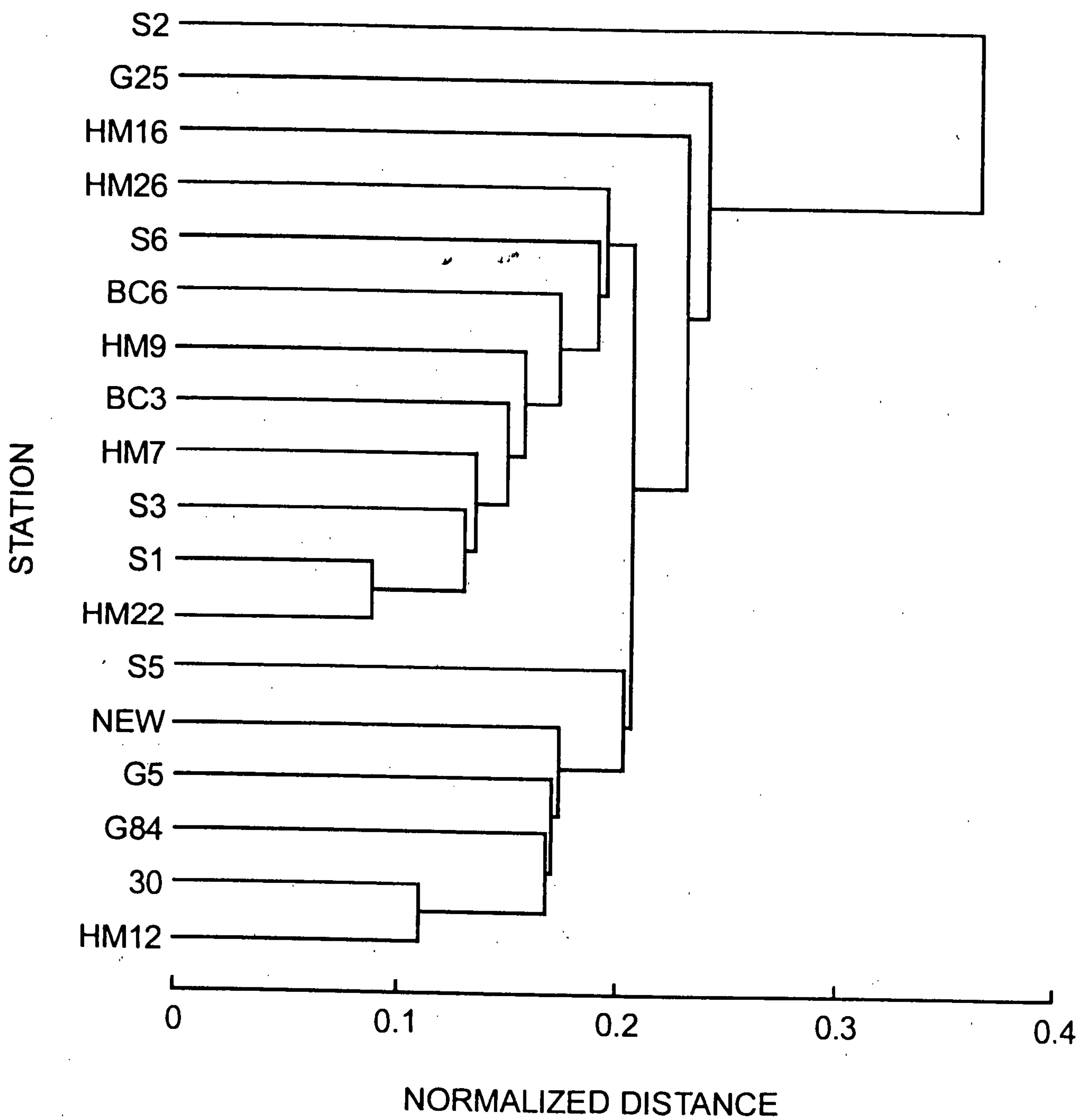

Figure 3-3. Cluster analysis for all HMI stations during the 16th year of benthic studies.

TABLE 3-2: A list of the 3 numerically dominant benthic organisms collected from each bottom type on each sampling date during the Sixteenth Year of Benthic Studies at HMI.

STATION	AUGUST 1997
NEARFIELD SILT-CLAY BOTTOM (S5,6,BC3)	Rangia cuneata Scolecolepides viridis Cyathura polita
NEARFIELD SHELL BOTTOM (S2)	Scolecolepides viridis Rithropanopeus harrisi Nereis succinea
NEARFIELD SAND BOTTOM (S1,S3)	Rangia cuneata Scolecolepides viridis Cyathura polita
REFERENCE SILT-CLAY BOTTOM (HM7,16,22,30,NEW,BC6)	Rangia cuneata Scolecolepides viridis Leptocheirus plumulosus
REFERENCE SHELL BOTTOM (HM9)	Rangia cuneata Scolecolepides viridis Cyathura polita
BACK RIVER REFERENCE SAND/SILT-CLAY BOTTOM (HM26)	Rangia cuneata Streblospio benedicti Cyathura polita
HISTORICALLY ZINC ENRICHED SILT-CLAY BOTTOM (G5,25,84,HM12)	Scolecolepides viridis Rangia cuneata Cyathura polita

TABLE 3-4: Number of benthic organisms per m squared (m2) found at the Nearfield Stations during the Sixteenth Year (August 1997) of Benthic Studies at HMI.

PHYLUM	SPECIES NAME	#	S1	S2	S3	S5	S6	BC3	TOTALS
RHYNCHOCOELA (ribbon worms)	Micrura leidyi	2		7	33	40	7	33	120
ANNELIDA (worms)	Heteromastus filiformis	3							0
	Nereis succinea	5		160		13	7	93	273
	Eteone heteropoda	8					20		20
	Polydora ligni	9		7			20	67	94
	Scolecolepides viridis	10	80	267	1200	1940	360	1193	5040
	Streblospio benedicti	11		40	53	173	373	200	839
	Hobsonia florida	12			20		13	7	40
	Limnodrilus hoffmeisteri	13							0
	Tubificoides heterochaetus	14		27	20	40	87	260	434
	Capitella capitata	15							0
MOLLUSCA (mollusks)	Ischadium recurvus	16							0
	Congeria leucophaeta	17		13		27		7	47
	Littoridinops sp.	18			13		33	27	73
	Macoma balthica	19							0
	Macoma mitchelli	20				13	20		33
	Rangia cuneata	21	973	7	2853	1020	2240	6233	13326
	Mya arenaria	22							0
	Hydrobia sp.	23							0
	Doridella obscura	25							0
ARTHROPODA (crustaceans)	Balanus improvisus	27		133				13	146
	Balanus subalbidus	28		7					7
	Leucon americanus	29							0
	Cyathura polita	30	40	53	260	287	333	567	1540
	Cassidinidea lunifrons	31		7					7
	Edotea triloba	33			87	7	40	47	181
	Gammarus palustris	35							0
	Leptocheirus plumulosus	36			87	347	313	7	754
	Corophium lacustre	37		7				7	14
	Gammarus daiberi	38							0
	Gammarus tigrinus	39							0
	Melita nitida	40		27		53	20		100
	Chirodotea almyra	41	33		20			7	60
	Monoculodes edwardsl	42					20		20
	Chironomid sp.	43			13	73	20	7	113
	Rithropanopeus harrisi	44		167				67	234
	Gammarus mucronatus	45							0
COELENTERA (hydroids)	Garvela franciscana	47							0
PLATYHELMIA (flatworms)	Stylochus ellipticus	48							0
BRYOZOA (bryozoans)	Membranipora tenuis	49		733		80		307	1120
	Victorella pavida	50							0
	TOTAL NUMBERS		1126	1662	4659	4113	3926	9149	49270

TABLE 3-6: Number of benthic organisms per m squared (m2) found at the Back River Transect Stations during the Sixteenth Year (August 1997) of Benthic Studies at HMI.

PHYLUM	SPECIES NAME	#	M1	M2	M3	M4	M5	BSM75	TOTALS
RHYNCHOCOELA (ribbon worms)	Micrura leidyi	2	40			7	27	53	127
ANNELIDA (worms)	Heteromastus filiformis	3	13				7		20
	Nereis succinea	5		7	20		7		34
	Eteone heteropoda	8							0
	Polydora ligni	9		33		33	13		79
	Scolecolepides viridis	10	300	180	260	153	467		1360
	Streblospio benedicti	11	467	80		7	20	47	621
	Hobsonia florida	12		20	100	87			207
	Limnodrilus hoffmeisteri	13							0
	Tubificoides heterochaetus	14	487	13	113		13	100	726
	Capitella capitata	15							0
MOLLUSCA (mollusks)	Ischadium recurvus	16							0
	Congeria leucophaeta	17					7		7
	Littoridinops sp.	18		20					20
	Macoma balthica	19							0
	Macoma mitchelli	20					20		20
	Rangia cuneata	21	167	1833	7780	1640	1040		12460
	Mya arenaria	22							0
	Hydrobia sp.	23							0
	Doridella obscura	25							0
ARTHROPODA (crustaceans)	Balanus improvisus	27							0
	Balanus subalbidus	28							0
	Leucon americanus	29							0
	Cyathura polita	30	267	100	353	127	107	13	967
	Cassidinidea lunifrons	31							0
	Edotea triloba	33	33	7	7				47
	Gammarus palustris	35							0
	Leptocheirus plumulosus	36	407	1207		133	253	120	2120
	Corophium lacustre	37		13					13
	Gammarus daiberi	38							0
	Gammarus tigrinus	39							0
	Melita nitida	40	40	20		7	53		120
	Chirodotea almyra	41	13		20			7	40
	Monoculodes edwardsi	42				27	7		34
	Chironomid sp.	43	333	373		93	60	873	1732
	Rithropanopeus harrisi	44		7	160	7			174
	Gammarus mucronatus	45							0
COELENTERA (hydroids)	Garvela franciscana	47							0
PLATYHELMIA (flatworms)	Stylochus ellipticus	48							0
BRYOZOA (bryozoans)	Membranipora tenuis	49							0
	Victorella pavida	50							0
	TOTAL NUMBERS		2567	3913	8813	2321	2101	1213	20928

TABLE 3-8. Number of species and the total number of individuals collected in three grab samples (0.05m2 each) at the infaunal stations for AUGUST 1997. Bottom substrate, species diversity (H') and dominance factor (S.I.) are also shown. Data for the Sixteenth Year of Benthic Studies at HMI.

STATION	SUBSTRATE	NO. SPECIES	NO. INDIVIDUALS	SPECIES DIVERSITY (H')	DOMINANCE FACTOR S.I.
NEARFIELD					
S1	Sand	4	169	0.775	0.754
S2	Shell	16	249	2.623	0.249
S3	Sand	12	699	1.658	0.445
S5	Silt-Clay	14	617	2.312	0.299
S6	Silt-Clay	17	589	2.233	0.357
BC3	Silt-Clay	19	1372	1.763	0.488
REFERENCE					
HM 7	Silt-Clay	14	2551	0.447	0.891
HM 9	Shell	19	2014	1.117	0.686
HM16	Silt-Clay	11	281	2.901	0.168
HM22	Silt-Clay	11	901	0.908	0.745
30	Silt-Clay	16	317	2.547	0.245
NEW	Silt-Clay	16	425	2.287	0.299
BC6	Silt-Clay	9	238	1.948	0.362
BACK RIVER REFERENCE					
HM26	Sand/Silt-Clay	18	1827	1.072	0.734
ZINC ENRICHED					
G5	Silt-Clay	16	431	2.759	0.193
G25	Silt-Clay	17	380	2.790	0.201
G84	Silt-Clay	16	290	2.708	0.213
HM12	Silt-Clay	16	458	2.086	0.333

TABLE 3-10. Results of Friedman's non-parametric test for differences in the abundances of (11) selected species between stations with silt/clay substrates for the Sixteenth Year of Benthic Studies at HMI. (Silt/clay stations are: NEARFIELD STAS.- S5, S6,BC3; REFERENCE STAS.- HM7, HM16, HM22,30,NEW,BC6; ZINC ENRICHED STAS.- G5, G25,G84,HM12.)

	SOURCE	D.F.	CHI-SQUARE	CHI-SQUARE (0.05)
AUG 1997				
	NEARFIELD	2	2.36	5.99
	REFERENCE	5	3.81	11.07
	ZINC ENRICHED	3	1.28	7.82
	NEARFIELD & REFERENCE	8	14.17	15.51
	ZINC ENRICHED & REFERENCE	9	11.71	16.92

Table 3-12: Benthic Index of Biotic Integrity (B-IBI) metric scores for the 16th year at the Back River Transect Stations.

STATIONS	ABUNDANCE (#m2)	BIOMASS (g m2)	ABUNDANCE OF POLLUTION INDICATIVE TAXA (%)	BIOMASS OF POLLUTION SENSITIVE TAXA (%)	AVERAGE SCORE
BSM75	3	1	1	1	*1.5
M1	3	1	3	5	3
M2	3	1	5	5	3.5
M3	1	3	5	5	3.5
M4	5	1	5	5	4
M5	5	3	5	5	4.5

* Assemblages with an average score of <3.0 are considered stressed, as they have metric values that are less than values at the poorest reference sites.

GLOSSARY

Accuracy: The ability to obtain a true value; determined by the degree of agreement between an observed value and an accepted reference value.

Acid volatile sulfide (AVS): The sulfides removed from sediment by cold acid extraction, consisting mainly of H2S and FeS. AVS is a possible predictive tool for divalent metal sediment toxicity.

Acute: Having a sudden onset, lasting a short time.

Acute toxicity: Short-term toxicity to organism(s) that have been affected by the properties of a substance, such as contaminated sediment. The acute toxicity of a sediment is generally determined by quantifying the mortality of appropriately sensitive organisms that are put into contact with the sediment, under either field or laboratory conditions, for a specified period.

Adduct: Additive product of the reaction between two compounds. In this report, the adduct is methylethylmercury, the product of the reaction between tetraethylborate and methylmercury.

Adjacent: Bordering, contiguous or neighboring. Wetlands separated from other waters of the United States by man-made dikes or barriers, natural river berms, beach dunes and the like are "adjacent wetlands".

Amphipod: A large group usually - an order of crustaceans - comprising the beach fleas and related forms - being mainly of small size with laterally compressed body, four anterior pairs of thoracic limbs directed forward - and three posterior pairs directed backward - and upward - the thoracic limbs bearing gills-aquatic in fresh or salt water.

Application factor (AF): A numerical, unitless value, calculated as the threshold chronically toxic concentration of a test substance divided by its acutely toxic concentration. The AF is usually reported as a range and is multiplied by the median lethal concentration as determined in a short-term (acute) toxicity test to estimate an expected no- effect concentration under chronic exposure.

Benchmark organism: Test organism designated by USACE and EPA as appropriately sensitive and useful for determining biological data applicable to the real world. Test protocols with such organisms are published, reproducible and standardized.

Bioaccumulation: The accumulation of contaminants in the tissue of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, pore water or dredged material. [The regulations require that bioaccumulation be considered as part of the environmental evaluation of dredged material proposed for disposal. This consideration involves predicting whether there will be a cause-and-effect relationship between an organism's presence in the area influenced by the dredged

Completeness: A measure of the amount of valid data obtained versus the amount of data originally intended to be collected.

Confined disposal: A disposal method that isolates the dredged material from the environment. Confined disposal is placement of dredged material within diked confined disposal facilities via pipeline or other means.

Confined disposal facility (CDF): A diked area, either in-water or upland, used to contain dredged material. The terms confined disposal facility (CDF), dredged material containment area, diked disposal facility, and confined disposal area are used interchangeably.

Constituents: Chemical substances, solids, liquids, organic matter, and organisms associated with or contained in or on dredged material.

Contaminant: A chemical or biological substance in a form that can be incorporated into, onto or be ingested by and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment, and includes but is not limited to the substances on the 307(a)(1) list of toxic pollutants promulgated on January 31, 1978 (43 FR 4109). [Note: A contaminant that causes actual harm is technically referred to as a pollutant, but the regulatory definition of a "pollutant" in the Guidelines is different, reflecting the intent of the CWA.]

Contaminant of concern: A contaminant present in a given sediment thought to have the potential for unacceptable adverse environmental impact due to a proposed discharge.

Control sediment: A sediment essentially free of contaminants and which is used routinely to assess the acceptability of a test. Control sediment may be the sediment from which the test organisms are collected or a laboratory sediment, provided the organisms meet control standards. Test procedures are conducted with the control sediment in the same way as the reference sediment and dredged material. The purpose of the control sediment is to confirm the biological acceptability of the test conditions and to help verify the health of the organisms during the test. Excessive mortality in the control sediment indicates a problem with the test conditions or organisms, and can invalidate the results of the corresponding dredged material test.

Data quality indicators: Quantitative statistics and qualitative descriptors which are used to interpret the degree of acceptability or utility of data to the user; include bias (systematic error), precision, accuracy, comparability, completeness, representativeness, detectability and statistical confidence.

Data quality objectives (DQOs): Qualitative and quantitative statements of the overall uncertainty that a decision maker is willing to accept in results or decisions derived from

environmental standards established by the 404(b)(1) evaluation process. [See Engler et al. (1988) and 33 CFR 335-338].

Fill material: Any material used for the primary purpose of replacing an aquatic area with dry land or changing the bottom elevation of a water body for any purpose. The term does not include any pollutant discharged into the water primarily to dispose of waste, as that activity is regulated under Section 402 of the Clean Water Act. [Note: dredged material can be used as fill material].

Grain-size effects: Mortality or other effects in laboratory toxicity tests due to sediment granulometry, not chemical toxicity. [It is clearly best to use test organisms which are not likely to react to grain-size but, if this is not reasonably possible, then testing must account for any grain-size effects.]

Guidelines: Substantive environmental criteria by which proposed discharges of dredged material are evaluated. CWA Section 404(b)(1) final rule (40 CFR 230) promulgated December 24, 1980.

Hydroid: An order of Hydrozoan coelenterates - comprising forms that alternate a well developed asexual polyp generation with a generation of free medusa or of an abortive medusoid reproductive structure on the polyps - resembling a polyp.

LC50: The median lethal concentration. The concentration of a substance that kills 50% of the organisms tested in a laboratory toxicity test of specified duration.

Leachate: Water or any other liquid that may contain dissolved (leached) soluble materials, such as organic salts and mineral salts, derived from a solid material.

Lethal: Causing death.

Loading density: The ratio of organism biomass or numbers to the volume of test solution in an exposure chamber.

Management actions: Those actions considered necessary to rapidly render harmless the material proposed for discharge (e.g., non-toxic, non-bioaccumulative) and which may include containment in or out of the waters of the U.S. (see 40 CFR Subpart H). Management actions are employed to reduce adverse impacts of proposed discharges of dredged material.

Management unit: A manageable, dredgeable unit of sediment which can be differentiated by sampling and which can be separately dredged and disposed within a larger dredging area. Management units are not differentiated solely on physical or other measures or tests but are also based on site- and project-specific considerations.

Method detection limit (MDL): The minimum concentration of a substance which can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

Reference sediment: Point of comparison for evaluating test sediment. Testing requirements in the Section 404(b)(1) Guidelines regarding the point of comparison for evaluating proposed discharges of dredged material are being updated to provide for comparison to a "reference sediment" as opposed to sediment from the disposal site. Because subsequent discharges at a disposal site could adversely impact the point of comparison, adoption of a reference sediment that is unimpacted by previous discharges of dredged material will result in a more scientifically sound evaluation of potential individual and cumulative contaminant-related impacts. This change to the Guidelines was proposed in the Federal Register in January 1995, public comments have been received, and a final rule Notice is being prepared. It is expected that the final rule will be published prior to July 1, 1998, and as a result the reference sediment approach will be implemented in the ITM.

Reference site: The location from which reference sediment is obtained.

Region: An EPA administrative area.

region: A geographical area.

Regulations: Procedures and concepts published in the Code of Federal Regulations for evaluating the discharge of dredged material into waters of the United States.

Representativeness: The degree to which sample data depict an existing environmental condition; a measure of the total variability associated with sampling and measuring that includes the two major error components: systematic error (bias) and random error. Sampling representativeness is accomplished through proper selection of sampling locations and sampling techniques, collection of sufficient number of samples, and use of appropriate subsampling and handling techniques.

Sediment: Material, such as sand, silt, or clay, suspended in or settled on the bottom of a water body.

Should: Is used to state that the specified condition is recommended and ought to be met unless there are clear and definite reasons not to do so.

Standard operating procedure (SOP): A written document which details an operation, analysis, or action whose mechanisms are thoroughly prescribed and which is commonly accepted as the method for performing certain routine or repetitive tasks.

Standardized: In the case of methodology, a published procedure which has been peer reviewed (e.g., journal, technical report), and generally accepted by the relevant technical community of experts.

Sublethal: Not directly causing death; producing less obvious effects on behavior, biochemical and/or physiological function, histology of organisms.

Water Quality Standard (Code of Maryland Regulations - COMAR): A law or regulation that consists of the beneficial designated use or uses of a water body, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular water body, and an anti- degradation statement.

Waters of the U.S.: In general, all waters landward of the baseline of the territorial sea and the territorial sea. Specifically, all waters defined in Section 230.3 (s) of the Guidelines. [See Appendix A].

Whole sediment: The sediment and interstitial waters of the proposed dredged material or reference sediment that have had minimal manipulation. For purposes of this manual, press-sieving to remove organisms from test sediments, homogenization of test sediments, compositing of sediment samples, and additions of small amounts of water to facilitate homogenizing or compositing sediments may be necessary to conducting bioassay tests. These procedures are considered unlikely to substantially alter chemical or toxicological properties of the respective whole sediments except in the case of AVS (acid volatile sulfide) measurements (EPA, 1991a) which are not presently required. Alternatively, wet sieving, elutriation, or freezing and thawing of sediments may alter chemical and/or toxicological properties, and sediment so processed should not be considered as whole sediment for bioassay purposes.

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