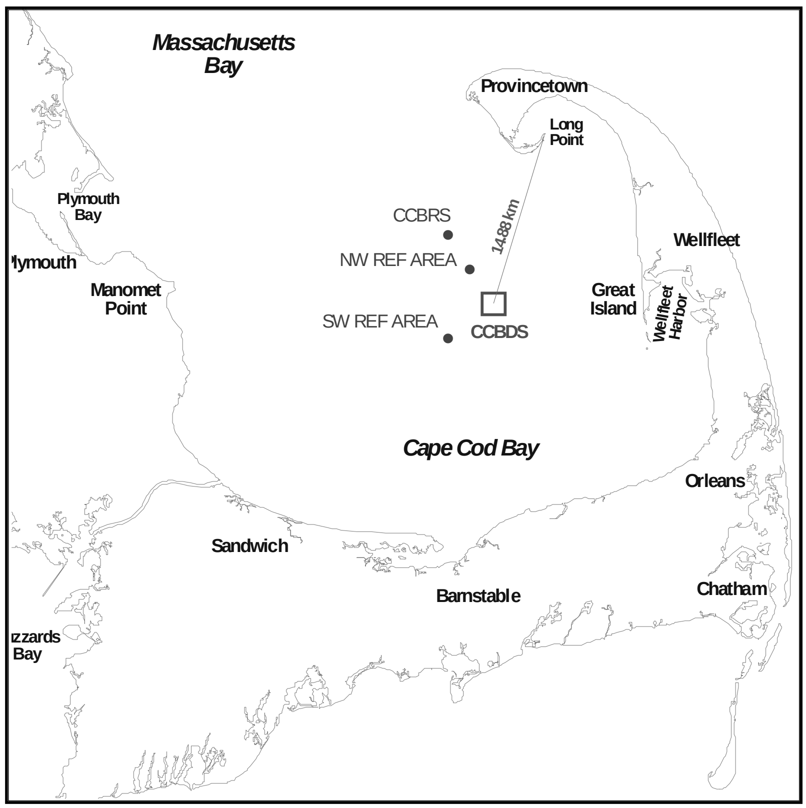
Monitoring Survey at the Cape Cod Bay Disposal Site
August 2001

Disposal Area Monitoring System DAMOS



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13. ABSTRACT

In support of the Disposal Area Monitoring System (DAMOS) Program, Science Applications International Corporation (SAIC) conducted an environmental monitoring survey at the Cape Cod Bay Disposal Site (CCBDS) from 17 to 21 August 2001. The August 2001 field effort consisted of collecting precision bathymetric and Remote Ecological Monitoring of the Seafloor (REMOTS®) data over two dredged material disposal mounds within CCBDS. The bathymetric survey area covered the entire disposal site and displayed a relatively flat and regular, natural seafloor within CCBDS; the only features found at the site consisted of three dredged material deposits. Two clearly distinguishable disposal mounds were detected, Mound A located in the southeastern corner and Mound B in the northeastern quadrant of the disposal site. A subtle dredged material mound was also detected near the center of CCBDS within the historic Wellfleet Disposal Area. Mound A is an older mound, formed in the fall of 1994 and winter of 1995 by the placement of 112,000 m^3 of dredged sediment. The August 2001 monitoring survey detected a water depth of 29.25 m at the base of the mound and a minimum depth of 28.65 m at its apex, yielding a mound height of 0.6 m. The largest and most recent bottom feature detected at CCBDS was the active disposal Mound B. Mound B was formed over a four-year period (June 1996 to December 2000) by the placement of 324,000 m^3 of sediment. Rising 4 m above surrounding seafloor, the apex of Mound B was 27.5 m below the water surface (the shallowest depth at CCBDS), with an estimated diameter based on the bathymetric survey alone of about 350 m.

The comparison between the August 2001 and May 1996 bathymetric survey data indicated only small-scale changes in seafloor topography over Mound A. At roughly six years following disposal activities, the benthic recolonization over the surface of Mound A appeared to be inhibited and slower than expected, with a dominance of Stage I surface dwelling taxa. A shallow redox potential discontinuity (RPD) depth and the dominance of only Stage I organisms served to diminish the overall median Organism-Sediment Index (OSI) for Mound A to a value lower than those documented at the reference areas and during prior surveys. The benthic community over Mound B appeared to be recovering as anticipated, with median OSI values indicating undisturbed benthic habitat quality. A diverse benthic community consisting of both surface-dwelling and deeper-dwelling infauna had recolonized Mound B and was comparable to conditions on the ambient seafloor. The bioturbational activity of this advanced benthic infaunal community was responsible for the formation of moderate to deep RPD depths, ranging from 1.4 to 3.7 cm below the sediment-water interface at the time of the August 2001 survey.

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

Page

Page

LIST OF FIGURES (continued)

EXECUTIVE SUMMARY

In support of the Disposal Area Monitoring System (DAMOS) Program, Science Applications International Corporation (SAIC) conducted an environmental monitoring survey at the Cape Cod Bay Disposal Site (CCBDS) from 17 to 21 August 2001. The August 2001 field effort consisted of collecting precision bathymetric and Remote Ecological Monitoring of the Seafloor (REMOTS®) data over two dredged material disposal mounds within CCBDS. These survey techniques were used to document changes in seafloor topography, evaluate the distribution of dredged material, and assess the recovery of the benthic community within the active areas of CCBDS relative to conditions within the surrounding ambient sediments.

Although several bathymetric surveys have been performed over small areas within CCBDS, the August 2001 monitoring effort was the first high-resolution, master bathymetric survey completed over the entire disposal site. The natural seafloor within CCBDS was found to be relatively flat and regular; the only features found at the site consisted of three dredged material deposits. Two clearly distinguishable disposal mounds were detected, Mound A located in the southeastern corner and Mound B in the northeastern quadrant of the disposal site. A subtle dredged material mound was also detected near the center of CCBDS within the historic Wellfleet Disposal Area.

Mound A is an older mound, formed in the fall of 1994 and winter of 1995 by the placement of 112,000 m^3 of sediment dredged from Wellfleet Harbor. The August 2001 monitoring survey detected a water depth of 29.25 m at the base of the mound and a minimum depth of 28.65 m at its apex, yielding a mound height of 0.6 m. The comparison between the August 2001 and May 1996 bathymetric survey data indicated only small-scale changes in seafloor topography over Mound A. The REMOTS® results agreed relatively well with the depth difference comparison over Mound A and showed that the mound apron extended 100 to 200 m to the south of the mound center and beyond 200 m to the east.

At roughly six years following disposal activities, the benthic recolonization over the surface of Mound A appeared to be inhibited and slower than expected, with a dominance of Stage I surface dwelling taxa. Stage III deep-dwelling infauna were present in only 31% of the images obtained over Mound A, compared to 68% at the reference area stations. A shallower overall redox potential discontinuity (RPD) depth of 1.9 cm and the dominance of only Stage I organisms served to diminish the overall median Organism-Sediment Index (OSI) value to +4.5 at Mound A, indicative of moderately degraded or disturbed benthic habitat quality; this value was considerably lower than the observed value of +7.9 at the reference areas. Results of the May 1996 survey suggested that complete benthic recolonization of the mound had occurred, with the presence of deep RPD depths and Stage III infauna. The August 2001 REMOTS® survey over a similar sampling grid of Mound A showed a significant decline in OSI values from +9.1 (1996) to +4.5 (2001).

The August 2001 REMOTS® stations over Mound A should be resampled to monitor the progress of benthic habitat recovery in the future.

The largest and most recent bottom feature detected at CCBDS was the active disposal Mound B. Mound B was formed over a four-year period (June 1996 to December 2000) by the placement of 324,000 m^3 of sediment dredged from Wellfleet, Plymouth, Sesuit, and Duxbury Harbors and deposited in the northeast quadrant (NE) of CCBDS. Rising four meters above surrounding seafloor, the apex of the Mound B was 27.5 m below the water surface (the shallowest depth at CCBDS), with an estimated diameter based on the bathymetric survey alone of about 350 meters. Because of the continued dredged material disposal over Mound B, the possibility of directing disposal to a new position should be considered before the stability of the mound is affected.

The results of the summer 2001 REMOTS® survey agreed relatively well with the bathymetric results over Mound B and indicated that the dredged material (fine-grained silt and clay occasionally mottled with white clay) was contained within the confines of the northeast portion of the disposal site. Ambient sediment (i.e., no dredged material) was detected at stations located primarily to the outer 300 m of the REMOTS® survey grid. Based on bathymetry and REMOTS®, the mound was estimated to be about 500 to 600 m in diameter.

The benthic community over Mound B appeared to be recovering as anticipated, with an overall median OSI value of +6.5, indicating undisturbed benthic habitat quality. A diverse benthic community consisting of both surface-dwelling and deeper-dwelling infauna had recolonized Mound B and was comparable to conditions on the ambient seafloor. The bioturbational activity of this advanced benthic infaunal community was responsible for the formation of moderate to deep RPD depths, ranging from 1.4 to 3.7 cm below the sediment-water interface at the time of the August 2001 survey. Because of its recent disposal history, variability in benthic habitat quality was expected (OSI values ranging from +3 to +9). This variability is expected to continue as new dredged material is deposited over Mound B during the 2001–02 disposal season.

The initial reference area around CCBDS (CCBRS) has been periodically monitored over the past seven years, while the newly designated NW REF and SW REF reference areas were first monitored in 1996. Results of the August 2001 monitoring survey indicated that the CCBDS reference areas have continued to show undisturbed benthic habitat quality, with an overall OSI value of +7.9, similar to previous 1996 results.

1.0 INTRODUCTION

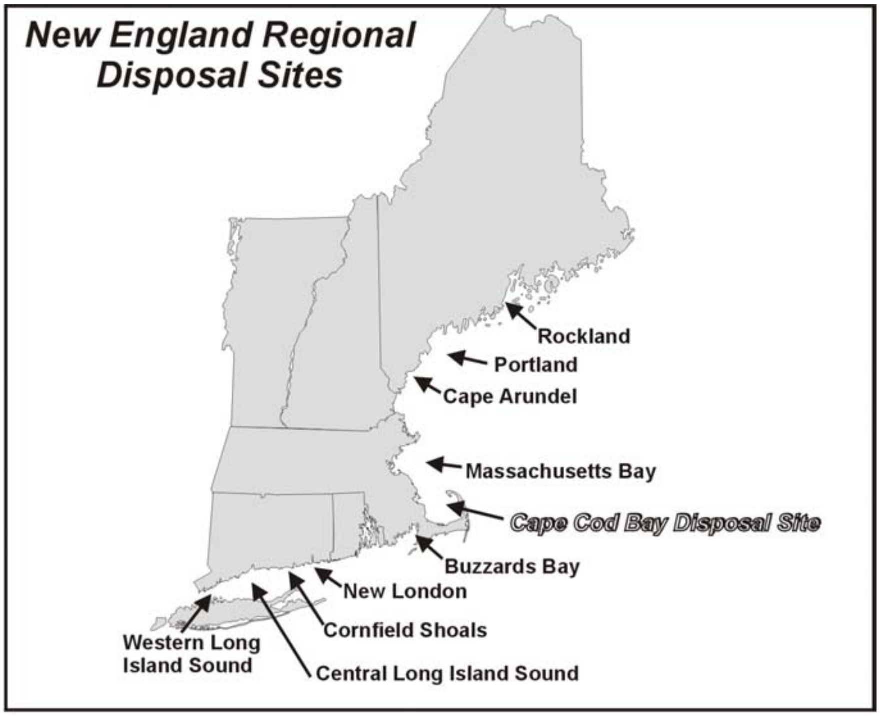
1.1 Background

In 1977, the New England District (NAE) of the U.S. Army Corps of Engineers established the Disposal Area Monitoring System (DAMOS) to monitor the environmental impacts associated with the subaqueous disposal of sediments dredged from harbors, inlets, and bays in the New England region. The DAMOS Program conducts detailed monitoring studies to detect and minimize any physical, chemical, and biological impacts of dredging and dredged material disposal activities. DAMOS monitoring helps to ensure that any effects of sediment deposition on the marine environment are confined to designated seafloor areas and are of limited duration. A flexible, tiered monitoring approach (Germano et al. 1994) is applied in the long-term management of sediment disposal at ten designated open-water dredged material disposal sites along the coast of New England (Figure 1-1A).

Dredging needs in the many harbors within the Cape Cod Bay region have increased over the past 15 years in response to the steady rise in the coastal population and related commercial and recreational boating activities. The recognized need for future maintenance and improvement dredging of channels and harbor facilities prompted the official selection of the Cape Cod Bay Disposal Site (CCBDS) in 1990. This relatively new open water dredged material disposal site is one of three regional dredged material disposal sites located off the coast of Massachusetts. The disposal site is centered at coordinates 41° 54.406´ N, 70° 13.268´ W (NAD 83) and is located approximately 14.9 km southwest of Long Point, Provincetown, Massachusetts (Figure 1-2). The site has a relatively flat, featureless seafloor with an average water depth of 31 m. The bottom gently slopes from a depth of 30.8 m in the southeast corner of the site to a depth of 31.4 m in the northwest. Encompassing a 3.42 km^2 (1 nmi^2) area of seafloor within the east-central region of Cape Cod Bay, CCBDS receives sediments dredged primarily from Wellfleet, Barnstable, Plymouth, and Duxbury Harbors.

The center of CCBDS corresponds to the position of the now historic Wellfleet Disposal Site, which was utilized for the placement of small to moderate volumes of sediment (estimated total of 172,900 m^3) dredged from Wellfleet Harbor in the 1970s and 1980s (Massachusetts Department of Environmental Management 1998; Figures 1-1B and 1-3). Throughout its history, this area of seafloor in Cape Cod Bay has consistently displayed a depositional nature, a low current regime, a scarcity of endangered right whale sightings, and a lack of a substantial Northern Lobster population. Based on these characteristics, as well as the existence of previously deposited dredged material, the Commonwealth of Massachusetts, US Environmental Protection Agency, and NAE approved the use of this site for the controlled placement of dredged material.

A



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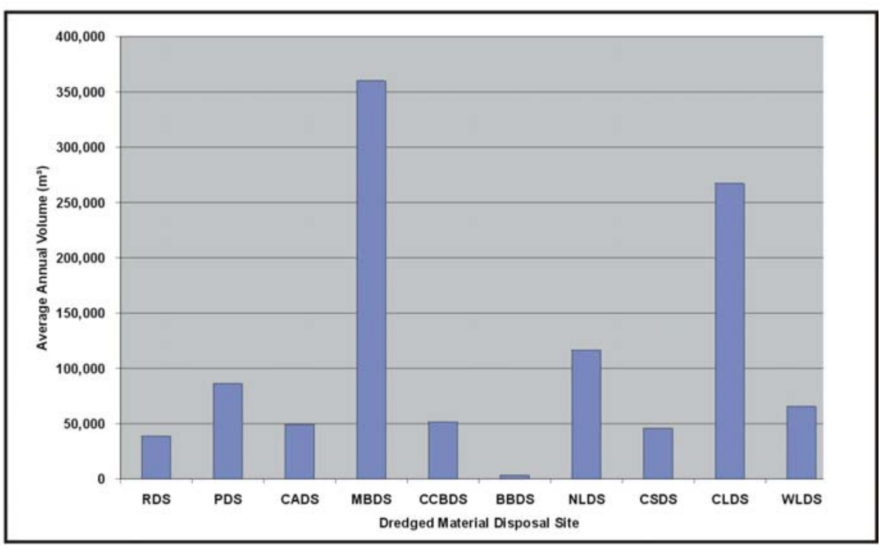


Figure 1-1. Location of the ten dredged material disposal sites along coastal New England (upper panel A) and average annual dredged material disposal volumes for the ten New England disposal sites from 1982 to 2001 (lower panel B).

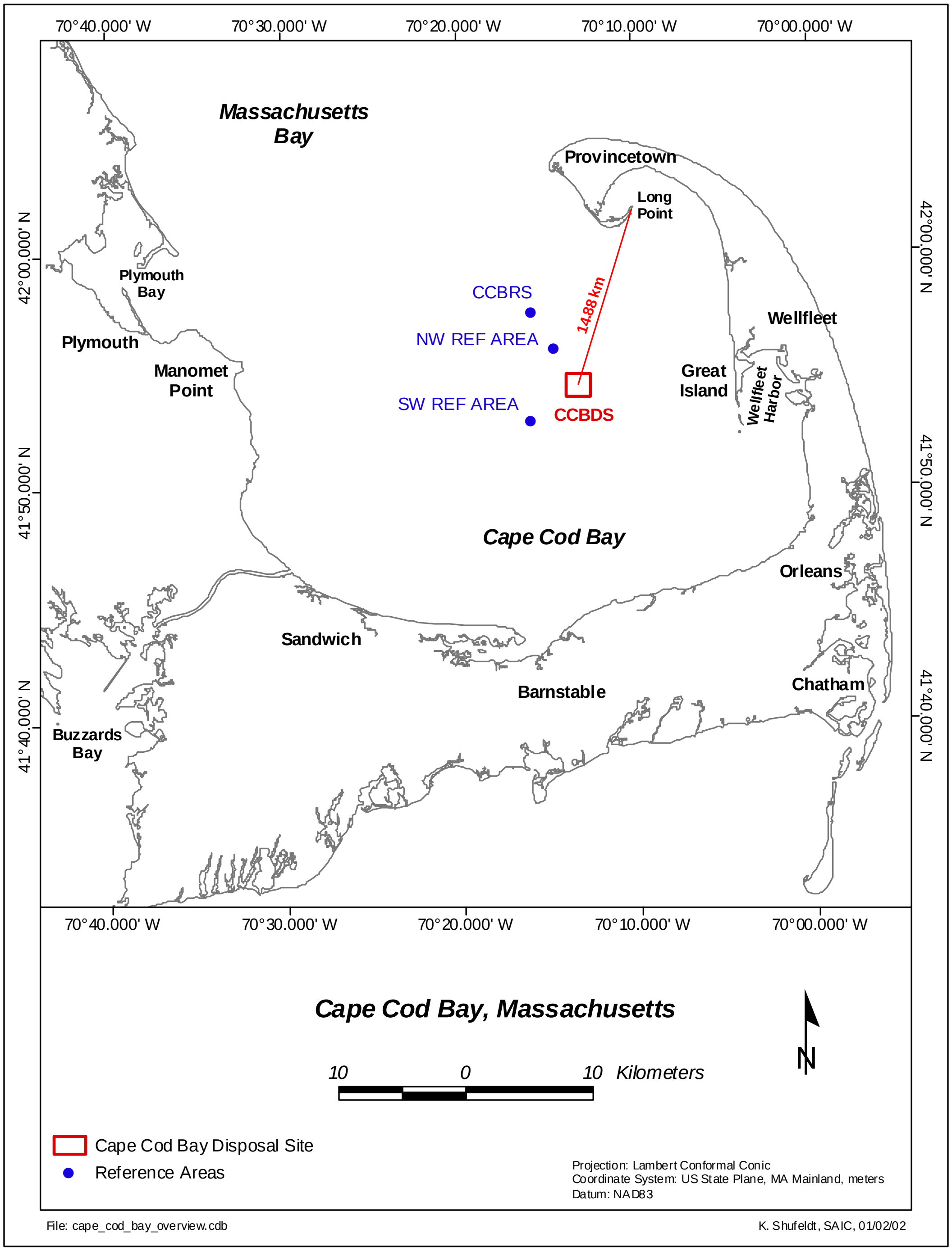


Figure 1-2. Location of the Cape Cod Bay Disposal Site (CCBDS) and nearby reference areas relative to Cape Cod Bay and Massachusetts Bay

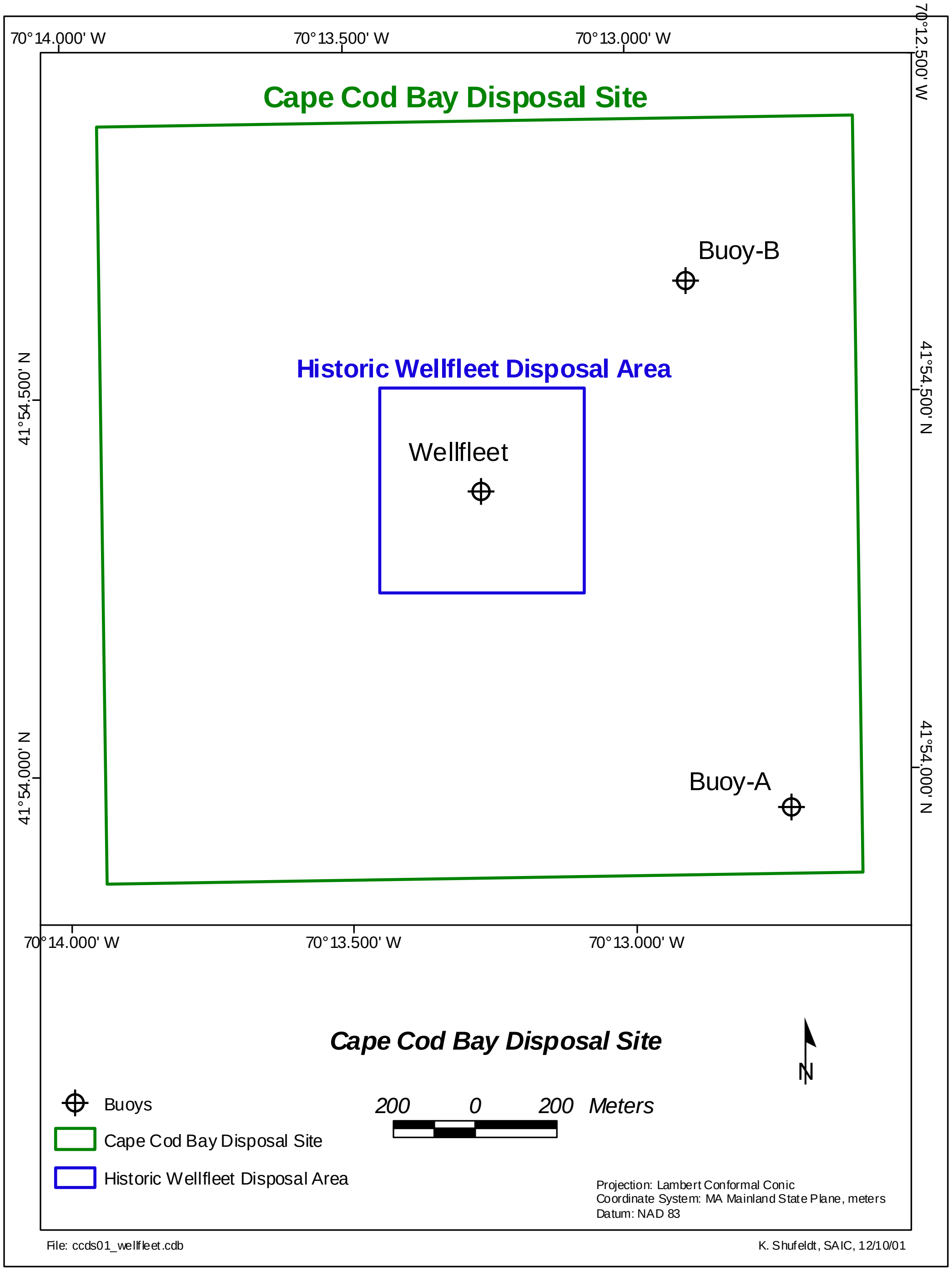


Figure 1-3. Location of buoys A and B within CCBDS relative to the Historic Wellfleet disposal area

Overall management of the disposal site and environmental monitoring of the dredged material deposited within the confines of CCBDS are the shared responsibilities of the Massachusetts Department of Environmental Management (MADEM) and the DAMOS Program. The current site management plan for CCBDS includes the subdivision of the 1.85 × 1.85 km disposal site into four quadrants (NW, NE, SE, and SW), which can be further subdivided as required (Figure 1-4). A disposal buoy is placed within a specified quadrant to indicate the desired disposal point within the site for a specific period of time. Sediments are then transported to CCBDS by disposal barge and deposited in close proximity to the surface buoy to form a dredged material mound on the seafloor. Disposal operations are restricted to the months between June and December in response to environmental concerns pertaining to resident and transient marine mammal populations.

1.2 Dredged Material Disposal Operations

1.2.1 Mound A (Southeastern Quadrant)

Although established in 1990, CCBDS was not utilized for dredged material disposal operations until 1994. During the fall of 1994, a disposal buoy (Buoy A) was deployed by MADEM at coordinates 41°53.996´N, 70°12.725´W (NAD 83) in the southeastern corner of the southeast (SE/SE) quadrant of the disposal site (Figure 1-4). From November 1994 through January 1995, approximately 112,000 m^3 of fine-grained sediment removed from Wellfleet Harbor was transported to CCBDS for disposal (Appendix A). Baseline and postdisposal surveys performed over CCBDS by Ocean Surveys Incorporated (OSI) of Old Saybrook, Connecticut confirmed the depositional nature of this area and the formation of a subtle, but discrete disposal mound in the southeast corner of the disposal site (Ocean Surveys Inc. 1995).

Additional environmental monitoring was performed over CCBDS in May 1996 to evaluate the distribution of dredged material and assess benthic habitat quality (CR Environmental 1997). The 1996 monitoring survey documented the topography and stability of Mound A and the presence of an advanced, stable benthic community within the surficial sediment layers at 16 months postdisposal. The 1996 survey effort was sponsored by both MADEM and the DAMOS Program.

1.2.2 Mound B (Northeastern Quadrant)

At the conclusion of the 1996 survey effort, a disposal buoy (Buoy B) was placed by MADEM at coordinates 41°54.686´ N and 70°12.900´ W (NAD 83) within the northeast quadrant of CCBDS (Figure 1-4). Between 6 June 1996 and 22 December 2000, a total

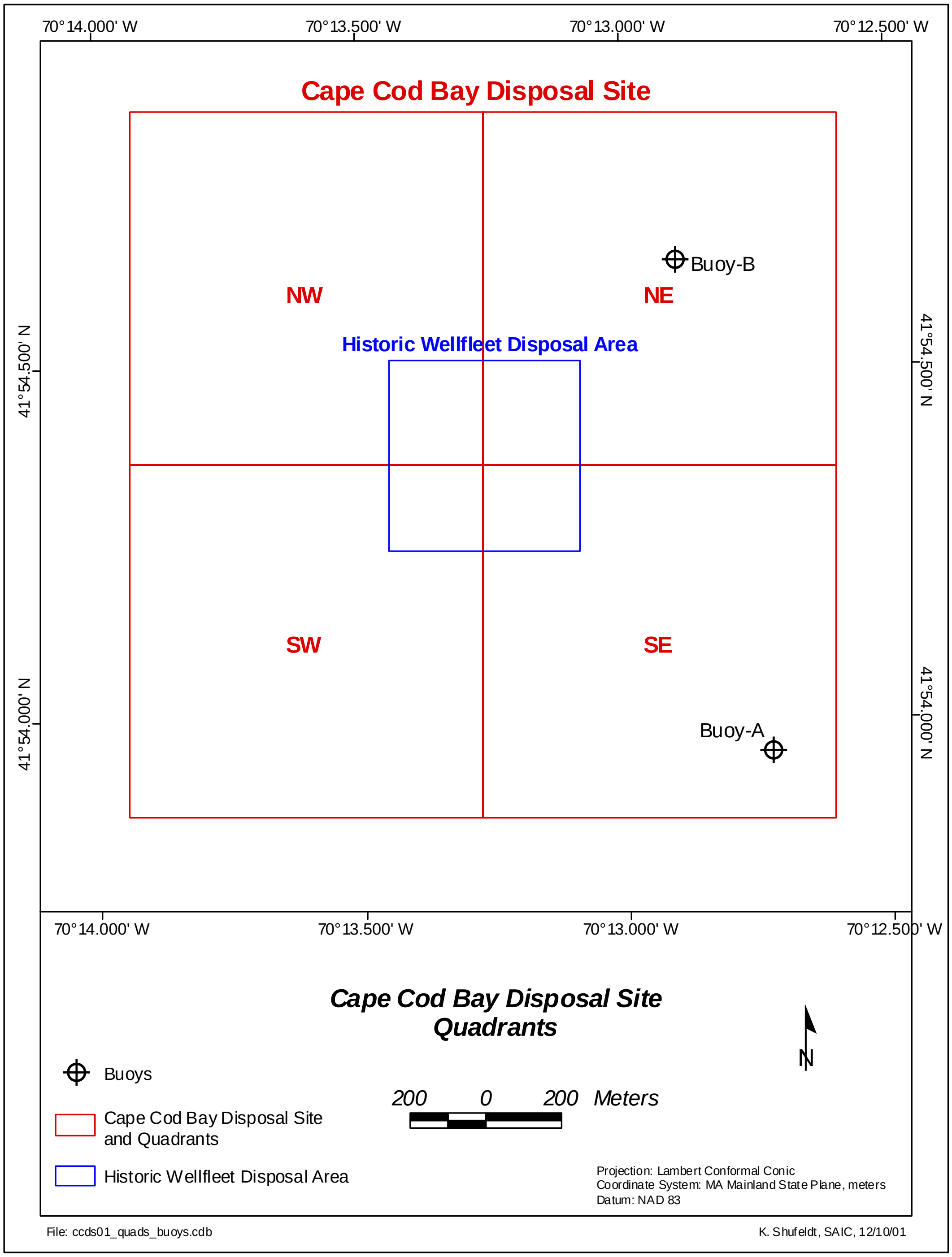


Figure 1-4. Management strategy (quadrant-system) for the Cape Cod Bay Disposal Site

estimated barge volume of 324,000 m^3 of sediment dredged from Wellfleet, Plymouth, Sesuit, and Duxbury Harbors was deposited in the northeast quadrant (NE) of CCBDS (Appendix A). One of the objectives of the August 2001 survey (this report) was to document the changes in seafloor topography resulting from the recent deposition of dredged material and evaluate benthic recolonization over the new disposal mound (Mound B) in the northeast quadrant.

1.3 Cape Cod Bay Disposal Site Reference Areas

Until 1996, there was only one reference area identified within Cape Cod Bay to provide a comparison between conditions existing at CCBDS and those on the ambient seafloor. Cape Cod Bay Reference Site (CCBRS) is located at coordinates 41°57.506´ N, 70°15.968´ W (NAD 83), approximately 6.7 km northwest of CCBDS. However, three reference areas are typically used at other New England disposal sites to provide a reasonable assessment of the variability present on the seafloor in surrounding areas unaffected by disposal (Hurlbert 1984). In 1996, the CCBDS Disposal and Monitoring Advisory Committee (DMAC) agreed that additional reference sites would bring this disposal site into conformity with standard practice at other disposal sites throughout New England (CR Environmental 1997). These alternate sites were necessary to provide an evaluation of seafloor conditions potentially resulting from regional events (e.g., seasonal stress, storm related impacts) relative to the site-specific impact of dredged material placement at the disposal site.

The proposed reference areas to supplement the CCBRS included a northwest (NW) site centered at coordinates 41°55.926´ N, 70°14.677´ W (NAD 83) and a southwest (SW) site centered at coordinates 41°52.871´ N and 70°16.014´ W (NAD 83; Figure 1-5). Both of these reference sites are located 4 km from the CCBDS and are also located within depositional areas of Cape Cod Bay. A sediment-profile imaging survey was conducted over the two proposed reference areas in May 1996 to evaluate their suitability for routine use in the future. The potential alternate reference sites NW and SW were selected based on their similar water depth and grain size to the disposal site and determined to be suitable (CR Environmental 1997). These reference areas, therefore, were sampled once again as part of the August 2001 monitoring survey.

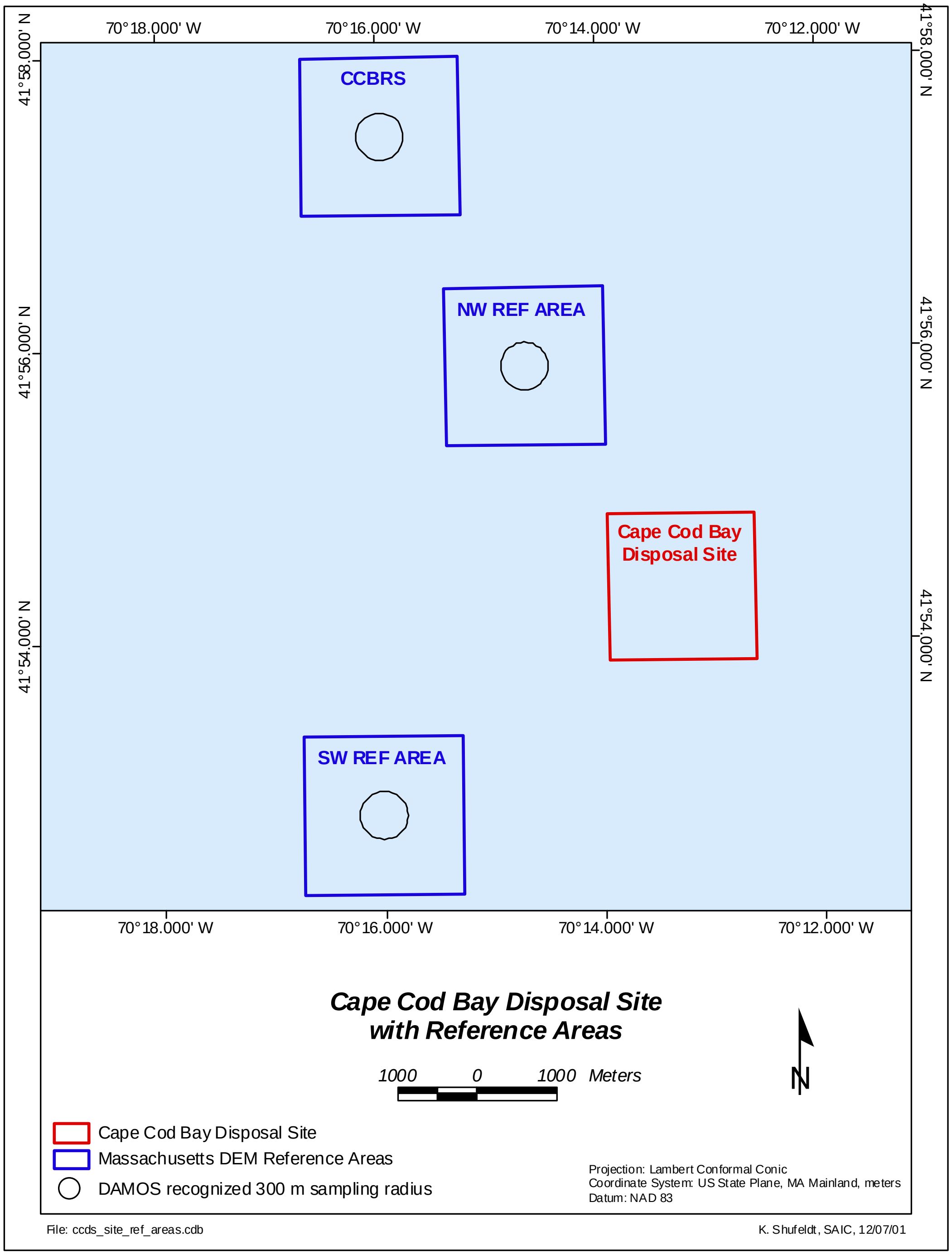


Figure 1-5. Location of the Cape Cod Bay Disposal Site Reference Areas (CCBRS, NW REF, and SW REF) relative to the disposal site boundary

1.4 Objectives and Predictions

The specific objectives of the August 2001 field operations, which consisted of single-beam bathymetric surveying and REMOTS® sediment-profile imaging, were:

1) To document changes in seafloor topography around the two CCBDS disposal buoy positions (Buoy A and Buoy B) relative to previous surveys

2) To evaluate the distribution of dredged material within CCBDS

3) To assess the benthic recolonization status within the active areas of the CCBDS relative to existing conditions at the three surrounding reference areas

The summer 2001 field effort tested the following predictions:

1) The 324,000 m^3 of sediment deposited at Buoy B between 1996 and 2000 disposal will result in the formation of a discrete dredged material mound in the northeastern quadrant of CCBDS.

2) The recently placed dredged material comprising Mound B is expected to be supporting a well-developed Stage I population with some progression into Stage II or Stage III communities as predicted by the DAMOS tiered monitoring protocols.

3) A moderate degree of dredged material consolidation will occur within Mound A located in the southeast quadrant relative to the 1996 survey.

4) The sediments of Mound A are expected to be displaying a mature and biologically active benthic assemblage consisting of Stages II and III, as predicted by the DAMOS tiered monitoring protocol.

2.0 METHODS

The following section will provide an overview of the methods employed during the August 2001 monitoring survey at the CCBDS. Field operations consisted of REMOTS® sediment-profile imaging and single-beam bathymetry. Both surveys were conducted aboard the M/V *Beavertail* from 17 to 21 August 2001. Two separate dredged material mounds were comprehensively sampled to document the distribution of dredged material and disposal mound morphology, as well as to evaluate benthic recolonization status relative to three surrounding reference areas.

2.1 Navigation

During the field operations, precise navigation data were provided by a Trimble 4000 RSi Global Positioning System (GPS) receiver interfaced with a Trimble NavBeacon XL differential receiver. Because of its proximity to the survey area, the U.S. Coast Guard differential beacon broadcasting from Portsmouth, NH (288 kHz) was used for generating the real-time differential corrections. During all survey operations, the Trimble DGPS system output real-time navigation data in the horizontal control of North American Datum of 1983 (NAD 83; Latitude and Longitude) at a rate of once per second to an accuracy of ±3 m.

Coastal Oceanographic's HYPACK® survey and data acquisition software was used to provide the real-time interface, display, and logging of the DGPS data. Prior to field operations, HYPACK® was used to define a Universal Transverse Mercator (UTM-Zone 19) grid around the survey area, to establish the planned sediment-profile imaging stations and to construct the planned bathymetric survey lanes. During the survey operations, the incoming DGPS navigation data were translated into UTM coordinates, time-tagged, and stored within HYPACK®. Depending on the type of field operation being conducted, the real-time navigation information was displayed in a variety of user-defined modes within HYPACK®.

2.2 Bathymetric Data Acquisition and Analysis

2.2.1 Bathymetric Data Acquisition

A 2100 × 2200 m bathymetric survey area was established over the study site to document changes in seafloor topography and delineate the disposal mounds resulting from past and recent dredged material deposition. The survey grid was centered at coordinates 41° 54.375´ N, 70° 13.169´ W and consisted of a total of 89 survey lanes, oriented north/south at 25 m lane spacing (Figure 2-1). To maximize data return within the survey

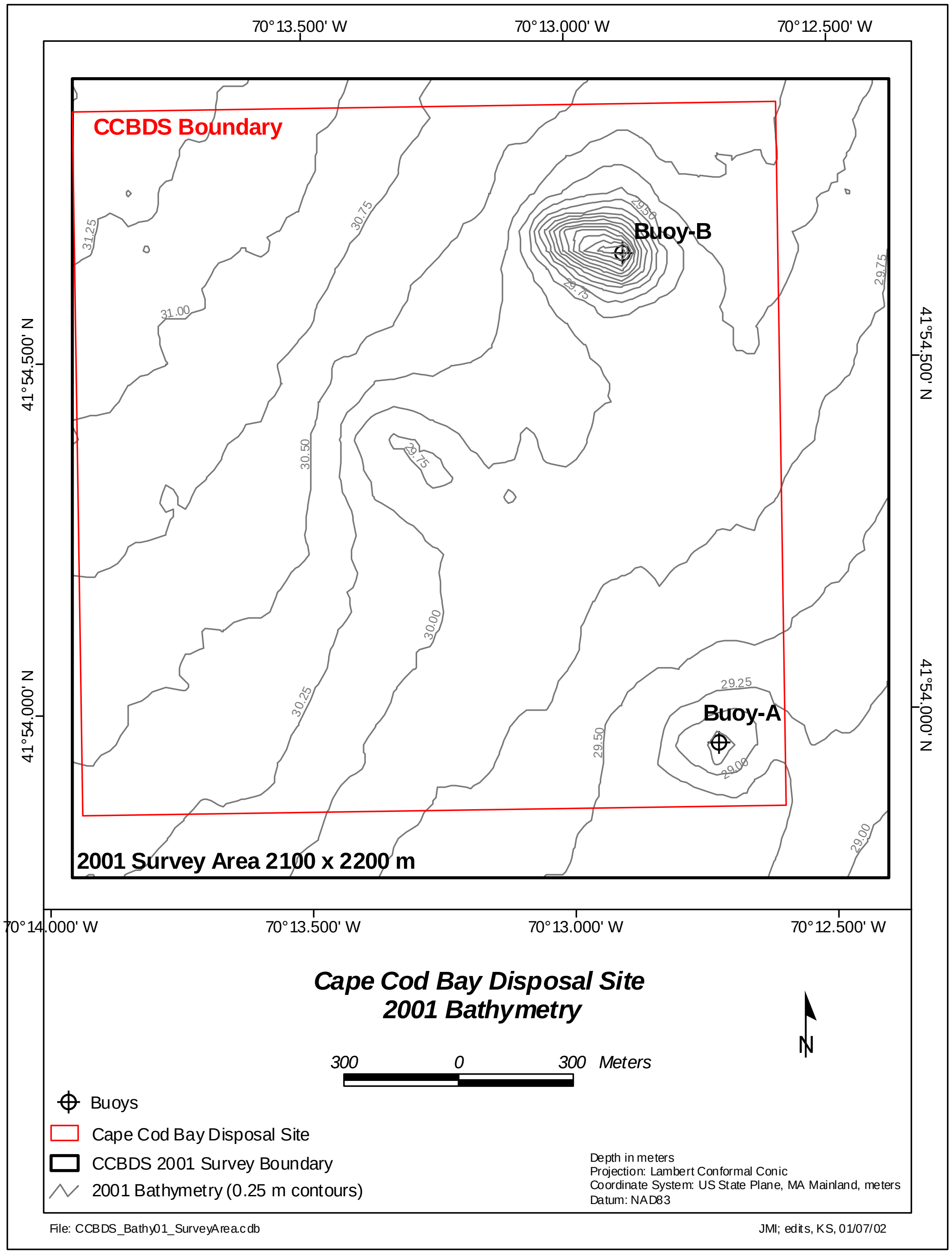


Figure 2-1. Single-beam bathymetric survey area occupied at CCBDS as part of the August 2001 field operations, relative to the disposal site boundary

time constraints, a priority was placed on first occupying every other lane to characterize the entire area at 50 m spacing. As a secondary objective, the project mounds (eastern half) were surveyed using 25 m lane spacing, while the third objective consisted of surveying the relatively flat western half of the site at 25 m lane spacing. A total of 78 survey lanes out of the 89 lanes were occupied. Four survey lanes oriented east/west (i.e., "cross-lines") were occupied for quality control purposes.

During the bathymetric survey, HYPACK® was interfaced with an Odom Hydrotrac® survey echosounder, as well as the Trimble DGPS. The Hydrotrac® uses a narrow-beam (3°), 208-kHz transducer to make discrete depth measurements and produce a continuous analog record of the seafloor. The Hydrotrac® transmitted approximately 10 digital depth values per second (depending on water depth) to the data acquisition system. Within HYPACK®, the time-tagged position and depth data were merged to create continuous depth records along the actual survey track. These records were viewed in near real-time to ensure adequate coverage of the survey area.

2.2.2 Bathymetric Data Processing

The bathymetric data were fully edited and processed using the HYPACK® data processing modules. Raw position and sounding data were edited as necessary to remove or correct questionable values, apply sound velocity and draft corrections, and reduce the depth soundings to the vertical datum of Mean Lower Low Water (MLLW) using observed tides obtained from the National Oceanic and Atmospheric Administration (NOAA).

During bathymetric survey data acquisition, an assumed and constant water column sound velocity was entered into the Odom echosounder. To account for the variable speed of sound through the water column, a Seabird Instruments, Inc. SEACAT SBE 19-01 Conductivity, Temperature, and Depth (CTD) probe was used to obtain sound velocity profiles at the start, midpoint, and end of each field survey day. An average sound velocity was calculated for each day from the water column profile data, and then entered into a HYPACK® sound velocity correction table. Using the assumed sound velocity entered into the echosounder and the computed sound velocity from the CTD casts, HYPACK® then computed and applied the required sound velocity corrections to all of the sounding records.

Observed tide data were obtained through the NOAA National Water Level Observation Network. The NOAA six-minute tide data were downloaded in the MLLW datum and corrected for tidal offsets. SAIC used the water level data available from the operating NOAA tide station in Boston, MA (Station number 8443970). In addition, a tide gauge mooring was deployed on site at 41°55.107´ N, 70°12.663´ W to document water levels over the survey area and aid in applying correctors to the Boston Harbor data. Based on the comparison between the NOAA tide data and the local tide gauge, a height corrector was calculated for the Boston Harbor data. Best fit between the NOAA observed data and the moored tide gauge data indicated no time offset and a height correction of 0.97 (Figure 2-2). After the bathymetric data were fully edited and reduced to MLLW, cross-check comparisons on overlapping data were performed to verify the proper application of the correctors and to evaluate the consistency of the data set.

2.2.3 Bathymetric Data Analysis

The purpose of the bathymetric analysis was to identify any changes or unique features in the seafloor topography resulting from dredged material disposal. Because single-beam bathymetric survey data typically cover only a small percentage of the total seafloor area (approximately 5%), these analysis tools rely on interpolation between the discrete survey data points to generate a three-dimensional seafloor surface model.

The processed HYPACK® 2001 CCBDS bathymetric survey data were converted from an XYZ (longitude, latitude, depth) data file to a regularly-spaced grid using Inverse Distance Weighted (IDW) Interpolation in ArcInfo 8.1. The created grid had a 25 × 25 m cell size and a specific extent (x min, y min, x max, y max). For each cell, an averaged depth was taken from points in the xyz data file that were nearest the cell center. The grid was used as a basis for the generation of all bathymetric figures. The data set was imported into ArcMap to produce report-ready graphics.

2.3 REMOTS® Sediment-Profile Imaging

REMOTS® (Remote Ecological Monitoring of the Seafloor sediment-profile imaging is a benthic sampling technique used to detect and map the distribution of thin (<20 cm) dredged material layers, delineate benthic disturbance gradients, and monitor the process of benthic recolonization following physical seafloor disturbance. This is a reconnaissance survey technique used for rapid collection, interpretation and mapping of data on physical and biological seafloor characteristics. The DAMOS Program has used this technique for routine disposal site monitoring for over 20 years.

The REMOTS® hardware consists of a Benthos Model 3731 sediment-profile camera designed to obtain undisturbed, vertical cross-section photographs (*in situ* profiles) of the upper 15 to 20 cm of the seafloor (Figure 2-3). Computer-aided analysis of each REMOTS® image yields a suite of standard measured parameters, including sediment grain size major mode, camera prism penetration depth (an indirect measure of sediment bearing

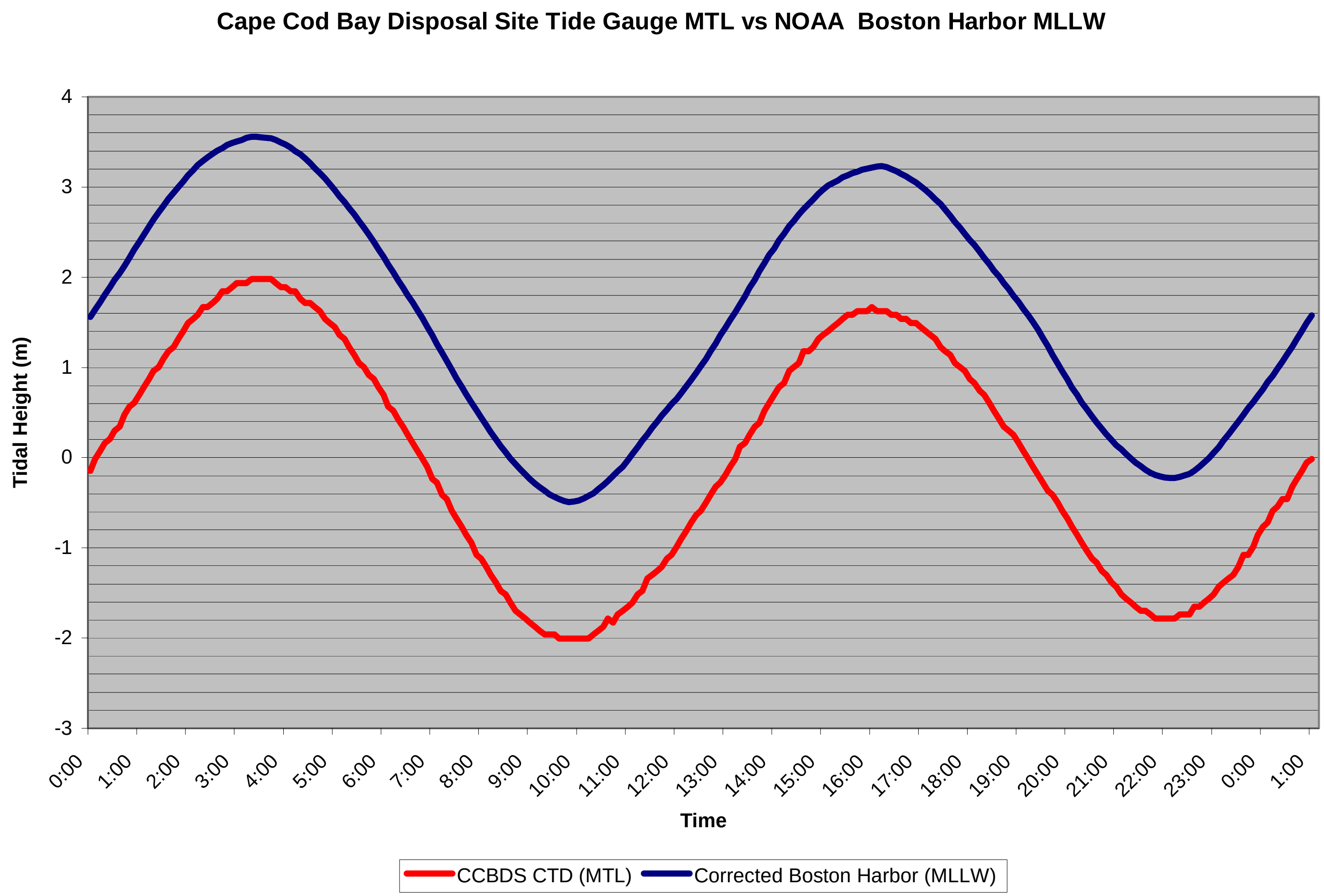


Figure 2-2. Comparison between the local tide data at CCBDS (MTL) and the NOAA Boston Harbor tide station (MLLW)

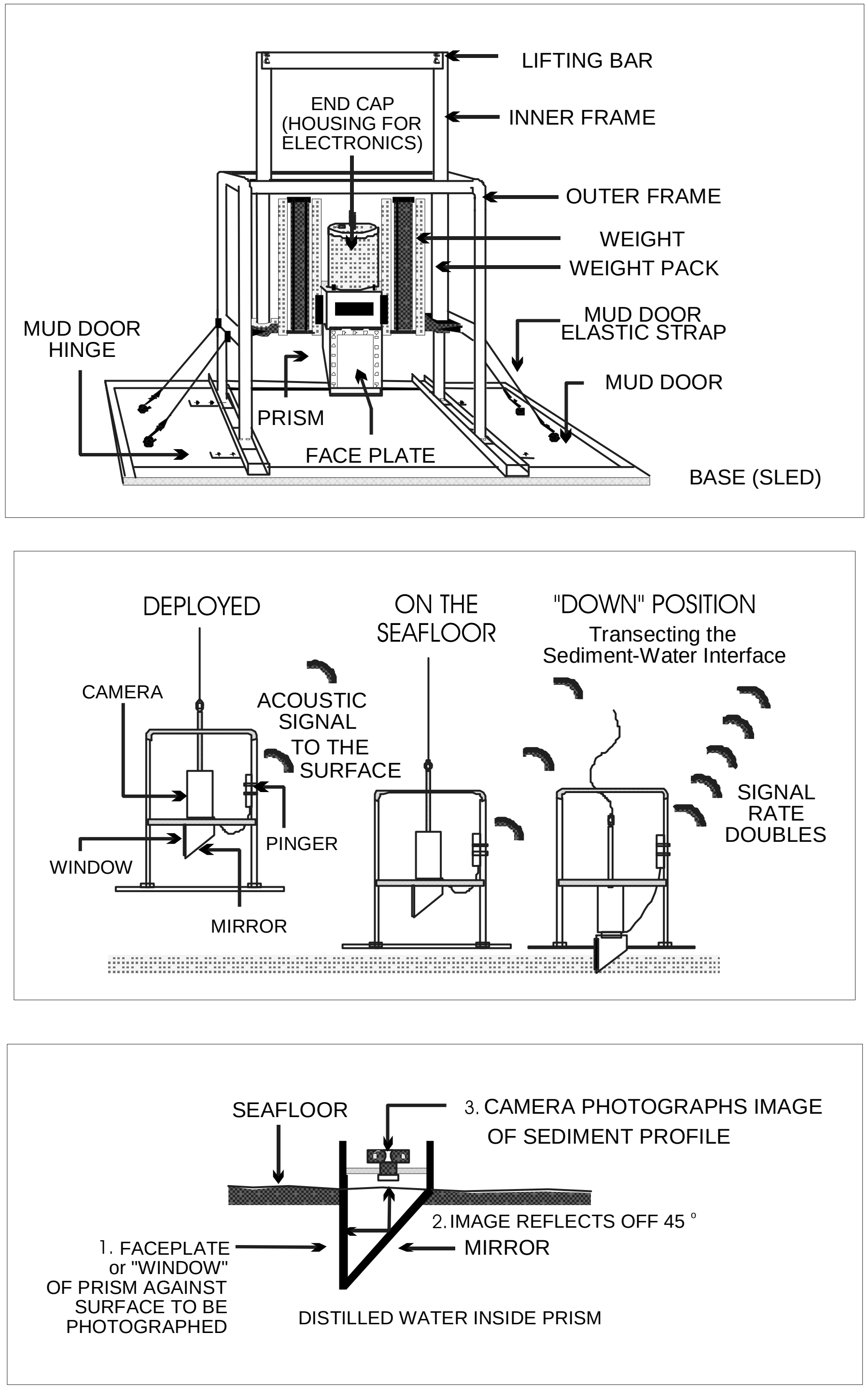


Figure 2-3. Schematic diagram of the Benthos, Inc. Model 3731 REMOTS® sediment-profile camera and sequence of operation on deployment

capacity/density), small-scale surface boundary roughness, depth of the apparent redox potential discontinuity (RPD, a measure of sediment aeration), infaunal successional stage, and Organism-Sediment Index (OSI, a summary parameter reflecting overall benthic habitat quality).

Organism-Sediment Index values may range from –10 (azoic with low sediment dissolved oxygen and/or presence of methane gas in the sediment) to +11 (healthy, aerobic environment with deep RPD depths and advanced successional stages). The OSI values are calculated using values assigned for the apparent RPD depth, successional status, and indicators of methane or low oxygen. Because the OSI is calculated using apparent RPD depths and successional stages, indeterminate apparent RPD depths and/or successional stages lead to indeterminate OSI values. REMOTS® image acquisition and analysis methods are described fully in Rhoads and Germano (1982; 1986) and in the recent DAMOS Contribution No. 128 (SAIC 2001).

A 25-station REMOTS® sampling grid centered at coordinates 41°54.685´ N, 70°12.900´ W was established over Mound B in the northeast quadrant of CCBDS as part of the August 2001 monitoring survey (Figure 2-4; Table 2-1). The grid consisted of eight radial station transects extending 300 meters in all directions from the disposal buoy position.

A 13-station, cross-shaped REMOTS® sampling grid, centered at coordinates 41° 53.978´ N, 70° 12.691´ W, also was established over Mound A in the southeast quadrant of CCBDS as part of the August 2001 survey. From the center point, a total of four station transects extended 300 meters out in the four primary compass directions (Figure 2-4; Table 2-2). Five stations were randomly distributed around the center of reference area CCBRS, while four stations were randomly distributed around the centers of both the Northwest and Southwest reference areas (NW REF and SW REF; Figure 2-5; Table 2-3). A 300 m radius watch circle was entered into the HYPACK® navigation system and placed around each reference area center to mark the area within which the stations were positioned at random. Data from the three reference areas (CCBRS, NW REF, and SW REF) were used to compare ambient sediment conditions to those at the disposal mounds. At each of the disposal site and reference area REMOTS® stations occupied in the August 2001 survey, the camera was lowered into the seafloor multiple times in an attempt to obtain at least three replicate images of suitable quality for subsequent analysis.

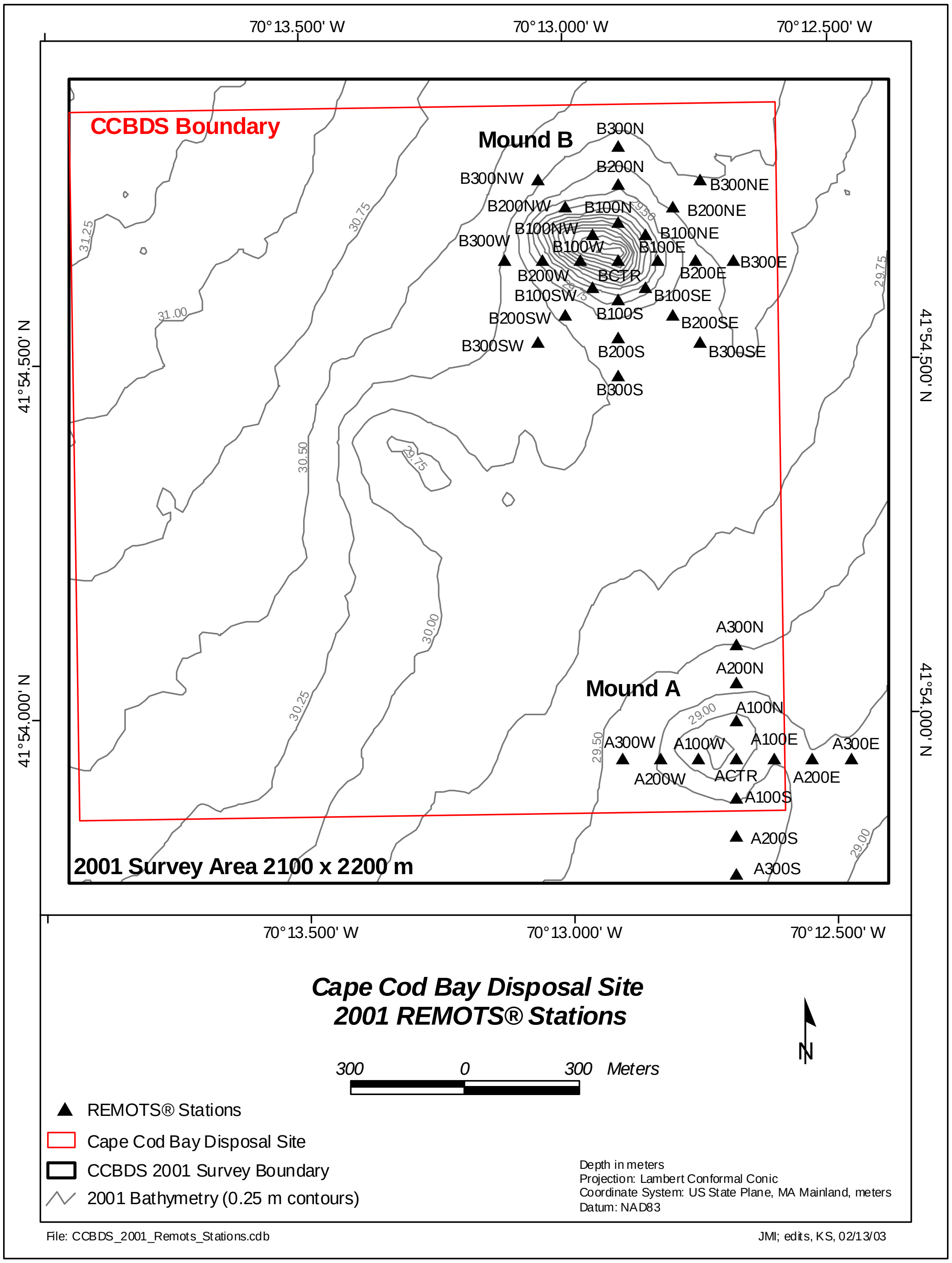


Figure 2-4. REMOTS® station locations established over the Cape Cod Bay Disposal Site as part of the August 2001 field operations

Table 2-1.

August 2001 REMOTS® Sediment-Profile Imaging
Station Locations over Mound A in the Southeast Quadrant of CCBDS

Area	Station	Latitude	Longitude
		NAD 83	
Mound A Southeast Quadrant 41° 53.978´ N 70° 12.691´ W	ACTR	41°53.978´ N	70°12.691´ W
	A100N	41°54.032´ N	70°12.690´ W
	A200N	41°54.086´ N	70°12.689´ W
	A300N	41°54.141´ N	70°12.688´ W
	A100E	41°53.978´ N	70°12.619´ W
	A200E	41°53.977´ N	70°12.546´ W
	A300E	41°53.976´ N	70°12.474´ W
	A100S	41°53.924´ N	70°12.692´ W
	A200S	41°53.870´ N	70°12.693´ W
	A300S	41°53.816´ N	70°12.694´ W
	A100W	41°53.979´ N	70°12.763´ W
	A200W	41°53.980´ N	70°12.836´ W
	A300W	41°53.981´ N	70°12.908´ W

Table 2-2.

August 2001 REMOTS® Sediment-Profile Imaging
Station Locations over Mound B in the Northeast Quadrant of CCBDS

Area	Station	Latitude	Longitude
		NAD 83	
Mound B Northeast Quadrant 41° 54.685´ N 70° 12.900´ W	BCTR	41°54.685´ N	70°12.900´ W
	B100N	41°54.739´ N	70°12.899´ W
	B200N	41°54.793´ N	70°12.898´ W
	B300N	41°54.847´ N	70°12.897´ W
	B100NE	41°54.723´ N	70°12.848´ W
	B200NE	41°54.761´ N	70°12.796´ W
	B300NE	41°54.798´ N	70°12.745´ W
	B100E	41°54.685´ N	70°12.828´ W
	B200E	41°54.684´ N	70°12.756´ W
	B300E	41°54.683´ N	70°12.683´ W
	B100SE	41°54.647´ N	70°12.850´ W
	B200SE	41°54.608´ N	70°12.800´ W
	B300SE	41°54.569´ N	70°12.749´ W
	B100S	41°54.631´ N	70°12.901´ W
	B200S	41°54.577´ N	70°12.902´ W
	B300S	41°54.523´ N	70°12.903´ W
	B100SW	41°54.648´ N	70°12.952´ W
	B200SW	41°54.610´ N	70°13.004´ W
	B300SW	41°54.572´ N	70°13.056´ W
	B100W	41°54.686´ N	70°12.973´ W
	B200W	41°54.687´ N	70°13.045´ W
	B300W	41°54.688´ N	70°13.117´ W
	B100NW	41°54.724´ N	70°12.951´ W
	B200NW	41°54.763´ N	70°13.001´ W
	B300NW	41°54.802´ N	70°13.051´ W

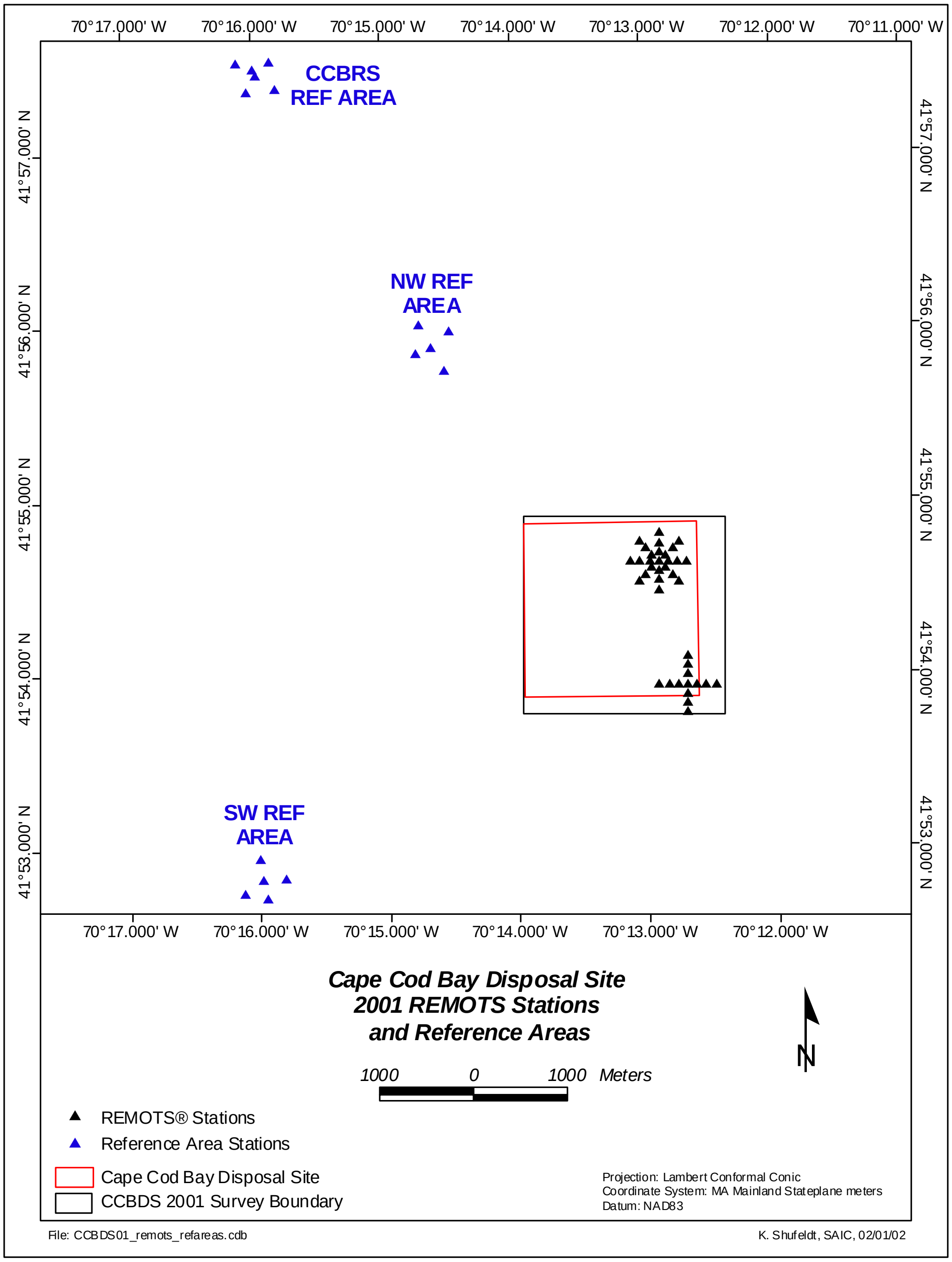


Figure 2-5. REMOTS® survey grids established over the Cape Cod Bay Disposal Site and surrounding reference areas as part of the August 2001 field operations

Table 2-3.

August 2001 REMOTS® Sediment-Profile Imaging
Station Locations over the CCBDS Reference Areas

Area	Station	Latitude	Longitude
		NAD 83	
CCBRS Reference Area 41° 57.506´ N 70° 15.968´ W	REF CTR	41°57.506´ N	70°15.968´ W
	REF1	41°57.579´ N	70°16.121´ W
	REF2	41°57.545´ N	70°15.990´ W
	REF3	41°57.584´ N	70°15.865´ W
	REF4	41°57.429´ N	70°15.823´ W
	REF5	41°57.412´ N	70°16.041´ W

Area	Station	Latitude	Longitude
		NAD 83	
Northwest Reference Area 41° 55.932´ N 70° 14.645´ W	NW REFCTR	41°55.932´ N	70°14.645´ W
	NW REF1	41°56.064´ N	70°14.734´ W
	NW REF2	41°56.026´ N	70°14.493´ W
	NW REF3	41°55.791´ N	70°14.535´ W
	NW REF4	41°55.893´ N	70°14.756´ W

Area	Station	Latitude	Longitude
		NAD 83	
Southwest Reference Area 41° 52.877´ N 70° 15.982´ W	SW REFCTR	41°52.877´ N	70°15.982´ W
	SW REF1	41°52.995´ N	70°16.011´ W
	SW REF2	41°52.884´ N	70°15.813´ W
	SW REF3	41°52.770´ N	70°15.950´ W
	SW REF4	41°52.800´ N	70°16.126´ W

3.0 RESULTS

3.1 Bathymetry

As part of the August 2001 monitoring effort, a bathymetric survey was performed over the entire 3.42 km^2 area of CCBDS. The natural seafloor within CCBDS was found to be relatively flat and featureless, sloping from a minimum depth of 28 m at southeast corner to a maximum depth of 31.5 m in the northwest corner of the survey area (Figure 3-1). Two roughly circular disposal mounds, located in the southeastern corner and northeastern quadrant of the disposal site, were clearly distinguishable relative to the surrounding flat seafloor (Figure 3-1). In addition, a subtle dredged material mound was detected near the center of CCBDS, corresponding to the reported position of the Wellfleet Disposal Site. Composed of sediments dredged from Wellfleet Harbor in the 1970s and 1980s, this bottom feature appears as a 0.25 to 0.5 m raised area rather than a distinct mound.

3.1.1 Mound B (Northeast Quadrant)

The largest bottom feature within the disposal site was Mound B, located in the northeast (NE) quadrant. This mound was created from an estimated barge volume of 324,000 m^3 of dredged material deposited at CCBDS between 1996 and 2001. While the lack of baseline (i.e., predisposal) bathymetric data precludes an accurate depth difference comparison of sequential surveys, the relative flatness of the existing bottom at the site allows reasonable measurements of the mound dimensions (Figure 3-2). By comparing the predisposal depth of 30 m found in the northeast quadrant in 1996 with the current depth over the mound apex of 26.2 m, a mound height of approximately 4 m can be determined for Mound B. The disposal mound was determined to be roughly conical in shape and approximately 350 m in diameter. With a calculated bottom slope of 1.5° or grade of 2.6%, the present configuration of Mound B appears to be relatively stable.

3.1.2 Mound A (Southeast Quadrant)

Mound A, located in the southeast corner of the southeast quadrant of CCBDS, is the older of the two detectable dredged material disposal mounds. From November 1994 through January 1995, approximately 112,000 m^3 of fine-grained sediment dredged from Wellfleet Harbor was transported to CCBDS for disposal. Monitoring surveys conducted in 1995 and 1996 served to document the development of the mound (Ocean Surveys Inc. 1995, CR Environmental 1997). The August 2001 follow-up survey indicated a water depth of 29.25 m at the base of the mound and a minimum depth of 28.65 m at its apex, yielding a mound height of 0.6 m (Figure 3-3).

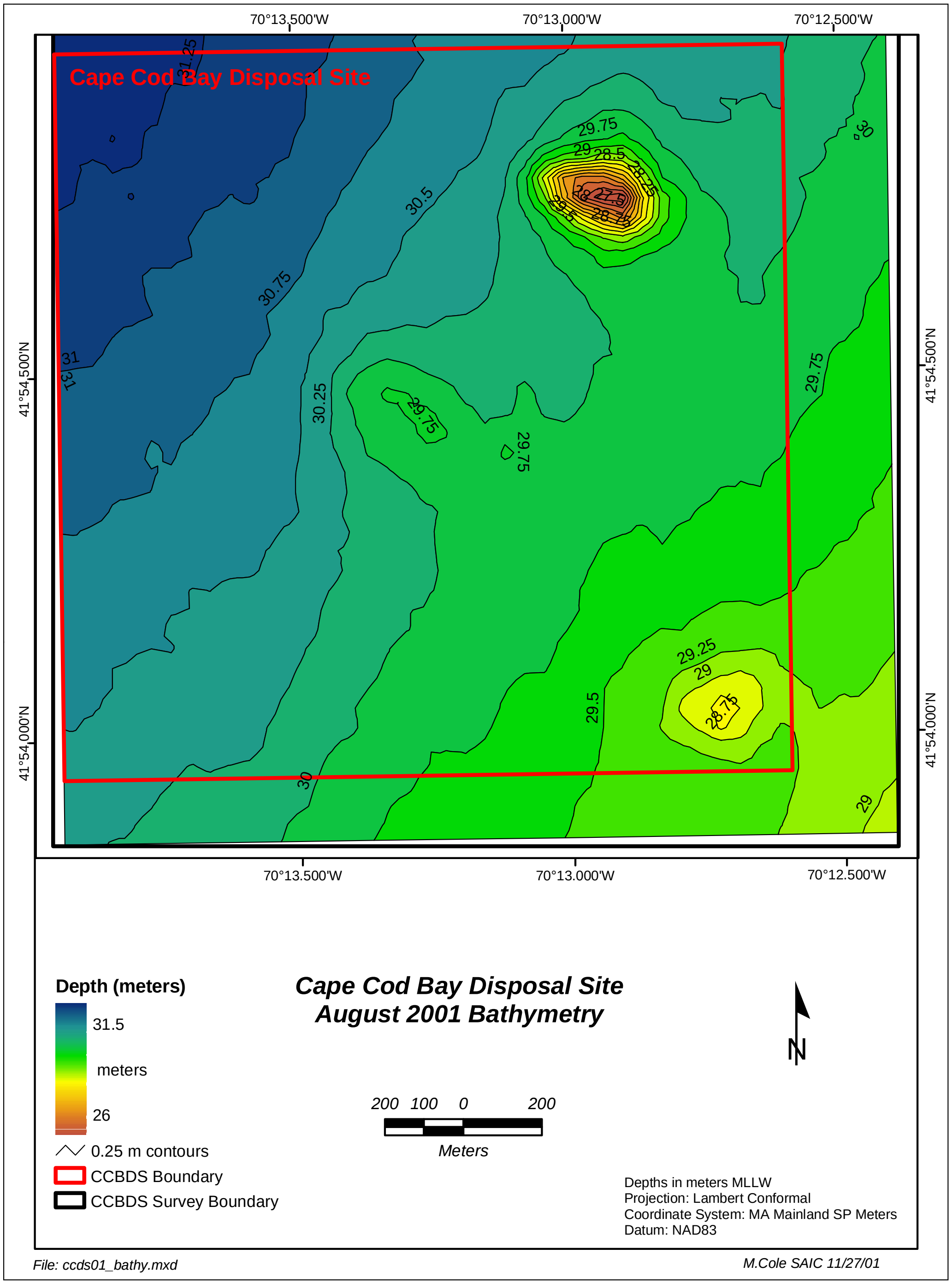


Figure 3-1. Bathymetric chart of CCBDS developed from the August 2001 bathymetric survey

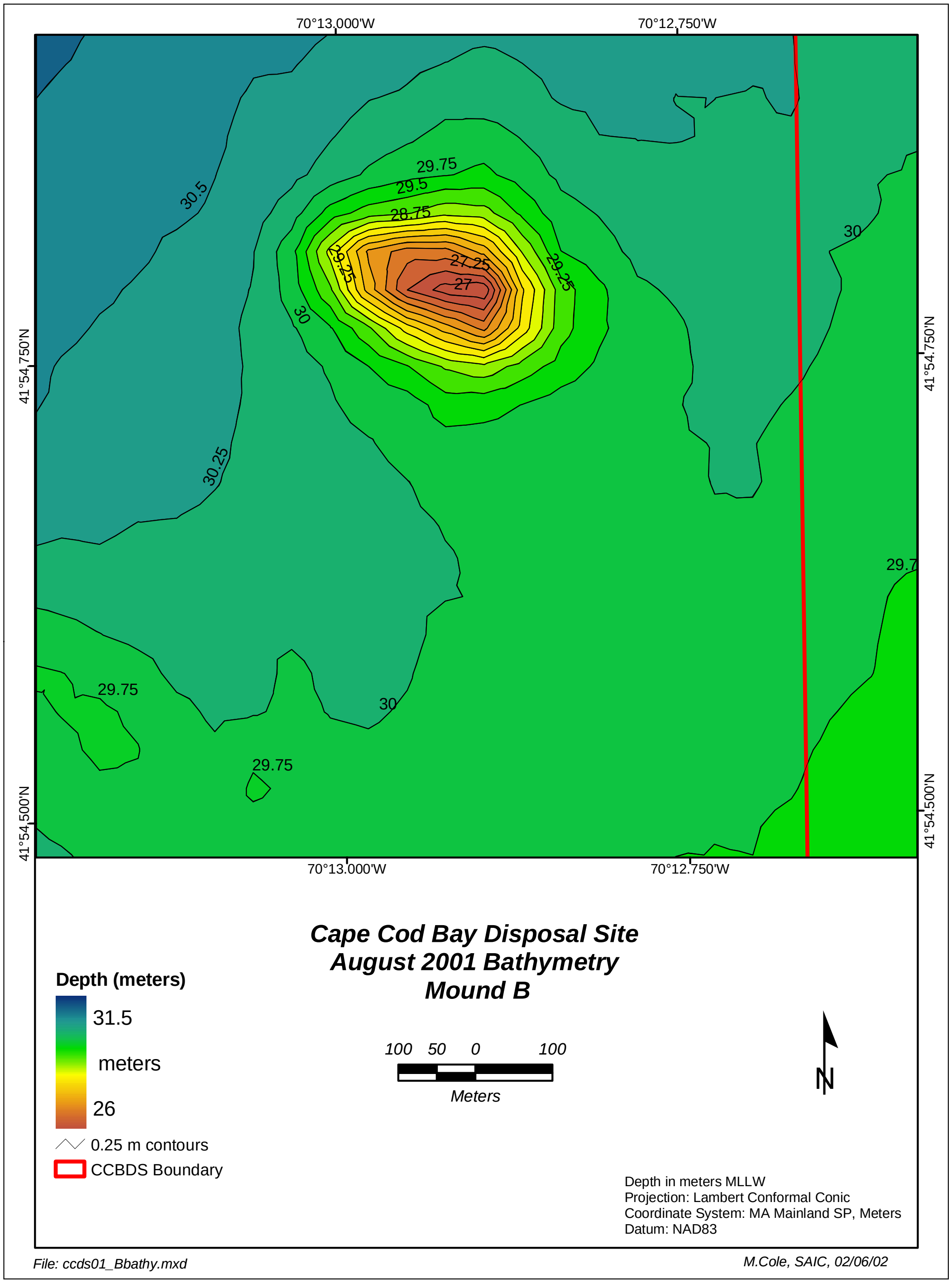


Figure 3-2. Bathymetric chart of CCBDS Mound B (Northeast Quadrant) developed from the August 2001 bathymetric survey

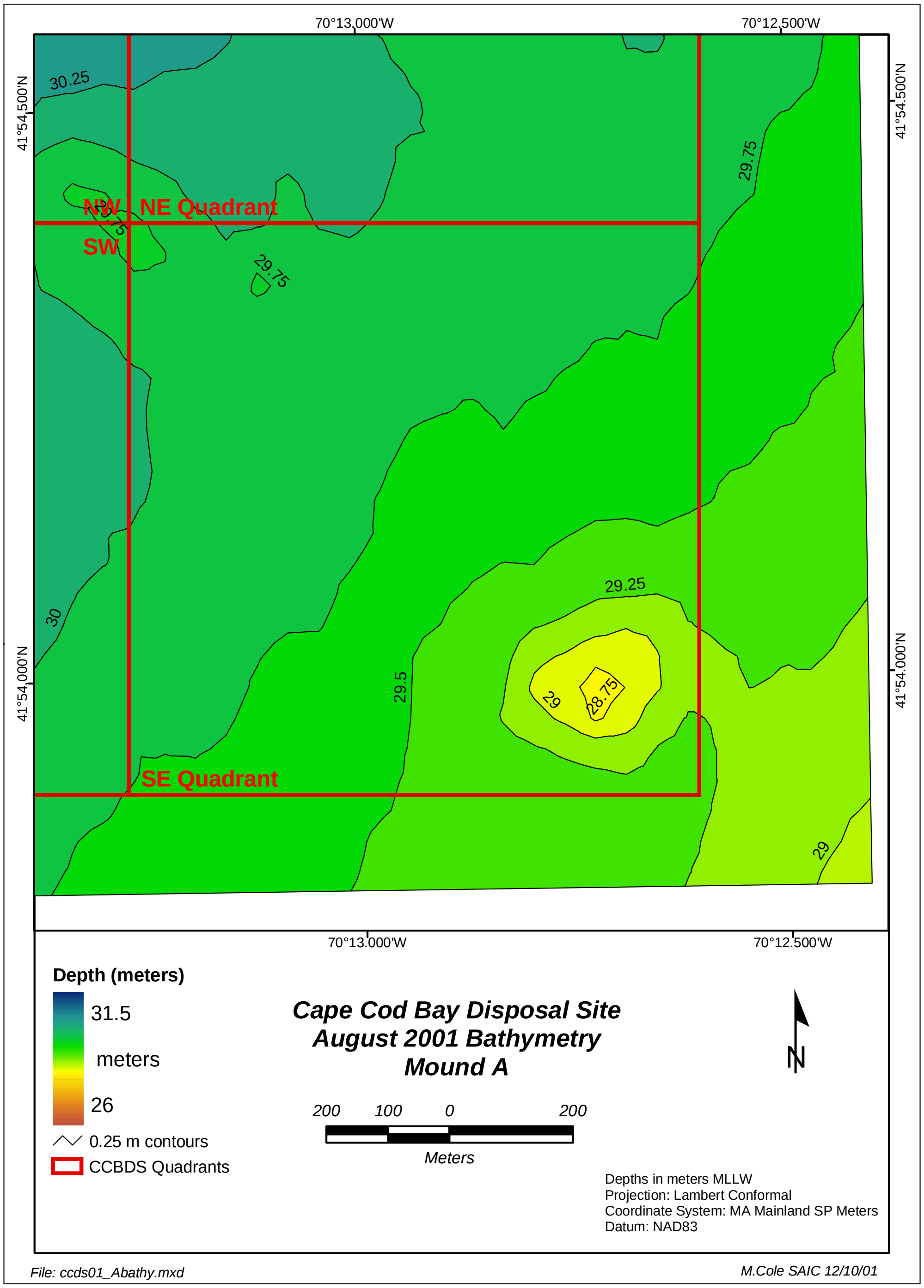


Figure 3-3. Bathymetric chart of CCBDS Mound A (Southeast Quadrant) developed from the August 2001 bathymetric survey

The depth difference comparison between the 1996 and 2001 bathymetric surveys indicated only small-scale changes in seafloor topography. In 1996, the shallowest depth over the mound was 28.4 m (Figure 3-4). The depth difference calculations utilizing the 1996 and 2001 bathymetric grids show a very minor reduction in mound height (Figure 3-5). Small areas of apparent consolidation on the order of 0.15 to 0.25 m appeared over the surface of the disposal mound. This reduction in mound height is attributed to limited consolidation within the dredged material deposit and perhaps some compression of the underlying ambient sediments. In addition, some changes in depth were apparent to the north of Mound A (Figure 3-5). However, these areas likely represent minor survey artifacts due to the small differences in the tidal corrections employed by the 1996 and 2001 bathymetric surveys.

3.2 REMOTS® Sediment-Profile Imaging

The REMOTS® results compiled for the CCBDS A and B Mounds were primarily used to assess the distribution of dredged material and monitor the subsequent recovery of the benthic infaunal community. A complete set of REMOTS® image analysis results for the CCBDS sampling stations is provided in Appendix B; these results are summarized in Tables 3-1 through 3-3.

3.2.1 Mound B (Northeast Quadrant)

3.2.1.1 Dredged Material Distribution and Physical Sediment Characteristics

The majority of the sediment observed in the REMOTS® images at the stations over Mound B was considered to be dredged material, which exceeded the penetration depth of the REMOTS® camera at most stations (i.e., dredged material greater than penetration; Figure 3-6). The dredged material comprising the surface sediments within Mound B was fine-grained, composed primarily of tan over gray silt that was occasionally mottled with gray and/or white clay or displaying white clay chips (grain size major mode of >4 phi; Table 3-1). The clay was detected exclusively at stations in close proximity to the mound apex, including Station BCTR and stations located within a 100 m radius (Figure 3-7A). A higher sand fraction was observed at Stations B100NW and BCTR, where the major modal grain size was classified as 4 to 3 phi (Table 3-1). No dredged material was observed in the images collected at Stations B300E and B300NW located just outside the mound apron. In addition, dredged material was detected in only two replicate images at Stations B300N and B300S and in one replicate image at Station B300NE. At these stations, the surface sediments appeared to consist primarily of tan over gray ambient silt (Figure 3-7B).

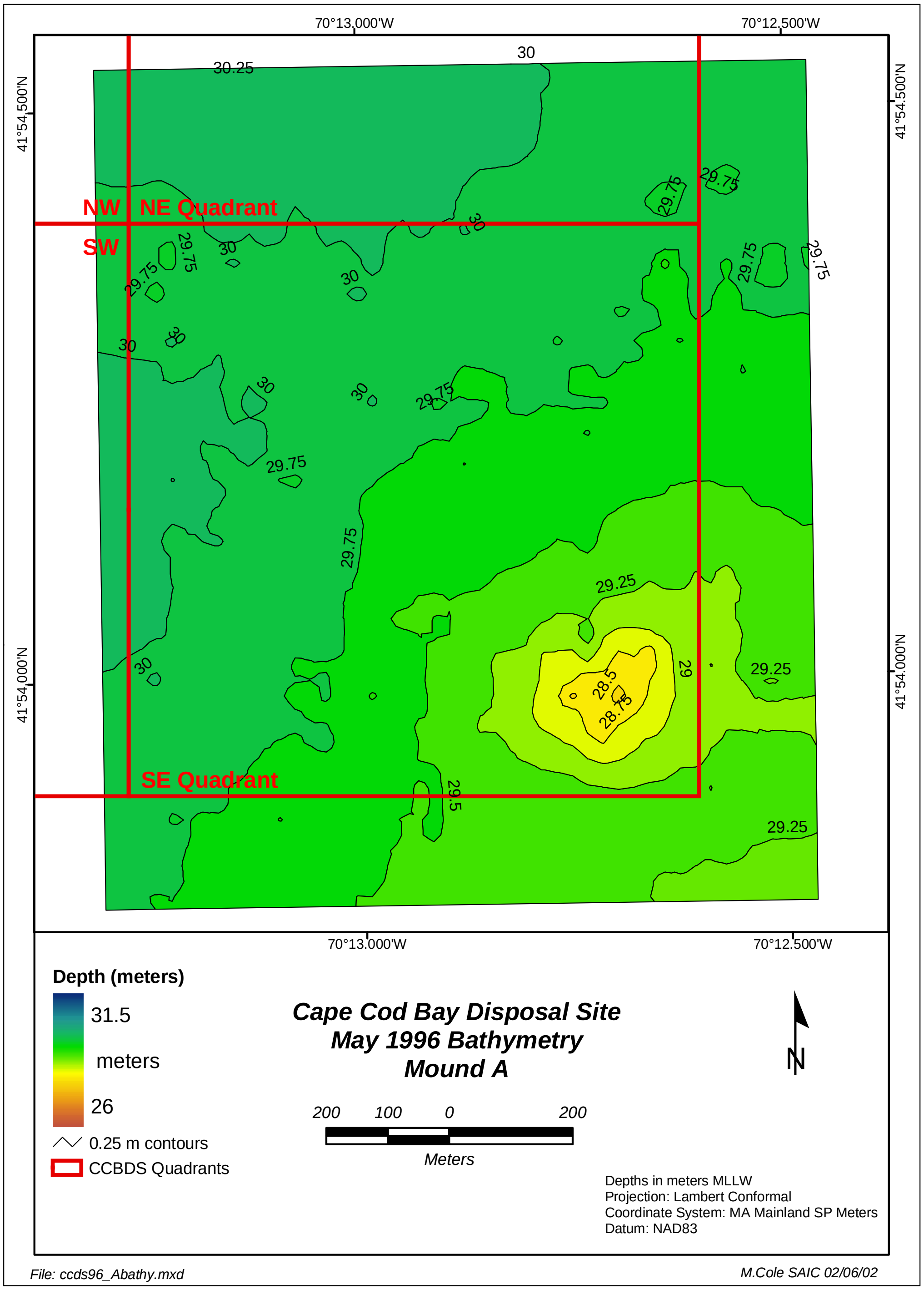


Figure 3-4. Bathymetric chart of CCBDS Mound A (Southeast Quadrant) developed from the May 1996 bathymetric survey

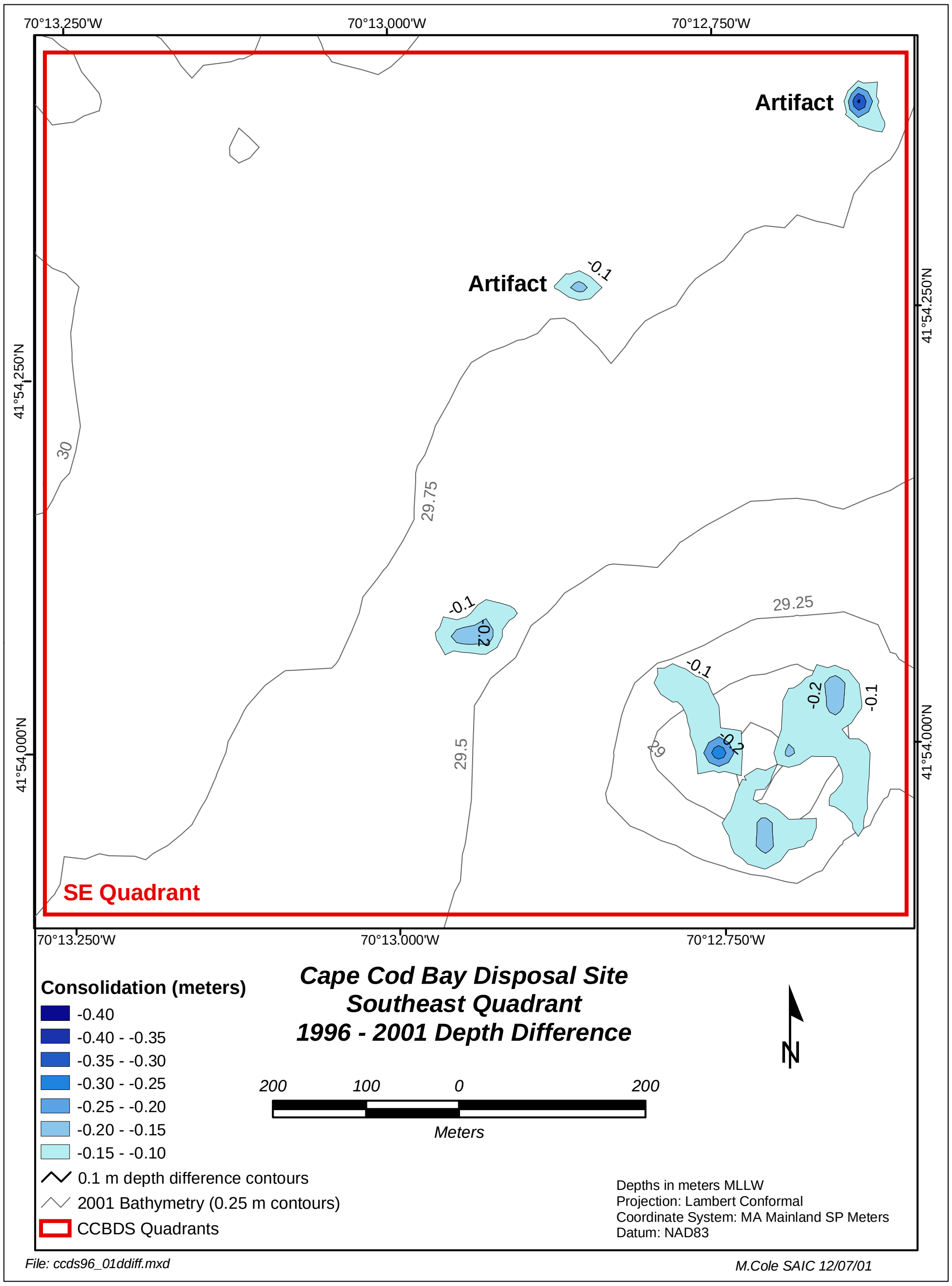


Figure 3-5. Chart showing the results of the depth-difference comparison between the May 1996 and August 2001 CCBDS bathymetric data sets over Mound A (Southeast Quadrant)

Table 3-1.

CCBDS 2001 REMOTS® Sediment-Profile Imaging Results Summary of Mound B Stations

Station	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	Methane Present	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
BCTR	9.07	>9.07	3	1.50	I,III	ST III	4-3	NO	6.33	7	1.13
B100E	18.79	>18.79	3	2.09	I,III	ST I on III	>4	NO	5.67	4	0.78
B100N	16.58	>16.58	3	2.34	I	ST I	>4	NO	4.33	4	0.73
B100NE	17.19	>17.19	3	2.12	I	ST I	>4	NO	4.67	5	0.67
B100NW	14.70	>14.70	3	1.94	I,III	ST I on III	4-3	NO	6.67	7	1.09
B100S	15.96	>15.96	3	2.42	I,III	ST I on III	>4	NO	6.00	6	1.48
B100SE	12.18	>12.18	3	2.05	I,III	ST I on III	>4	NO	5.67	5	1.09
B100SW	8.72	>8.72	3	1.48	I,III	ST I on III	>4	NO	7.50	7.5	1.82
B100W	16.14	>16.14	3	1.73	I,III	ST I on III	>4	NO	7.67	7	1.87
B200E	18.41	>18.41	3	2.29	I,III	ST I on III	>4	NO	7.00	9	1.57
B200N	15.00	>15.00	3	2.89	I,III	ST I on III	>4	NO	6.67	5	0.78
B200NE	18.36	>18.36	3	1.54	I,II,III	ST I on III	>4	NO	5.00	3	0.72
B200NW	15.82	>15.82	3	1.43	I,III	ST I on III	>4	NO	7.33	7	2.12
B200S	16.78	>16.78	3	3.69	I,III	ST I on III	>4	NO	8.33	8	1.24
B200SE	18.80	>18.80	3	3.47	I,II,III	ST II on III	>4	NO	8.67	9	0.95
B200SW	16.82	>16.82	3	2.44	I,III	ST I on III	>4	NO	5.67	6	1.51
B200W	17.47	>17.47	3	2.77	I,III	ST I on III	>4	NO	8.00	9	1.48
B300E	17.42	0.00	0	2.05	I,III	ST I on III	>4	NO	8.33	9	1.07
B300N	16.40	>11.15	2	1.46	I,III	ST I on III	>4	NO	6.33	7	2.09
B300NE	16.34	5.14	1	2.42	I,III	ST I on III	>4	NO	7.33	9	0.59
B300NW	16.09	0.00	0	1.49	I,III	ST I on III	>4	NO	6.00	6	2.51
B300S	17.75	>11.91	2	2.29	I,III	ST I on III	>4	NO	6.00	4	1.65
B300SE	17.07	>17.07	3	1.71	I,III	ST I on III	>4	NO	5.33	4	1.20
B300SW	14.40	>14.40	3	2.83	I,III	ST I on III	>4	NO	7.67	9	0.96
B300W	16.53	>16.53	3	2.13	I,III	ST I on III	>4	NO	5.67	5	2.43
AVG	16.24	>13.72	2.6	2.21			>4		6.56	6.46	1.35
MAX	18.80	>18.80	3	3.69			4-3		8.67	9	2.51
MIN	8.72	0.00	0	1.43			>4		4.33	3	0.59

Table 3-2.

CCBDS 2001 REMOTS® Sediment-Profile Imaging Results Summary of Reference Area Stations

Station	Camera Penetration Mean (cm)	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	Methane Present	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
CCBRS									
REF1	17.33	0.77	I,III	ST I on III	>4	NO	6.67	6	1.25
REF3	16.12	1.69	I,III	ST I on III	>4	NO	7.67	7	1.07
REF4	18.22	2.72	I,III	ST I on III	>4	NO	9.33	9	1.37
REF5	19.29	1.09	I,III	ST I on III	>4	NO	7.00	7	0.69
REFCTR	19.60	3.13	I,III	ST I on III	>4	NO	7.50	7.5	0.49
NORTHWEST									
NW REF1	15.02	2.97	I,III	ST I on III	>4	NO	8.00	9	1.45
NW REF2	18.79	3.30	I,III	ST I on III	>4	NO	8.67	9	1.05
NW REF3	14.60	3.53	I,III	ST I on III	>4	NO	10.33	11	0.66
NW REF4	15.44	2.92	I	ST I	>4	NO	5.33	5	0.84
SOUTHWEST									
SW REF1	12.15	2.65	I,III	ST I on III	>4	NO	8.00	9	2.22
SW REF2	14.28	3.15	I,III	ST I on III	>4	NO	7.00	6	1.13
SW REF3	10.79	2.48	I,III	ST I on III	>4	NO	7.67	8	1.06
SW REF4	10.60	2.24	I,III	ST I on III	>4	NO	8.33	9	1.05
AVG	15.56	2.51			>4		7.81	7.88	1.10
MAX	19.60	3.53			>4		10.33	11	2.22
MIN	10.60	0.77			>4		5.33	5	0.49

Table 3-3.

CCBDS 2001 REMOTS® Sediment-Profile Imaging Results Summary of Mound A Stations

Station	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	Methane Present	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
ACTR	16.34	>16.34	3	2.07	I,III	ST I on III	>4	NO	7.00	6	0.83
A100E	16.00	>16.00	3	1.64	I,III	ST I on III	>4	NO	5.00	5	1.30
A200E	13.94	>13.94	3	2.54	I,III	ST I on III	>4	NO	8.50	8.5	3.23
A300E	14.05	0.00	0	2.90	I,III	ST I on III	>4	NO	6.67	6	0.95
A100N	18.72	>18.72	3	2.39	I,III	ST I on III	>4	NO	6.00	5	1.20
A200N	15.83	>15.83	3	1.58	I	ST I	>4	NO	3.33	3	1.58
A300N	19.13	>19.13	3	1.45	I,III	ST I on III	>4	NO	4.33	3	1.43
A100S	14.77	>14.77	3	0.63	I	ST I	>4	NO	2.00	2	1.17
A200S	12.69	0.00	0	1.66	I,III	ST I on III	>4	NO	5.00	5	0.93
A300S	13.38	0.00	0	2.99	I,III	ST I on III	>4	NO	7.00	6	0.87
A100W	15.51	>15.51	3	2.02	I	ST I	>4	NO	4.00	4	0.76
A200W	17.08	>17.08	3	1.29	I,III	ST I on III	>4	NO	4.33	3	1.02
A300W	13.80	>13.80	3	0.96	I	ST I	>4	NO	2.67	2	1.48
AVG	15.48	>12.39	2.31	1.86			>4		5.06	4.50	1.29
MAX	19.13	>19.13	3	2.99			>4		8.50	8.5	3.23
MIN	12.69	0.00	0	0.63			>4		2.00	2	0.76

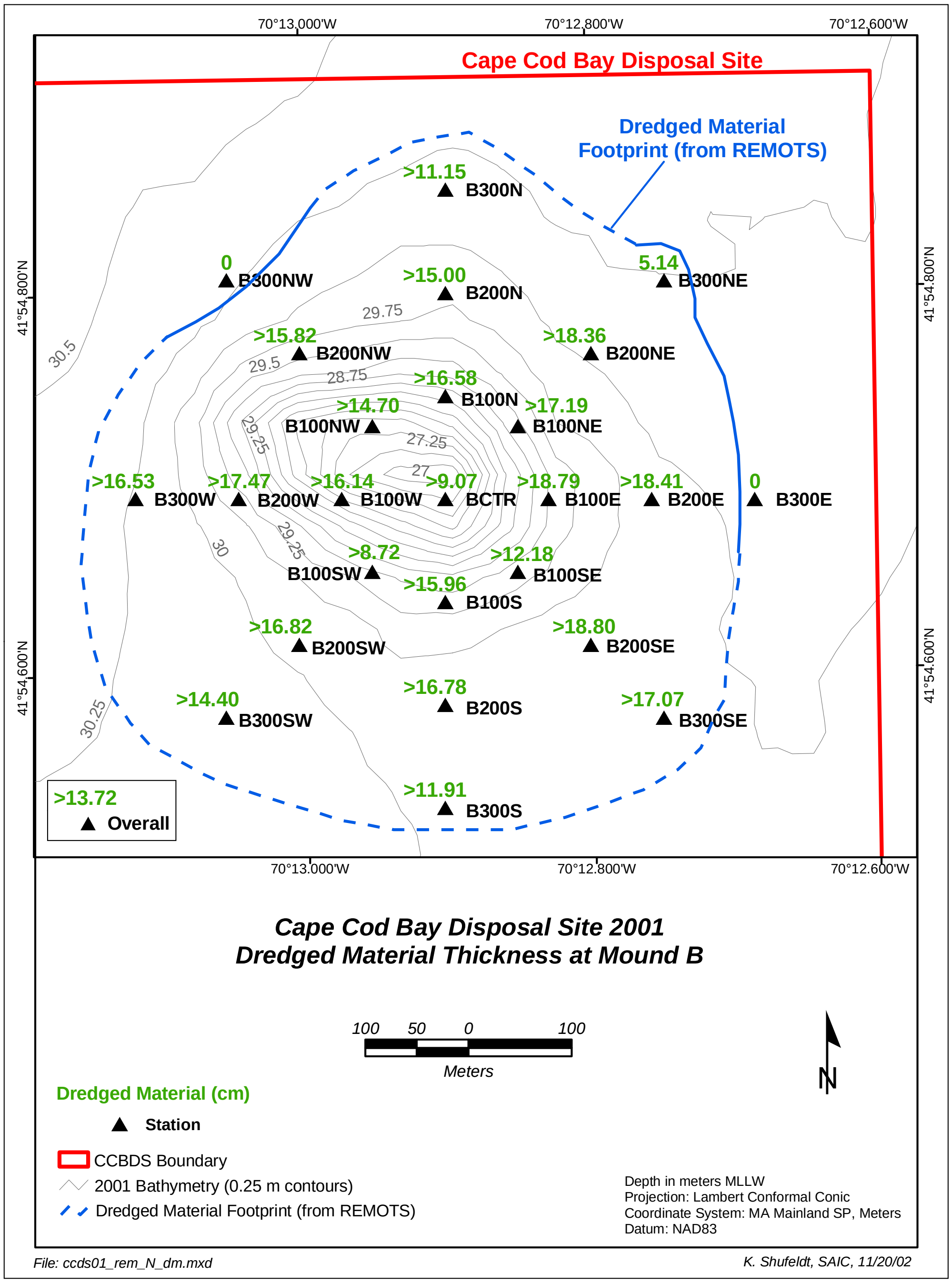
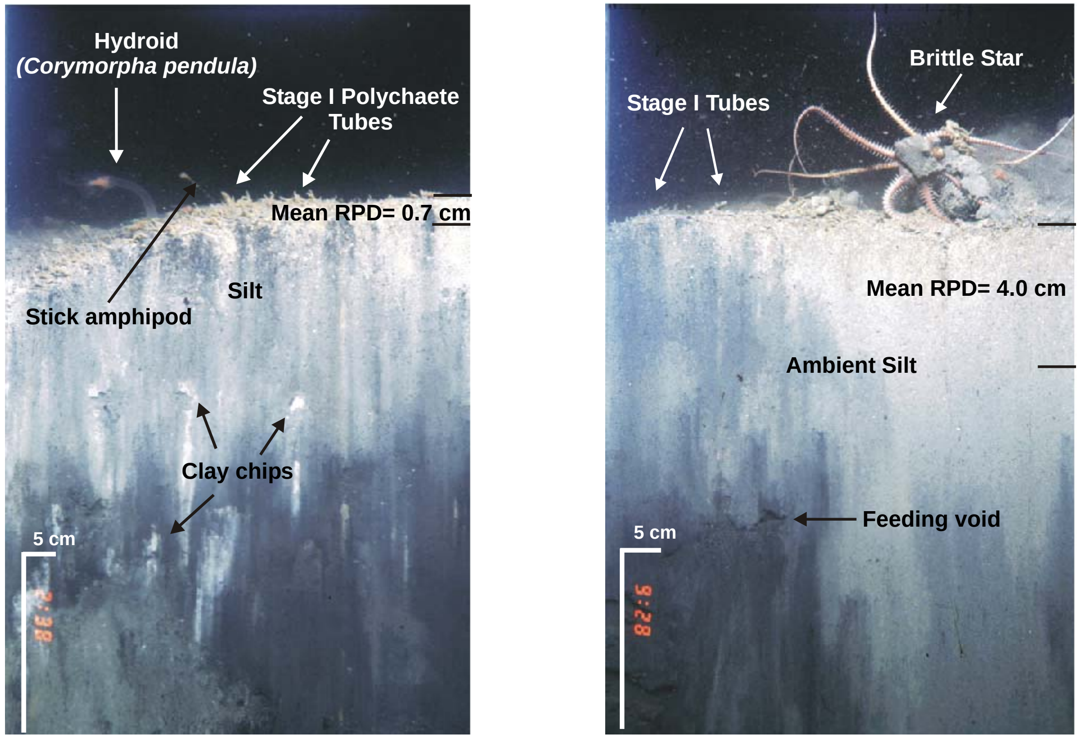


Figure 3-6. Map showing the average thickness of the dredged material layer (in cm) at stations over Mound B. A greater than sign (>) indicates that the thickness of the dredged material layer exceeded the camera penetration depth. Bathymetric contours are from the August 2001 survey.



A **B**

Figure 3-7. Two REMOTS® images illustrating the subtle difference in the appearance of dredged material (image A from Station B100W) versus ambient sediment (image B from Station B300NE). Image A shows silty sediment with a relatively shallow RPD of 0.7 cm and a mottled appearance due to the presence of small white clay chips. Image B shows naturally occurring fine-grained sediment with a well-developed RPD of 4 cm. Biogenic surface roughness was detected in both images, with macrofauna at the sediment-water interface. Due to the presence of a Stage III feeding void at depth and the relatively deep RPD, image B has an OSI value of +11, indicating undisturbed benthic habitat quality.

Multiple dredged material layers, comprised of tan, gray, and black silt and fine sand, were visible in various replicate images at 12 stations (Figure 3-8). These discrete layers were the result of multiple disposal events and were often accompanied by relic RPDs (an indicator of sediment layering) and a reduced sediment band (a layer of black sulfidic sediment). Relic RPDs are characterized by a lighter band of sediment, with a higher reflectance than the surrounding sediments, in the middle or lower section of the image (Rhoads and Germano 1982). A relic RPD occurs when a relatively thin layer of dredged material is placed over an older deposit or ambient sediments, and represents the depth of oxygenation in the underlying material prior to being covered by a fresh dredged material deposit (or represents the former ambient RPD). A new RPD will be formed at the sediment surface as oxygen is incorporated via diffusion and the bioturbational activity of benthic infauna. The thickness of the recently deposited dredged material can be measured from the surface to the top of the relic RPD.

The penetration depth of the sediment-profile camera prism usually serves as a measure of sediment density or compaction. Mean camera prism penetration measurements for stations over Mound B varied from 8.7 cm at Station B100SW to 18.8 cm at Station B200SE, with an overall average of 16.0 cm, indicating relatively soft sediment (Table 3-1). Over- or under-penetration of the REMOTS® camera prevented the analysis of key parameters (e.g., RPD, successional status, surface roughness, and OSI) in two replicate images.

Replicate-averaged small-scale boundary roughness values for Mound B stations ranged from 0.6 cm at Station B300NE to 2.5 cm at Station B300NW and averaged 1.3 cm, which was comparable to the reference area average of 1.1 cm (Tables 3-1 and 3-2). There was no obvious spatial pattern to these relatively low boundary roughness values at stations over Mound B. Surface roughness was attributed to physical disturbance at the sediment-water interface at most stations, most likely due to recent dredged material deposition. A number of replicate images, however, exhibited biogenic surface roughness as a result of dense surface tubes and biological surface reworking by burrowing infauna at the sediment-water interface. Burrowing anemone, stick amphipods (Family Podoceridae), and brittle stars (Ophiuroid) were observed at or near the sediment-water interface in replicate images throughout the area (Figures 3-7 and 3-9).

3.2.1.2 Biological Conditions and Benthic Recolonization

Three parameters were used to assess the benthic recolonization status and overall benthic habitat quality over Mound B relative to the reference areas: apparent redox potential discontinuity (RPD) depth, Organism-Sediment Index (OSI), and infaunal successional status.

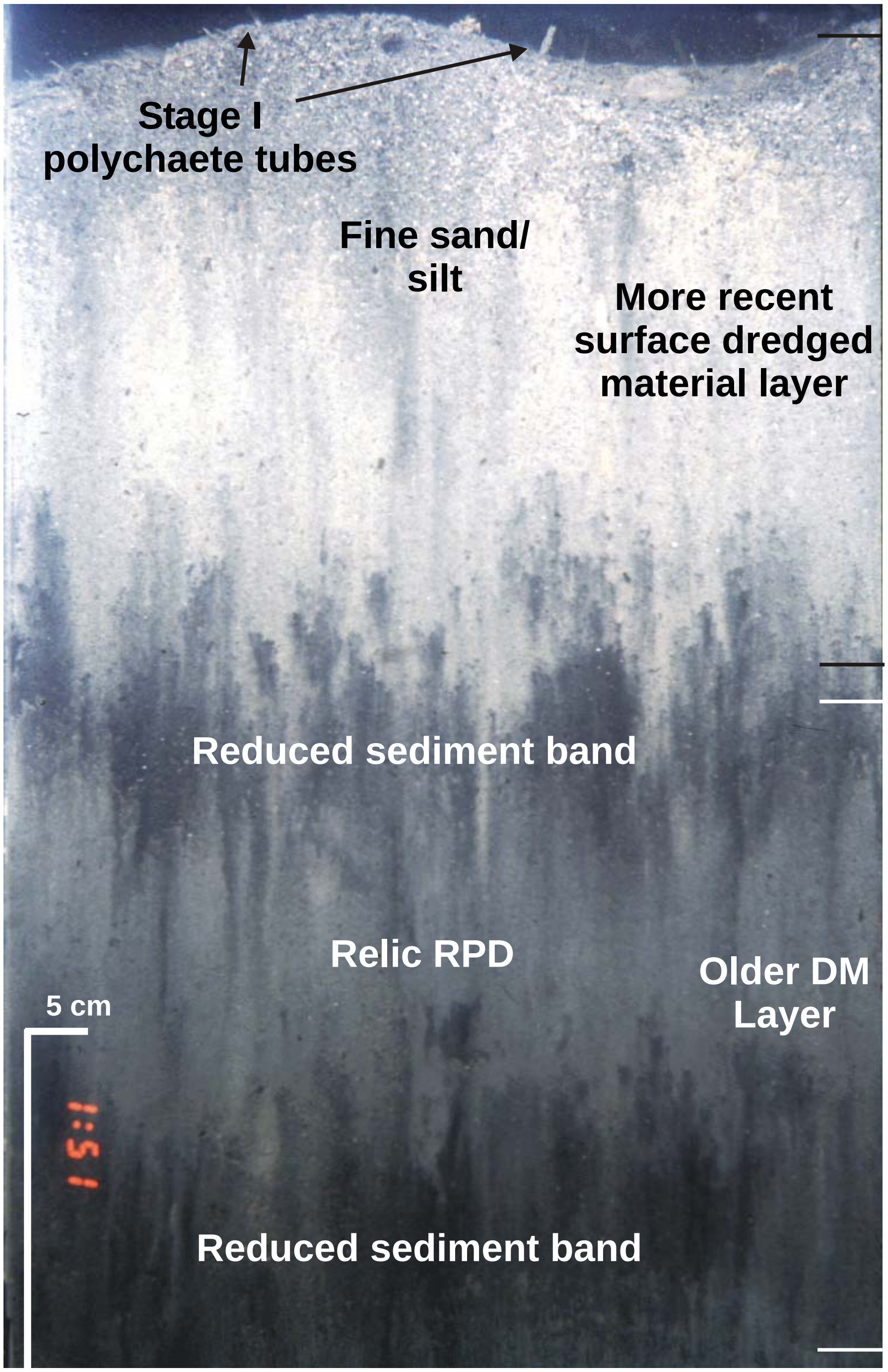


Figure 3-8. REMOTS® image obtained at Station B200SE within Mound B illustrating multiple dredged material layers, with a layer of fine sand visible over a layer of silt. A relic RPD and bands of black sulfidic sediment are visible in the subsurface sediment.

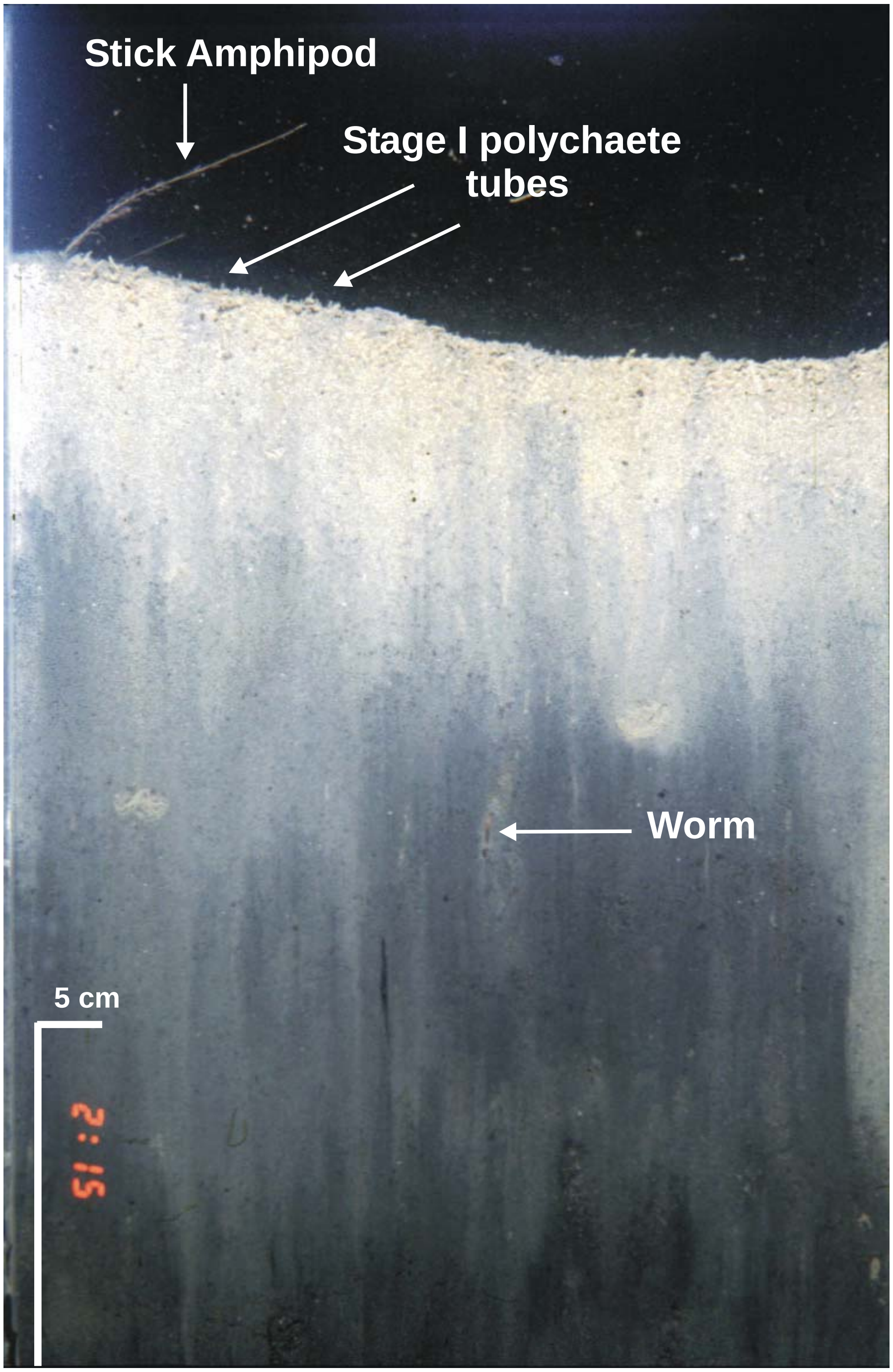


Figure 3-9. REMOTS® image from Station B100S within Mound B showing a biologically active benthic environment with an amphipod stalk (family Podoceridae) and Stage I polychaetes tubes at the sediment-water interface.

The redox potential discontinuity (RPD) provides a measure of the apparent depth of oxygen penetration into the surface sediments and the degree of biogenic sediment mixing. The replicate-averaged RPD measurements for stations over disposal Mound B ranged from 1.4 cm at Station B200NW to 3.7 cm at Station B200S (Table 3-1; Figure 3-10). The overall RPD average of 2.2 cm indicates moderately well-oxygenated surface sediments over the disposal mound. The RPD depths over Mound B were comparable to those at the reference areas, which ranged from 0.8 cm to 3.5 cm (average of 2.5 cm; Table 3-2). Although pockets of reduced sediment were observed at the sediment water interface and at depth in many replicate images, none of the stations occupied over Mound B showed any evidence of low sediment dissolved oxygen conditions, visible redox rebounds, or methane gas bubbles.

The successional stage recolonization status over Mound B included both surface-dwelling, opportunistic, Stage I polychaetes and Stage III head-down, deposit-feeding infauna (Table 3-1; Figure 3-11). Stage I accompanied Stage III at 21 of the 25 stations, while 2 stations near the center of the mound exhibited only Stage I taxa, possibly a reflection of more recent disposal activity at this location. Overall, Stage III individuals were detected in 39 of the 73 total analyzable images (52%) obtained over Mound B. The tubes of Stage I organisms (surface dwelling polychaetes) were clearly visible at the sediment water interface (Figures 3-7, 3-8, 3-9, and 3-12). When present, Stage III activity was marked by active feeding voids in the subsurface sediments at disposal mound stations, and with the exception of two replicates, was consistently accompanied by Stage I pioneering individuals at the sediment-water interface (Figure 3-12). In addition, amphipods tubes (*Ampelisca* sp), representative of Stage II organisms, were observed in two replicate images. Reference area stations also exhibited relatively advanced successional status, with both Stage I and Stage III present at all but one station (Table 3-2). Overall, the presence of a diverse mixture of Stages I, II, and III at stations over Mound B indicates that benthic recolonization was well advanced at the time of the survey, consistent with expectations at approximately eight months postdisposal.

Replicate-averaged median OSI values for the stations over Mound B ranged from +3 at Station B200NE to +9 at Stations B200E, B200SE, B200W, B300E, B300NE, and B300SW, with an overall mound average of +6.5 (Table 3-1; Figure 3-10). A value > +6 is indicative of undisturbed benthic conditions. As anticipated, the composite median OSI value of +7.9 at the reference areas was slightly higher than that observed at the disposal mound stations (Table 3-2). One of the replicate images from Station B300NE provides an example of an OSI value of +11, with an advanced Stage I on III successional status and a relatively deep RPD of 4.0 cm in ambient sediment (Figure 3-7B).

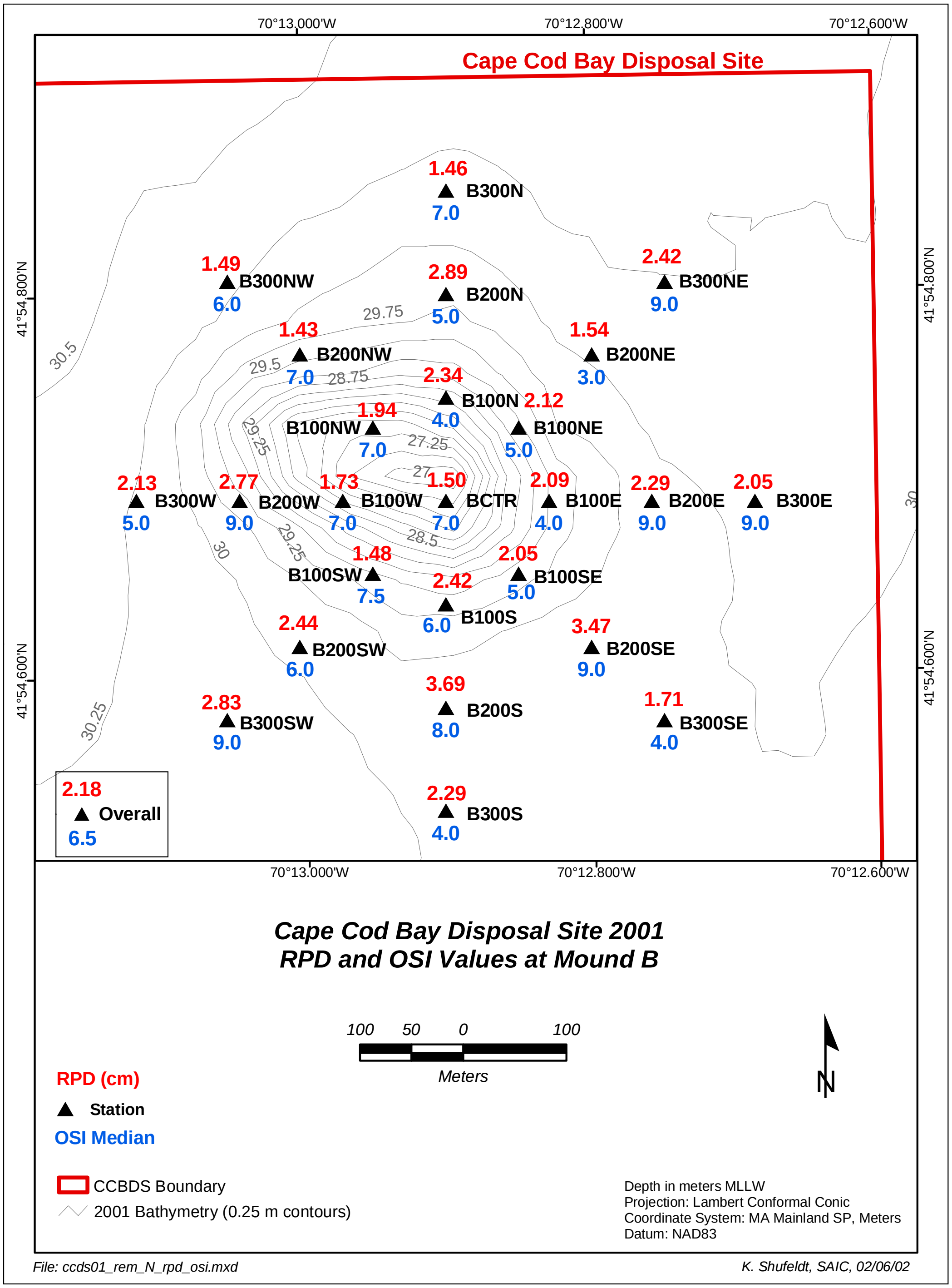


Figure 3-10. Map of replicate-averaged RPD depths (red) and median OSI values (blue) over CCBDS Mound B, plotted over 2001 bathymetry

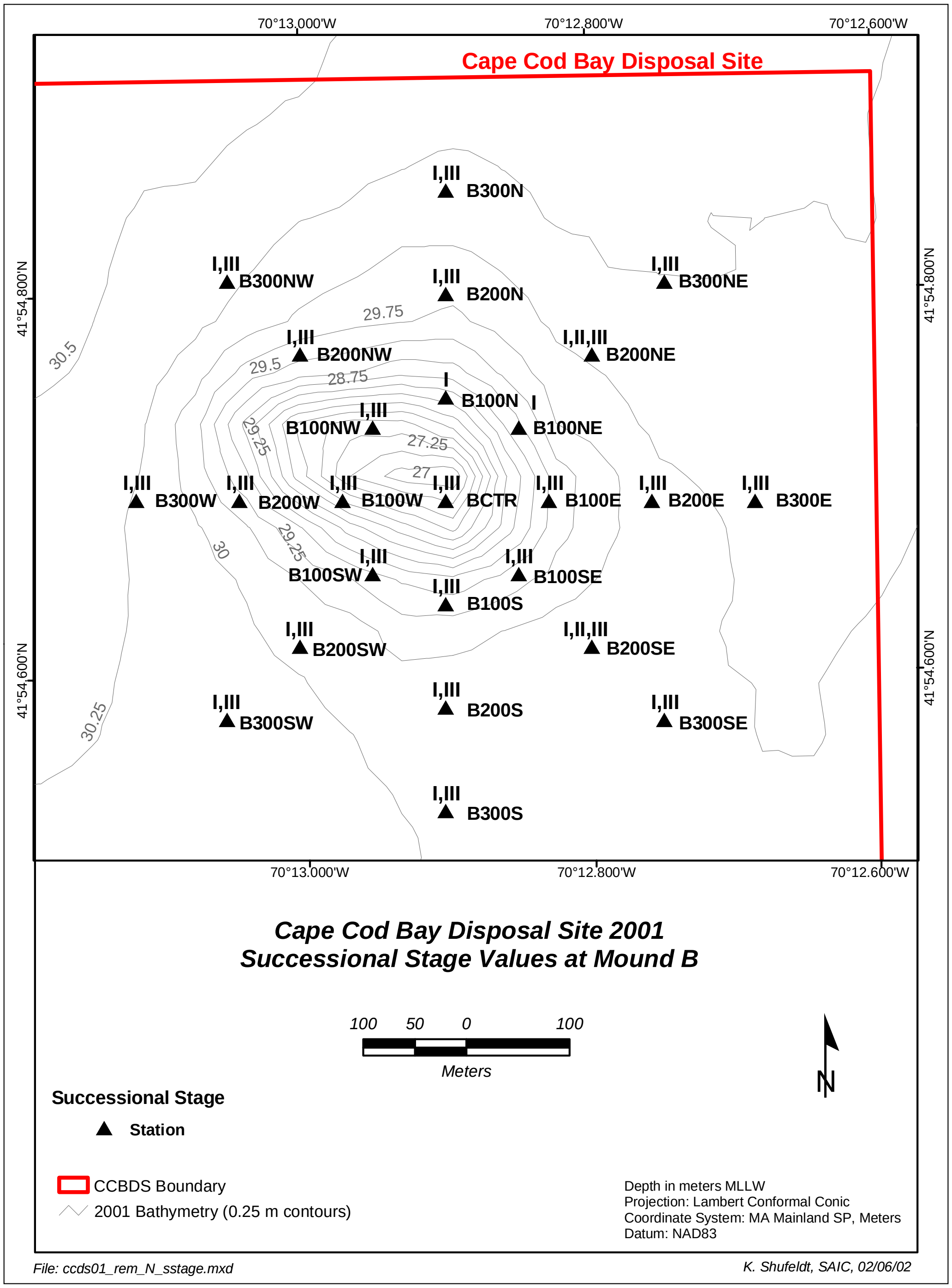


Figure 3-11. Map of infaunal successional stages for the REMOTS® stations over CCBDS Mound B, plotted over 2001 bathymetry

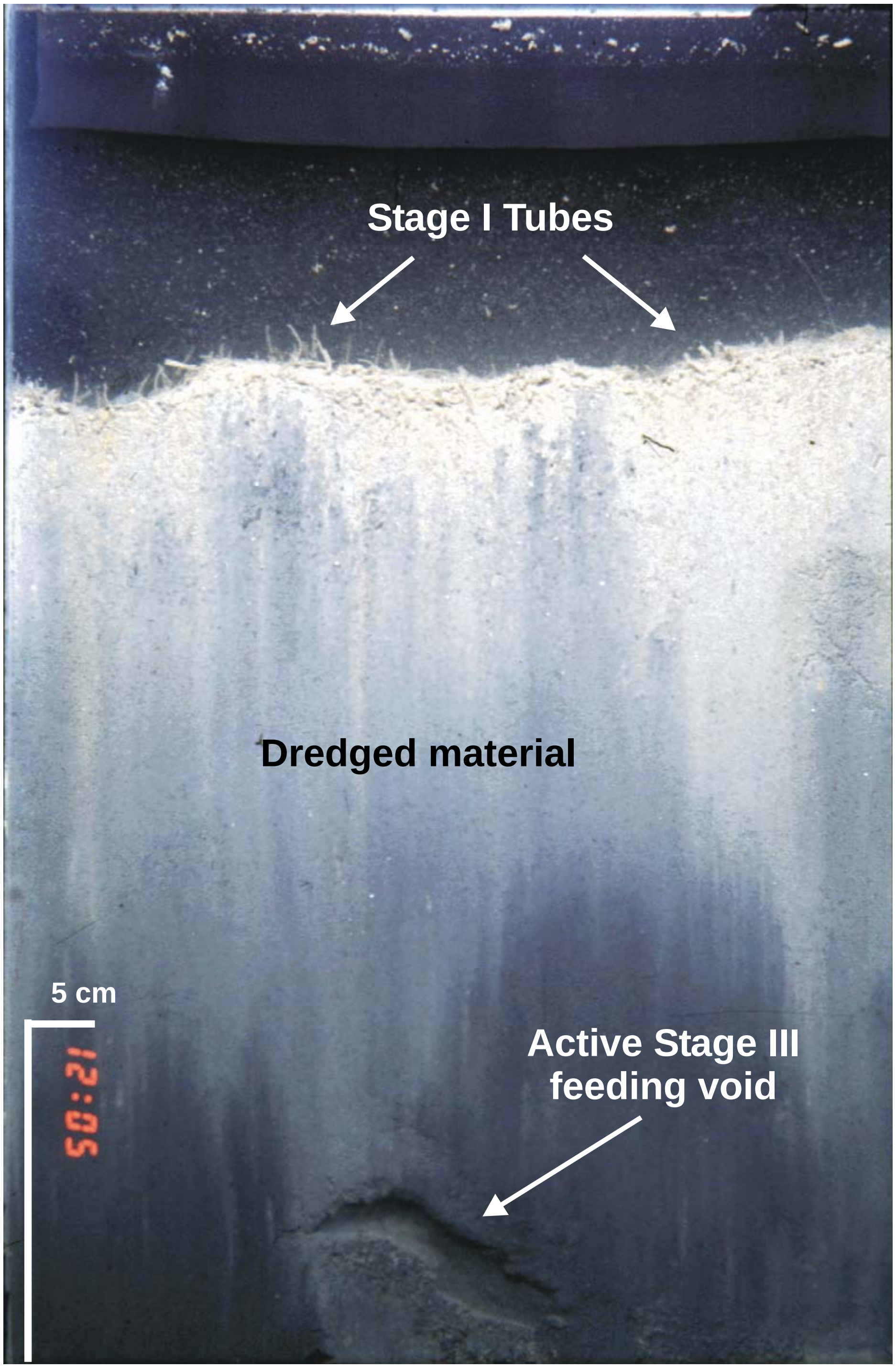


Figure 3-12. REMOTS® image obtained at Station B300N illustrating Stage I on III successional status within the dredged material of Mound B. Stage I polychaete tubes and an active Stage III feeding void are visible.

Dredged material disposal activity has continued to target Mound B in recent years as the active area of dredged material placement at CCBDS. As anticipated over an active disposal mound, the range of OSI values in August 2001 indicated variable benthic habitat conditions, ranging from moderately (marginally) colonized and disturbed (OSI values $\leq +6$) to highly colonized or undisturbed (OSI values $> +6$). For example, Station B300NE displayed OSI values of +11, +9, and +2, while Station B300S had OSI values of +11, +4, and +3; these values reflect both variable RPD depths and successional stages in different replicate images (Figure 3-13). The low values calculated at various stations reflect relatively shallow RPD depths and lack of Stage III infauna in some or all replicate images (Figure 3-13, left image). Conversely, the higher median OSI values for disposal site and reference area stations exhibiting more biologically active environments reflected relatively higher mean RPD depths and the presence of Stage III organisms (Figure 3-13, right image). Such variability in conditions was anticipated for Mound B, which appears to be in a relatively advanced yet continuing state of recovery from the ongoing disturbance associated with dredged material placement over the course of four years (1996 to 2000).

3.2.2 Mound A (Southeast Quadrant)

3.2.2.1 Dredged Material Distribution and Physical Sediment Characteristics

Historic or "relic" dredged material from past disposal activities was evident at most (10 of the 13) REMOTS® stations occupied over Mound A (Table 3-3 and Figure 3-14). The thickness of the dredged material layer exceeded the penetration depth of the REMOTS® camera at all 10 stations (indicated with a "greater than" sign in Table 3-3 and Figure 3-14). The historic dredged material comprising the surface sediments within Mound A was fine-grained, composed mainly of tan silt over black silt-clay (grain size major mode of >4 phi; Table 3-3 and Figure 3-15). Apparent ambient sediment was observed at Stations A300E, A200S, and A300S located on the periphery of the historic disposal mound, outside the disposal site boundary (Table 3-3; Figures 3-14 and 3-16). At these stations, the surface sediment consisted of ambient tan over gray and black silt-clay.

Mean camera prism penetration measurements ranged from 12.7 cm at Station A200S to 19.1 cm at Station A300N, with an overall average of 15.5 cm indicating relatively soft sediments (Table 3-3). Over-penetration of the REMOTS® camera prevented the determination of surface roughness in 2 of the 39 total replicate images collected over Mound A.

The overall average boundary roughness value for Mound A stations was 1.3 cm, suggesting only minor small-scale surface relief. This value was comparable to the

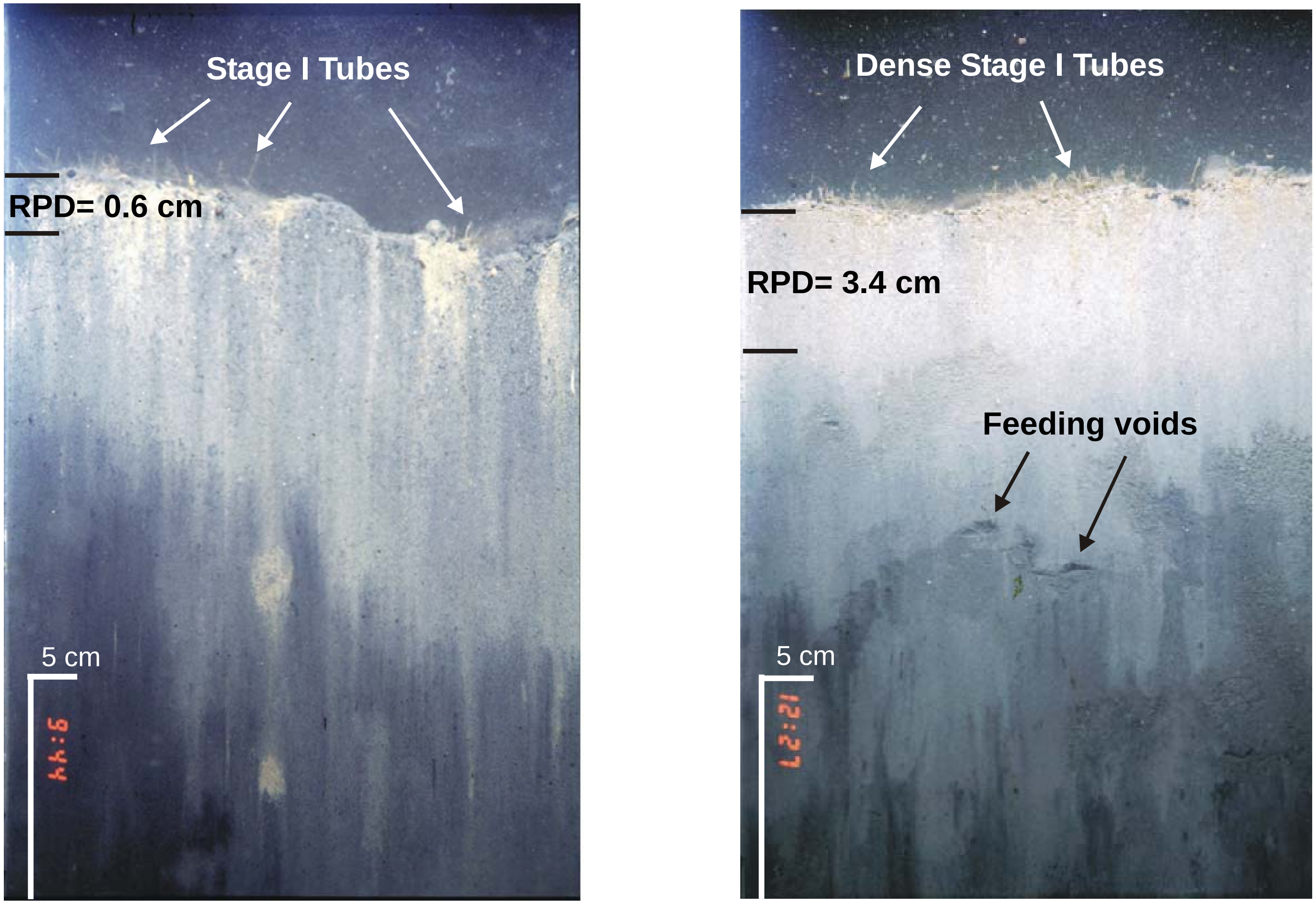


Figure 3-13. REMOTS® images illustrating both degraded benthic habitat quality (OSI +2 at Station B200E, left image) and undisturbed benthic habitat conditions (OSI +10 at Station B300SW, right image) at varying distances from the center of the mound.

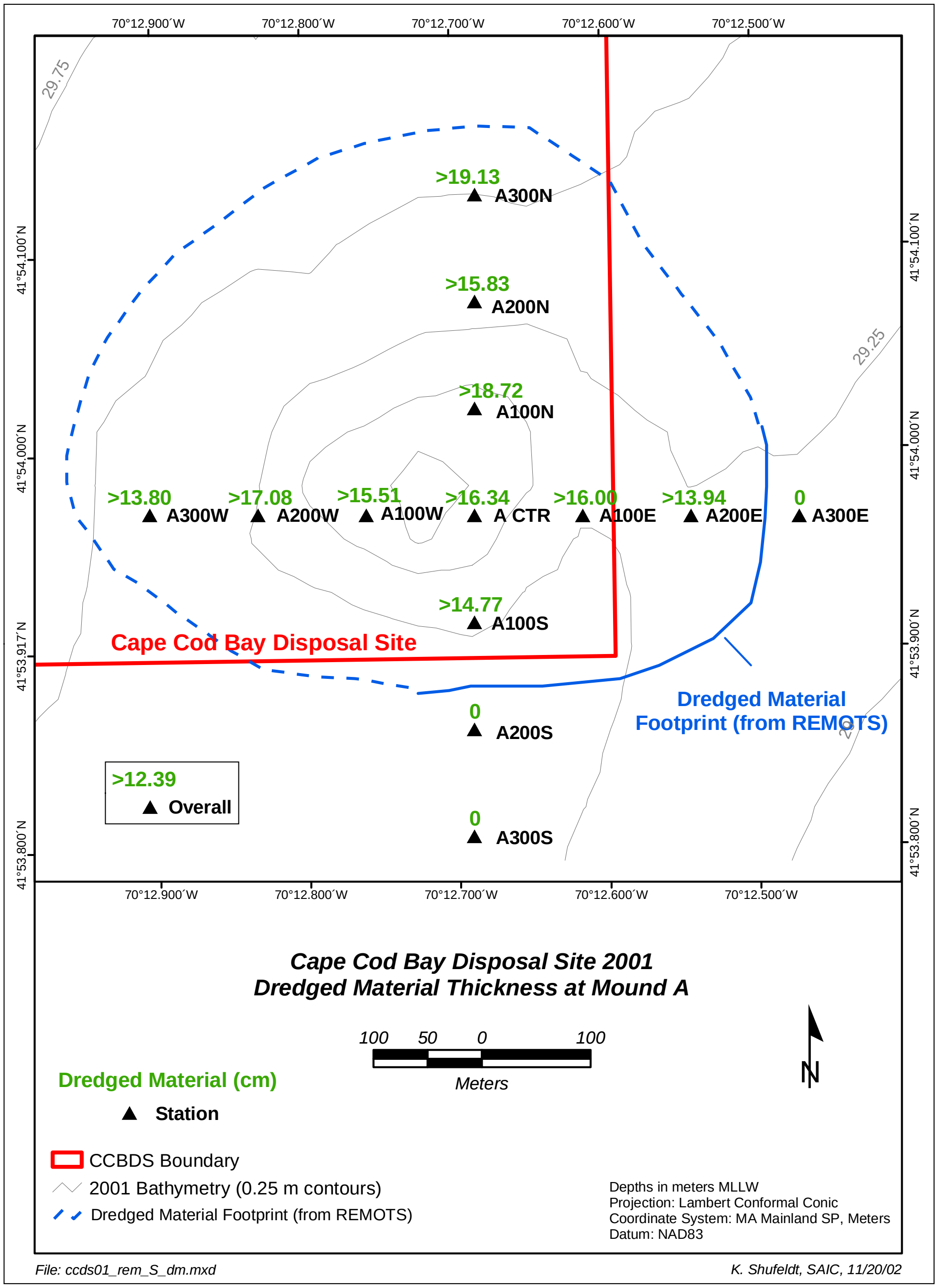


Figure 3-14. Map showing the average thickness of the dredged material layer (in cm) at stations over Mound A. A greater than sign (>) indicates that the thickness of the dredged material layer exceeded the camera penetration depth. Bathymetric contours are from the August 2001 survey.

Figure 3-15. REMOTS® image from Station A100E showing the characteristics of historic dredged material (oxidized silt over black silt-clay) observed over Mound A

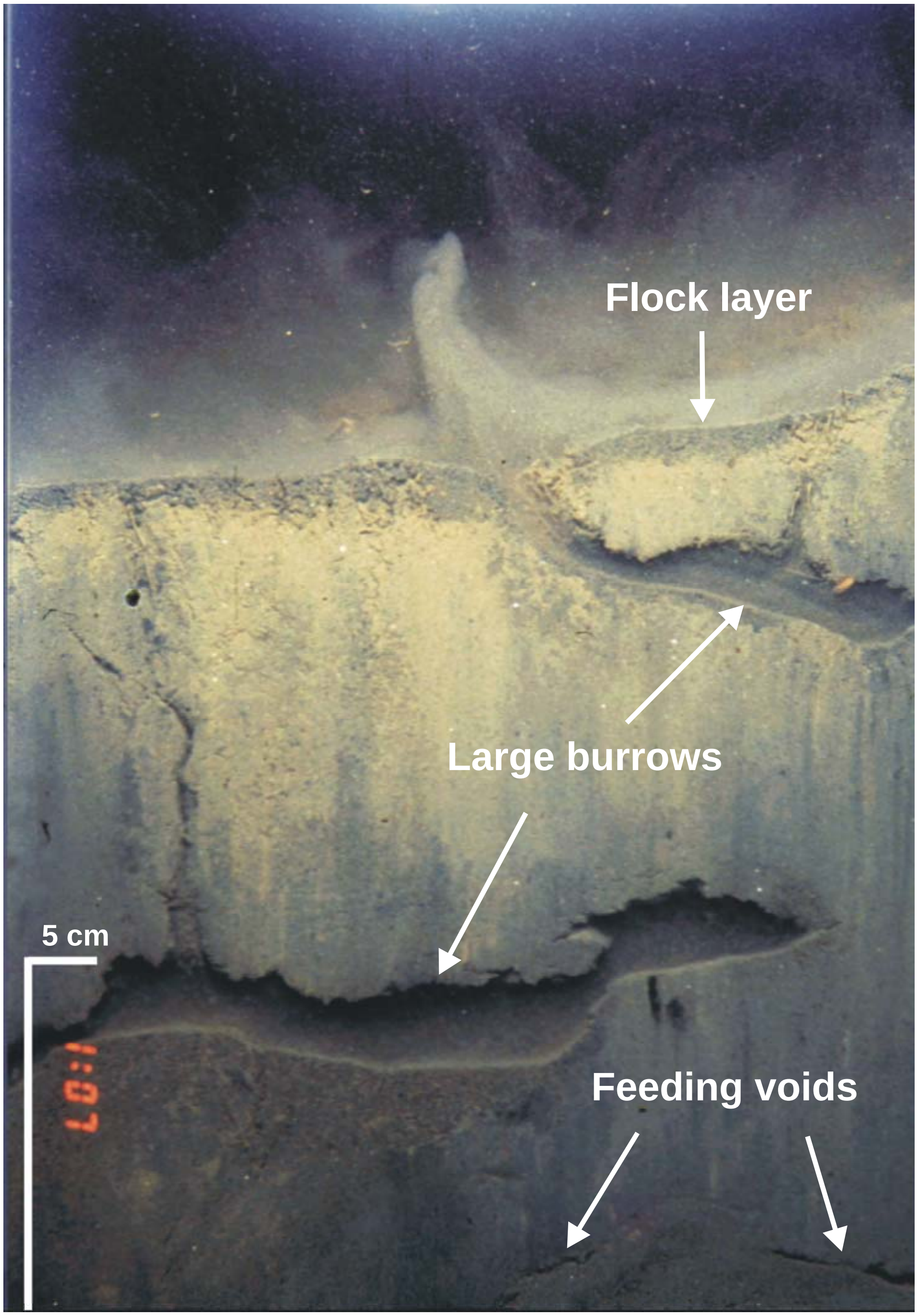


Figure 3-16. REMOTS® image from Station A200S showing apparent ambient sediment to the south of Mound A. Surface reworking by burrowing infauna is evidenced by an extensive burrow system. A thin layer of darker sediment ejected by the burrowing organism(s) is visible at the sediment surface.

reference area average of 1.1 cm (Table 3-2). Replicate-averaged boundary values ranged from 0.8 cm at Station A100W to 3.2 cm at Station A200E (Table 3-3). There was no obvious spatial pattern to these relatively low boundary roughness values. Surface roughness was attributed equally to both physical processes and biogenic activity (e.g., Figure 3-16) over the sediment-water interface.

3.2.2.2 Biological Conditions and Benthic Recolonization

The replicate-averaged apparent RPD measurements ranged from 0.6 cm at Station A100S to 3.0 cm within the ambient sediment at Station A300S (Table 3-1; Figure 3-17). The overall average of 1.9 cm, indicative of moderately well-aerated surface sediments, was lower than the value observed at the reference areas (2.5 cm). None of the stations occupied over the historic disposal mound showed any evidence of low sediment dissolved oxygen conditions, visible redox rebounds, or methane gas bubbles.

Considering the long period of time between the end of disposal activity at Mound A in January 1995 and the August 2001 monitoring event, it was anticipated that the benthic community would be in an advanced stage of recolonization. The successional stage recolonization status for stations over Mound A included both Stage I opportunistic polychaetes at the sediment surface and Stage III head-down, deposit-feeding infauna (Figure 3-18). When present, Stage III activity was marked by active feeding voids in the subsurface sediments, and was consistently accompanied by Stage I taxa at the sediment-water interface (i.e., Stage I on III successional status). Evidence of Stage III activity occurred in 12 of the 37 analyzable images obtained at the stations over Mound A (31%), compared to 26 of the 38 replicate images (68%) at the reference area stations. Stage I organisms were the only benthic infauna observed at 4 of the 13 stations (A100W, A100S, A200N, and A300W) over Mound A (Figure 3-18).

Replicate-averaged median OSI values for stations over Mound A ranged from +2 at Stations A100S and A300W to +8.5 at Station A200E (Table 3-3 and Figure 3-17). The overall median OSI value of +4.5 is indicative of moderately degraded or disturbed (marginal) benthic habitat quality (OSI values between +3 and +6) and was lower than the observed value of +7.9 at the reference areas. Shallow RPD depths and the presence of only Stage I organisms at 4 of the 13 stations served to diminish the median OSI values at Mound A. Of the 13 stations, only one station (A200E) displayed an average median OSI value that was considered indicative of non-degraded or undisturbed benthic habitat quality (OSI values > +6). In general, lower OSI values were observed within the confines of the disposal site; however, ambient stations positioned outside the disposal site boundaries where no dredged material was observed also displayed OSI values ≤+6 (Figure 3-17).

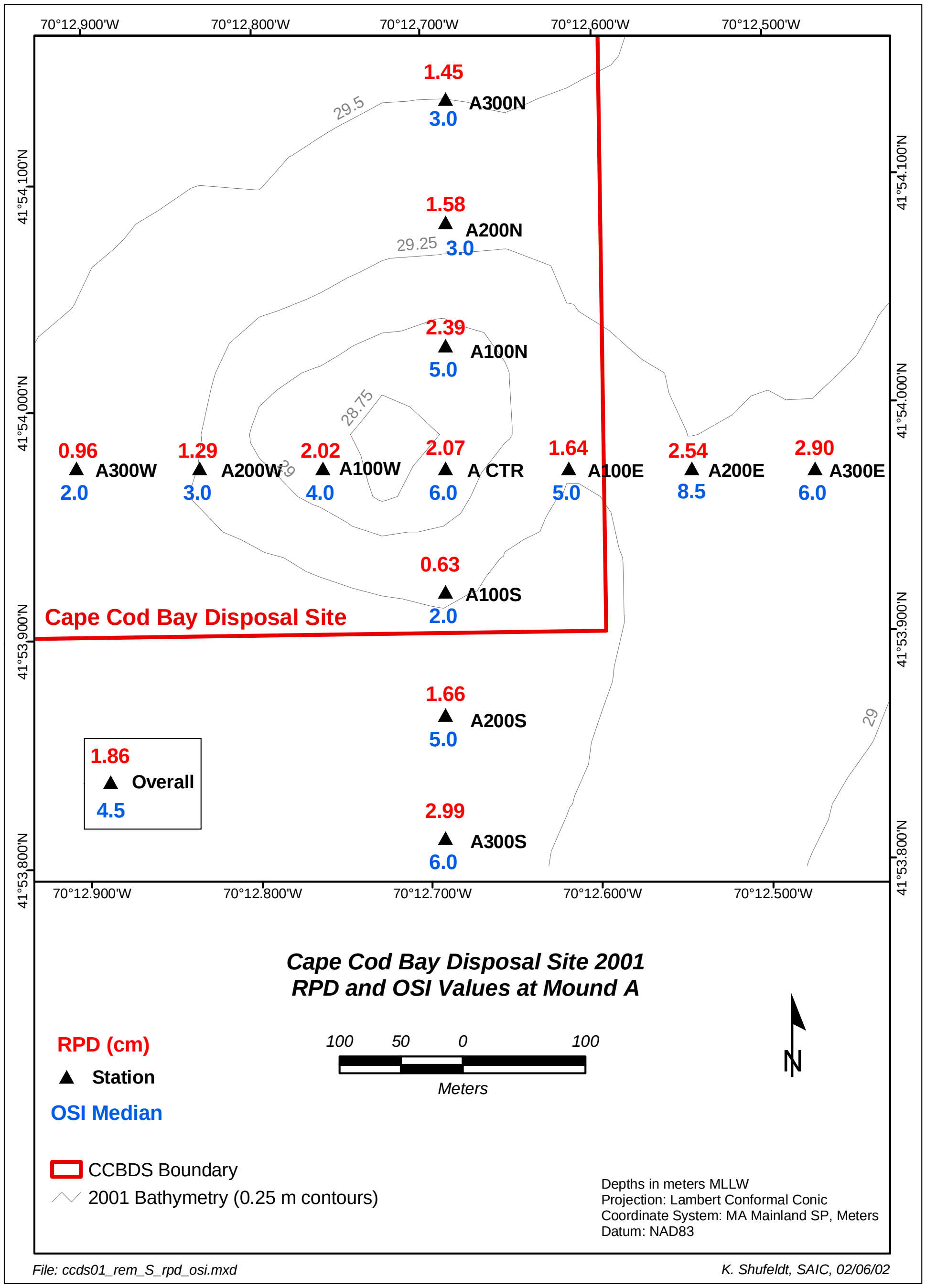


Figure 3-17. Map of replicate-averaged RPD depths (red) and median OSI values (blue) at the August 2001 REMOTS® stations over CCBDS Mound A, plotted over 2001 bathymetry

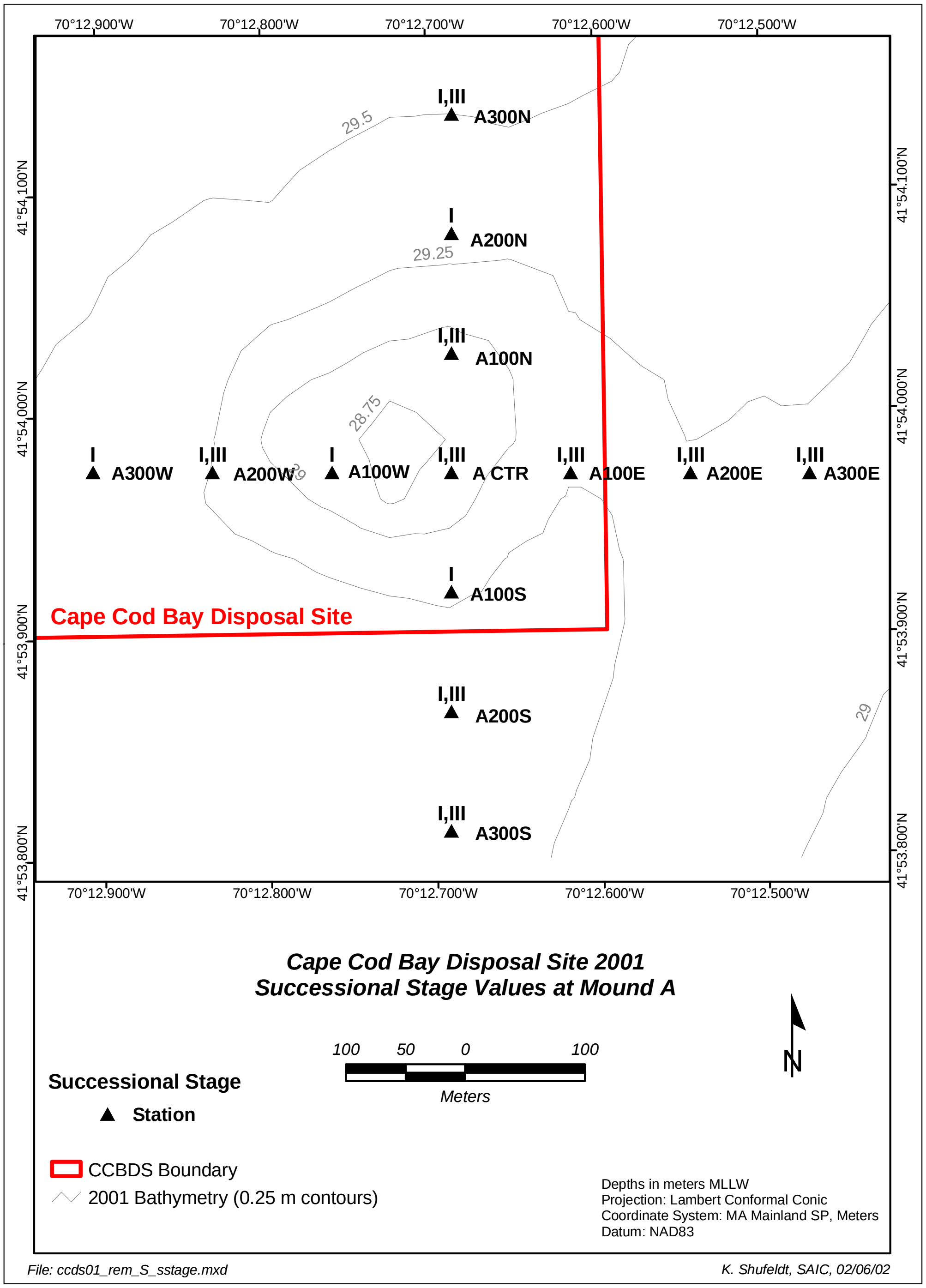


Figure 3-18. Map of successional stage status for the REMOTS® stations established over CCBDS Mound A, plotted over 2001 bathymetry

Although some variability in OSI values existed among replicate images at particular stations, all three replicates at Stations A200N, A100S, and A300W displayed low OSI values (between +1 and +4).

3.2.3 CCBDS Reference Areas

3.2.3.1 Physical Sediment Characteristics

The August 2001 monitoring survey marked the first time reference areas NW REF and SW REF were sampled since their selection in 1996. These reference areas served to supplement the previously established reference site CCBRS. Ambient sediment was observed at all of the reference area stations. The ambient sediment was fine-grained, comprised of tan over gray silt and clay, having a major modal grain size of >4 phi (Table 3-2 and Figure 3-19).

Mean camera penetration prism depths at the reference area stations were similar to those observed at the disposal site stations, ranging from 10.6 cm at Station SW REF4 to 19.6 cm at Station REFCTR (overall average 15.6 cm; Table 3-2). Over-penetration of the REMOTS® camera prism prevented the analysis of key parameters (e.g., RPD, successional status, surface roughness, and OSI) in 2 of the 38 total images obtained in the August 2001 REMOTS® survey.

Reference area boundary roughness values ranged from 0.5 to 2.2 cm, with an overall average of 1.1 cm signifying only small amounts of small-scale surface relief (Table 3-2). These values were very similar to the values over Mounds A and B (1.3 cm; Tables 3-1 and 3-3). There was no obvious spatial pattern to these relatively low boundary roughness values at the reference area stations. Surface roughness was due equally to both physical processes and biogenic activity over the sediment-water interface. Biogenic surface roughness was attributed to dense surface tubes (Figure 3-19) and biological surface reworking by burrowing infauna at the sediment-water interface. Numerous brittle stars (Ophiuroids) were present at or near the sediment-water interface at five stations (Figure 3-20), while stick amphipods (Family Podoceridae) were visible at the surface of three stations.

3.2.3.2 Biological Conditions

The composite average RPD value for the reference area stations (2.5 cm) was higher than that observed at the disposal site stations and indicated moderately well-aerated surface sediments (Table 3-2). Replicate-averaged RPD measurements ranged from 0.8 cm at Station REF1 to 3.5 cm at Station NW REF3, with the deepest apparent RPD

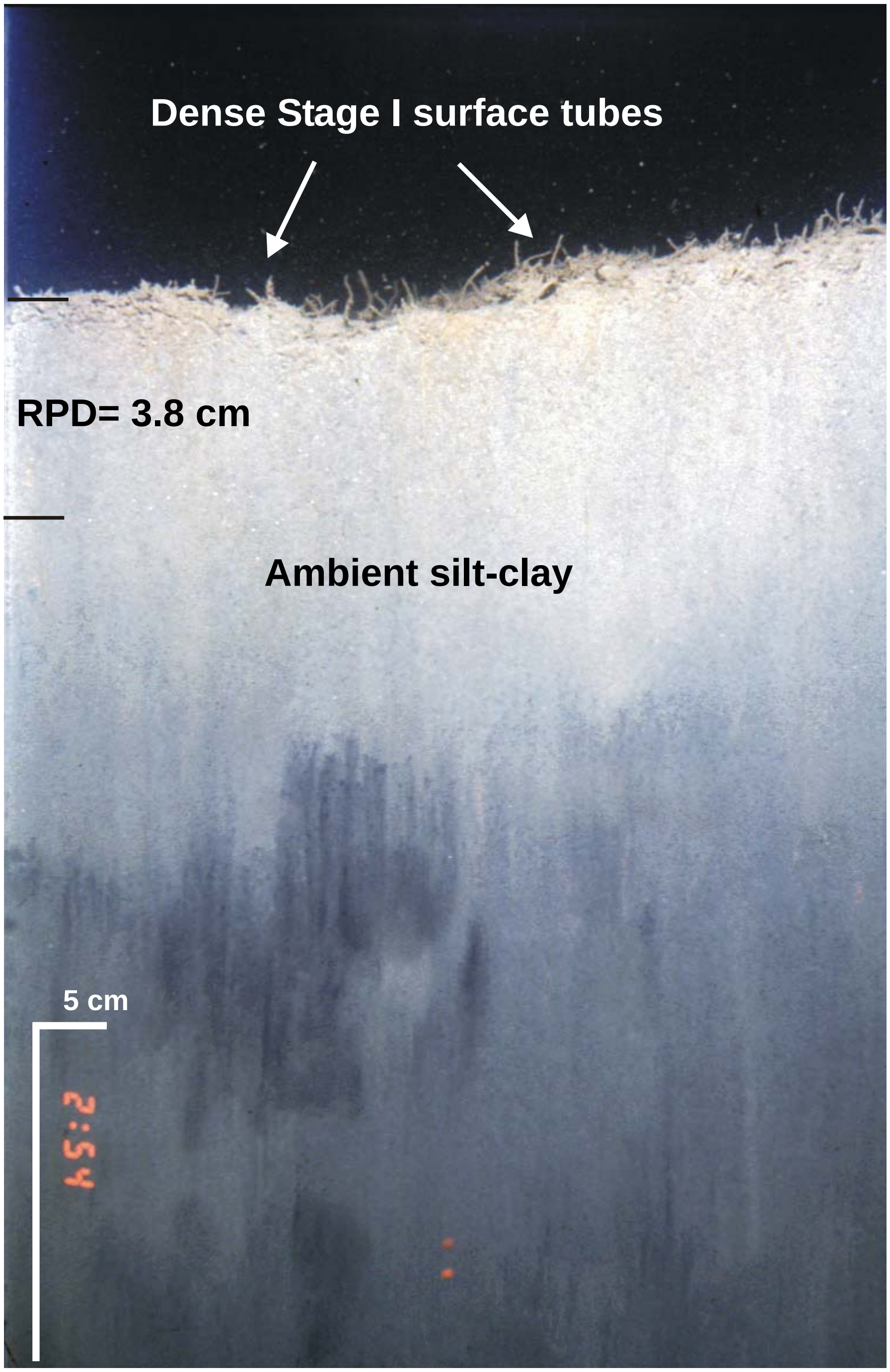


Figure 3-19. REMOTS® image from NW REF Station NW REF2 showing the characteristics of ambient sediment (gray silt-clay) observed throughout the NW reference area images. A dense assemblage of Stage I polychaete tubes is visible at the sediment surface.

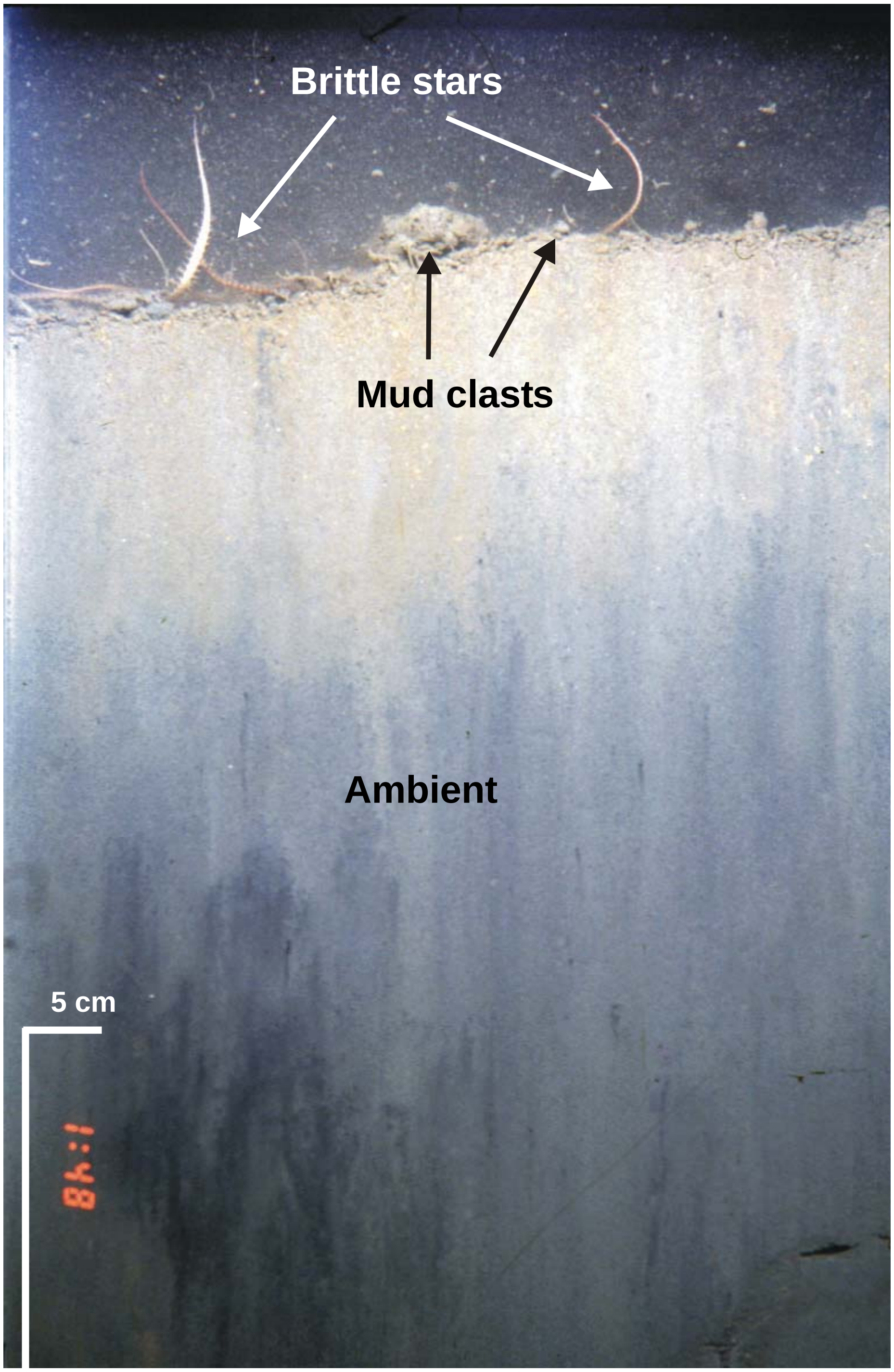


Figure 3-20. REMOTS® image from Station CCBRS-REF4 showing a biologically active benthic environment, with brittle stars (Ophiuroids) at the sediment-water interface in ambient sediment

measurements observed at the NW REF stations (Table 3-2). Small patches of reduced sediment (black) were detected at three stations of reference area CCBRS (Figure 3-21). There was no evidence of low sediment dissolved oxygen conditions, methane, or visible redox rebounds in any of the sediment-profile images from the reference areas.

The successional status at the reference area stations was roughly comparable to the disposal site stations, with primarily Stage I and Stage III activity detected (Table 3-2). The successional stage was relatively advanced, with Stage III occurring in 26 of the 38 total replicate images (68%) obtained at the reference areas compared to 52% at Mound B and 31% at Mound A. When present, Stage III activity was consistently associated with Stage I polychaetes at the sediment-water interface. Stage I taxa occurred alone in 10 of the 38 total replicate images (26%), with all replicate images at Station NW REF4 displaying Stage I successional status.

Median OSI values at the reference areas were consistently higher than those at the disposal mound stations, with an overall average of +7.9 (Table 3-2). Such a value is indicative of undisturbed or non-degraded benthic habitat quality, mainly related to deeper RPD depths and an abundance of Stage III activity. Of the three reference areas, CCBRS had the lowest average median OSI value, due to shallower RPD depths (Table 3-2).

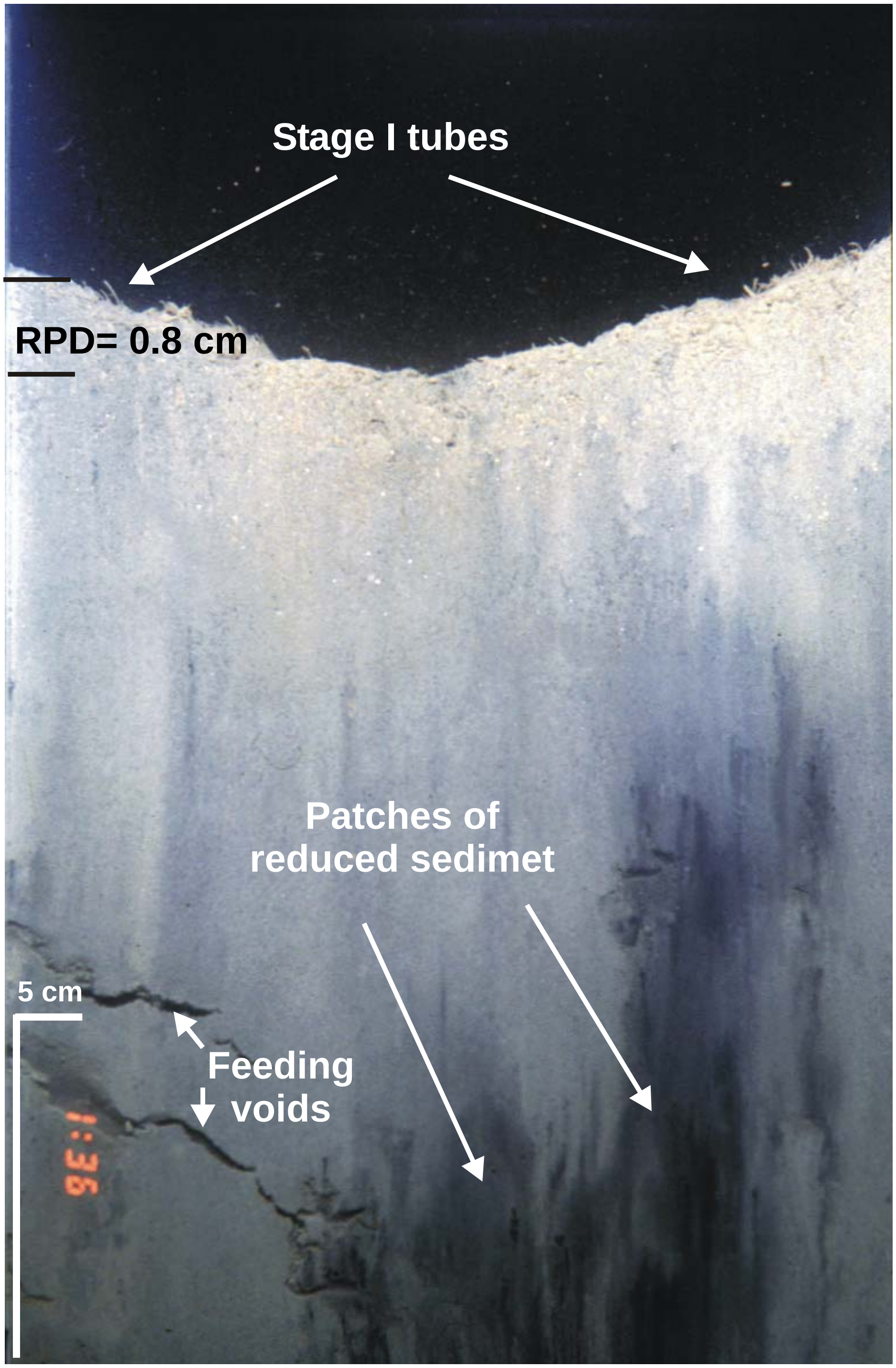


Figure 3-21. REMOTS® image from reference area Station REF3 displaying patches of reduced sediment at depth. Shallower RPD depths were common among CCBRS reference area stations compared to NW REF and SW REF.

4.0 DISCUSSION

4.1 Dredged Material Distribution

The objectives of the August 2001 survey over the CCBDS were to document changes in seafloor topography around the two disposal buoy positions (Buoy A and Buoy B) and evaluate the spatial distribution and benthic recolonization of the deposited dredged material. The August 2001 monitoring effort was the first bathymetric survey performed over the entire 3.42 km^2 area of CCBDS. The natural seafloor within CCBDS was found to be relatively flat and regular; the only features found at the site consisted of the three dredged material deposits (Mounds A, B, and a subtle mound within the historic Wellfleet Disposal Area). Bathymetric depth differencing to document the development of the most recent mound could not be performed without baseline survey data; however, the relatively flat and featureless seafloor at CCBDS enabled a reasonable estimate of the mound dimensions.

4.1.1 Mound B

The largest and most recent bottom feature detected at CCBDS was the active disposal Mound B. Rising four meters above the surrounding seafloor, the apex of Mound B was 27.5 m below the water surface (the shallowest depth at CCBDS), with an estimated diameter based on the bathymetric survey alone of about 350 meters. An estimated barge volume of 324,000 m^3 of sediment was deposited at Mound B between 1996 and 2001. Dredged material disposal has continued at this mound during the 2001/2002 disposal season. While the mound was determined to be stable at the time of the 2001 survey, continued disposal could increase its slope and height while decreasing its stability and the overall water depth at the site. The possibility of directing disposal to a new position should be considered before the stability of the present mound is affected.

Since 1993, the DAMOS program has utilized a technique of constructing bowl-like “containment cells” on the seafloor to maximize capacity at several other dredged material disposal sites (Fredette 1994; Morris and Tufts 1997). In this technique, disposal buoys are moved around periodically to promote the formation of mounds in a circular pattern on the seafloor. These rings of disposal mounds eventually merge to create the walls of a large-scale containment basin within which dredged material that requires confined aquatic disposal (i.e., capping) can be placed. The ring of disposal mounds is sufficient to function as a containment basin, while still enabling discrete and independent monitoring of each mound.

The artificial containment cells created by the rings limit the lateral spread of large deposits of unconsolidated sediments; such cells could eventually be utilized to promote efficient capping operations on the CCBDS seafloor. The conditions existing at CCBDS (low current regime, moderate water depth, and protected nature) make it an excellent candidate for capping operations. Due to the lack of industrialized harbors along the Cape Cod shoreline, the volume of material that would actually require capping would be quite low. However, such a disposal site management strategy would result in the formation of smaller mounds that should be stable over a broader range of hydrodynamic conditions, and would establish containment areas that would minimize lateral spread of dredged material deposits on the sloping substrate at CCBDS.

The REMOTS® results agreed relatively well with the bathymetric results over Mound B and indicated that the dredged material was contained within the confines of the northeast portion of the disposal site. The REMOTS® images indicated that the dredged material constituting Mound B was mostly fine-grained sediment (silt). However, gray and/or white clay chips mixed with the silt (Figure 3-7) were observed at a number of stations, located primarily near the mound apex. The measured average thickness of the dredged material layer, where detected, exceeded the penetration depth of the sediment-profile camera at most of the Mound B stations. Ambient sediments (i.e., no dredged material) occurred at Stations B300NW and B300E, and in a few of the replicate images at Stations B300N, B300NE, and B300S. In general, at the outlying 300 m stations, it was sometimes difficult to differentiate between ambient sediments and older, weathered dredged material in the sediment-profile images. Given the uncertainty in the detection of dredged material at these stations, the mound diameter based on the combination of bathymetry and REMOTS® is estimated to be on the order of 500 to 600 m (Figure 3-6).

4.1.2 Mound A

Mound A, the older of the two dredged material disposal mounds, is located in the southeast corner of the southeast quadrant of CCBDS. The depth difference comparison between the 1996 and 2001 bathymetric surveys indicated only small areas of apparent consolidation, on the order of 0.15 to 0.25 m, over the surface of this mound. The 1996 bathymetric survey occurred approximately one year following the creation of Mound A. Most of the consolidation of a dredged material mound is expected to occur rapidly, typically in the first year following disposal (Poindexter-Rollings 1990; Silva et al. 1994; SAIC 1995). Therefore, the minimal consolidation observed between the 1996 and 2001 surveys was expected.

Due to a 100 m offset between the 2001 and 1996 REMOTS® survey grids, all of the same sediment-profile imaging stations were not occupied, but they did cover the same general area with a similar number of sampling points (Figure 4-1). The center of the 2001 REMOTS® sampling grid was based on disposal log information and established in the center of the disposal points, and was 100 m east of the center station used in the 1996 survey. The 13-station radial arm grid used in 2001 extended 100 m farther east relative to the 1996 baseline grid, reaching approximately 200 m beyond the boundary of CCBDS (Station A300E; Figure 4-1). The REMOTS® results agreed relatively well with the depth difference comparison over Mound A and showed that the mound apron extended 100 to 200 m to the south of the mound center and beyond 200 m to the east (Figure 3-14). Because dredged material was detected at the outlying northern and western stations (300 m), the full extent and diameter of the mound apron could not be determined in those directions. However, by compiling the information pertaining to dredged material thickness from both 1996 and 2001 data sets, the extent of the dredged material footprint could be estimated (Figure 4-1).

Given the significant amount of time between the cessation of disposal activities (1996) and the summer 2001 monitoring events, it is reasonable to expect the sediments comprising Mound A to begin displaying characteristics similar to ambient sediments. Apparent older dredged material was detected outside the CCBDS boundary at Station A200E in 2001, while ambient sediment was observed primarily at the perimeter of the sampling grid (Stations A200S, A300E, and A300S; Figures 3-14 and 4-1).

The May 1996 survey detected the presence of ambient sediment within the top 20 cm of sediment at stations 200 to 300 m from the apex of the disposal mound (CR Environmental 1997). Discrete, measurable layers of dredged material over ambient sediment were detected in the outermost stations of the 1996 survey. However, in evaluating the images from the August 2001 survey, it was often difficult to clearly and definitively distinguish between apparent older, fine-grained and biologically reworked dredged material (i.e., historic) and ambient fine-grained sediment. The apparent historic dredged material noted at some of the 2001 sampling locations in Mound A has been in place on the seafloor for over five years. As a result, reworking of the surface sediments by the benthic infauna and the removal of organic material by primary consumers now gives the historic dredged material present at some stations a visual appearance similar to that of ambient Cape Cod Bay sediments.

4.2 Biological Conditions and Benthic Recolonization

4.2.1 Mound B

The August 2001 monitoring survey over Mound B in the northeast quadrant of CCBDS was conducted approximately eight months following the completion of disposal

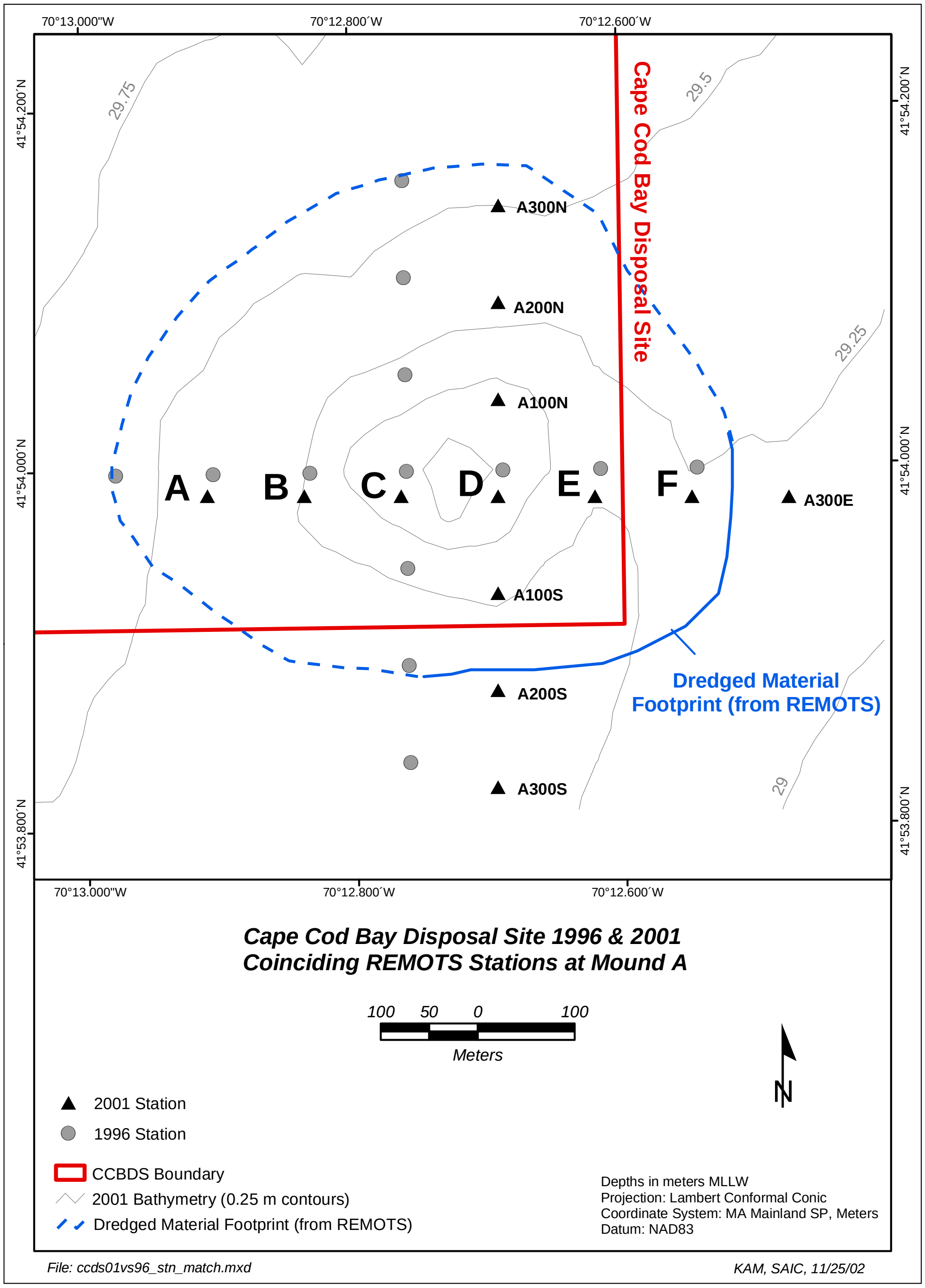


Figure 4-1. Map of REMOTS® sediment-profile imaging stations occupied over Mound A as part of the May 1996 (gray) and August 2001 (black) monitoring surveys. Stations lying close enough to facilitate direct comparison are denoted with a designation of A through F.

operations in December 2000. According to the DAMOS tiered monitoring approach (Germano et al. 1994), a disposal mound experiencing a normal benthic recolonization pattern is expected to support a widespread and abundant Stage I community at eight months following disposal, with some progression into more advanced Stage II or III assemblages. The August 2001 REMOTS® results indicate that surface sediments comprising Mound B within the CCBDS had been recolonized by a diverse benthic community consisting of both surface-dwelling and deeper-dwelling infauna. This community appeared to be comparable to that observed on the ambient seafloor. Specifically, the stations over Mound B included a diverse mixture of low-order successional stages (Stage I), Stage II seres, and advanced Stage III assemblages. The dominance of only Stage I successional status at two stations near the mound apex (B100N and B100NE) is expected because of the recent disposal activity in the area. Evidence of advanced succession (Stage III) was observed in 39 of the 73 (52%) replicate images obtained over Mound B, indicating that benthic recolonization over the surface of the mound has met and exceeded expectations at eight months postdisposal.

Newly deposited sediments frequently support higher population densities of foraging invertebrates by providing a concentrated food source (organically enriched sediment) within a competition free space, relative to ambient material (Germano et al. 1994). As a result, dredged material placement mounds often recover at a rate that meets or exceeds expectations by displaying an advanced benthic infaunal population within six months to one year of placement.

A variety of benthic invertebrates inhabit the seafloor of Cape Cod Bay. The seafloor within the CCBDS, in particular the northeast quadrant over Mound B, appears to be quite biologically active. Interesting biological features in the sediment-profile images included polychaetes and larger infauna such as burrowing anemone, stick amphipods (Family Podoceridae), brittle stars (Ophiuroid), and solitary hydroids (*Corymorpha pendula;* Figures 3-7 and 3-9). These marine organisms have been observed in other regions of the CCBDS and surrounding reference areas during both the 1996 postdisposal and 2001 monitoring surveys (Figures 3-7, 3-9, and 4-2; CR Environmental 1997). Although not observed in the 2001 survey, sea cucumbers (*Molpadia oolitica*) have been documented by prior studies as a major bioturbating species throughout Cape Cod Bay (CR Environmental 1997, Ocean Surveys, Inc. 1995).

The OSI provides a summary measure of overall benthic habitat conditions. In general, the stations over Mound B showed variable benthic habitat conditions, with median OSI values ranging from moderately disturbed (OSI values $\leq +6$) to undisturbed (OSI values $> +6$). The overall median OSI of +6.5, indicating undisturbed benthic

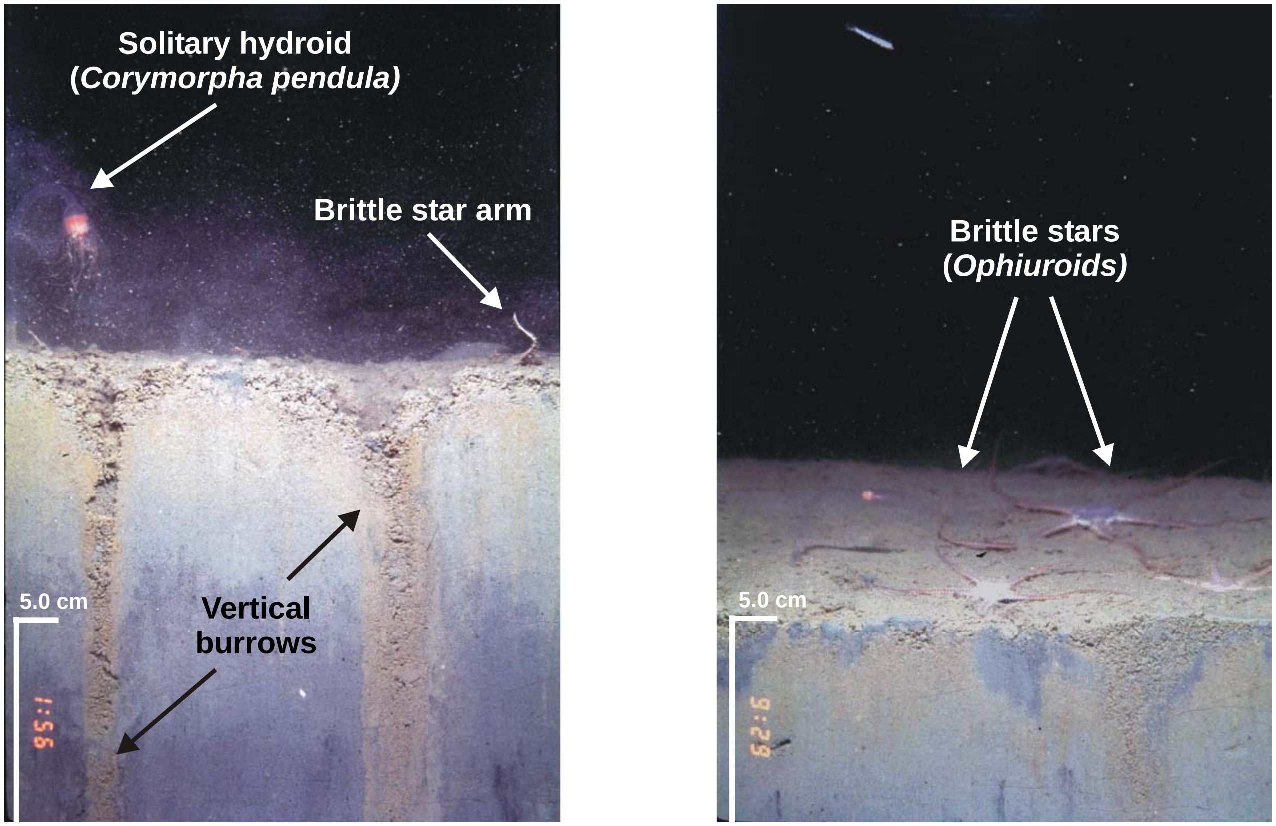


Figure 4-2. REMOTS® images obtained from reference area Station NW REF200E (left) and CCBRS-REF3A (right) during the May 1996 survey displaying a biologically active benthic environment. A solitary hydroid (*Corymorpha pendula)* and a brittle star arm are visible at the sediment-water interface, while evidence of burrowing infauna is visible at depth at Station NW REF200E. Numerous brittle stars inhabit the sediment surface at Station CCBRS-REF3A.

habitat, reflects moderately well oxygenated surface sediments (overall RPD of 2.2 cm) and the presence of mainly Stage I and III organisms over the disposal mound. Slightly shallower RPD depths and resultant OSI values at the disposal mound stations, compared to the reference areas, probably reflect a higher inventory of organic matter associated with the dredged material and/or the less developed colonization status at some stations. It is expected that the RPD depths will gradually deepen over time as the organic matter is consumed and the dredged material continues to experience extensive bioturbation by the recolonizing organisms.

Because of its recent disposal history and associated ongoing disturbance, variability in benthic conditions over Mound B was expected. The current disposal plans for CCBDS include continued dredged material placement over Mound B during the 2001/2002 disposal season. Therefore, it is expected that variability in benthic habitat conditions will continue as new dredged material is deposited from various sources in the present and upcoming disposal seasons.

4.2.2 Mound A

The August 2001 monitoring survey over Mound A was conducted roughly six years since the last disposal of dredged material in the winter of 1995. Assuming there was no further disturbance to retrograde the succession over this "historic" mound, it was expected that the sediments would be supporting a mature and stable Stage III benthic community. General comparisons of conditions over Mound A from the 1996 and 2001 surveys were made using average RPD depths, successional stages present and median OSI values (Figures 4-3 and 4-4). The 100 m offset between the 1996 and 2001 survey grids restricted direct station comparisons to six locations (designated stations A through F) distributed along the east-west transect of the survey grid (Figure 4-1). In addition to these comparisons, a general assessment of the changes in benthic habitat conditions over Mound A was possible by comparing conditions to nearby reference areas, and by compiling data obtained from the replicate images acquired as part of both the 1996 and 2001 surveys to examine the mound in its entirety.

4.2.2.1 General Comparisons

The May 1996 survey results indicated the presence of dredged material over most of the survey area. Deep RPDs and the widespread presence of Stage III infauna suggested that complete benthic recolonization had occurred over Mound A (CR Environmental 1997). Median OSI values were quite high at most of the stations occupied as part of the 1996 survey, ranging from +5 to +11 (Figure 4-3; Appendix C1). The composite OSI of +9.1 for Mound A in 1996 reflected the deep RPD depths (5.5 cm average) and Stage III

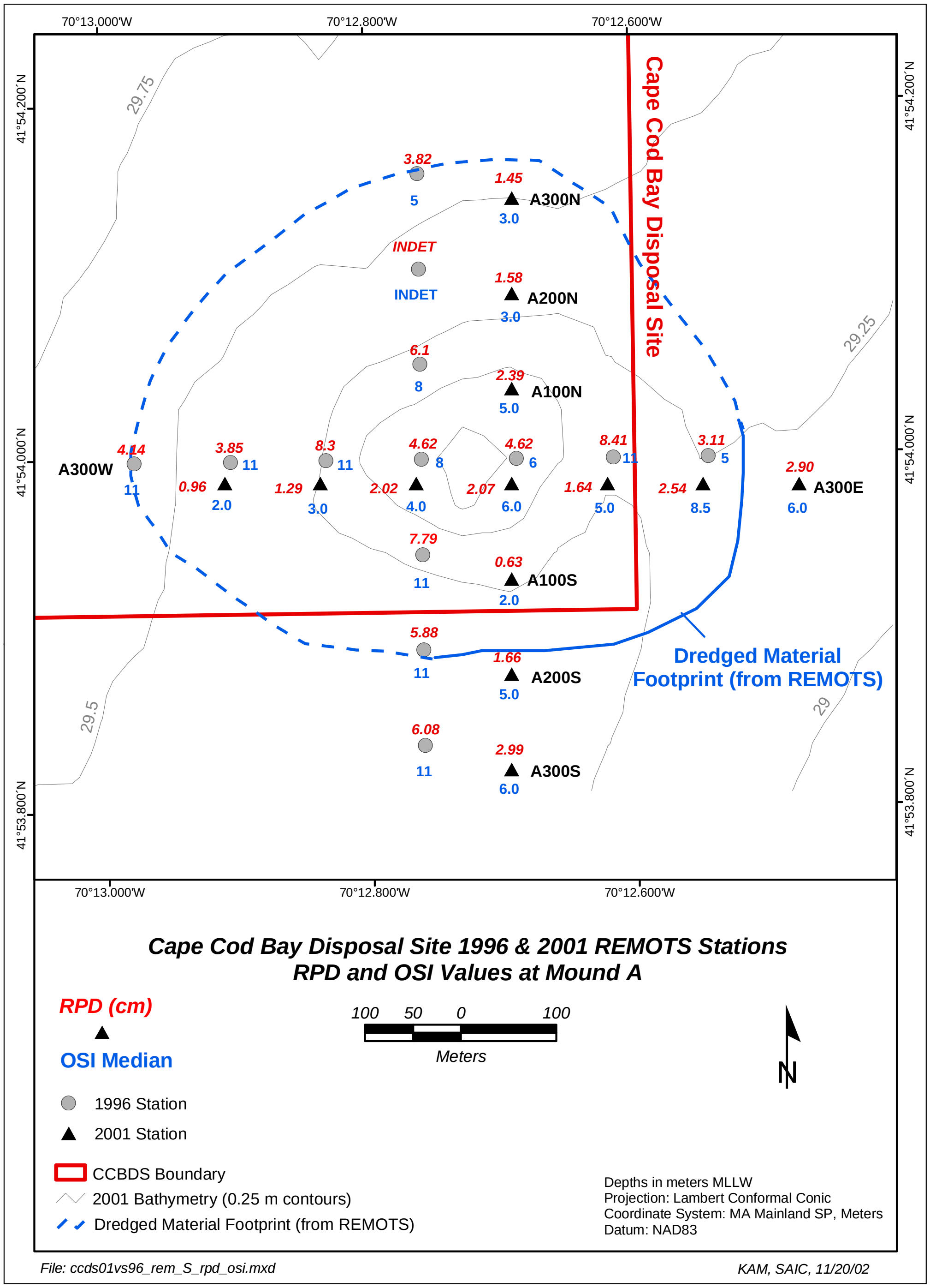


Figure 4-3. Summary of replicate-averaged RPD depths (red) and median OSI values (blue) for the May 1996 and August 2001 REMOTS® stations over Mound A, plotted over 2001 bathymetry

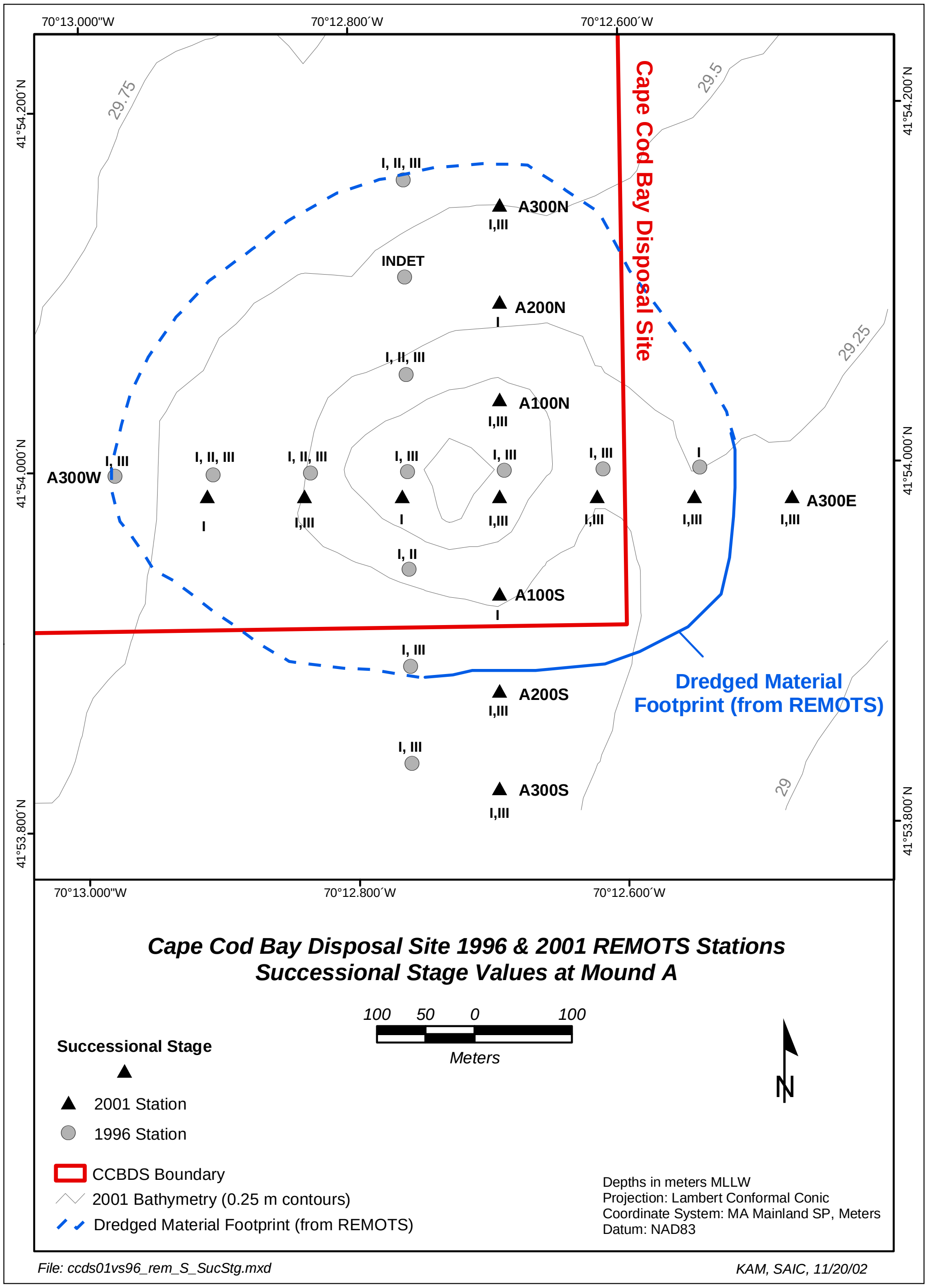


Figure 4-4. Map of successional stage status for the May 1996 and August 2001 REMOTS® stations established over CCBDS Mound A, plotted over 2001 bathymetry

activity at 11 of the 13 stations (85%; Appendices C1 and C2; CR Environmental 1997). RPD depths in replicate images ranged from 2.6 to 12.4 cm, which constitutes a substantial RPD maximum compared to typical dredged material deposits. Brittle stars (Ophiourids) were seen in abundance within the 1996 sediment-profile images (Figure 3-7). In addition, burrowing sea cucumbers (*Molpadia oolittica*) were observed in sediment grab samples obtained over Mound A during the 1996 postdisposal survey and in earlier surveys over the southeast quadrant (Battelle 1990; Ocean Surveys Inc. 1995; CR Environmental 1997). This species is considered a deep bioturbator that incorporates oxygen rich bottom water well below the sediment-water interface, and was likely responsible for the deep RPD depths detected in 1996. Despite the relatively high prevalence of Stage III organisms by station (85%), evaluation of individual replicate images indicated a more patchy distribution, with approximately 66% of the replicates having Stage III organisms present.

The 1996 survey RPD depths for Mound A stations (average of 5.5 cm) were deeper than at nearby reference areas (average RPD of 2.4 cm at SW REF, 4.1 cm at NW REF, and 4.2 cm at CCBRS). Conversely, presence of Stage III organisms was slightly less at Mound A stations (85%) compared to 92% of the stations at SW REF, and 100% of the stations at CCBRS and NW REF.

The August 2001 data set showed a distinct decline in benthic habitat conditions over most of Mound A, with a pronounced degradation of habitat over the southern and western flanks (Figure 4-3). Similar but less pronounced declines were evident at the reference areas for the 2001 survey. In general, the Mound A replicate-averaged RPD depths were substantially shallower, and the abundance of deeper-dwelling Stage III organisms was reduced, in the 2001 survey in comparison to May 1996 (Figures 4-3 and 4-4). As a result, median OSI values over most of Mound A were lower than anticipated for a six year old sediment deposit. The composite OSI value of +4.5 for Mound A is indicative of moderately degraded or disturbed benthic habitat conditions and represents a 4.6 point reduction relative to May 1996. In addition, the average OSI values for Mound A were substantially lower than the composite value of +7.9 calculated for the reference areas during the 2001 survey.

Comparisons between the 1996 and 2001 reference area datasets indicate a similar, but less pronounced trend in benthic habitat conditions (Figures 4-5, 4-6, and 4-7). Composite OSI values decreased by 1 point, primarily due to shallower RPD depths (overall average of 3.4 cm in 1996 compared to 2.5 cm in 2001). Prevalence of Stage III organisms by station indicates a minor difference between the 1996 survey (97% of reference area stations had Stage III organisms present) and the 2001 survey (92% of reference area stations had Stage III organisms present). An evaluation using individual replicates provides more insight on the decline, which is useful in describing the patchiness

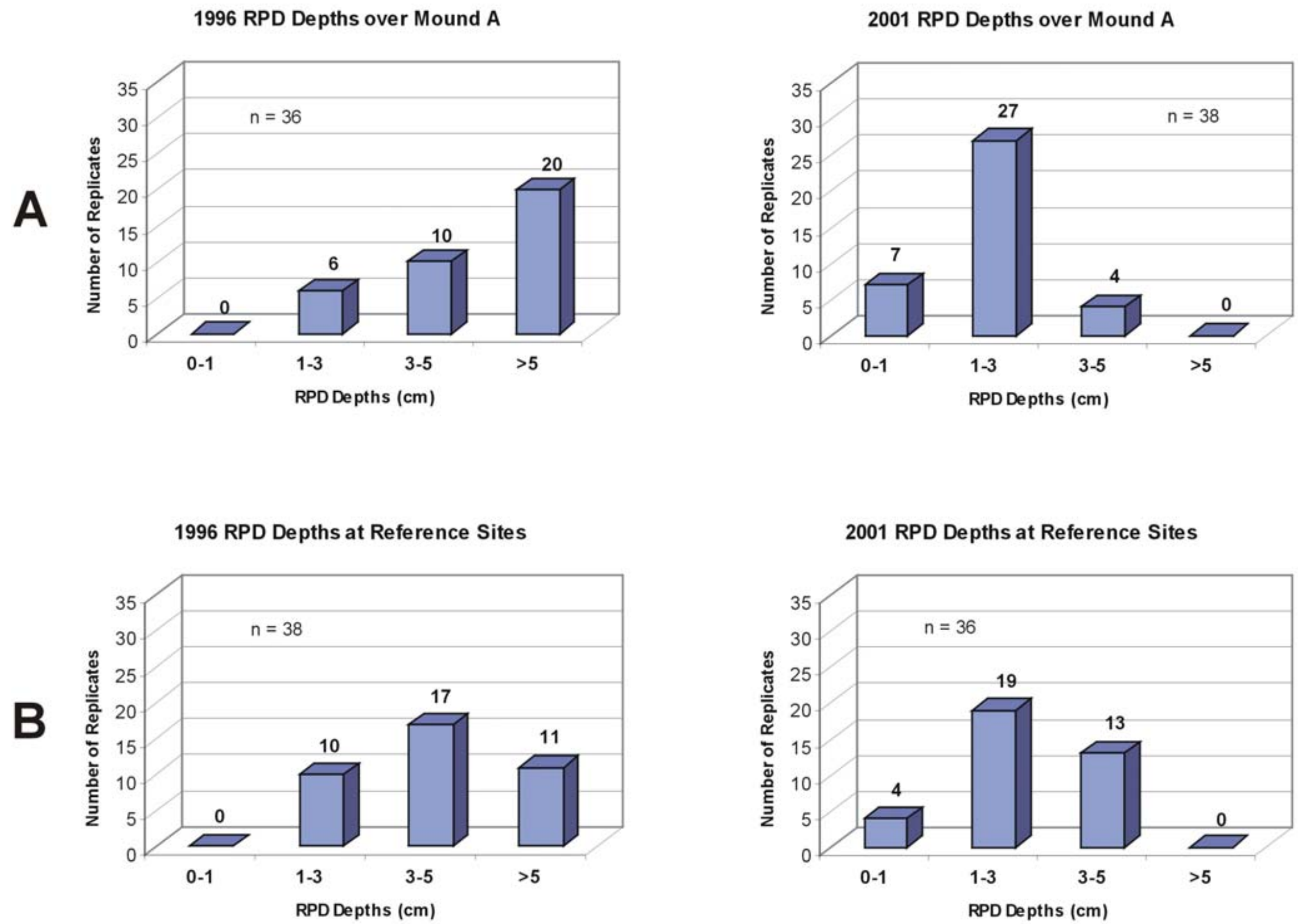


Figure 4-5. Histograms comparing number of replicate images collected over Mound A (A) and the CCBDS reference areas (B) displaying RPDs within various depth classes to evaluate changes in depth of sediment oxygenation between the May 1996 and August 2001 surveys.

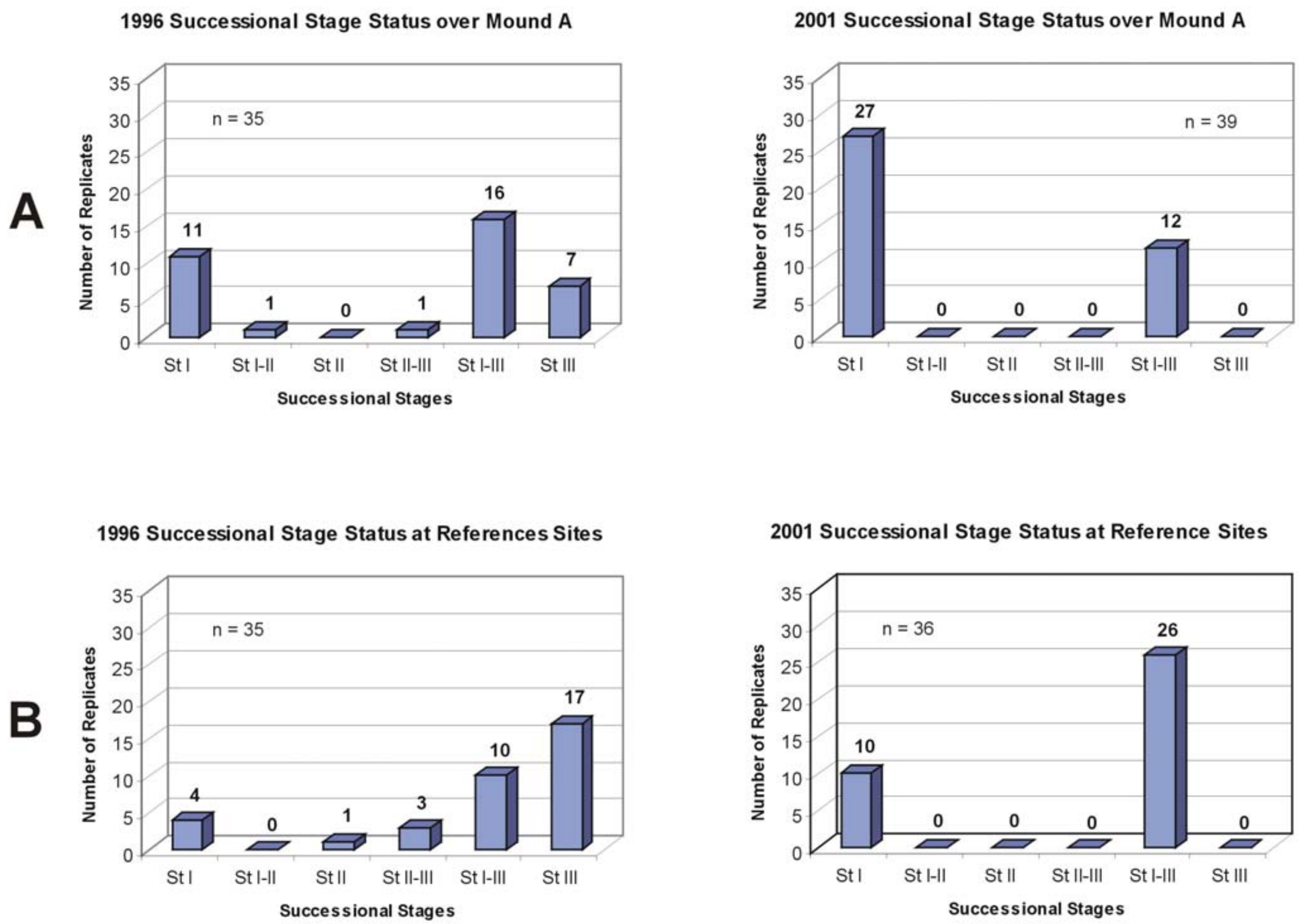


Figure 4-6. Histograms comparing number of replicate images collected over Mound A (A) and the CCBDS reference areas (B) displaying biological activity within the various successional stage seres to evaluate changes in benthic recolonization status between the May 1996 and August 2001 surveys.

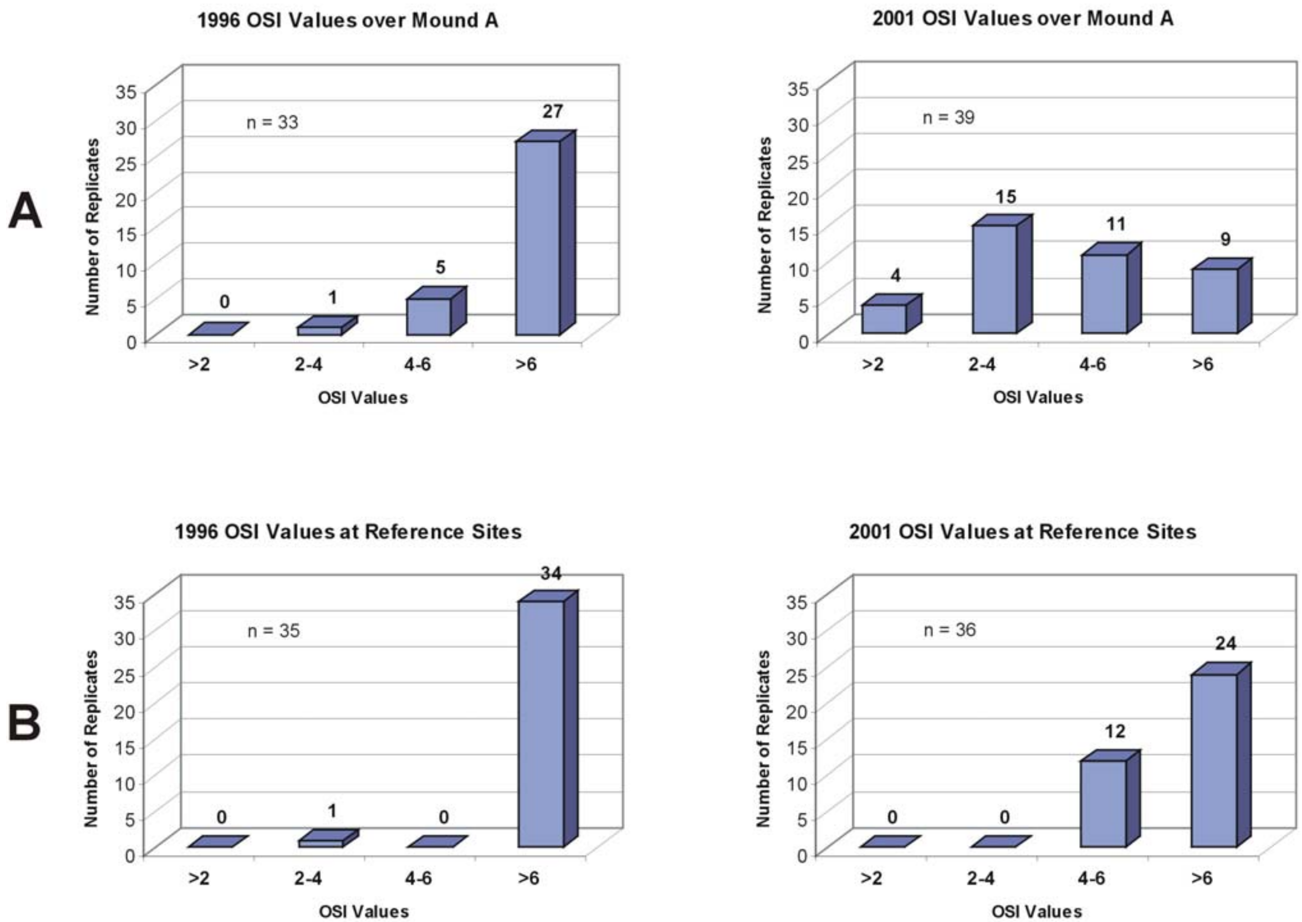


Figure 4-7. Histograms comparing number of replicate images collected over Mound A (A) and the CCBDS reference areas (B) displaying OSI values within the various classes to evaluate changes in benthic habitat conditions between the May 1996 and August 2001 surveys.

of Stage III organisms. In the 1996 survey, 96% of the replicate images had Stage III organisms present, and in the 2001 survey, only 68% of the replicate images had Stage III organisms present. This indicates that despite comparable results when considered by station, there was a more patchy distribution throughout the reference area stations for the 2001 survey.

4.2.2.2 Station Comparisons

Direct comparisons among Stations A through F distributed along the east-west transect reflect the overall trend of declining benthic habitat conditions between the 1996 and 2001 surveys, as median OSI values decreased significantly (4 points or more) at four of the six stations (Table 4-1). Stations A, B, C, and E all exhibited lower OSI values due to shallower RPD depths and reduced abundance of Stage III organisms relative to 1996. The most significant change in benthic habitat conditions was noted at Station A on the western flank of the mound, with lack of an advanced successional stage and limited oxygen penetration below the sediment-water interface resulting in a 9 point reduction in median OSI values (Table 4-1; Figures 4-3 and 4-4). Station F located on the eastern flank displayed improved habitat conditions, as evidence of Stage III activity was detected in all three replicate images collected in August 2001 (Table 4-1). Despite a minor decrease in RPD depths, OSI values remained constant at Station D located near the apex of the disposal mound.

4.2.2.3 Summary

Regional declines in RPD depth and prevalence of Stage III organisms were evident in the comparison of reference area data from the 1996 and 2001 surveys (Figures 4-5 and 4-6). Most of the Mound A stations, as well as the adjacent areas beyond the disposal mound to the south and east, showed a more dramatic decline in benthic habitat conditions between the two surveys (Figures 4-3 and 4-4). This was partly due to the greater RPD depths that were evident over Mound A and the surrounding stations in 1996, as well as a more dramatic decrease in the prevalence of Stage III organisms at Mound A survey stations in 2001. As indicated above, the deep RPD depths were likely attributable to the presence of deeply burrowing infauna and their bioturbating effects (i.e., brittle stars and sea cucumbers). It is possible that these organisms were attracted by the recently deposited dredged material, and that the organically enriched dredged material resulted in a short-term increase in productivity over the mound.

The shallower RPD depths over Mound A during the August 2001 survey may also reflect higher levels of organic carbon in the dredged material. Localized enrichment in total organic carbon levels (TOC) could increase the potential for elevated sediment oxygen

Table 4-1.

1996 and 2001 REMOTS® Sediment-Profile Imaging Results Comparison for Mound A Stations A through F

Station A

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	OSI Mean	OSI Median
May 1996	3.9	I, II, III	ST III	10.33	11
August 2001	1	I	ST I	2.67	2

Station B

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	OSI Mean	OSI Median
May 1996	8.3	I, II, III	ST III	9.67	11
August 2001	1.3	I, III	ST I on III	4.33	3

Station C

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	OSI Mean	OSI Median
May 1996	4.6	I, III	ST III	8	8
August 2001	2	I	ST I	4	4

Station D

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	OSI Mean	OSI Median
May 1996	3.4	I, III	ST III	7.33	6
August 2001	2.1	I, III	ST I on III	7	6

Station E

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	OSI Mean	OSI Median
May 1996	8.4	I, III	ST I on III	11	11
August 2001	1.6	I, III	ST I on III	5	5

Station F

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	OSI Mean	OSI Median
May 1996	3.1	I	ST I	5.67	5
August 2001	2.5	I, III	ST I on III	8.5	8.5

demand and sulfide production. As a result, recovery would proceed more slowly as the organics were chemically broken down at sediment depth. The apparent inhibited recolonization over Mound A at approximately six years postdisposal may be attributed to the elevated organic content associated with the dredged material, or perhaps some other form of physical seafloor disturbance in that area of CCBDS (e.g., trawling). An alternative explanation for the apparent reduction in habitat conditions over Mound A is that the chemical constituents within the sediment are affecting the ability of the dredged material deposit to support an advanced benthic community (i.e., chronic effects due to contaminants in the sediment) and/or making the benthic population more susceptible to seafloor disturbance than the nearby reference areas.

Based on the environmental testing performed on the in-place harbor sediments in the early 1990s, Mound A is comprised of dredged material deemed suitable for unconfined open water disposal. Given the conditions detected over Mound A, the normal course of action as defined by the tiered monitoring protocol includes the completion of additional monitoring activity, potentially followed by sediment sampling to determine the cause for degradation in benthic habitat conditions (Germano et al. 1994). If these data collection efforts indicate remediation of the mound is required, supplemental dredged material would be strategically placed over the disposal mound to isolate any sediment exhibiting toxicity or deemed unable to support an advanced benthic community. As a result, additional monitoring over Mound A is recommended to determine if the anomalous conditions detected during the August 2001 survey represent a response to an acute stimulus (i.e., reduced bottom water dissolved oxygen concentrations) or a chronic problem within the surficial sediments. Based on the distinct differences in benthic community conditions between Mound A and Mound B, if an adequate supply of suitable dredged material is readily available in the near future, the distribution of additional sediment over the surface of Mound A would be advisable. Based upon the 2001 survey OSI values, several locations on the western portion of the disposal mound should be targeted for dredged material placement (Figure 4-8).

4.2.3 CCBDS Reference Areas

In general, successional status appeared to be more advanced at the reference area stations, with Stage III occurring in 68% of the reference station images compared to 52% at Mound B and 31% at Mound A. Advanced successional status and deeper RPD depths (overall average of 2.5 cm) at the reference areas resulted in an elevated OSI value of +7.9, indicative of undisturbed or non-degraded benthic habitat quality. Reference area CCBRS had a slightly lower average OSI value than NW REF and SW REF, due to shallower RPD depths.

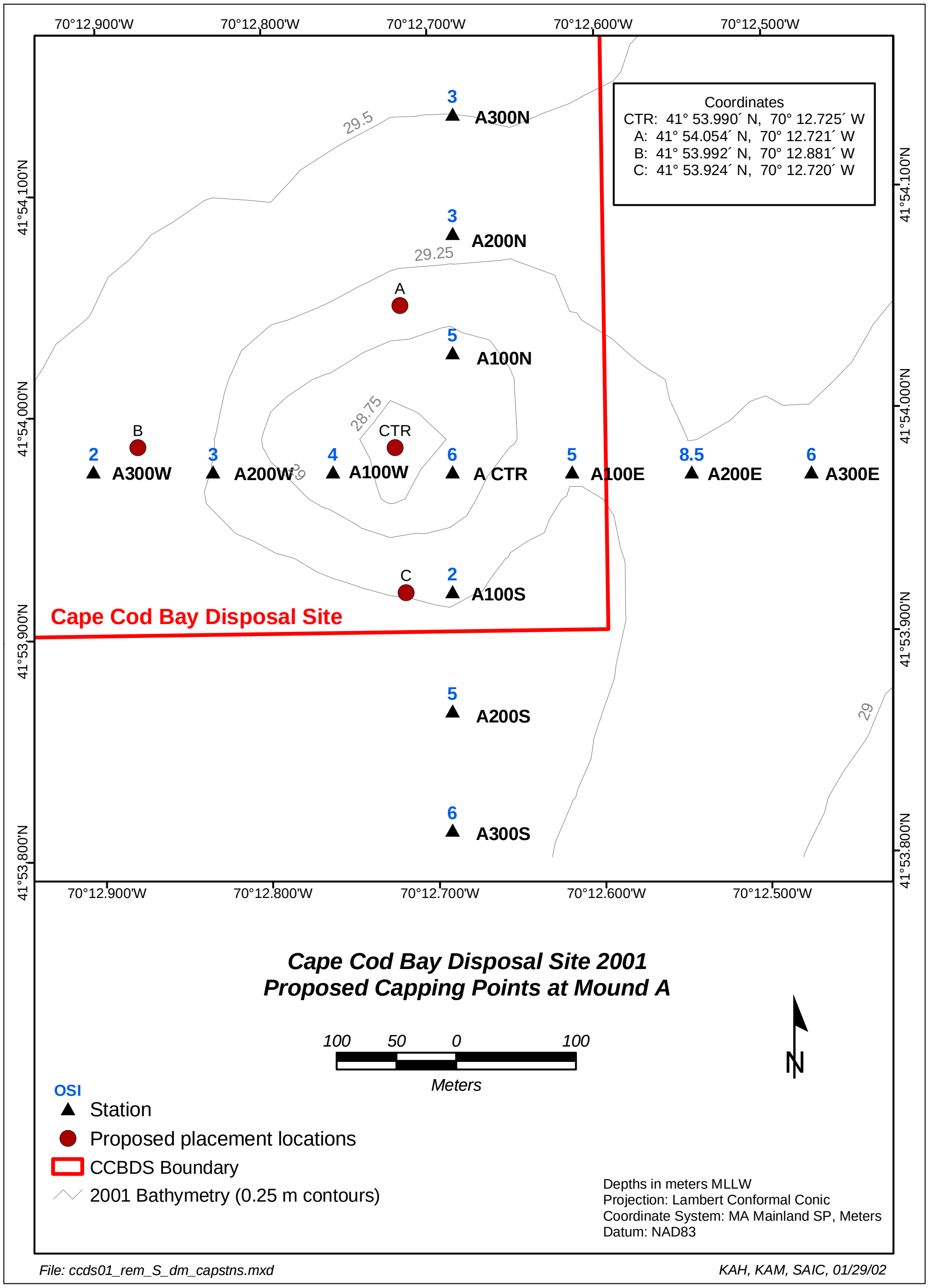


Figure 4-8. Map of REMOTS® sediment-profile imaging stations occupied over Mound A and median OSI values calculated as part of the August 2001 monitoring survey, as well as recommended locations for placement of additional sediment.

The initial designated reference area around CCBDS (CCBRS) has been periodically monitored over the past 7 years (1994 to 2001) and is useful for documenting longer-term benthic conditions in the Cape Cod Bay region. This area has consistently shown undisturbed benthic habitat conditions, with a median OSI value of +7.3 observed in the 2001 survey. Earlier REMOTS® surveys at reference area CCBRS found OSI values of +10 or +11 at the majority of the sampling stations (CR Environmental 1997). Stage III organisms have consistently occurred in abundance at CCBRS (Appendix D1). In general, the overall mean RPD depth in the 2001 survey (1.9 cm) was shallower than the May 1996 survey value (4.2 cm; Figure 4-9). This may partially be an artifact of the overestimation of RPD depths in the 1996 image analysis, but it may also be due to a seasonal increase in sediment organic loading or physical seafloor disturbance associated with trawling. Although the overall OSI value decreased slightly from +9.8 during the 1996 survey, an OSI of +7.3 remains indicative of non-degraded or undisturbed conditions (Appendix D1).

Prior to the August 2001 monitoring survey, proposed reference areas NW REF and SW REF had first been sampled in May 1996 and were subsequently selected as additional reference areas to the CCBDS. The 2001 REMOTS® sediment-profile imaging results indicated that both NW REF and SW REF continued to show favorable benthic habitat conditions, with average median OSI values of +8.5 and +8 respectively (Table 3-2). Successional status, RPD depths, and OSI values from the 2001 survey were all comparable to the May 1996 REMOTS® results at NW REF and SW REF (Appendices D2 and D3).

Similar to previous surveys over disposal Mound B of CCBDS and surrounding reference areas CCBRS, NW REF, and SW REF, the reference area stations sampled in 2001 also displayed a biologically active benthic environment. Brittle stars (Ophiuroids) and stick amphipods (Family Podoceridae) occurred in abundance at many reference area stations in both the 1996 and 2001 surveys (Figures 4-9 and 4-10). Solitary hydroids (*Corymorpha pendula*), observed but incorrectly identified as anemones in the 1996 survey at SW REF and NW REF, were not detected at these two reference areas in August 2001, although they were visible over disposal Mound B (Figure 4-2).

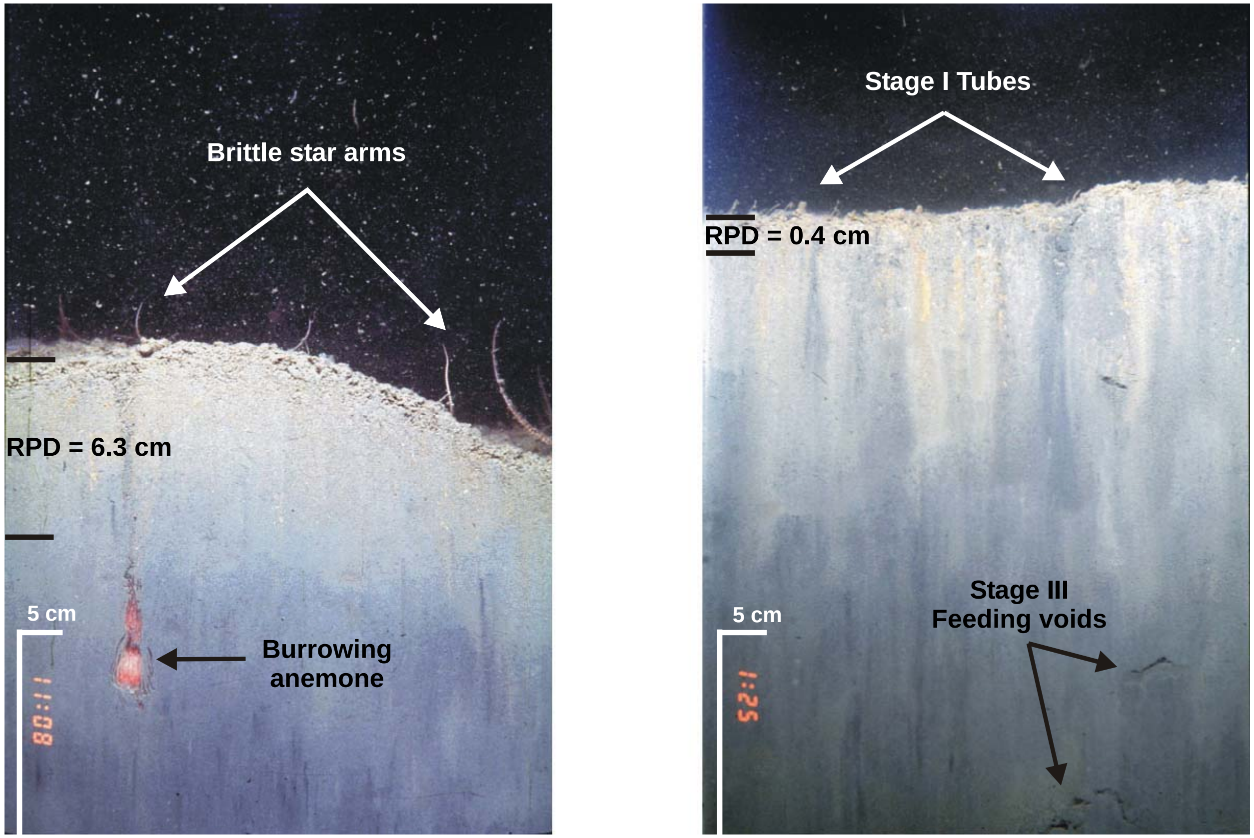


Figure 4-9. REMOTS® images collected from Station CCBRS-REF1 during the 1996 survey (left) and the 2001 survey (right) showing a reduction in the RPD depths and OSI values in 2001. The 1996 image displays a biologically active and undisturbed benthic environment, with an OSI of +11. The 2001 image also shows advanced successional status; however, a shallower RPD depth resulted in an OSI of +6, indicative of moderately disturbed benthic habitat quality.

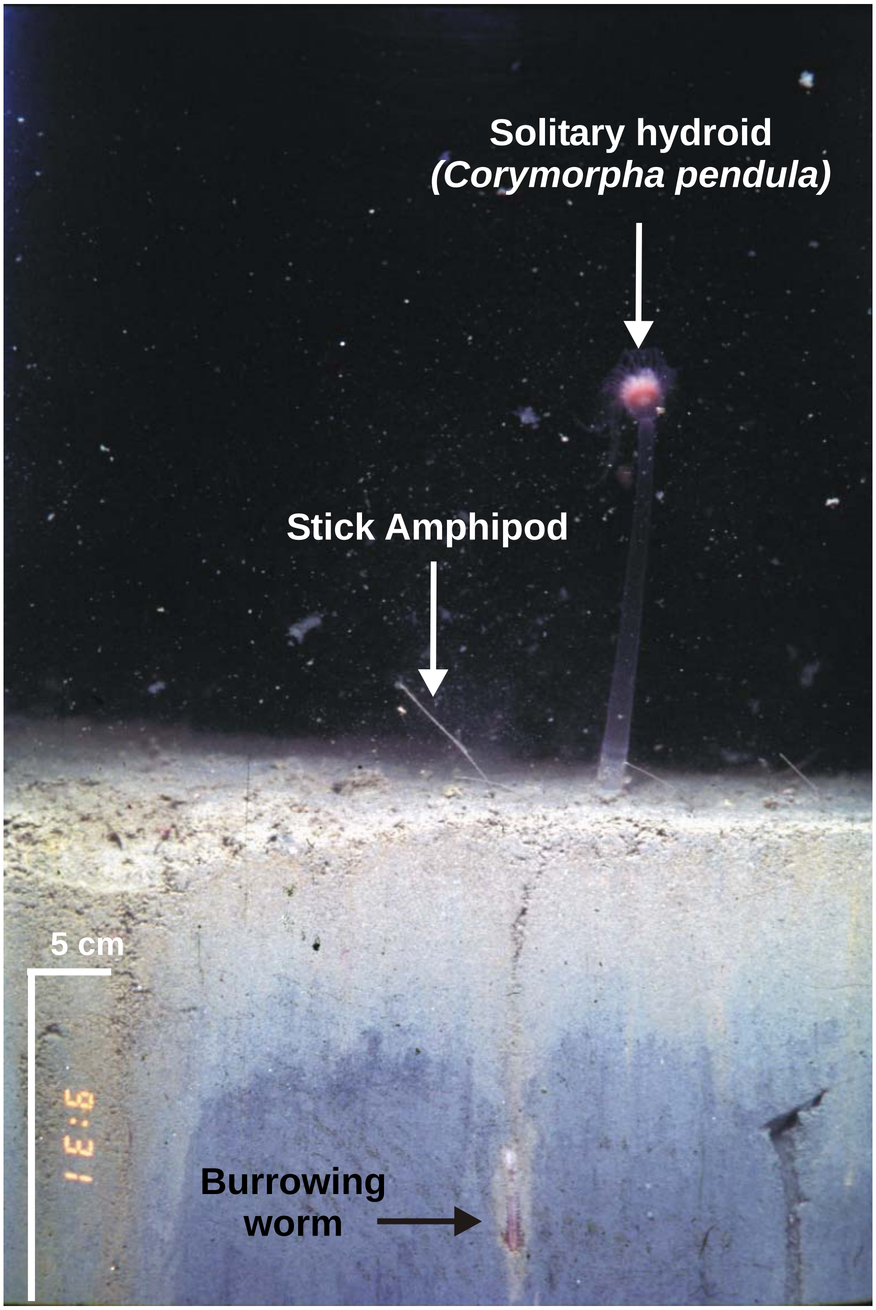


Figure 4-10. REMOTS® image from reference area Station SW REF300N obtained during the May 1996 survey showing examples of common biological features on the ambient seafloor of Cape Cod Bay. A solitary hydroid (*Corymorpha pendula)* and a stick amphipod are visible at the sediment-water interface, while a burrowing worm is detected in the subsurface sediments.

5.0 CONCLUSIONS

- Following the disposal of dredged material from Wellfleet, Plymouth, Sesuit, and Duxbury Harbors between 1996 and 2001, the August 2001 bathymetric survey indicated the formation of a discrete sediment deposit (Mound B) on the seafloor in the northeast quadrant of CCBDS. Mound B rose four meters above the surrounding seafloor, with an estimated diameter based on both bathymetry and REMOTS® sediment-profile imaging of about 500 to 600 m.

- Benthic habitat conditions over Mound B met or exceeded expectations, despite the relatively short amount of time between the completion of disposal operations and the summer 2001 monitoring survey (eight months). Benthic habitat quality was classified as undisturbed, with an overall OSI value of +6.5 reflecting moderately well oxygenated surface sediments (overall RPD of 2.2 cm) and the presence of relatively advanced successional stages (Stages II and III). Periodic monitoring of this disposal mound is recommended to document changes in benthic habitat quality as additional layers of dredged material are added in the future.

- The August 2001 bathymetric survey documented the continued presence of an older sediment deposit in the southeastern quadrant of CCBDS (Mound A). Depth difference comparisons between the 1996 and 2001 bathymetric data indicated a small degree of consolidation (approximately 0.15 to 0.25 m) over Mound A.

- Benthic habitat conditions over the surface of Mound A were classified as moderately degraded or disturbed (median OSI value of +4.5). At many stations, only surface-dwelling infauna (Stage I) were observed in conjunction with an intermediate overall RPD depth of 1.9 cm. Comparisons between the August 2001 and May 1996 REMOTS® results indicated a general decline in both RPD depths and OSI values (OSI +9.1 in 1996 vs. +4.5 in 2001). The apparent inhibited recolonization and shallower RPD depths over Mound A may be due to elevated organic content or contaminants associated with the dredged material, a reduction of deeply burrowing infauna, or some other form of physical seafloor disturbance in that area of CCBDS (e.g., trawling). In future monitoring of the CCBDS, it is recommended that the August 2001 REMOTS® stations over Mound A be resampled to monitor the progress of benthic habitat recovery and assess whether remedial action is warranted.

- At the CCBDS reference areas, an advanced successional status (Stage III taxa in 68% of reference station images) and relatively deeper RPD depths (overall average of 2.5 cm) resulted in an OSI value of +7.9 indicative of undisturbed or non-degraded benthic habitat quality in August 2001.

- It is recommended that disposal be directed to a new position within the northeast quadrant of the CCBDS to avoid the peak of Mound B. Continued disposal over the present Mound B could increase its slope and height, while decreasing its stability and the overall water depth at the site.

6.0 REFERENCES

Battelle Memorial Institute, Duxbury Operations. 1990. Final environmental impact report or the identification of dredged-material disposal site(s) in Cape Cod Bay, Massachusetts

CR Environmental, Inc. 1997. Final Report Cape Cod Disposal Site First Year Monitoring. Submitted to: Commonwealth of Massachusetts, Executive Office of Environmental Affairs, DEM, Office of Waterways, 349 Lincoln St., Bldg. 45, Hingham, MA 02043.

Fredette, T.J. 1994. Disposal site capping management: New Haven Harbor. In: Dredging '94, Proceedings of the Second International Conference, November 3-16, 1994. U.S. Army Corps of Engineers, New England Division, Waltham MA.

Hurlbert, S.II. 1984. Pseudoreplication and the design of ecological field experiments, Ecol. Monogr. 54:187-211.

Germano, J.D., Rhoads, D.C., Lunz, J.D. 1994. An integrated, tiered approach to monitoring and management of dredged material disposal sites in the New England region. DAMOS Contribution No. 87 (SAIC Report No. 7575&234). U.S. Army Corps of Engineers, New England Division, Waltham, MA.

Massachusetts Department of Environmental Management. 1998. Cape Cod Disposal Site Management and Monitoring Plan. Submitted to: DEM, 100 Cambridge St., 19th floor, Boston, MA 02202.

Morris, J.T., Tufts, G.J. 1997. Monitoring Cruise at the Central Long Island Sound Disposal Site, July 1994. DAMOS Contribution No. 117 (SAIC Report No. 327). U.S. Army Corps of Engineers, New England Division, Waltham, MA.

Ocean Surveys Inc., 1995. Final Report Pre-Disposal Surveys, Cape Cod Disposal Site, Cape Cod Bay, Massachusetts. OSI Report #94ES024 F. Old Saybrook, CT.

Poidexter-Rollings, M.E. 1990. Methodology for analysis of subaqueous sediment mounds. Tech. Report D-90-2. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Rhoads, D.C., Germano, J.D. 1982. Characterization of organism-sediment relations using sediment-profile imaging: An efficient method of Remote Ecological Monitoring of the Seafloor (REMOTS® System). Mar. Ecol. Prog. Ser. 8:115-128.

Rhoads, D.C., Germano, J.D. 1986. Interpreting long-term changes in benthic community structure: a new protocol. Hydrobiologia 142:291-308.

SAIC. 2001. Monitoring at the New London Disposal Site, 1992-1998, Volume II: Seawolf Mound. DAMOS Contribution No. 128. (SAIC Report No. 515). U.S. Army Corps of Engineers, New England Division, Waltham, MA.

SAIC. 1995. Sediment capping of subaqueous dredged material disposal mounds: an overview of the New England experience. DAMOS contribution No. 95. (SAIC Report No. SAIC-90/7573&C84). U.S. Army Corps of Engineers, New England Division, Waltham, MA.

Silva, A.J., Brandes, H.G., Uchytil, C.J., Fredette, T.J., Carey, D.A. 1994. Geotechnical analysis of capped dredged material mounds. In: McNair, E.C. Jr. (ed.), Proceedings of the Second International Conference on Dredging and Dredged Material Placement, Vol. I. Lake Buena Vista, FL., Nov 13-16, 1994. Amer. Soc. Civ. Eng., New York, pp. 411-419.

APPENDIX A

Appendix A, Disposal Logs

Buoy A

Project: WELLFLEET HARBOR

Permit Number: 1995C0001 **Permittee:** COE-WELLFLEET

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
11/29/1994	11/29/1994	11/30/1994	41.89943333	-70.2113833	100' E	1500
11/29/1994	11/30/1994	11/30/1994	41.89916667	-70.2119333	75' E	3100
11/30/1994	11/30/1994	11/30/1994	41.89927225	-70.2114014	25' E	3100
11/30/1994	12/1/1994	12/1/1994	41.89953891	-70.2097347	100' E	2510
12/2/1994	12/2/1994	12/2/1994	41.89924407	-70.2111627	50' E	2984
12/3/1994	12/3/1994	12/3/1994	41.90034404	-70.2122627	50' N	3292
12/4/1994	12/4/1994	12/4/1994	41.90057739	-70.2103294	100' SE	2675
12/4/1994	12/4/1994	12/4/1994	41.89924406	-70.2119960	50' N	3292
12/5/1994	12/5/1994	12/5/1994	41.89924407	-70.2117127	20' W	2438
12/6/1994	12/6/1994	12/6/1994	41.89924406	-70.2119960	100' W	3210
12/7/1994	12/7/1994	12/7/1994	41.89951072	-70.2114294	100' W	2510
12/7/1994	12/7/1994	12/7/1994	41.89924406	-70.2119960	100' W	3128
12/7/1994	12/8/1994	12/8/1994	41.89951074	-70.2105960	100' E	2366
12/9/1994	12/9/1994	12/9/1994	41.89951073	-70.2111627	5' E	2984
12/9/1994	12/9/1994	12/10/1994	41.89924408	-70.2108794	50' E	3056
12/10/1994	12/10/1994	12/10/1994	41.89951073	-70.2108794	20' E	2984
12/10/1994	12/10/1994	12/11/1994	41.90174404	-70.2094961	75' NE	3056
12/12/1994	12/12/1994	12/12/1994	41.89927225	-70.2111347	75' E	3128
12/12/1994	12/12/1994	12/13/1994	41.8995389	-70.2114014	100' E	3056
12/12/1994	12/13/1994	12/13/1994	41.89927224	-70.2122347	1' W	3056
12/13/1994	12/13/1994	12/13/1994	41.8995389	-70.2114014	10' E	3056
12/13/1994	12/14/1994	12/14/1994	41.90010556	-70.2122348	250' NW	2202
12/14/1994	12/14/1994	12/14/1994	41.8995389	-70.2122347	100' W	3128
12/14/1994	12/15/1994	12/15/1994	41.90177219	-70.2128015	250' N	3056
12/15/1994	12/15/1994	12/15/1994	41.90177219	-70.2119681	250' N	2901
12/15/1994	12/16/1994	12/16/1994	41.90010555	-70.2128014	250' N	2747
12/16/1994	12/16/1994	12/16/1994	41.89927225	-70.2105680	250' N	3056
12/17/1994	12/17/1994	12/17/1994	41.89982223	-70.2119681	250' N	2901
12/18/1994	12/18/1994	12/18/1994	41.90010556	-70.2119681	250' N	2675
12/18/1994	12/18/1994	12/18/1994	41.90010556	-70.2121348	250' N	3056
12/18/1994	12/19/1994	12/19/1994	41.8995389	-70.2121347	250' N	2593
12/20/1994	12/20/1994	12/20/1994	41.90010556	-70.2119681	250' S	2901
12/21/1994	12/21/1994	12/21/1994	41.899539	-70.212135	250' N	2901
12/21/1994	12/21/1994	12/21/1994	41.90010556	-70.2116848	250' N	3374
12/22/1994	12/22/1994	12/22/1994	41.8995389	-70.2111347	250' NE	2984
12/22/1994	12/22/1994	12/22/1994	41.90232218	-70.2105681	200' NE	2901
12/23/1994	12/23/1994	12/23/1994	41.89927225	-70.2119681	200' NE	2058
12/24/1994	12/24/1994	12/25/1994	41.89927225	-70.2116347	250' NE	2984
12/25/1994	12/25/1994	12/26/1994	41.8994389	-70.2116347	250' N	2819
12/26/1994	12/26/1994	12/26/1994	41.89977223	-70.2119681	250' N	3056
12/26/1994	12/26/1994	12/26/1994	41.89977223	-70.2116347	250' N	2819
12/27/1994	12/27/1994	12/27/1994	41.8994389	-70.2119681	200' N	3128

Project: WELLFLEET HARBOR

Permit Number: 1995C0001 **Permittee:** COE-WELLFLEET

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)	
12/27/1994	12/27/1994	12/28/1994	41.90010556	-70.2114014	200' N	2747	
12/28/1994	12/28/1994	12/28/1994	41.90010556	-70.2116348	200' N	2058	
12/28/1994	12/28/1994	12/29/1994	41.90010556	-70.2114014	200' N	2438	
12/29/1994	12/30/1994	12/30/1994	41.89807229	-70.2059513	250' N	2284	
12/30/1994	12/31/1994	12/31/1994	41.8994389	-70.2130681	250' NE	2675	
12/31/1994	12/31/1994	12/31/1994	41.89982223	-70.2114014	150' N	2675	
1/2/1995	1/2/1995	1/2/1995	41.89977224	-70.2114014	100' N	2202	
1/2/1995	1/2/1995	1/2/1995	41.8995389	-70.2122347	250' NE	2202	
1/4/1995	1/4/1995	1/4/1995	41.90010555	-70.2128014	200' N	3374	
1/5/1995	1/5/1995	1/5/1995	41.89977224	-70.2109681	200' N	3400	
					Project Total Volume:	**112,225 CM**	**146,776 CY**
					Buoy Total Volume:	**112,225 CM**	**146,776 CY**

Buoy B

Project: DUXBURY HARBOR

Permit Number: 199402805 **Permittee:** TOWN OF DUXBURY

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
10/24/1996	10/24/1996	10/24/1996	41.91145	-70.2150667	50' NW	1600
10/25/1996	10/26/1996	10/26/1996	41.91136667	-70.2149		400
10/26/1996	10/26/1996	10/26/1996	41.91141667	-70.215	30' N	1200
10/26/1996	10/26/1996	10/26/1996	41.91141667	-70.2150667		1737
10/26/1996	10/26/1996	10/26/1996	41.91135	-70.21505	80' SW	1700
11/14/1996	11/14/1996	11/14/1996	41.91136667	-70.21475		1300
11/17/1996	11/17/1996	11/17/1996	41.91153333	-70.2151833		1300

Project Total Volume: **7,063 CM** **9,237 CY**

Project: BREWERS PLYMOUTH MARINE

Permit Number: 199603135 **Permittee:** HARBOR MARINE INC.

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
11/9/1998	11/9/1998	11/9/1998	41.9113	-70.2152667	30' S	750
11/10/1998	11/10/1998	11/11/1998	41.9113	-70.2152667	75' S	750
11/12/1998	11/12/1998	11/13/1998	41.9113	-70.21525	50' S	750
11/13/1998	11/13/1998	11/14/1998	41.9113	-70.21525	75' S	750
11/15/1998	11/16/1998	11/16/1998	41.91128333	-70.21525	75' S	750
11/18/1998	11/18/1998	11/18/1998	41.9113	-70.21525	75' SW	750
11/19/1998	11/19/1998	11/19/1998	41.9113	-70.2152667	50' W	750
11/20/1998	11/20/1998	11/20/1998	41.91131667	-70.2152333	75' S	750
11/20/1998	11/20/1998	11/20/1998	41.91128333	-70.2152333	80' WS	750
11/21/1998	11/21/1998	11/21/1998	41.91126667	-70.2152167	75' S	750
12/1/1998	12/1/1998	12/1/1998	41.90678333	-70.20915	100' S	750
12/1/1998	12/2/1998	12/2/1998	41.90678333	-70.2091333	75'	750
12/2/1998	12/2/1998	12/2/1998	41.90678333	-70.2091333	100' ENE	750
12/3/1998	12/3/1998	12/3/1998	41.90678333	-70.2091333	75' NE	750
12/4/1998	12/4/1998	12/4/1998	41.90678333	-70.20915	50'	750
12/4/1998	12/4/1998	12/4/1998	41.9068	-70.20915	100' E	750
12/14/1998	12/14/1998	12/14/1998	41.90676667	-70.20915	75'	750
12/14/1998	12/15/1998	12/15/1998	41.90678333	-70.20915	100'	750
12/17/1998	12/17/1998	12/17/1998	41.90676667	-70.20915	75'	750
12/17/1998	12/17/1998	12/17/1998	41.90678333	-70.20915	100'	750
12/18/1998	12/18/1998	12/19/1998	41.90676667	-70.20915	100' NE	750
12/21/1998	12/21/1998	12/21/1998	41.90678333	-70.20915	100'	750
12/28/1998	12/28/1998	12/28/1998	41.90676667	-70.20915	75' SW	750
12/28/1998	12/29/1998	12/29/1998	41.90678333	-70.20915	25'	750
12/29/1998	12/29/1998	12/29/1998	41.90678333	-70.20915	15'	750
11/9/1999	11/10/1999	11/10/1999	41.90942333	-70.20045	50' S	750
11/12/1999	11/12/1999	11/12/1999	41.91636667	-70.2148	75' S	750
11/12/1999	11/12/1999	11/13/1999	41.91128333	-70.2149833	75' S	750
11/17/1999	11/17/1999	11/18/1999	41.91136667	-70.21465	50' S	750
11/18/1999	11/18/1999	11/18/1999	41.91135	-70.2141833	25' S	750
11/23/1999	11/24/1999	11/24/1999	41.91086667	-70.2147667	100' S	750
11/24/1999	11/24/1999	11/24/1999	41.91131667	-70.2145333	50' S	750
11/29/1999	11/29/1999	11/30/1999	41.91158333	-70.21455	50' E	750

Project: BREWERS PLYMOUTH MARINE

Permit Number: 199603135 **Permittee:** HARBOR MARINE INC.

Departure	Disposal	Return	Latitude	Longitude	Buoy’s Vector	Volume (CY)
12/2/1999	12/3/1999	12/3/1999	41.91093333	-70.2155167	25' SE	750
12/3/1999	12/3/1999	12/4/1999	41.91143333	-70.21505	10' SE	750
12/6/1999	12/6/1999	12/6/1999	41.91146667	-70.2149333	10' SE	750
12/7/1999	12/7/1999	12/7/1999	41.91121667	-70.215	25' SE	750
12/8/1999	12/8/1999	12/8/1999	41.91141667	-70.2149667	10' SE	750
12/9/1999	12/9/1999	12/9/1999	41.91126667	-70.2147833	10' SE	750
12/10/1999	12/10/1999	12/10/1999	41.91155	-70.2149167	25' SE	750
12/13/1999	12/13/1999	12/14/1999	41.91151667	-70.2141167	100' SE	750
12/16/1999	12/16/1999	12/16/1999	41.9114	-70.2150833	10' SE	750
12/16/1999	12/16/1999	12/17/1999	41.91156667	-70.215	15' SE	750
12/17/1999	12/17/1999	12/17/1999	41.91131667	-70.21535	50' SE	750
12/20/1999	12/21/1999	12/21/1999	41.91146667	-70.2150333	20' E	750
12/21/1999	12/22/1999	12/22/1999	41.91135	-70.2150833	20' E	750
12/22/1999	12/22/1999	12/22/1999	41.91121667	-70.215	50' E	750
12/23/1999	12/23/1999	12/23/1999	41.91133333	-70.215	15' SE	750
12/28/1999	12/28/1999	12/18/1999	41.91158333	-70.21485	50' E	750
12/29/1999	12/29/1999	12/30/1999	41.9113	-70.2153667	80' E	750
12/30/1999	12/30/1999	12/31/1999	41.91143333	-70.215	0' E	750

Project Total Volume: **29,246 CM** **38,250 CY**

Project: MAINT. DREDGING DUXBURY

Permit Number: 1996C0029 **Permittee:** COE DUXBURY HARBOR

Departure	Disposal	Return	Latitude	Longitude	Buoy’s Vector	Volume (CY)
6/6/1996	6/7/1996	6/7/1996	41.9125	-70.2137667	25'	1556
8/14/1996	8/14/1996	8/14/1996	41.9111	-70.214	W	748
8/15/1996	8/15/1996	8/15/1996	41.9114	-70.2144		317
8/16/1996	8/16/1996	8/16/1996	41.9115	-70.2147667	25' E	950
8/16/1996	8/16/1996	8/17/1996	41.9113	-70.2144833	30' E	580
8/17/1996	8/17/1996	8/17/1996	41.9114	-70.21505		1300
8/17/1996	8/17/1996	8/18/1996	41.9115	-70.2145		1300
8/18/1996	8/18/1996	8/18/1996	41.91148333	-70.21465		1169
8/18/1996	8/18/1996	8/19/1996	41.91151667	-70.2141667		1350
8/19/1996	8/19/1996	8/19/1996	41.91166667	-70.2138333	25 E	1600
8/19/1996	8/19/1996	8/20/1996	41.91146667	-70.2155	30 N	1417
8/20/1996	8/20/1996	8/20/1996	41.91165	-70.21505		1775
8/20/1996	8/20/1996	8/21/1996	41.91143333	-70.215	50 S	1462
8/21/1996	8/21/1996	8/22/1996	41.91158333	-70.2152	20 N	1498
8/21/1996	8/22/1996	8/22/1996	41.91158333	-70.21465	30 E	1706
8/22/1996	8/22/1996	8/22/1996	41.91133333	-70.2151833		1612
8/22/1996	8/23/1996	8/23/1996	41.9116	-70.2146333	E	1720
8/23/1996	8/23/1996	8/23/1996	41.91163333	-70.2149167		1347
8/23/1996	8/24/1996	8/24/1996	41.9118	-70.2148167		1717
8/24/1996	8/24/1996	8/24/1996	41.91166667	-70.2148	30' E	1500
8/24/1996	8/25/1996	8/25/1996	41.91121667	-70.2147167	10' S	1660
8/25/1996	8/25/1996	8/25/1996	41.91443333	-70.2148	10' E	1524
8/26/1996	8/26/1996	8/26/1996	41.91138333	-70.2153167	12' N	1476

Project: MAINT. DREDGING DUXBURY

Permit Number: 1996C0029 **Permittee:** COE DUXBURY HARBOR

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector		Volume (CY)
8/27/1996	8/27/1996	8/27/1996	41.91153333	-70.2151833	3.5'	NNW	1826
8/27/1996	8/27/1996	8/27/1996	41.91123333	-70.21565	15	SSW	1488
8/28/1996	8/28/1996	8/28/1996	41.91125	-70.2152167	15'	SSW	1870
8/28/1996	8/28/1996	8/28/1996	41.91095	-70.21475	25	N	1400
8/29/1996	8/29/1996	8/29/1996	41.91116667	-70.2150667	20'	SW	1807
8/29/1996	8/29/1996	8/30/1996	41.91118333	-70.21465	25'	N	1495
8/30/1996	8/30/1996	8/30/1996	41.91161667	-70.2158167	15'	SSW	1803
8/30/1996	8/30/1996	8/31/1996	41.91108333	-70.2148333	20'	N	1105
8/31/1996	8/31/1996	8/31/1996	41.91118333	-70.2146	10	SSE	1208
8/31/1996	8/31/1996	9/1/1996	41.91163333	-70.2153333	45'	NW	1528
9/1/1996	9/1/1996	9/1/1996	41.9108	-70.21515	15'	NW	1042
9/2/1996	9/3/1996	9/3/1996	41.91118333	-70.2153	45'	W	1103
9/3/1996	9/3/1996	9/4/1996	41.91153333	-70.2152667	15'	W	1691
9/4/1996	9/4/1996	9/4/1996	41.91153333	-70.2151333	7.5'	NNE	1459
9/4/1996	9/4/1996	9/5/1996	41.91156667	-70.21485	30'	NNW	1566
9/4/1996	9/5/1996	9/5/1996	41.91135	-70.2145167	10'	SW	1788
9/5/1996	9/5/1996	9/5/1996	41.91165	-70.21495	10'		1194
9/6/1996	9/6/1996	9/6/1996	41.91165	-70.2149333	20'		1359
9/6/1996	9/6/1996	9/7/1996	41.9115	-70.215	30	N	1693
9/8/1996	9/8/1996	9/8/1996	41.9115	-70.2151667	25'	WS	1364
9/8/1996	9/9/1996	9/9/1996	41.91265	-70.2160667	30'		1075
9/9/1996	9/9/1996	9/9/1996	41.91115	-70.2154333	10'		1274
9/9/1996	9/9/1996	9/9/1996	41.91133333	-70.2153	30'	N	1343
9/10/1996	9/10/1996	9/10/1996	41.91146667	-70.2150833	30'	NNW	1465
9/10/1996	9/11/1996	9/11/1996	41.9113	-70.215	10'	S	1911
9/11/1996	9/11/1996	9/11/1996	41.9112	-70.2147167			1742
9/11/1996	9/11/1996	9/11/1996	41.91131667	-70.2153			1571
9/12/1996	9/12/1996	9/13/1996	41.91145	-70.2151			1793
9/12/1996	9/13/1996	9/13/1996	41.91466667	-70.2138833			1595
9/13/1996	9/13/1996	9/13/1996	41.91125	-70.2148833			1837
9/13/1996	9/13/1996	9/13/1996	41.91196667	-70.2158667			1632
9/13/1996	9/13/1996	9/14/1996	41.91155	-70.2148667			1687
9/13/1996	9/14/1996	9/14/1996	41.91131667	-70.2148833			1451
9/14/1996	9/14/1996	9/14/1996	41.91141667	-70.2151667			1917
9/14/1996	9/15/1996	9/15/1996	41.91128333	-70.21455			1788
9/15/1996	9/15/1996	9/15/1996	41.91148333	-70.2144167			1482
9/15/1996	9/15/1996	9/15/1996	41.91135	-70.2148167			1800
9/15/1996	9/15/1996	9/15/1996	41.91145	-70.2149667			1668
9/16/1996	9/16/1996	9/16/1996	41.91196667	-70.2146333			1691
9/16/1996	9/16/1996	9/17/1996	41.91141667	-70.21475			1586
9/16/1996	9/16/1996	9/17/1996	41.9115	-70.21485			2048
9/17/1996	9/17/1996	9/17/1996	41.91145	-70.21505			1812
9/17/1996	9/17/1996	9/17/1996	41.91148333	-70.2151667			1843
9/18/1996	9/19/1996	9/19/1996	41.9114	-70.2147833			1629
9/18/1996	9/19/1996	9/19/1996	41.91135	-70.2146833			1709

Project: MAINT. DREDGING DUXBURY

Permit Number: 1996C0029 **Permittee:** COE DUXBURY HARBOR

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
9/20/1996	9/20/1996	9/20/1996	41.91141667	-70.21485		1637
9/20/1996	9/20/1996	9/21/1996	41.91143333	-70.215		1923
9/20/1996	9/21/1996	9/21/1996	41.9113	-70.2153		1754
9/21/1996	9/21/1996	9/21/1996	41.9116	-70.2154167		1718
9/21/1996	9/21/1996	9/21/1996	41.91153333	-70.2152833		1776
9/21/1996	9/21/1996	9/22/1996	41.91138333	-70.2151333		2124
9/22/1996	9/22/1996	9/22/1996	41.91136667	-70.21505		1923
9/22/1996	9/22/1996	9/23/1996	41.91143333	-70.2150667		1699
9/22/1996	9/23/1996	9/23/1996	41.91168333	-70.2150167		1552
9/22/1996	9/23/1996	9/23/1996	41.91145	-70.2151		1861
9/23/1996	9/24/1996	9/24/1996	41.91146667	-70.2151167		1837
9/23/1996	9/24/1996	9/24/1996	41.91146667	-70.2150667		1801
9/24/1996	9/24/1996	9/24/1996	41.9115	-70.21505		1800
9/24/1996	9/24/1996	9/24/1996	41.91138333	-70.2150333		1516
9/24/1996	9/25/1996	9/25/1996	41.91146667	-70.2147667		1558
9/25/1996	9/26/1996	9/26/1996	41.91163333	-70.2151667		1668
9/26/1996	9/26/1996	9/26/1996	41.9114	-70.2148667		1887
9/26/1996	9/26/1996	9/26/1996	41.91203333	-70.2146833	50 E	2075
9/26/1996	9/27/1996	9/27/1996	41.91145	-70.2150667		2057
9/27/1996	9/27/1996	9/27/1996	41.91096667	-70.2152167	50 E	1886
9/27/1996	9/27/1996	9/27/1996	41.91148333	-70.2152833		1978
9/27/1996	9/27/1996	9/27/1996	41.9115	-70.2152333		1705
9/28/1996	9/28/1996	9/28/1996	41.91145	-70.2149667		1784
9/28/1996	9/28/1996	9/28/1996	41.91153333	-70.2152167		1703
9/28/1996	9/28/1996	9/29/1996	41.91145	-70.2151		1706
9/28/1996	9/29/1996	9/29/1996	41.91136667	-70.2147667		1861
9/29/1996	9/29/1996	9/29/1996	41.9116	-70.21515		1425
9/29/1996	9/29/1996	9/29/1996	41.9116	-70.21535		1861
9/30/1996	9/30/1996	9/30/1996	41.91145	-70.2150667		1643
9/30/1996	9/30/1996	9/30/1996	41.91153333	-70.2149		2081
9/30/1996	9/30/1996	9/30/1996	41.91146667	-70.2152667		2114
10/1/1996	10/1/1996	10/1/1996	41.91158333	-70.2149333		1845
10/1/1996	10/1/1996	10/1/1996	41.91151667	-70.2152167		2130
10/1/1996	10/1/1996	10/1/1996	41.9114	-70.21505		2002
10/1/1996	10/1/1996	10/1/1996	41.91146667	-70.2153		1827
10/2/1996	10/2/1996	10/2/1996	41.91151667	-70.2150667		2189
10/2/1996	10/2/1996	10/2/1996	41.91148333	-70.2152833		1776
10/3/1996	10/3/1996	10/4/1996	41.91145	-70.2149667		1784
10/4/1996	10/5/1996	10/5/1996	41.91145	-70.2150167		2172
10/5/1996	10/5/1996	10/5/1996	41.91146667	-70.2147833		1742
10/5/1996	10/5/1996	10/5/1996	41.91141667	-70.2150167		1714
10/5/1996	10/5/1996	10/5/1996	41.91141667	-70.2151167		1477
10/5/1996	10/5/1996	10/6/1996	41.9114	-70.2149		1876
10/5/1996	10/6/1996	10/6/1996	41.91131667	-70.2152333		1596
10/6/1996	10/6/1996	10/6/1996	41.91145	-70.2150833		1500

Project: MAINT. DREDGING DUXBURY

Permit Number: 1996C0029 **Permittee:** COE DUXBURY HARBOR

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
10/6/1996	10/6/1996	10/6/1996	41.91138333	-70.21485		1699
10/6/1996	10/6/1996	10/7/1996	41.91148333	-70.2149833		2203
10/6/1996	10/7/1996	10/7/1996	41.91145	-70.2150833		2154
10/7/1996	10/7/1996	10/7/1996	41.91146667	-70.21515		2046
10/7/1996	10/7/1996	10/7/1996	41.90781667	-70.2151667		1950
10/8/1996	10/8/1996	10/8/1996	41.91138333	-70.2150667		2200
10/8/1996	10/8/1996	10/8/1996	41.91148333	-70.21515		2101
10/8/1996	10/8/1996	10/8/1996	41.91146667	-70.21505		2225
10/9/1996	10/10/1996	10/10/1996	41.91133333	-70.2149333		2150
10/9/1996	10/10/1996	10/10/1996	41.91141667	-70.2150167		2180
10/10/1996	10/10/1996	10/10/1996	41.91146667	-70.2151667		1025
10/10/1996	10/10/1996	10/10/1996	41.91148333	-70.2151167		1980
10/10/1996	10/11/1996	10/11/1996	41.91146667	-70.2151833		2155
10/11/1996	10/11/1996	10/12/1996	41.91146667	-70.21515		1905
10/11/1996	10/12/1996	10/12/1996	41.91146667	-70.2150167		1890
10/12/1996	10/12/1996	10/12/1996	41.91148333	-70.2151		1950
10/12/1996	10/12/1996	10/12/1996	41.91155	-70.2151167		1727
10/13/1996	10/13/1996	10/13/1996	41.9115	-70.2149833	40' NNE	1727
10/13/1996	10/13/1996	10/13/1996	41.91143333	-70.215		2000
10/13/1996	10/13/1996	10/13/1996	41.91166667	-70.2149333	50' NNE	2030
10/13/1996	10/13/1996	10/14/1996	41.9115	-70.2151333		1880
10/13/1996	10/13/1996	10/14/1996	41.91155	-70.2150333	40' NW	1650
10/14/1996	10/14/1996	10/14/1996	41.91143333	-70.2152833	35' W	1400
10/14/1996	10/14/1996	10/14/1996	41.91151667	-70.2152167		2030
10/14/1996	10/14/1996	10/15/1996	41.9115	-70.2148667	50' ENE	1590
10/15/1996	10/15/1996	10/16/1996	41.91155	-70.215	20' S	1500
10/15/1996	10/15/1996	10/16/1996	41.91143333	-70.215		2000
10/15/1996	10/16/1996	10/16/1996	41.91143333	-70.215	10' W	800
10/15/1996	10/16/1996	10/16/1996	41.91151667	-70.2150333		1975
10/16/1996	10/16/1996	10/16/1996	41.91135	-70.21225	30' S	1600
10/16/1996	10/16/1996	10/16/1996	41.91	-70.215		2050
10/16/1996	10/16/1996	10/16/1996	41.91143333	-70.2150333	40' W	1750
10/16/1996	10/16/1996	10/17/1996	41.9115	-70.215		2071
10/17/1996	10/17/1996	10/17/1996	41.91146667	-70.2148	60' NW	1650
10/17/1996	10/17/1996	10/17/1996	41.91133333	-70.2151667		1941
10/17/1996	10/17/1996	10/17/1996	41.91143333	-70.2151167		1900
10/17/1996	10/17/1996	10/17/1996	41.91143333	-70.2142667	20' NE	1700
10/17/1996	10/17/1996	10/18/1996	41.91135	-70.215		1647
10/18/1996	10/18/1996	10/18/1996	41.91143333	-70.2142667	20' N	1700
10/18/1996	10/18/1996	10/18/1996	41.91148333	-70.2153333		2100
10/18/1996	10/18/1996	10/18/1996	41.91153333	-70.2149333	20' NE	1550
10/18/1996	10/18/1996	10/18/1996	41.91148333	-70.2151		2250
10/19/1996	10/19/1996	10/19/1996	41.91145	-70.2152333	60' E	1650
10/19/1996	10/19/1996	10/19/1996	41.91141667	-70.2150833		2200
10/19/1996	10/19/1996	10/19/1996	41.91136667	-70.2150333		1622

Project: MAINT. DREDGING DUXBURY

Permit Number: 1996C0029 **Permittee:** COE DUXBURY HARBOR

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector		Volume (CY)
10/20/1996	10/21/1996	10/21/1996	41.91146667	-70.215	50'	NE	1650
10/21/1996	10/21/1996	10/21/1996	41.91145	-70.215	866'	SW	800
10/21/1996	10/21/1996	10/21/1996	41.91148333	-70.2149667			1850
10/21/1996	10/21/1996	10/21/1996	41.9115	-70.2150167			1796
10/21/1996	10/21/1996	10/22/1996	41.91156667	-70.21515			1900
10/21/1996	10/22/1996	10/22/1996	41.91148333	-70.2151167			1975
10/21/1996	10/22/1996	10/22/1996	41.91135	-70.2151			1992
10/22/1996	10/22/1996	10/22/1996	41.91138333	-70.2150167	70'	W	1700
10/22/1996	10/22/1996	10/22/1996	41.91143333	-70.2150333			1890
10/22/1996	10/22/1996	10/22/1996	41.91141667	-70.215			1979
10/22/1996	10/22/1996	10/23/1996	41.91173333	-70.2150167	50'	W	1600
10/22/1996	10/23/1996	10/23/1996	41.91151667	-70.2149167			1880
10/22/1996	10/23/1996	10/23/1996	41.91141667	-70.2150167	50'	NW	1400
10/23/1996	10/23/1996	10/23/1996	41.9112	-70.2150333	50'	W	1200
10/23/1996	10/23/1996	10/23/1996	41.9116	-70.2150667			1770
10/23/1996	10/23/1996	10/23/1996	41.91145	-70.2149833	50'	NNE	1800
10/24/1996	10/24/1996	10/24/1996	41.91143333	-70.21475			1980
10/24/1996	10/24/1996	10/24/1996	41.91165	-70.2148667			1752
10/24/1996	10/24/1996	10/24/1996	41.91148333	-70.2152333	50	NW	1600
10/24/1996	10/25/1996	10/25/1996	41.91146667	-70.2149333			1600
10/25/1996	10/25/1996	10/25/1996	41.91143333	-70.21505			1600
10/25/1996	10/25/1996	10/25/1996	41.91156667	-70.2148333			1576
10/25/1996	10/25/1996	10/25/1996	41.91155	-70.2149833	50'	NNW	1700
10/25/1996	10/26/1996	10/26/1996	41.91136667	-70.2149			1200
10/26/1996	10/26/1996	10/26/1996	41.91141667	-70.215	30	N	1200
10/26/1996	10/27/1996	10/27/1996	41.91141667	-70.2149667			1700
10/27/1996	10/27/1996	10/27/1996	41.91135	-70.2150167	50'	S	1400
10/27/1996	10/27/1996	10/27/1996	41.91146667	-70.2149667			1583
10/27/1996	10/27/1996	10/27/1996	41.91118333	-70.2153	50'	N	1800
10/28/1996	10/28/1996	10/28/1996	41.91141667	-70.2150333			1619
10/28/1996	10/28/1996	10/28/1996	41.91145	-70.2149167	30'	NW	1300
10/28/1996	10/28/1996	10/28/1996	41.91143333	-70.2149167			1600
10/29/1996	10/29/1996	10/29/1996	41.91158333	-70.21485	30'	NW	1700
10/28/1996	10/29/1996	10/29/1996	41.91143333	-70.2152			1282
10/29/1996	10/29/1996	10/30/1996	41.91138333	-70.21505	30'	W	1400
10/30/1996	10/30/1996	10/30/1996	41.91141667	-70.2149333			1500
10/30/1996	10/30/1996	10/30/1996	41.91133333	-70.2149333	50'	SW	1000
10/30/1996	10/30/1996	10/30/1996	41.91123333	-70.2149333			1814
10/31/1996	10/31/1996	10/31/1996	41.91145	-70.2149833	10'	NW	690
11/1/1996	11/1/1996	11/1/1996	41.91156667	-70.2152667	50'	E	1400
11/2/1996	11/2/1996	11/3/1996	41.91023333	-70.2137833	75'	S	1600
11/3/1996	11/3/1996	11/3/1996	41.91135	-70.2149167			1616
11/4/1996	11/4/1996	11/4/1996	41.91148333	-70.2153167	75'	E	1600
11/4/1996	11/4/1996	11/4/1996	41.91155	-70.21495			1277
11/4/1996	11/4/1996	11/5/1996	41.91158333	-70.2148833			1400

Project: MAINT. DREDGING DUXBURY

Permit Number: 1996C0029 **Permittee:** COE DUXBURY HARBOR

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
11/5/1996	11/5/1996	11/5/1996	41.91145	-70.21525		1600
11/5/1996	11/5/1996	11/5/1996	41.91151667	-70.2151167		1483
11/5/1996	11/5/1996	11/6/1996	41.91151667	-70.2152667		1500
11/6/1996	11/6/1996	11/6/1996	41.9115	-70.2150333		1438
11/6/1996	11/7/1996	11/7/1996	41.91151667	-70.2146667	50' E	1500
11/6/1996	11/7/1996	11/7/1996	41.91143333	-70.2150333		1450
11/7/1996	11/7/1996	11/7/1996	41.91156667	-70.2148167		1512
11/8/1996	11/9/1996	11/9/1996	41.91146667	-70.2151833		800
11/9/1996	11/10/1996	11/10/1996	41.91148333	-70.21505		1200
11/10/1996	11/10/1996	11/10/1996	41.91141667	-70.2149		900
11/10/1996	11/11/1996	11/11/1996	41.91138333	-70.21505		1100
11/11/1996	11/12/1996	11/12/1996	41.91153333	-70.2152167		1300
11/13/1996	11/13/1996	11/13/1996	41.91145	-70.21505		1100
9/22/1997	9/22/1997	9/22/1997	41.91146667	-70.2150167		2117
9/24/1997	9/25/1997	9/25/1997	41.9114	-70.2149333		1984
9/25/1997	9/25/1997	9/25/1997	41.91151667	-70.2151		1729
9/25/1997	9/25/1997	9/25/1997	41.91153333	-70.2151833		2050

Project Total Volume: **277,475 CM** **362,902 CY**

Project: SESUIT HARBOR DREDGING

Permit Number: 199800257 **Permittee:** TOWN OF DENNIS

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
12/20/1998	12/20/1998	12/20/1998	41.91108333	-70.2148667		433
12/23/1998	12/23/1998	12/23/1998	41.91108333	-70.21495	100' SW	800
12/28/1998	12/28/1998	12/28/1998	41.91128333	-70.21455	50' E	433
12/31/1998	12/31/1998	12/31/1998	41.91116667	-70.2151667	150' E	550

Project Total Volume: **1,694 CM** **2,216 CY**

Project: Wellfleet Harbor

Permit Number: 199800874 **Permittee:** TOWN OF WELLFLEET

Departure	Disposal	Return	Latitude	Longitude	Buoy's Vector	Volume (CY)
12/6/2000	12/6/2000	12/7/2000	41.91107	-70.2144	50 E	1100
12/7/2000	12/7/2000	12/8/2000	41.911	-70.2145	75 E	950
12/8/2000	12/9/2000	12/9/2000	41.91142	-70.2148	75 NE	1100
12/9/2000	12/10/2000	12/10/2000	41.9115	-70.21458	75 N	1100
12/10/2000	12/11/2000	12/11/2000	41.91112	-70.2147	50 E	1000
12/11/2000	12/12/2000	12/12/2000	41.91075	-70.21467	100 S	900
12/14/2000	12/14/2000	12/14/2000	41.91168	-70.2155	100 N	950
12/16/2000	12/16/2000	12/16/2000	41.91175	-70.21467	75 N	850
12/19/2000	12/19/2000	12/20/2000	41.91167	-70.21525	75 N	850
12/21/2000	12/21/2000	12/21/2000	41.91087	-70.21467	75 S	850
12/22/2000	12/22/2000	12/22/2000	41.91168	-70.21484	100 N	850

Project Total Volume: **8,028 CM** **10,500 CY**

Buoy Total Volume: **323,506 CM** **423,105 CY**

Report Total Volume: **435,731 CM** **569,881 CY**

APPENDIX B

Appendix B1

CCBDS REMOTS® Sediment-Profile Imaging Data over Mound B from the August 2001 Survey

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi)			Mud Clasts		Camera Penetration (cm)				Dredged Material Thickness (cm)			Redox Rebound Thickness (cm)		
					Min	Max	Maj Mode	Count	Avg. Diam	Min	Max	Range	Mean	Min	Max	Mean	Min	Max	Mean
B100E	A	8/18/2001	09:48	ST I	> 4 phi	3-2 phi	> 4 phi	5	0.4	18.62	19.52	0.9	19.07	18.62	19.52	>19.07	0	0	0
B100E	B	8/18/2001	09:49	ST I	> 4 phi	3-2 phi	> 4 phi	6	0.3	18.46	19.36	0.9	18.91	18.46	19.36	>18.91	0	0	0
B100E	C	8/18/2001	09:50	ST I on III	> 4 phi	3-2 phi	> 4 phi	10	0.29	18.13	18.67	0.54	18.4	18.13	18.67	>18.4	0	0	0
B100N	A	8/18/2001	09:05	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	17.56	18.24	0.68	17.9	17.56	18.24	>17.9	0	0	0
B100N	B	8/18/2001	09:06	ST I	> 4 phi	3-2 phi	>4 phi	8	0.42	16.28	16.87	0.59	16.58	16.28	16.87	>16.58	0	0	0
B100N	C	8/18/2001	09:07	ST I	> 4 phi	3-2 phi	4-3 phi	0	0	14.8	15.73	0.93	15.26	14.8	15.73	>15.26	0	0	0
B100NE	A	8/18/2001	09:18	ST I	> 4 phi	3-2 phi	>4 phi	0	0	17.41	17.97	0.56	17.69	17.41	17.97	>17.69	0	0	0
B100NE	B	8/18/2001	09:19	ST I	> 4 phi	3-2 phi	> 4 phi	12	0.3	15.46	16.3	0.84	15.88	15.46	16.3	>15.88	0	0	0
B100NE	C	8/18/2001	09:19	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	17.71	18.32	0.61	18.01	17.71	18.32	>18.01	0	0	0
B100NW	A	8/18/2001	14:42	ST I on III	> 4 phi	3-2 phi	4-3 phi	0	0	13.74	14.63	0.89	14.18	13.74	14.63	>14.18	0	0	0
B100NW	B	8/18/2001	14:43	ST I on III	> 4 phi	3-2 phi	> 4 phi	0	0	11.88	12.66	0.78	12.27	11.88	12.66	>12.27	0	0	0
B100NW	C	8/18/2001	14:44	ST I	> 4 phi	3-2 phi	4-3 phi	0	0	16.85	18.46	1.61	17.65	16.85	18.46	>17.65	0	0	0
B100S	A	8/18/2001	14:15	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	15.52	17.12	1.6	16.32	15.52	17.12	>16.32	0	0	0
B100S	B	8/18/2001	14:18	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	15.83	17.04	1.21	16.44	15.83	17.04	>16.44	0	0	0
B100S	C	8/18/2001	14:19	ST I	> 4 phi	4-3 phi	> 4 phi	7	0.15	14.3	15.93	1.63	15.11	14.3	15.93	>15.11	0	0	0
B100SE	A	8/18/2001	09:55	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	11.29	11.88	0.59	11.59	11.29	11.88	>11.59	0	0	0
B100SE	B	8/18/2001	09:56	ST I	> 4 phi	3-2 phi	4-3 phi	12	0.19	5.8	7.45	1.65	6.62	5.8	7.45	>6.62	0	0	0
B100SE	C	8/18/2001	09:56	ST I on III	> 4 phi	4-3 phi	> 4 phi	1	0.4	17.81	18.84	1.03	18.33	17.81	18.84	>18.33	0	0	0
B100SW	B	8/18/2001	14:27	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	15.62	17.59	1.97	16.6	15.62	17.59	>16.6	0	0	0
B100SW	C	8/18/2001	14:28	INDET	> 4 phi	4-3 phi	4-3 phi	4	0.86	0.89	3.9	2.86	2.39	0.89	3.9	>2.39	0	0	0
B100SW	E	8/20/2001	12:40	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	6.84	7.48	0.64	7.16	6.84	7.48	>7.16	0	0	0
B100W	A	8/18/2001	14:33	ST I on III	> 4 phi	3-2 phi	4-3 phi	1	0.38	16.98	18.8	1.82	17.89	16.98	18.8	>17.89	0	0	0
B100W	C	8/18/2001	14:35	ST I on III	> 4 phi	4-3 phi	> 4 phi	4	0.18	15.79	16.89	1.1	16.34	15.79	16.89	>16.34	0	0	0
B100W	D	8/18/2001	14:38	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	12.86	15.55	2.69	14.2	12.86	15.55	>14.2	0	0	0
B200E	A	8/18/2001	09:42	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	17.85	20.06	2.21	18.95	17.85	20.06	>18.95	0	0	0
B200E	B	8/18/2001	09:43	ST I on III	> 4 phi	4-3 phi	> 4 phi	2	0.46	19.9	20.39	0.49	20.15	19.9	20.39	>20.15	0	0	0
B200E	C	8/18/2001	09:44	ST I	> 4 phi	4-3 phi	> 4 phi	12	0.5	15.14	17.14	2	16.14	15.14	17.14	>16.14	0	0	0
B200N	C	8/18/2001	08:48	ST I on III	> 4 phi	4-3 phi	> 4 phi	5	0.17	20.71	20.92	0.21	20.81	20.71	20.92	>20.81	0	0	0
B200N	D	8/20/2001	12:10	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	8.52	9.73	1.21	9.12	8.52	9.73	>9.12	0	0	0
B200N	E	8/20/2001	12:11	ST I	> 4 phi	4-3 phi	> 4 phi	2	0.08	14.59	15.52	0.93	15.06	14.59	15.52	>15.06	0	0	0
B200NE	B	8/18/2001	09:24	ST I	> 4 phi	4-3 phi	> 4 phi	1	0.8	18.29	18.93	0.64	18.61	18.29	18.93	>18.61	0	0	0
B200NE	C	8/18/2001	09:25	ST I to II	> 4 phi	4-3 phi	> 4 phi	0	0	18.37	19.58	1.21	18.98	18.37	19.58	>18.98	0	0	0
B200NE	D	8/20/2001	12:27	ST I on III	> 4 phi	4-3 phi	> 4 phi	2	0.7	17.33	17.65	0.32	17.49	17.33	17.65	>17.49	0	0	0
B200NW	A	8/18/2001	14:49	ST I on III	> 4 phi	4-3 phi	> 4 phi	1	1.23	18.59	19.43	0.84	19.01	18.59	19.43	>19.01	0	0	0
B200NW	C	8/18/2001	14:52	ST I on III	> 4 phi	3-2 phi	> 4 phi	3	1.67	11.7	16.54	4.84	14.12	11.7	16.54	>14.12	0	0	0
B200NW	D	8/20/2001	12:16	ST I on III	> 4 phi	3-2 phi	4-3 phi	0	0	13.98	14.66	0.68	14.32	13.98	14.66	>14.32	0	0	0
B200S	A	8/18/2001	14:10	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	17.04	17.43	0.39	17.24	17.04	17.43	>17.24	0	0	0
B200S	B	8/18/2001	14:11	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	18.61	20.78	2.17	19.69	18.61	20.78	>19.69	0	0	0
B200S	D	8/20/2001	12:44	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	12.83	13.99	1.16	13.41	12.83	13.99	>13.41	0	0	0
B200SE	A	8/18/2001	13:50	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	19.5	20.39	0.89	19.94	19.5	20.39	>19.94	0	0	0
B200SE	B	8/18/2001	13:51	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	19.65	20.81	1.16	20.23	19.65	20.81	>20.23	0	0	0
B200SE	D	8/18/2001	13:56	ST II on III	> 4 phi	4-3 phi	> 4 phi	0	0	15.82	16.61	0.79	16.22	15.82	16.61	>16.22	0	0	0
B200SW	A	8/19/2001	12:21	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	14.33	16.08	1.75	15.2	14.33	16.08	>15.2	0	0	0
B200SW	B	8/19/2001	12:21	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	20.06	21	0.94	20.53	20.06	21	>20.53	0	0	0
B200SW	C	8/19/2001	12:22	ST I on III	> 4 phi	4-3 phi	> 4 phi	1	2.13	13.82	15.66	1.84	14.74	13.82	15.66	>14.74	0	0	0
B200W	A	8/18/2001	15:08	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	18.34	19.31	0.97	18.83	18.34	19.31	>18.83	0	0	0
B200W	B	8/18/2001	15:09	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	15.05	15.71	0.66	15.38	15.05	15.71	>15.38	0	0	0
B200W	C	8/18/2001	15:10	ST I on III	> 4 phi	4-3 phi	> 4 phi	5	0.41	16.79	19.6	2.81	18.19	16.79	19.6	>18.19	0	0	0
B300E	A	8/18/2001	09:36	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	13.43	14.7	1.27	14.07	0	0	0	0	0	0
B300E	B	8/18/2001	09:36	ST I on III	> 4 phi	4-3 phi	> 4 phi	7	0.16	18.56	19.2	0.64	18.88	0	0	0	0	0	0
B300E	C	8/18/2001	09:37	ST I on III	> 4 phi	4-3 phi	> 4 phi	4	0.32	18.67	19.97	1.3	19.32	0	0	0	0	0	0
B300N	B	8/18/2001	08:42	ST I	> 4 phi	4-3 phi	> 4 phi	6	0.29	18.96	19.5	0.54	19.23	18.96	19.5	>19.23	0	0	0
B300N	D	8/20/2001	12:05	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	15.29	16.18	0.89	15.74	0	0	0	0	0	0
B300N	E	8/20/2001	12:06	ST I on III	> 4 phi	4-3 phi	> 4 phi	3	1.15	11.81	16.65	4.84	14.23	11.81	16.65	>14.23	0	0	0
B300NE	A	8/18/2001	09:28	ST I on III	> 4 phi	4-3 phi	> 4 phi	4	0.27	14.59	15.34	0.75	14.97	0	0	0	0	0	0
B300NE	B	8/18/2001	09:29	ST I on III	> 4 phi	3-2 phi	> 4 phi	0	0	18.43	18.88	0.45	18.65	0	0	0	0	0	0
B300NE	C	8/18/2001	09:30	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	15.12	15.7	0.58	15.41	15.12	15.7	>15.41	0	0	0
B300NW	C	8/18/2001	15:02	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	18.49	19.13	0.64	18.81	0	0	0	0	0	0
B300NW	D	8/20/2001	12:20	ST I on III	> 4 phi	4-3 phi	> 4 phi	4	0.18	14.8	15.66	0.86	15.23	0	0	0	0	0	0
B300NW	E	8/20/2001	12:21	ST I	> 4 phi	3-2 phi	> 4 phi	1	0.56	11.22	17.24	6.02	14.23	0	0	0	0	0	0
B300S	A	8/18/2001	14:03	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	16.77	18.27	1.5	17.52	0	0	0	0	0	0
B300S	B	8/18/2001	14:04	ST I	> 4 phi	4-3 phi	> 4 phi	2	0.64	18.27	19.57	1.3	18.92	18.27	19.57	>18.92	0	0	0
B300S	C	8/18/2001	14:05	ST I	> 4 phi	4-3 phi	> 4 phi	5	0.35	15.74	17.9	2.16	16.82	15.74	17.9	>16.82	0	0	0
B300SE	A	8/18/2001	13:41	ST I on III	> 4 phi	3-2 phi	> 4 phi	0	0	19.15	20.06	0.91	19.6	19.15	20.06	>19.6	0	0	0
B300SE	B	8/18/2001	13:44	ST I	> 4 phi	4-3 phi	> 4 phi	6	0.61	19.38	20.39	1.01	19.88	19.38	20.39	>19.88	0	0	0
B300SE	D	8/20/2001	12:50	ST I	> 4 phi	3-2 phi	> 4 phi	8	0.6	10.88	12.57	1.69	11.73	10.88	12.57	>11.73	0	0	0
B300SW	A	8/19/2001	12:27	ST I on III	> 4 phi	3-2 phi	> 4 phi	7	0.15	16.37	17.21	0.84	16.79	16.37	17.21	>16.79	0	0	0
B300SW	B	8/19/2001	12:28	ST I on III	> 4 phi	4-3 phi	> 4 phi	8	0.14	16.58	18.12	1.54	17.35	16.58	18.12	>17.35	0	0	0
B300SW	C	8/19/2001	12:29	ST I	> 4 phi	4-3 phi	> 4 phi	2	0.6	8.79	9.3	0.51	9.05	8.79	9.3	>9.05	0	0	0
B300W	A	8/19/2001	12:13	ST I	> 4 phi	3-2 phi	> 4 phi	4	0.12	17.36	18.4	1.04	17.88	17.36	18.4	>17.88	0	0	0
B300W	C	8/19/2001	12:15	ST I	> 4 phi	3-2 phi	> 4 phi	5	0.15	15.2	16.74	1.54	15.97	15.2	16.74	>15.97	0	0	0
B300W	D	8/20/2001	12:34	ST I on III	> 4 phi	4-3 phi	> 4 phi	1	1.2	13.38	18.1	4.72	15.74	13.38	18.1	>15.74	0	0	0
BCTR	A	8/18/2001	09:12	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	12.76	14.07	1.31	13.41	12.76	14.07	>13.41	0	0	0
BCTR	B	8/18/2001	09:12	ST III	> 4 phi	3-2 phi	4-3 phi	0	0	7.23	7.91	0.68	7.57	7.23	7.91	>7.57	0	0	0
BCTR	C	8/18/2001	09:13	ST I	> 4 phi	3-2 phi	4-3 phi	4	0.17	5.54	6.93	1.39	6.23	5.54	6.93	>6.23	0	0	0

Appendix B1 (continued)

CCBDS REMOTS® Sediment-Profile Imaging Data over Mound B from the August 2001 Survey

Station	Replicate	Date	Time	Apparent RPD Thickness (cm) Min	Max	Mean	Methane Min	Max	Mean	OSI	Surface Roughness	Low DO	Comments
B100E	A	8/18/2001	09:48	0.07	5.62	1.73	0	0	0	4	Biogenic	NO	DM>P, TAN&GRY SANDY M>P, SURF TUBES, FECAL MOUND?,LG BURROWING WORMS@Z,SM WORMS@Z, VERT BURROW, OX&RED CLSTS, RED SED@Z
B100E	B	8/18/2001	09:49	0.07	5.41	1.82	0	0	0	4	Physical	NO	DM>P, DM LYRING, TAN/GRY & BLK SANDY M, OX & RED CLASTS, TUBES, SULFIDIC M @Z, BANDING-SED LAYERS
B100E	C	8/18/2001	09:50	0.07	6.33	2.73	0	0	0	9	Physical	NO	DM>P, DM LAYERING, TAN&GRY SANDY M>P, TUBES, OX & RED CLASTS, VOIDS, SM WORM @Z
B100N	A	8/18/2001	09:05	0.07	4.77	2.14	0	0	0	4	Biogenic	NO	DM>P, TAN/GRY&BLK SANDY M, DENSE SURF TUBES, SM WORMS @Z, SM CLAY CHIPS
B100N	B	8/18/2001	09:06	1.14	5.62	2.64	0	0	0	5	Physical	NO	DM>P, DM LAYERING, TAN/BLK SANDY M, RED CLASTS, SM TUBES, RED SED @Z
B100N	C	8/18/2001	09:07	1.72	4.3	2.25	0	0	0	4	Biogenic	NO	DM>P, DM LAYERING, TAN/BLK SANDY M>P, LG VERTICAL OXIDIZED BURROW-OPENING, SM TUBES, RED SED @Z , WORM @Z
B100NE	A	8/18/2001	09:18	0.07	5.33	2.42	0	0	0	5	Physical	NO	DM>P, DM LAYERING, TAN/GRY&BLK SANDY M, TUBES, ORG OR DETRITUS @SURF?, WORMS @Z, RELIC RPD
B100NE	B	8/18/2001	09:19	0.14	4.28	2.41	0	0	0	5	Physical	NO	DM>P, DM LAYERING, TAN/GRY&BLK SANDY M, TUBES, OX & RED CLASTS, SM WORMS @Z, ORG @ SURF?
B100NE	C	8/18/2001	09:19	0.21	3.27	1.54	0	0	0	4	Physical	NO	DM>P, TAN/GRY & BLK M, TUBES, VOIDS, RED SED @ SURF, BURROWING ORG @Z, RELIC RPD?, DETRTIUS @ SURF?
B100NW	A	8/18/2001	14:42	0.43	5.15	2.79	0	0	0	9	Physical	NO	DM>P, TAN SANDY M/BLK&WHITE MOTTLED SILTY CLAY, WHT CLAY CHIPS @ Z, TUBES, VOIDS, WORMS @ Z
B100NW	B	8/18/2001	14:43	0.07	3.2	1.15	0	0	0	7	Physical	NO	DM>P, TAN SANDY M/WHT&GRY MOTTLED CLAY, TUBES, VOIDS, RED SED @ Z, WORMS @ Z, RED SED @ SURF, WHITE COHESIVE CLAY CHIPS
B100NW	C	8/18/2001	14:44	0.86	3.07	1.87	0	0	0	4	Physical	NO	DM>P, TAN SANDY M/TAN& BLK SILTY CLAY, WHITE CLAY CHIPS @ SURF AND @ Z, TUBES, burrowing anemone@surf
B100S	A	8/18/2001	14:15	0.36	5.66	3.49	0	0	0	6	Physical	NO	DM > P, TAN&GRY SANDY M, SM TUBES, WORMS @Z, ROUND BURROWING ORGS @Z, AMPHIPOD STALK
B100S	B	8/18/2001	14:18	1.01	4.61	2.7	0	0	0	9	Biogenic	NO	DM>P, TAN & GRY SANDY M, DENSE SURFACE TUBES, VOIDS, BURROWS
B100S	C	8/18/2001	14:19	0.29	2.72	1.06	0	0	0	3	Physical	NO	DM>P, TAN/GRY&BLK SANDY M, TUBES, OX & RED CLASTS, SHALLOW RPD, WORM @Z, RED SED @ SURF, RELIC RPD-SED LAYERING
B100SE	A	8/18/2001	09:55	0.07	2.5	0.91	0	0	0	3	Biogenic	NO	DM>P, DM LYRING, TAN/GRY& BLK SANDY M, DENSE SURF TUBES, WORMS @ Z
B100SE	B	8/18/2001	09:56	0.29	4.06	2.31	0	0	0	5	Physical	NO	DM>P, TAN FINE SAND/GRY SANDY M, OX & RED CLASTS, WORM @ Z, SESSILE JELLYFISH POLYP, RED SED @Z, MUD CLUMP-FARFIELD
B100SE	C	8/18/2001	09:56	0.28	4.91	2.94	0	0	0	9	Physical	NO	DM>P, DM LYRING, TAN/GRY & BLK SANDY M, TUBES, OX CLAST, RELIC RPD, VOID ON LWR RT
B100SW	B	8/18/2001	14:27	0.57	5.12	2.05	0	0	0	8	Physical	NO	DM>P, TAN/GRY AND BLK SANDY M, TUBES, FLOCK LAYER, SURF REWORKING, LG VOIDS, BURROWS, BURROWING WORMS @Z, RED SED @Z
B100SW	C	8/18/2001	14:28	-99	-99	-99	0	0	0	99	Physical	NO	DM>P, TAN& GRY SILT AND CLAY, MOTTLED WHITE AND GRY CLAY, UNDERPEN, SLOPING AND IRREGULAR TOPOGRAPHY, CLAY CLASTS, TUBES
B100SW	E	8/20/2001	12:40	0.5	1.78	0.91	0	0	0	7	Physical	NO	DM>P, TAN/GRY & BLACK SANDY M, WHITE CLAY STREAKS, PATCHY RPD, VOIDS, TUBES, RED SED @ SURF, SM WORMS NEAR SURF
B100W	A	8/18/2001	14:33	0.07	5.2	1	0	0	0	7	Biogenic	NO	DM>P, TAN/GRY SANDY SILT, DENSE SURF TUBES. VOIDS, WORM NEAR SURF, OX CLAST, SHALLOW RPD
B100W	C	8/18/2001	14:35	1.57	6.36	3.47	0	0	0	10	Biogenic	NO	DM>P, TAN/GRY SANDY M, TUBES, LG VOID, OX & RED CLASTS, NUMEROUS WORMS @Z, SM CLAY CHIPS @Z, BURROWS, AMPHIPOD STALK @ SURF
B100W	D	8/18/2001	14:38	0.21	2.28	0.71	0	0	0	6	Biogenic	NO	DM>P,TAN SANDY SILT/GRY&WHT MOTLD CLAY,WHT CHIPS,TUBES,AMP STALK?,burowing anemone,VOIDS,BURROW,WORMS@Z,SHALLOW RPD,RED SED@SURF
B200E	A	8/18/2001	09:42	1.43	6.43	3.57	0	0	0	10	Biogenic	NO	DM>P, TAN & GRY SANDY SILT, DENSE SURF TUBES, VOIDS, SM WORMS @Z?
B200E	B	8/18/2001	09:43	2.07	4.06	2.73	0	0	0	9	Physical	NO	DM>P, TAN&GRY SANDY SILT, RPD OBSCURED BY DRAG-DOWN, TUBES, VOIDS, WORMS @Z, RED CLASTS
B200E	C	8/18/2001	09:44	0.07	4.69	0.57	0	0	0	2	Physical	NO	DM>P, TAN/GRY SANDY SILT, DENSE LG TUBES, PATCHY RPD, RED CLASTS, WORMS @Z
B200N	C	8/18/2001	08:48	0.07	7.19	3.53	0	0	0	10	Indeterminate	NO	DM>P, TAN/GRY SANDY M, OVERPEN, TUBES, LG VOIDS, BURROWING WORM @Z, RED CLASTS,
B200N	D	8/20/2001	12:10	1.43	4.44	2.54	0	0	0	5	Physical	NO	DM>P, TAN/GRY SANDY M, TUBES
B200N	E	8/20/2001	12:11	0.21	5.42	2.61	0	0	0	5	Physical	NO	DM>P, DM LAYERING, TAN/GRY SANDY M, TUBES, RED CLASTS
B200NE	B	8/18/2001	09:24	0.07	3.63	1.12	0	0	0	3	Physical	NO	DM>P, TAN/ GRY&BLK SANDY M, TUBES, OX CLASTS, WORMS @ Z, RED OJBECT NEAR SURF=WORM?, RED SED @ SURF
B200NE	C	8/18/2001	09:25	0.07	2.49	0.74	0	0	0	3	Biogenic	NO	DM>P, TAN/GRY/BLK SANDY M, SED LAYERING, DENSE SURF TUBES, AMP TUBES?, WORMS @Z, SHALOW RPD
B200NE	D	8/20/2001	12:27	1.14	4.14	2.77	0	0	0	9	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, DENSE SURF TUBES, LG BURROW SYSTEM AND VOID, ORANGE OBJECT=IRON OXIDE?, OX CLASTS
B200NW	A	8/18/2001	14:49	0.07	5.53	1.96	0	0	0	8	Physical	NO	DM>P, TAN/GRY & BLK SANDY SILT, DENSE SURF TUBES, LG RED M CLUMP, FLOCK LAYER, VOIDS, WORMS @ Z, SM SHELL BITS?
B200NW	C	8/18/2001	14:52	0.07	3.61	1.23	0	0	0	7	Physical	NO	DM>P, TAN/GRY & BLK SANDY M, SURF TUBES, LG RED & OX M CLAST, SLOPING TOPOGRAPHY, WORMS @Z, VOIDS
B200NW	D	8/20/2001	12:16	0.07	3.7	1.09	0	0	0	7	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, TUBES, AMP STALK, VOIDS, PATCHY RPD, SURF REWORKING, WORM @Z?
B200S	A	8/18/2001	14:10	0.07	5.1	2.24	0	0	0	8	Physical	NO	DM>P, TAN/GRY SANDY M, SM TUBES, SLIGHT WIPER SMEARS, VOIDS, BURROWS-OCCUPIED? SM WORMS @Z
B200S	B	8/18/2001	14:11	4.57	8.57	5.41	0	0	0	11	Physical	NO	DM>P, TAN/GRY SANDY M, IRREG TOPO, TUBES, LG VOIDS, WORMS @Z, BURROW
B200S	D	8/20/2001	12:44	2.57	5.64	3.43	0	0	0	6	Biogenic	NO	DM>P, TAN/GRY SANDY M, DENSE SURF TUBES, IRON OXIDE STREAKS, AMP STALK
B200SE	A	8/18/2001	13:50	0.14	7.51	3.57	0	0	0	10	Physical	NO	DM>P, TAN/GRY SANDY M, SURF TUBES, VOIDS, BURROWS, WORMS @Z?, RED SED @Z
B200SE	B	8/18/2001	13:51	0.14	6.12	4.29	0	0	0	7	Physical	NO	DM>P, TAN FINE SAND/GRY & BLK SANDY M, multiple dm layers, RED SED BANDS, RELIC RPD, TUBES, LG WORM @Z
B200SE	D	8/18/2001	13:56	0.72	4.05	2.56	0	0	0	9	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, DENSE SURF TUBES, AMP TUBES?, DM LAYERING, VOIDS, WORMS @Z
B200SW	A	8/19/2001	12:21	0.07	5.01	1.45	0	0	0	3	Physical	NO	DM>P, TAN/GRY SANDY M, DENSE SURF TUBES, PULL AWAY, WORMS @Z
B200SW	B	8/19/2001	12:21	1.5	7.13	3.65	0	0	0	6	Physical	NO	DM>P, TAN/GRY SANDY M, OVERPEN, TUBES
B200SW	C	8/19/2001	12:22	0.5	4.7	2.23	0	0	0	8	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, TUBES, VOIDS, BURROW SYSTEM, RED CLAST, FLOCK LAYER, AMP STALK, WORMS @Z
B200W	A	8/18/2001	15:08	1.78	5.5	3.1	0	0	0	6	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, DENSE SURF TUBES, WORMS @Z, BURROW, VOID?
B200W	B	8/18/2001	15:09	1.14	3.49	2.28	0	0	0	9	Physical	NO	DM>P, TAN/BLK SANDY M, SED LAYERING, RELIC RPD,rpd smearing artifact, RED SED @ SURF, TUBES, VOID
B200W	C	8/18/2001	15:10	0.5	7.34	2.92	0	0	0	9	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, TUBES, OX & RED CLASTS, LG BURROW-OPENING, VOID, ORG DETRITUS @ SURF, RED SED @ SURF, WORM @Z
B300E	A	8/18/2001	09:36	0.29	3.64	2.48	0	0	0	9	Biogenic	NO	AMBIENT, TAN&GRY SANDY M, DENSE SURF TUBES, shallow VOID, AMP STALK
B300E	B	8/18/2001	09:36	0.07	5.42	2.28	0	0	0	9	Physical	NO	AMBIENT, TAN&GRY M, SURF TUBES, RED CLASTS, WIPER CLASTS, BURROWING ANEMONE@Z
B300E	C	8/18/2001	09:37	0.07	4.15	1.4	0	0	0	7	Physical	NO	AMBIENT, TAN & GRY SANDY M, TUBES, WIPER SMEARS, VOID, BURROW OPENING, WORM @ Z
B300N	B	8/18/2001	08:42	0.14	5.14	1.54	0	0	0	4	Biogenic	NO	DM>P, TAN& GRY SANDY M, SURF TUBES, OX & RED CLASTS, WORMS @ Z, ORG DETRITUS?
B300N	D	8/20/2001	12:05	0.29	4.37	1.54	0	0	0	8	Biogenic	NO	AMBIENT, TAN/GRY SANDY M, DENSE TUBES, LG VOID
B300N	E	8/20/2001	12:06	0.07	6.07	1.29	0	0	0	7	Physical	NO	DM>P, TAN/GRY & BLK SANDY M, DENSE SURF TUBES, SLOPING TOPO, LG RED M CLASTS, VOIDS, PATCHY RPD, RED SED @ SURF
B300NE	A	8/18/2001	09:28	0.07	8.3	4.03	0	0	0	11	Physical	NO	AMBIENT, TAN/GRY SANDY SILT, BRITTLE STAR @ SURF W/ MUD CLUMPS, TUBES, OX CLASTS, VOIDS, SM BURROW OPENING
B300NE	B	8/18/2001	09:29	0.28	5.33	2.5	0	0	0	9	Physical	NO	AMBIENT, TAN/GRY SANDY SILT, SM TUBES, VOID, SM SHELL BITS, THIN VERT BURROWS
B300NE	C	8/18/2001	09:30	0.07	2.49	0.72	0	0	0	2	Physical	NO	DM>P, TAN,GRY & BLK SANDY M, AMP STALK, SM SHELL BITS
B300NW	C	8/18/2001	15:02	0.07	3.72	0.46	0	0	0	6	Biogenic	NO	AMBIENT, TAN/ GRY SANDY M, DENSE SURF TUBES, VOIDS, SHALLOW & PATCHY RPD, RED SED @ SURF
B300NW	D	8/20/2001	12:20	2.63	5.62	3.32	0	0	0	10	Biogenic	NO	AMBIENT, TAN/ GRY SANDY M, DENSE SURF TUBES, BURROW-OPENING, VOIDS, OX & RED CLASTS, WORM @ Z
B300NW	E	8/20/2001	12:21	0.07	6.12	0.69	0	0	0	2	Physical	NO	AMBIENT, TAN/GRY SANDY M, SURF TUBES, SLOPING & IRREG TOPO, OX CLAST, RED M CLUMPS-FAR, PATCHY RPD, VERT BURROW-OPENING ON LFT
B300S	A	8/18/2001	14:03	0.57	6.24	3.86	0	0	0	11	Biogenic	NO	AMBIENT, TAN/GRY SANDY M, DENSE SURF TUBES, VOIDS, SM WORMS @Z
B300S	B	8/18/2001	14:04	0.07	6.19	1.71	0	0	0	4	Physical	NO	DM>P, TAN/GRY & BLK SANDY M, DENSE SURF TUBES, FLOCK LAYER, LG RED CLASTS, PATCHY RPD, RED SED @ SURF
B300S	C	8/18/2001	14:05	0.07	5.97	1.3	0	0	0	3	Physical	NO	DM>P, TAN/GRY & BLK SANDY M, TUBES, OX & RED CLASTS, RED SED @ SURF, SM WORM @Z, IRREG TOPO, PLANT MATERIAL?
B300SE	A	8/18/2001	13:41	0.29	6.6	2.72	0	0	0	9	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, DENSE SURF TUBES, LG VOIDS, BLUE STREAK ON IMAGE
B300SE	B	8/18/2001	13:44	0.07	2.36	0.81	0	0	0	3	Physical	NO	DM>P, TAN & GRY SANDY M, SURF TUBES, OX & RED CLASTS, SHALLOW RPD
B300SE	D	8/20/2001	12:50	0.72	3.96	1.61	0	0	0	4	Physical	NO	DM>P, BRN/GRY SANDY SILT, TUBES, RED CLASTS, LG M CLUMP, WIPER CLAST
B300SW	A	8/19/2001	12:27	2.85	5.33	3.41	0	0	0	10	Biogenic	NO	DM>P, TAN/GRY SANDY M, DENSE SUF TUBES, OX & RED CLASTS, VOIDS, BURROW, RED SED @Z
B300SW	B	8/19/2001	12:28	1.8	4.24	2.9	0	0	0	9	Physical	NO	DM>P, TAN/GRY & BLK SANDY M, SED LAYERING-RELIC RPD? RPD smearing artifact, SM TUBES, RED CLASTS, VOIDS
B300SW	C	8/19/2001	12:29	0.36	6.58	2.18	0	0	0	4	Physical	NO	DM>P, TAN/GRY & BLK SANDY M, SM TUBES, RED CLASTS, WORMS @Z, RED SED @ SURF, BURROW
B300W	A	8/19/2001	12:13	0.93	5.51	2.97	0	0	0	5	Biogenic	NO	DM>P, TAN/GRY & BLK SANDY M, TUBES, BURROW OPENING, LG BURROWING WORM @Z, OX & RED CLASTS, BLUE STREAK
B300W	C	8/19/2001	12:15	0.07	5.77	1.64	0	0	0	4	Physical	NO	DM>P, TAN/ GRY & BLK SANDY M, TUBES, RED CLASTS, RED SED @ SURF, SM WORM @Z, SURF REWORKING?
B300W	D	8/20/2001	12:34	0.29	3.71	1.78	0	0	0	8	Physical	NO	DM>P, TAN/ GRY & BLK SANDY M, SED LAYERING-RED SED BAND, RELIC RPD?, TUBES, RED CLASTS, IRREG & SLOPING TOPO, VOID, WORM @Z
BCTR	A	8/18/2001	09:12	0.21	3.77	1.91	0	0	0	8	Biogenic	NO	DM>P, TAN SANDY SILT/BLK&WHT MOTTLED CLAY, SED LAYERING, TUBES, SESSILE JELLYFISH POLYP @SURF, AMP TUBES?, LG WORMS @ Z, VOIDS
BCTR	B	8/18/2001	09:12	0.21	2.07	0.95	0	0	0	7	Physical	NO	DM>P, TAN SANDY SILT/WHT&GRY MOTTLED CLAY, VOIDS, WORMS @Z, RED SED @ SURF, WHT COHESIVE CLAY CHIPS
BCTR	C	8/18/2001	09:13	0.07	4.7	1.63	0	0	0	4	Physical	NO	DM>P, TAN SANDY SILT/ BLK&WHT MOTTLED CLAY, COH CLAY CHIPS, RED CLASTS WORMS @Z

Appendix B2

CCBDS Reference Areas REMOTS® Sediment-Profile Imaging Data from the August 2001 Survey

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi)			Mud Clasts		Camera Penetration (cm)				Dredged Material Thickness (cm)		
					Min	Max	Maj Mode	Count	Avg. Diam	Min	Max	Range	Mean	Min	Max	Mean
CCBRS																
REF1	A	8/17/2001	13:24	ST I on III	> 4 phi	4-3 phi	> 4 phi	7	0.28	17.49	18.79	1.3	18.14	0	0	0
REF1	B	8/17/2001	13:25	ST I on III	> 4 phi	4-3 phi	> 4 phi	3	0.22	15.66	16.6	0.94	16.13	0	0	0
REF1	C	8/17/2001	13:25	ST I on III	> 4 phi	4-3 phi	> 4 phi	10	0.22	16.97	18.49	1.52	17.73	0	0	0
REF3	A	8/17/2001	13:36	ST I on III	> 4 phi	3-2 phi	> 4 phi	0	0	15.61	17.6	1.99	16.6	0	0	0
REF3	B	8/17/2001	13:36	ST I on III	> 4 phi	4-3 phi	> 4 phi	8	0.17	16.55	17.22	0.67	16.88	0	0	0
REF3	D	8/21/2001	11:53	ST I on III	> 4 phi	4-3 phi	> 4 phi	1	0.57	14.61	15.15	0.54	14.88	0	0	0
REF4	A	8/17/2001	13:46	ST I on III	> 4 phi	4-3 phi	> 4 phi	2	0.38	19.74	20.07	0.33	19.9	0	0	0
REF4	B	8/17/2001	13:47	ST I on III	> 4 phi	4-3 phi	> 4 phi	4	0.68	16.55	18.67	2.12	17.61	0	0	0
REF4	C	8/17/2001	13:48	ST I on III	> 4 phi	4-3 phi	> 4 phi	15	0.31	16.33	17.98	1.65	17.15	0	0	0
REF5	B	8/17/2001	13:03	INDET	> 4 phi	4-3 phi	> 4 phi	0	0	21	21	.	21	0	0	0
REF5	C	8/17/2001	13:04	ST I on III	> 4 phi	4-3 phi	> 4 phi	3	0.78	16.89	18.27	1.38	17.58	0	0	0
REFCTR	A	8/17/2001	13:10	INDET	> 4 phi	4-3 phi	> 4 phi	0	0	20.98	21	0.02	20.99	0	0	0
REFCTR	B	8/17/2001	13:10	ST I	> 4 phi	4-3 phi	> 4 phi	14	0.34	17.66	18.15	0.49	17.9	0	0	0
REFCTR	C	8/17/2001	13:11	ST I on III	> 4 phi	4-3 phi	> 4 phi	17	0.17	19.42	20.39	0.97	19.9	0	0	0
NORTHWEST																
NWREF1	D	8/21/2001	12:11	ST I on III	> 4 phi	4-3 phi	> 4 phi	2	0.18	16.11	16.62	0.51	16.37	0	0	0
NWREF1	E	8/21/2001	12:12	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	15.62	17.01	1.39	16.32	0	0	0
NWREF1	G	8/21/2001	12:14	ST I on III	> 4 phi	4-3 phi	> 4 phi	7	0.3	11.16	13.6	2.44	12.38	0	0	0
NWREF2	B	8/17/2001	14:54	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	16.33	17.78	1.45	17.06	0	0	0
NWREF2	C	8/17/2001	14:55	ST I on III	> 4 phi	4-3 phi	> 4 phi	6	0.17	18.19	19.6	1.41	18.9	0	0	0
NWREF2	D	8/17/2001	14:56	ST I on III	> 4 phi	4-3 phi	> 4 phi	4	0.13	20.26	20.54	0.28	20.4	0	0	0
NWREF3	A	8/17/2001	14:13	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	18.54	18.81	0.27	18.67	0	0	0
NWREF3	D	8/21/2001	12:30	ST I on III	> 4 phi	4-3 phi	> 4 phi	2	0.27	13.35	13.8	0.45	13.58	0	0	0
NWREF3	E	8/21/2001	12:31	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	10.94	12.19	1.25	11.56	0	0	0
NWREF4	B	8/17/2001	14:25	ST I	> 4 phi	4-3 phi	> 4 phi	17	0.15	16.67	18.56	1.89	17.61	0	0	0
NWREF4	E	8/21/2001	12:24	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	15.15	15.3	0.15	15.23	0	0	0
NWREF4	F	8/21/2001	12:24	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	13.23	13.72	0.49	13.48	0	0	0
SOUTHWEST																
SWREF1	A	8/19/2001	16:08	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	5.71	9.34	3.63	7.53	0	0	0
SWREF1	B	8/19/2001	16:09	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	14.43	16.69	2.26	15.56	0	0	0
SWREF1	C	8/19/2001	16:10	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	12.96	13.74	0.78	13.35	0	0	0
SWREF2	A	8/19/2001	16:18	ST I on III	> 4 phi	4-3 phi	> 4 phi	2	0.23	15.74	16.15	0.41	15.94	0	0	0
SWREF2	B	8/19/2001	16:19	ST I	> 4 phi	4-3 phi	> 4 phi	1	0.7	13.16	13.8	0.64	13.48	0	0	0
SWREF2	C	8/19/2001	16:20	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	12.25	14.6	2.35	13.43	0	0	0
SWREF3	A	8/19/2001	16:27	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	10.13	11.66	1.53	10.9	0	0	0
SWREF3	B	8/19/2001	16:28	ST I	> 4 phi	4-3 phi	> 4 phi	2	0.29	11.81	12.4	0.59	12.1	0	0	0
SWREF3	C	8/19/2001	16:29	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	8.83	9.89	1.06	9.36	0	0	0
SWREF4	A	8/19/2001	16:35	ST I on III	> 4 phi	4-3 phi	> 4 phi	12	0.32	9.57	10.2	0.63	9.89	0	0	0
SWREF4	B	8/19/2001	16:38	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	12.1	13.42	1.32	12.76	0	0	0
SWREF4	C	8/19/2001	16:38	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	8.54	9.74	1.2	9.14	0	0	0

Appendix B2 (continued)

CCBDS Reference Areas REMOTS® Sediment-Profile Imaging Data from the August 2001 Survey

Station	Replicate	Date	Time	Redox Rebound Thickness (cm)			Apparent RPD Thickness (cm)			Methane			OSI	Surface Roughness	Low DO	Comments
				Min	Max	Mean	Min	Max	Mean	Min	Max	Mean				
CCBRS																
REF1	A	8/17/2001	13:24	0	0	0	0.43	3.41	1.57	0	0	0	8	Biogenic	NO	TAN&GRY SANDY M>P, TUBES, VOIDS, WORMS @Z, OX&RED CLASTS
REF1	B	8/17/2001	13:25	0	0	0	0.07	2.64	0.4	0	0	0	6	Physical	NO	TAN&GRY SANDY M>P, TUBES, VOIDS, OX&RED CLASTS, IRON OXIDE STREAKS, PATCHY RPD
REF1	C	8/17/2001	13:25	0	0	0	0.07	2.42	0.33	0	0	0	6	Physical	NO	TAN&GRY SANDY M>P, TUBES, SM VOIDS, OX&RED CLASTS
REF3	A	8/17/2001	13:36	0	0	0	0.07	5.69	0.8	0	0	0	7	Physical	NO	TAN&GRY M>P, TUBES, VOIDS, RED SED @Z
REF3	B	8/17/2001	13:36	0	0	0	0.07	1.85	0.68	0	0	0	6	Biogenic	NO	TAN&GRY SOFT M>P, TUBES, BRITTLE STAR ARMS, OX CLASTS, SM VOID LWR LEFT
REF3	D	8/21/2001	11:53	0	0	0	2.08	6.18	3.59	0	0	0	10	Biogenic	NO	TAN&GRY M>P, TUBES, VOIDS, BRITTLE STARS @SURF
REF4	A	8/17/2001	13:46	0	0	0	0.21	6.05	3.2	0	0	0	10	Physical	NO	TAN& GRAY M>P, TUBES, VOIDS, BRITTLE STAR ARM @SURF, OX&RED CLASTS, WORM @Z?
REF4	B	8/17/2001	13:47	0	0	0	0.14	5.77	2.53	0	0	0	9	Physical	NO	TAN&GRY M>P, DENSE SURF TUBES, LG VOID, OX&RED CLASTS, SM WORM @Z
REF4	C	8/17/2001	13:48	0	0	0	0.07	4.98	2.43	0	0	0	9	Biogenic	NO	TAN&GRY M>P, TUBES, VOIDS, BRITTLE STARS @SURF, OX&RED CLASTS, RED SED@Z
REF5	B	8/17/2001	13:03	0	0	0	-99	-99	-99	0	0	0	99	Indeterminate	NO	TAN&GRY M>P, OVERPENETRATION, VOIDS, SM WORM @Z
REF5	C	8/17/2001	13:04	0	0	0	0.07	2.85	1.09	0	0	0	7	Physical	NO	TAN&GRY M>P, TUBES, VOIDS, RED CLASTS, RED SED @Z, SM WORMS @Z
REFCTR	A	8/17/2001	13:10	0	0	0	-99	-99	-99	0	0	0	99	Indeterminate	NO	TAN&GRY M>P, OVERPENETRATION, VIODS, WORMS @Z, BURROW
REFCTR	B	8/17/2001	13:10	0	0	0	0.21	5.69	2.7	0	0	0	5	Physical	NO	TAN&GRY M>P, TUBES, OX&RED CLASTS, IRON OXIDE STREAK
REFCTR	C	8/17/2001	13:11	0	0	0	0.57	7.04	3.55	0	0	0	10	Biogenic	NO	TAN&GRY M>P, DENSE TUBES, VOIDS, OX&RED CLASTS, WORM @Z, BRITTLE STAR ARM
NORTHWEST																
NWREF1	D	8/21/2001	12:11	0	0	0	0.07	5.4	2.69	0	0	0	9	Biogenic	NO	TAN&GRY M>P, DENSE SURF TUBES, VOIDS, OX CLASTS, WORM @Z
NWREF1	E	8/21/2001	12:12	0	0	0	0.43	4.98	2.82	0	0	0	5	Physical	NO	TAN&GRY M>P, SM TUBES, IRON OXIDE STREAK
NWREF1	G	8/21/2001	12:14	0	0	0	0.07	5.97	3.41	0	0	0	10	Physical	NO	TAN&GRY M>P, SLOPING TOPOGRAPHY, TUBES, SM VOID, RED M CLASTS-FARFIELD
NWREF2	B	8/17/2001	14:54	0	0	0	2.49	6.48	3.83	0	0	0	7	Biogenic	NO	TAN&GRY M>P, DENSE SURF TUBES
NWREF2	C	8/17/2001	14:55	0	0	0	1.21	5.92	2.75	0	0	0	9	Physical	NO	TAN&GRY M>P, TUBES, VOIDS, Partial pull-away, IRON OXIDE @Z, PATCHTY RPD= artifact of pull-away
NWREF2	D	8/17/2001	14:56	0	0	0	1.71	5.62	3.32	0	0	0	10	Physical	NO	TAN&GRY M>P, TUBES, LG VOIDS, WIPER CLASTS, OX&RED CLASTS
NWREF3	A	8/17/2001	14:13	0	0	0	1.15	7.19	4.17	0	0	0	11	Biogenic	NO	TAN&GRY M>P, TUBES, VOIDS, LG FILLED VERTICAL BURROW, BRITTLE STAR @SURF, FLOCK LYR
NWREF3	D	8/21/2001	12:30	0	0	0	0.22	4.89	2.61	0	0	0	9	Physical	NO	TAN&GRY M>P, TUBES, VOID, OX&RED CLASTS, WORM @Z?
NWREF3	E	8/21/2001	12:31	0	0	0	1.87	6.12	3.82	0	0	0	11	Biogenic	NO	TAN&GRY M>P, DENSE SURF TUBES, LG VOID, RED SED @SURF= artifact?, ROUND ORG @SURF?
NWREF4	B	8/17/2001	14:25	0	0	0	0.43	6.04	3.16	0	0	0	6	Biogenic	NO	TAN&GRY SANDY M>P, TUBES, OX&RED CLASTS, BRITTLE STAR ARM, BURROW-OPENING
NWREF4	E	8/21/2001	12:24	0	0	0	1.01	5.04	2.75	0	0	0	5	Physical	NO	TAN&GRY M>P, SM TUBES, LG BURROWING WORM @Z, amphipod stalk@surf=Corophium?
NWREF4	F	8/21/2001	12:24	0	0	0	0.22	4.75	2.85	0	0	0	5	Biogenic	NO	TAN&GRY M>P,DENSE SURF TUBES, CLEAR&ROUND ORG @ SURF?,IRON OXIDE STREAK,SM VOID?
SOUTHWEST																
SWREF1	A	8/19/2001	16:08	0	0	0	0.79	7.08	3.16	0	0	0	6	Biogenic	NO	BRN&GRY M>P, TUBES, BURROW OPENING? IRREG TOPO, BLUE STREAK ON IMAGE
SWREF1	B	8/19/2001	16:09	0	0	0	2.13	4.55	2.5	0	0	0	9	Physical	NO	TAN&GRY M>P, TUBES, VOIDS
SWREF1	C	8/19/2001	16:10	0	0	0	0.07	3.85	2.28	0	0	0	9	Physical	NO	TAN&GRY M>P, TUBES, WIPER CLASTS, VOIDS, AMPHIPOD STALKS
SWREF2	A	8/19/2001	16:18	0	0	0	0.07	5.27	3.27	0	0	0	10	Biogenic	NO	TAN&GRY M>P, DENSE SURF TUBES, VOIDS, OX CLASTS, BIO REWORKING OF SURFACE
SWREF2	B	8/19/2001	16:19	0	0	0	1.71	5.05	2.63	0	0	0	5	Physical	NO	TAN&GRY M>P, TUBES, ORG @SURF?
SWREF2	C	8/19/2001	16:20	0	0	0	0.14	5.9	3.56	0	0	0	6	Physical	NO	TAN&GRY M>P, TUBES, AMPHIPOD STALK, BIOLOGICAL SURF REWORKING
SWREF3	A	8/19/2001	16:27	0	0	0	0.07	5.84	2.41	0	0	0	9	Biogenic	NO	TAN&GRY M>P, DENSE SURF TUBES, VOIDS
SWREF3	B	8/19/2001	16:28	0	0	0	2.35	4.48	3.12	0	0	0	6	Physical	NO	TAN&GRY M>P, TUBES, OX & RED CLASTS
SWREF3	C	8/19/2001	16:29	0	0	0	0.92	3.98	1.92	0	0	0	8	Biogenic	NO	TAN&GRY M>P, VOIDS, BURROW, WORM@Z, PATCHY RPD, FECAL MOUND,SURF REWORK, TUBES
SWREF4	A	8/19/2001	16:35	0	0	0	0.21	4.99	2.63	0	0	0	9	Biogenic	NO	TAN&GRY M>P, VOIDS, OX & RED CLAST LAYER, TUBES, SM WORM @Z, VOID/BURROW
SWREF4	B	8/19/2001	16:38	0	0	0	0.07	4.84	2.75	0	0	0	9	Biogenic	NO	TAN&GRY M>P, DENSE SURF TUBES, VOIDS, WORM @Z
SWREF4	C	8/19/2001	16:38	0	0	0	0.07	6.85	1.33	0	0	0	7	Biogenic	NO	TAN&GRY M>P, VOIDS, DENSE TUBES-MOUND, DETRITUS @ SURF, PATCHY RPD

Appendix B3

CCBDS REMOTS® Sediment-Profile Imaging Data over Mound A from the August 2001 Survey

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi)			Mud Clasts		Camera Penetration (cm)				Dredged Material Thickness (cm)			Redox Rebound Thickness (cm)		
					Min	Max	Maj Mode	Count	Avg. Diam	Min	Max	Range	Mean	Min	Max	Mean	Min	Max	Mean
MOUND-A																			
ACTR	A	8/19/2001	12:55	ST I on III	> 4 phi	4-3 phi	> 4 phi	1	0.4	14.45	15.48	1.03	14.97	14.45	15.48	>14.97	0	0	0
ACTR	B	8/19/2001	12:55	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	15.99	16.96	0.97	16.47	15.99	16.96	>16.47	0	0	0
ACTR	C	8/19/2001	12:56	ST I	> 4 phi	4-3 phi	> 4 phi	4	0.4	17.33	17.81	0.48	17.57	17.33	17.81	>17.57	0	0	0
A100E	C	8/19/2001	15:27	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	18.88	19.74	0.86	19.31	18.88	19.74	>19.31	0	0	0
A100E	D	8/20/2001	13:33	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	15.25	15.99	0.74	15.62	15.25	15.99	>15.62	0	0	0
A100E	E	8/20/2001	13:34	ST I on III	> 4 phi	3-2 phi	> 4 phi	1	0.71	11.92	14.22	2.3	13.07	11.92	14.22	>13.07	0	0	0
A200E	A	8/19/2001	15:19	ST I on III	> 4 phi	3-2 phi	> 4 phi	20	0.33	14.88	18.1	3.22	16.49	14.88	18.1	>16.49	0	0	0
A200E	B	8/19/2001	15:20	ST I on III	> 4 phi	4-3 phi	> 4 phi	4	1.1	10.55	14.58	4.03	12.57	10.55	14.58	>12.57	0	0	0
A200E	C	8/19/2001	15:21	ST I on III	> 4 phi	3-2 phi	> 4 phi	0	0	11.54	13.97	2.43	12.76	11.54	13.97	>12.76	0	0	0
A300E	A	8/19/2001	13:21	ST I	> 4 phi	4-3 phi	> 4 phi	1	0.61	11.78	13.1	1.32	12.44	0	0	0	0	0	0
A300E	B	8/19/2001	13:22	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	13.84	14.68	0.84	14.26	0	0	0	0	0	0
A300E	C	8/19/2001	13:23	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	15.1	15.79	0.69	15.44	0	0	0	0	0	0
A100N	A	8/19/2001	12:49	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	17.75	19.48	1.73	18.61	17.75	19.48	>18.61	0	0	0
A100N	B	8/19/2001	12:50	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	16.77	17.81	1.04	17.29	16.77	17.81	>17.29	0	0	0
A100N	C	8/19/2001	12:51	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	19.85	20.68	0.83	20.26	19.85	20.68	>20.26	0	0	0
A200N	D	8/20/2001	13:05	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	16.99	17.76	0.77	17.38	16.99	17.76	>17.38	0	0	0
A200N	F	8/20/2001	13:07	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	10.93	13.16	2.23	12.05	10.93	13.16	>12.05	0	0	0
A200N	G	8/20/2001	13:08	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	17.19	18.94	1.75	18.07	17.19	18.94	>18.07	0	0	0
A300N	B	8/19/2001	12:39	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	18.54	20.76	2.22	19.65	18.54	20.76	>19.65	0	0	0
A300N	C	8/19/2001	12:39	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	20.75	21	0.25	20.88	20.75	21	>20.88	0	0	0
A300N	D	8/20/2001	13:00	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	15.93	17.76	1.83	16.85	15.93	17.76	>16.85	0	0	0
A100S	C	8/19/2001	13:02	ST I	> 4 phi	3-2 phi	> 4 phi	2	0.23	15.3	16.57	1.27	15.93	15.3	16.57	>15.93	0	0	0
A100S	E	8/20/2001	13:41	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	14.66	16.02	1.36	15.34	14.66	16.02	>15.34	0	0	0
A100S	F	8/20/2001	13:42	ST I	> 4 phi	3-2 phi	> 4 phi	4	0.39	12.6	13.49	0.89	13.05	12.6	13.49	>13.05	0	0	0
A200S	A	8/19/2001	13:06	ST I	> 4 phi	4-3 phi	> 4 phi	15	0.86	9.78	10.16	0.38	9.97	0	0	0	0	0	0
A200S	B	8/19/2001	13:07	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	15.4	15.88	0.48	15.64	0	0	0	0	0	0
A200S	C	8/19/2001	13:07	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	11.51	13.43	1.92	12.47	0	0	0	0	0	0
A300S	A	8/19/2001	13:12	ST I on III	> 4 phi	4-3 phi	> 4 phi	2	0.31	13.01	14.72	1.71	13.86	0	0	0	0	0	0
A300S	B	8/19/2001	13:12	ST I	> 4 phi	4-3 phi	> 4 phi	3	0.22	12.02	12.44	0.42	12.23	0	0	0	0	0	0
A300S	C	8/19/2001	13:13	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	13.82	14.29	0.47	14.06	0	0	0	0	0	0
A100W	B	8/19/2001	15:34	ST I	> 4 phi	4-3 phi	> 4 phi	3	0.51	19.38	20.75	1.37	20.06	19.38	20.75	>20.06	0	0	0
A100W	E	8/20/2001	13:27	ST I	> 4 phi	4-3 phi	> 4 phi	12	0.26	11.91	12.31	0.4	12.11	11.91	12.31	>12.11	0	0	0
A100W	F	8/20/2001	13:28	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	14.12	14.62	0.5	14.37	14.12	14.62	>14.37	0	0	0
A200W	B	8/19/2001	15:40	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	19.11	19.85	0.74	19.48	19.11	19.85	>19.48	0	0	0
A200W	D	8/20/2001	13:19	ST I on III	> 4 phi	4-3 phi	> 4 phi	0	0	14.26	15.51	1.25	14.89	14.26	15.51	>14.89	0	0	0
A200W	E	8/20/2001	13:20	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	16.33	17.39	1.06	16.86	16.33	17.39	>16.86	0	0	0
A300W	B	8/19/2001	15:46	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	14.33	16.42	2.09	15.38	14.33	16.42	>15.38	0	0	0
A300W	C	8/19/2001	15:47	ST I	> 4 phi	4-3 phi	> 4 phi	0	0	12.25	13.26	1.01	12.76	12.25	13.26	>12.76	0	0	0
A300W	D	8/20/2001	13:13	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	12.59	13.94	1.35	13.26	12.59	13.94	>13.26	0	0	0

Appendix B3 (continued)

CCBDS REMOTS® Sediment-Profile Imaging Data over Mound A from the August 2001 Survey

Station	Replicate	Date	Time	Apparent RPD Thickness (cm) Min	Max	Mean	Methane Min	Max	Mean	OSI	Surface Roughness	Low DO	Comments
MOUND-A													
ACTR	A	8/19/2001	12:55	0.07	1.28	0.56	0	0	0	6	Physical	NO	HISTORIC DM>P, TAN/BLK M, TUBES, LG TUBES, VOIDS, THIN RPD, OX CLAST, RED SED @SURF
ACTR	B	8/19/2001	12:55	0.36	4.71	2.61	0	0	0	9	Biogenic	NO	HISTORIC DM>P, TAN/BLK M, DENSE SURF TUBES, VOID, BURROW
ACTR	C	8/19/2001	12:56	0.64	5.28	3.03	0	0	0	6	Physical	NO	HISTORIC DM>P, TAN/BLACK M, TUBES, RED CLASTS, WIPER CLASTS, BURROWING WORMS @Z,
A100E	C	8/19/2001	15:27	0.07	6.05	2.77	0	0	0	5	Biogenic	NO	HISTORIC DM>P, TAN/BLK M, DENSE SURF TUBES, BURROW OPENING?
A100E	D	8/20/2001	13:33	0.21	3.21	1.7	0	0	0	4	Biogenic	NO	HISTORIC DM>P, TAN/BLACK SANDY M, DENSE SURF TUBES, WORM @Z
A100E	E	8/20/2001	13:34	0.14	1.14	0.46	0	0	0	6	Biogenic	NO	HISTORIC DM>P, TAN/BLK SANDY M, REDUCED SED, DENSE SURF TUBES, OX CLAST, VOID, WORMS @Z, SHALLOW RPD
A200E	A	8/19/2001	15:19	0.07	4.29	2.25	0	0	0	8	Physical	NO	HISTORIC DM>P, TAN/BLACK SANDY M, TUBES, OX&RED CLASTS, LG BURROWING WORM @Z, VOID, BLUE STREAK ON IMAGE
A200E	B	8/19/2001	15:20	-99	-99	-99	0	0	0	99	Biogenic	NO	HISTORIC DM>P, TAN&GRY M, DIST&IRREG SURF,DENSE TUBES,SURF REWORK,OX&RED CLSTS,RED SED BURROWS,VOIDS,M CLUMPS-FAR
A200E	C	8/19/2001	15:21	0.07	5.22	2.83	0	0	0	9	Physical	NO	HISTORIC DM>P, TAN/BLK SANDY M, VOID, TUBES
A300E	A	8/19/2001	13:21	0.29	5.78	2.58	0	0	0	5	Biogenic	NO	AMBIENT M>P, TAN/GRY&BLK SANDY M, SURF TUBES, BURROW OPENING?, OX CLAST
A300E	B	8/19/2001	13:22	0.07	5.41	2.67	0	0	0	9	Physical	NO	AMBIENT M>P, TAN/BLK M, TUBES,amphipod stalk, BURROW OPENING
A300E	C	8/19/2001	13:23	1.58	5.47	3.44	0	0	0	6	Physical	NO	AMBIENT M>P, TAN/GRY M, SURF TUBES, SM WORM @Z
A100N	A	8/19/2001	12:49	0.07	5.19	2.03	0	0	0	4	Biogenic	NO	HISTORIC DM>P, TAN/BLK SULFIDIC M, DENSE SURFACE TUBES, SM WORMS @Z
A100N	B	8/19/2001	12:50	0.14	5.72	2.72	0	0	0	9	Physical	NO	HISTORIC DM>P, TAN/BLK SULFIDIC M, TUBES, RED SED @SURF, FLOCK LAYER?
A100N	C	8/19/2001	12:51	1.79	4.01	2.42	0	0	0	5	Indeterminate	NO	HISTORIC DM>P, TAN/BLACK SULFIDIC M,, WIPER BLADE@SURF, TUBES, RED SED @SURF
A200N	D	8/20/2001	13:05	0.14	4.44	2.04	0	0	0	4	Indeterminate	NO	HISTORIC DM>P, BRNISH GRY/BLK SUFLIDIC M, WIPER BLADE@SURF, TUBES, BURROW
A200N	F	8/20/2001	13:07	0.22	3.8	1.25	0	0	0	3	Physical	NO	HISTORIC DM>P, TAN&GRY/BLK SANDY M, SULFIDIC M @Z, SM TUBES, PATCHY RPD
A200N	G	8/20/2001	13:08	0.14	2.65	1.45	0	0	0	3	Indeterminate	NO	HISTORIC DM>P, TAN&GRY/BLK M, SULFIDIC M @Z, WIPER BLADE @SURF, TUBES
A300N	B	8/19/2001	12:39	0.07	4.07	2.24	0	0	0	8	Physical	NO	HISTORIC DM>P, TAN/BLACK SANDY M, TUBES, WIPER CLASTS, VOID, RED SED @Z,
A300N	C	8/19/2001	12:39	0.07	3.71	1.21	0	0	0	3	Indeterminate	NO	HISTORIC DM>P, TAN&GRY/BLK SANDY M, OVERPEN, TUBES, LG BURROWING WORM @Z, RED SED @SURF
A300N	D	8/20/2001	13:00	0.07	4.28	0.89	0	0	0	3	Physical	NO	HISTORIC DM>P, BRN/BLACK SULFIDIC M, TUBES, SM VOIDS?, SM WORMS @Z?, RED SED @Z
A100S	C	8/19/2001	13:02	0.29	3.08	1.33	0	0	0	3	Physical	NO	HISTORIC DM>P, TAN/BLK M, TUBES, RED SED @Z, RED CLASTS, WORM @Z
A100S	E	8/20/2001	13:41	0.00	0.00	0.00	0	0	0	1	Indeterminate	NO	HISTORIC DM>P, BLK SULFIDIC SANDY M, WIPER BLADE @SURF, BURROW-OPENING, TUBES, FLOCK LAYER, NO RPD
A100S	F	8/20/2001	13:42	0.03	2.88	0.55	0	0	0	2	Biogenic	NO	HISTORIC DM>P, TAN/BLK SANDY M, PATCHY RPD, RED CLASTS, DENSE TUBES, BURROW OPENING, RED SED @Z, FLOCK LAYER
A200S	A	8/19/2001	13:06	0.21	2.86	1.44	0	0	0	3	Physical	NO	AMBIENT, TAN/BLK M, SURF TUBES, OX&RED CLASTS, M CLUMPS-FARFIELD
A200S	B	8/19/2001	13:07	0.29	4.57	2.42	0	0	0	5	Biogenic	NO	AMBIENT, TAN/GRY&BLK M, DENSE SURF TUBES, RED SED@SURF/WIPER CLASTS, OX CLASTS-FAR
A200S	C	8/19/2001	13:07	0.07	3.78	1.11	0	0	0	7	Biogenic	NO	AMBIENT, TAN/GRY&BLK M, TUBES, LG BURROW SYSTEM-OCCUPIED, BUROW OPENING, FLOCK LAYER, VOIDS
A300S	A	8/19/2001	13:12	0.14	6.91	3.3	0	0	0	10	Biogenic	NO	AMBIENT M>P, BRNISH GRY M, DENSE SURF TUBES, VOIDS, IRREG TOPO
A300S	B	8/19/2001	13:12	2.07	4.43	2.62	0	0	0	5	Physical	NO	AMBIENT M>P, BRNISH GRY M, TUBES, RED CLASTS
A300S	C	8/19/2001	13:13	2.34	5.18	3.06	0	0	0	6	Biogenic	NO	AMBIENT, TAN/BLACK M, DENSE SURF TUBES, LG BURROWING WORMS @Z, burrowing anemone
A100W	B	8/19/2001	15:34	0.07	3.94	1.2	0	0	0	3	Physical	NO	HISTORIC DM>P, TAN/BLACK SULFIDIC M, DENSE SURF TUBES, OX CLASTS
A100W	E	8/20/2001	13:27	1.64	2.93	2.17	0	0	0	4	Physical	NO	HISTORIC DM>P, TAN/BLK SULFIDIC M, DENSE SURF TUBES, OX&RED CLASTS, LG BURROWING WORM @Z
A100W	F	8/20/2001	13:28	0.14	4.5	2.69	0	0	0	5	Biogenic	NO	HISTORIC DM>P, TAN/BLK M, DENSE SURF TUBES, WORM @Z, RED SED
A200W	B	8/19/2001	15:40	0.07	4.94	1.49	0	0	0	3	Biogenic	NO	HISTORIC DM>P, TAN/BLACK M, DENSE SURF TUBES, WORMS @Z, RED SED @SURF
A200W	D	8/20/2001	13:19	0.07	4.1	1.12	0	0	0	7	Biogenic	NO	HISTORIC DM>P, TAN/BLACK M, LG TUBES, WORMS @Z, VOIDS, BURROW, FLOCK LAYER, WOOD/PLANT MATERIAL?, RED SED
A200W	E	8/20/2001	13:20	0.07	3.78	1.27	0	0	0	3	Physical	NO	HISTORIC DM>P, TAN/BLACK SANDY M, WIPER BLADE @SURF, RED SED
A300W	B	8/19/2001	15:46	0.14	1.14	0.42	0	0	0	2	Biogenic	NO	HISTORIC DM>P, TAN/BLACK M, DENSE SURF TUBES, LG WORMS @Z, RED SED
A300W	C	8/19/2001	15:47	0.78	4.06	1.94	0	0	0	4	Biogenic	NO	HISTORIC DM>P, TAN/BLACK M, DENSE SURF TUBES, BURROW, M CLASTS-FARFIELD
A300W	D	8/20/2001	13:13	0.07	1.46	0.53	0	0	0	2	Physical	NO	HISTORIC DM>P, TAN/GRY&BLK M, THIN RPD, SM DENSE SURF TUBES, WORM @Z

APPENDIX C

Appendix C1

CCBRS REMOTS® Sediment-Profile Imaging Data from the May 1996 Survey over Mound A

Station	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
CD100E	9.13	7.13	2	3.42	I,III	ST_III	4 to 3	7.33	6	1.8
CD100N	18.54	15.31	3	6.1	I,II,III	ST_I_ON_III	4 to 3	8.67	8	1.84
CD100S	10.92	10.72	3	7.79	I,III	ST_I_ON_III	4 to 3	9.67	11	0.83
CD100W	15.46	15.46	3	8.3	I,II,III	ST_III	4 to 3	9.67	11	0.53
CD200E	19.36	19.5	3	8.41	I,III	ST_I_ON_III	>4	11	11	0.78
CD200N	20.83	15.41	3	INDET	INDET	INDET	>4	INDET	INDET	0
CD200S	11.67	10.4	1	5.88	I,III	ST_I_ON_III	>4	11	11	1.25
CD200W	16.2	16.2	3	3.85	I,II,III	ST_III	>4	10.33	11	1.5
CD300E	9.46	0.69	1	3.11	I	ST_I	>4	5.67	5	1.32
CD300S	8.19	0	0	6.08	I,III	ST_III	>4	11	11	1.71
CD300W	10.64	7.05	2	4.14	I,III	ST_I_ON_III	>4	9.67	11	0.74
CD300N	15.0	14.18	4	3.82	I,II,III	ST_III	4 to 3	5	5	0.38
CDCTR	10.77	8.71	3	4.62	I,III	ST_III	3 to 2	8	8	1.35
AVG	13.55	10.83	2.38	5.46				8.92	9.08	1.08
MAX	20.83	19.5	3	8.41				11	11	1.84
MIN	8.19	0	0	3.11				5	5	0

Appendix C2

CCBDS REMOTS® Sediment-Profile Imaging Data over Mound A from the May 1996 Survey

Sation	Replicate	Successional Stage	Grain Size (phi)			Mud Clast		Camera Penetration (cm)		Dredged Material Thickness (cm)			Apparent RPD Thickness (cm)			OSI	Surface Roughness	Low DO	Additional Comments	Additional Values	Comment
			Min	Max	Major Mode	Count	Avg. Diam	Range	Mean	Min	Max	Mean	Min	Max	Mean						
cd100e	b	ST_III	2	4	4 to 3	12	0.53	2.06	8.6	7.56	9.63	8.6	2.22	6.45	4.02	11	Biogenic	No	NoAddm	0	DGP: pelletized surface layer; ophiuroids
cd100e	c	ST_I	1	4	4 to 3	0	0	1.9	12.8	11.85	13.75	12.8	0.32	5.55	3.4	6	Physical	No	NoAddm	0	DGP; layer of worm tubes and coarse sed at surface; sulfidic
cd100e	d	ST_I	2	4	>4	0	0	1.43	6	0	0	0	0.48	4.6	2.85	5	Biogenic	No	NoAddm	0	wiper smear (DM); thin layer of forams(?) at surface
cd100n	a	ST_I_TO_II	1	4	4 to 3	0	0	2.34	18.4	17.3	19.26	18.29	4.89	9.73	7.57	8	Physical	No	NoAddm	0	DGP; mod sorting; sulfidic
cd100n	b	ST_I_ON_III	1	4	4 to 3	0	0	2.34	18.35	7.29	11.86	9.08	0.11	8.4	6.09	11	Physical	No	NoAddm	0	DGP; S/M; mod sorting; sulfidic
cd100n	c	ST_I	1	4	4 to 3	0	0	0.85	18.88	17.99	18.94	18.55	0.05	7.82	4.64	7	Biogenic	No	NoAddm	0	DGP; sulfidic; pelletal surface
cd100s	a	ST_I_ON_III	1	4	4 to 3	0	0	1.22	19.71	4.47	10.27	7.62	5.64	11.49	8.65	11	Physical	No	NoAddm	0	DGP;s/m; mod sorting; sulfidic
cd100s	b	ST_I_ON_III	1	4	3 to 2	3	0.75	1.28	19.63	9.04	13.56	11.64	5.21	10.8	7.72	11	Physical	No	NoAddm	0	DGP; S/m; moderate sorting; sufidic
cd100s	c	ST_I	1	4	4 to 3	20	0.17	0	13.14	6.56	13.23	12.91	0.16	12.23	7.01	7	Biogenic	No	NoAddm	0	s/m; wiper artifact; sulfidic
cd100w	a	ST_I_ON_III	2	4	4 to 3	2	0.37	1.06	11.06	10.53	11.59	11.06	7.56	10.79	9.42	11	Biogenic	No	NoAddm	0	DGP; RPD>Pen; mod sorted; pellatized surface
cd100w	b	ST_III	1	4	4 to 3	0	0	0.32	17.03	16.88	17.19	17.03	6.45	10	8.23	11	Biogenic	No	NoAddm	0	DGP; poorly sorted;s/m; sulfidic; ophiuroids
cd100w	c	ST_I	1	4	4 to 3	1	0.43	0.21	18.3	18.2	18.41	18.3	2.06	9.47	7.24	7	Biogenic	No	NoAddm	0	DGP; s/m; poorly sorted; sulfidic
cd200e	h	ST_I_ON_III	2	>4	4 to 3	1	1.45	0.64	20.32	19.79	20.75	20.53	1.93	6.26	5.3	11	Biogenic	No	Sulfides	14.87	DGP; s/m; sulfides
cd200e	I	ST_I_ON_III	2	>4	>4	0	0	1.07	18.77	18.13	19.36	18.76	4.22	9.36	7.54	11	Physical	No	NoAddm	10.86	DGP; s/m sulfides; wiper artifacts
cd200e	k	ST_I_ON_III	3	>4	>4	0	0	0.64	18.98	18.66	19.52	19.2	9.36	14.92	12.38	11	Biogenic	No	NoAddm	14.44	s/m; DGP; sulfides
cd200n	a	Indet	1	4	4 to 3	0	0	0	20.85	18.08	19.47	18.63	NA	NA	NA	IND	Indet	No	NoAddm	0	DGP; mod sorting; sulfidic
cd200n	b	Indet	1	4	>4	0	0	0	20.85	15	17.18	15.75	NA	NA	NA	IND	Indet	No	NoAddm	4.41	over pen DGP; mod sorting; sulfidic
cd200n	c	Indet	1	4	>4	0	0	0	20.8	8.88	14.41	11.85	NA	NA	NA	IND	Indet	No	NoAddm	0	over pen DGP; mod sorting; sulfidic
cd200s	a	ST_I_ON_III	2	>4	4 to 3	0	0	0.21	13.56	9.63	11.48	10.4	4.79	6.86	5.9	11	Biogenic	No	NoAddm	0	pelletal surface; DM flank deposit
cd200s	b	ST_I_ON_III	2	4	>4	3	0.8	1.69	11.59	0	0	0	3.28	8.62	5.94	11	Biogenic	No	NoAddm	0	well sorted; orphiuroids
cd200s	c	Indet	2	>4	>4	0	0	1.85	9.87	0	0	0	3.12	9.57	5.79	IND	Biogenic	No	NoAddm	0	brittle stars; well sorted
cd200w	a	ST_III	1	4	4 to 3	0	0	2.12	17.35	16.29	18.41	17.35	1.38	4.44	2.92	9	Indet	No	NoAddm	0	DGP; pelletized surface layer; sulfidic
cd200w	b	ST_I_ON_III	1	4	>4	0	0	0.74	18.89	18.51	19.26	18.89	0.16	6.72	4.26	11	Biogenic	No	NoAddm	0	DGP; mod sorted; wiper smear
cd200w	c	ST_I_ON_III	1	4	>4	1	2.35	1.64	12.35	11.53	13.17	12.35	1.22	6.14	4.38	11	Physical	No	NoAddm	0	DGP; reduced silt layer on surface; biogenic excavation?
cd300e	a	ST_I	3	4	>4	0	0	1.43	7.54	0	0	0	2.17	3.28	2.68	5	Physical	No	NoAddm	0	wiper smear of DM
cd300e	b	ST_I	2	>4	>4	0	0	1.22	13.15	0	0	0	0.69	4.92	4.01	7	Biogenic	No	NoAddm	0	mod sorting
cd300e	d	ST_I	2	4	3 to 2	0	0	1.32	7.7	0.21	2.75	2.07	1.75	3.33	2.65	5	Physical	No	NoAddm	0	piece of DM in ambient FG sand
cd300s	a	ST_III	2	>4	>4	0	0	1.38	9.57	0	0	0	2.96	6.45	5.43	11	Biogenic	No	NoAddm	0	well sorted; pelletal surface
cd300s	b	ST_I_ON_III	2	>4	>4	0	0	1.38	6.3	0	0	0	5.61	6.98	6.3	11	Biogenic	No	NoAddm	0	mod sorting; RPD>pen; pelletal surface
cd300s	c	ST_I_ON_III	2	4	4 to 3	0	0	2.38	8.7	0	0	0	3.23	8.09	6.51	11	Indet	No	NoAddm	0	mod sorting; foraging excav
cd300w	b	ST_I	2	4	>4	0	0	0.53	10.53	10.26	10.79	10.53	3.44	5.61	4.64	7	Biogenic	No	NoAddm	0	DGP; brittle star; sulfidic; Stage III?
cd300w	c	ST_I_ON_III	2	>4	>4	0	0	1.22	10.61	10	11.21	10.61	2.01	7.41	3.81	11	Indet	No	NoAddm	0	DGP; mod sorted; sulfidic
cd300w	d	ST_I_ON_III	2	4	>4	0	0	0.48	10.77	0	0	0	2.91	5.18	3.97	11	Biogenic	No	NoAddm	0	pellatized surface; ambient bottom; moderate sorting
cd300n	a	ST_III	4	1	3 to 2	0	0	0.21	20.74	20.74	20.74	20.74	2.39	5.74	3.98	7	Physical	No	NoAddm	0.64	over pen dm>pen, mod sort, sulfidic
cd300n	b	Indet	4	1	4 to 3	0	0	0.16	20.82	20.82	20.82	20.82	0.21	9.73	5.89	IND	Indet	No	NoAddm	0	over pen dm>pen, mod sort, sulfidic
cd300n	c	ST_III	4	1	>4	0	0	0	20.74	20.74	20.74	20.74	NA	NA	NA	IND	Indet	No	NoAddm	0	over pen dm>pen, mod sort, sulfidic, RPD>?
cd300n	e	ST_II_III	>4	3	4 to 3	0	0	0.74	4.13	0	0	0	0.83	2.28	1.6	3	Biogenic	No	NoAddm	0	Ambient
cd300n	f	ST_I	4	2	3 to 2	0	0	0.79	8.6	8.2	8.9	8.6	NA	NA	NA	IND	Biogenic	No	NoAddm	0	Disturbed surface
cdctr	a	ST_I_ON_III	0	4	3 to 2	0	0	1.76	7.85	6.93	8.46	7.79	3.39	7.99	6.27	11	Physical	No	NoAddm	0	
cdctr	b	ST_III	0	4	3 to 2	0	0	1.76	7.85	0.16	4.04	1.89	NA	NA	NA	IND	Physical	No	NoAddm	0	Surface/water shot
cdctr	c	ST_I	1	4	4 to 3	15	0.53	0.53	16.6	15.55	16.72	16.44	1.33	4.57	2.96	5	Physical	No	NoAddm	0	s/m; DGP; sulfidic

APPENDIX D

Appendix D1

Reference Area CCBRS REMOTS® Sediment-Profile Imaging Data from the May 1996 Survey

Station	Camera Penetration Mean (cm)	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
CR1	9.61	4.92	III	ST_III	>4	10.67	11	1.7
CR2	10.55	3.08	I,III	ST_III	>4	9.33	10	1.99
CR3	10.79	3.67	III	ST_III	>4	9.5	9.5	0.72
CR4	10.86	3.24	II,III	ST_III	>4	10	10	0.94
CR5	7.96	4.75	I,III	ST_III	>4	11	11	1.14
CR6	8.38	4.69	II,III	ST_III	>4	10.33	10	2.22
CR7	12.29	2.8	I,III	ST_I_ON_III	>4	9	8	0.86
CR8	11.16	5.35	I,II,III	ST_II_ON_III	>4	11	11	1.32
CR9	14.13	7.52	I,III	ST_III	>4	11	11	1.94
CR10	3.83	1.74	I,III	ST_III	>4	5.5	5.5	0.97
CR11	14.5	5.09	I,III	ST_III	>4	10.67	11	0.63
CR12	11.58	4.21	I,III	ST_III	>4	10.33	10	1.72
CR13	11.07	3.23	I,III	ST_III	>4	9.67	9	1.66
AVG	10.52	4.18				9.85	9.77	1.37
MAX	14.5	7.52				11	11	2.22
MIN	3.83	1.74				5.5	5.5	0.63

Appendix D2

CCBDS NW Reference Area REMOTS® Sediment-Profile Imaging Data from the May 1996 Survey

Station	Camera Penetration Mean (cm)	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
NW100E	9.96	1.83	I,III	ST_I_ON_III	>4	9	9	2.51
NW100N	11.00	5.09	I,III	ST_III	>4	9	9	3.05
NW100S	8.47	2.46	I,III	ST_III	>4	8.5	8.5	1.43
NW100W	9.46	3.8	I,II,III	ST_II_ON_III	>4	10.33	10	0.62
NW200E	9.91	3.19	I,III	ST_III	>4	9.67	11	1.67
NW200N	8.47	5.15	I,II,III	ST_II_ON_III	>4	9	11	1.99
NW200S	8.89	3.44	I,III	ST_III	>4	10	10	1.55
NW200W	9.27	3.39	I,II,III	ST_I_ON_III	>4	9.33	10	0.94
NW300E	12.06	7.07	I,III	ST_I_ON_III	>4	11	11	1.03
NW300N	7.74	4.81	I,II,III	ST_III	>4	10	11	0.81
NW300S	12.89	4.21	I,III	ST_I_ON_III	>4	10.67	11	1.21
NW300W	8.22	3.75	I,III	ST_I_ON_III	>4	10.5	10.5	0.82
NWCTR	10.97	5.61	I,III	ST_III	>4	8.33	7	1.11

AVG	9.79	4.14				9.64	9.92	1.44
MAX	12.89	7.07				11	11	3.05
MIN	7.74	1.83				8.33	7	0.62

Appendix D3

CCBDS SW Reference Area REMOTS® Sediment-Profile Imaging Data from the May 1996 Survey

Station	Camera Penetration Mean (cm)	RPD Mean (cm)	Successional Stages Present	Highest Stage Present	Grain Size Major Mode (phi)	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
SW100E	9.18	2.16	I,III	ST_I_ON_III	>4	7.33	8	0.78
SW100N	6.44	2.0	I,III	ST_I_ON_III	4 to 3	5.67	5	0.94
SW100S	9.84	2.55	I,III	ST_I_ON_III	>4	7.33	8	2.02
SW100W	9.55	2.13	I,III	ST_I_ON_III	>4	9.5	9.5	1.39
SW200E	8.75	3.19	I	ST_I	>4	5.5	5.5	1.66
SW200N	9.31	2.2	I,II,III	ST_III	>4	6	6	1.62
SW200S	9.79	3.32	I,III	ST_III	>4	7	5	0.6
SW200W	7.88	2.38	I,II,III	ST_I_ON_III	>4	6.67	8	1.43
SW300E	8.34	2.65	I,II,III	ST_I_ON_III	>4	7	7	2.33
SW300N	7.65	2.25	I,II,III	ST_II_ON_III	>4	8.5	8.5	2.52
SW300S	6.52	1.95	I,III	ST_I_ON_III	>4	7	7	1.07
SW300W	9.11	1.77	I,III	ST_I_ON_III	>4	5	5	0.88
SWCTR	7.37	3.17	II,III	ST_III	>4	10	10	1.89
AVG	8.44	2.44				7.12	7.12	1.47
MAX	9.84	3.32				10	10	2.52
MIN	6.44	1.77				5	5	0.6

INDEX