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13. ABSTRACT

The Central Long Island Sound Disposal Site (CLIS) was monitored as part of the Disposal Area Monitoring System (DAMOS) from 11 through 23 September 1999 aboard the M/V *Beavertail* and on 8 and 9 September 2000 aboard the R/V *Ocean Explorer*. The 1999 field operations consisted of single-beam bathymetry, as well as sediment-profile imaging surveys, over multiple disposal mounds and reference areas. The 1999 REMOTS® survey conducted at CLIS showed generally improving benthic conditions throughout the survey area. The 2000 data collection effort consisted of a precision multibeam bathymetric survey that provided full bottom coverage over an
8.6 km² area of seafloor encompassing CLIS. The 2000 multibeam data were compared against both the 1996 and 1999 single-beam bathymetric surveys to evaluate the consistency of the survey results and to detect changes in seafloor topography.

The 1999 REMOTS® over the active region of CLIS indicated substantial benthic recovery of the dredged material deposits with rapid recolonization of the most recently placed sediments comprising the 1997/98 Mound Complex. The benthic conditions showed continued improvement over the CLIS 95/96 Mound Complex relative the September 1997 monitoring survey. The NHAV 93 Mound, identified as having a decline in benthic community conditions in the 1997 monitoring survey, showed some improvement in the 1999 REMOTS® survey with somewhat deeper redox potential discontinuity (RPD) depths and higher organism-sediment index (OSI) values. NHAV 93 exhibited overall improved conditions in September 1999, with the exception of Station 200S that continued to demonstrate poor benthic habitat conditions, with lower than expected OSI values for a five-year old dredged material deposit. In addition, spatial variability was identified in the replicate photographs collected at Stations 200S, 200E, and 200W, which suggests an alternative management approach (i.e., cap augmentation) may be required along the fringes of the mound. The MQR Mound was formed during the 1981/82 and 1982/83 disposal seasons, with additional cap material placed during the 1993/94 disposal season. The September 1999 survey provided evidence of improved benthic conditions since the last monitoring event over this mound in July 1994. Additional monitoring may be required in the southern area of the MQR Mound, where low OSI values indicated slower benthic recovery at Stations 100S and 150S. The 1999 REMOTS® survey indicated healthy benthic conditions existed over the FVP Mound, with OSI values comparable to the nearby reference areas. However, since the long-term study of this uncapped deposit of unacceptably contaminated dredged material (UDM) has now been conducted for over 18 years, it is recommended that this mound be considered for future capping to isolate the UDM from the surrounding marine environment.

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EXECUTIVE SUMMARY

The Central Long Island Sound Disposal Site (CLIS) is one of the most active disposal sites in the New England region. Sediments deposited at CLIS have originated from major dredging projects in New Haven, Bridgeport, Stamford, and Norwalk Harbors, as well as numerous smaller harbors in the adjacent coastal areas. CLIS was monitored as part of the Disposal Area Monitoring System (DAMOS) from 11 through 23 September 1999 aboard the M/V *Beavertail* and on 8 and 9 September 2000 aboard the R/V *Ocean Explorer*. Prior to these survey efforts, the last DAMOS environmental monitoring survey was conducted at CLIS in September 1997. The purpose of this report is to provide a synthesis of the 1999 and 2000 survey results.

The 1999 field operations consisted of single-beam bathymetry, as well as sediment-profile imaging surveys, over multiple disposal mounds and reference areas. The bathymetry data were used to document changes in seafloor topography resulting from the placement of dredged sediments during the 1997–98 and 1998–99 disposal seasons. The sediment-profile images were used to map the distribution of dredged material on the seafloor and examine the benthic recolonization status over the recently formed CLIS 95/96 and CLIS 97/98 Mound Complexes. In addition, the images were utilized to assess benthic habitat conditions over the New Haven 1993 (NHAV 93) Mound center, as well as the historic Field Verification Project (FVP) and Mill-Quinnipiac River (MQR) Mounds relative to the three CLIS reference areas and the results of past monitoring surveys.

The 2000 data collection effort consisted of a precision multibeam bathymetric survey that provided full bottom coverage over an 8.6 km² area of seafloor. The 2000 multibeam survey at CLIS was used to develop a high-resolution master bathymetric data set for the entire disposal site that documents the effects of more than 25 years of dredged material deposition and provides a new baseline survey for future survey comparisons. Furthermore, these data were employed to map the distribution of dredged material deposited at the site during the 1999–2000 disposal season. The multibeam data confirmed the general findings from previous single-beam bathymetric surveys and highlighted numerous small-scale features throughout CLIS that were not detected previously in the single-beam data.

The 2000 multibeam data were compared against both the 1996 and 1999 single-beam bathymetric surveys to evaluate the consistency of the survey results and to detect changes in seafloor topography. These comparisons suggest that reasonable and consistent results can be obtained with both single-beam and multibeam bathymetric techniques. The depth difference comparisons showed the only significant seafloor changes in CLIS were the result of recent dredged material placement activity or disposal mound consolidation. In comparison to the 1996 bathymetric survey, changes in seafloor topography were noted over CLIS 95/96 and CLIS 97/98 Mound Complexes, as well as the CLIS 99 Mound.

In addition to the prominent positive depth differences associated with recently formed mounds, the results also showed some areas of negative depth differences that were evidence of the varying rates of disposal mound consolidation that occurred over multiple bottom features.

The 1999 REMOTS® survey conducted at CLIS showed generally improving benthic conditions throughout the survey area. The REMOTS® data over the active region of CLIS indicated substantial benthic recovery of the dredged material deposits with rapid recolonization over the most recently placed sediments. The benthic conditions showed continued improvement over the CLIS 95/96 Mound Complex relative to the September 1997 survey.

The NHAV 93 Mound, identified as having a decline in benthic community conditions in the 1997 monitoring survey, showed some improvement in the 1999 REMOTS® survey with somewhat deeper redox potential discontinuity (RPD) depths and higher organism-sediment index (OSI) values. This mound contains organic-rich sediments, which fosters increased sediment oxygen demand as the organic material within these sediments decomposes over time. Because of this high sediment oxygen demand, benthic recolonization tends to be impacted during summer low-dissolved oxygen events affecting the entire western and central Long Island Sound regions, when bottom water dissolved oxygen concentrations at CLIS decrease to levels between 5.0 and 3.0 $mg \cdot l^{-1}$. The presence of methane bubbles, a product of anaerobic decomposition of organics, in some of the REMOTS® images confirmed the elevated organic material content within the NHAV 93 capping sediments. It is anticipated that benthic conditions should improve over this mound with increased biological activity promoting further oxidation of the organic matter within the sediments.

NHAV 93 exhibited overall improved conditions in September 1999, with the exception of Station 200S that continued to demonstrate poor benthic habitat conditions, with lower than expected OSI values for a five-year old dredged material deposit. Spatial variability was identified in the replicate photographs collected at Stations 200S, 200E, and 200W, which suggests an alternative management approach (i.e., cap augmentation) may be required along the fringes of the mound.

The MQR Mound was formed during the 1981/82 and 1982/83 disposal seasons, with additional cap material placed during the 1993/94 disposal season. The September 1999 survey provided evidence of improved benthic conditions since the last monitoring event over this mound in July 1994. Additional monitoring may be required in the southern area of the MQR Mound, where low OSI values indicated slower benthic recovery at Stations 100S and 150S.

The 1999 REMOTS® survey indicated healthy benthic conditions existed over the FVP Mound, with OSI values comparable to the nearby reference areas. However, since the long-term study of this uncapped deposit of unacceptably contaminated dredged material (UDM) has now been conducted for over 18 years, it is recommended that this mound be considered for future capping to isolate the UDM from the surrounding marine environment.

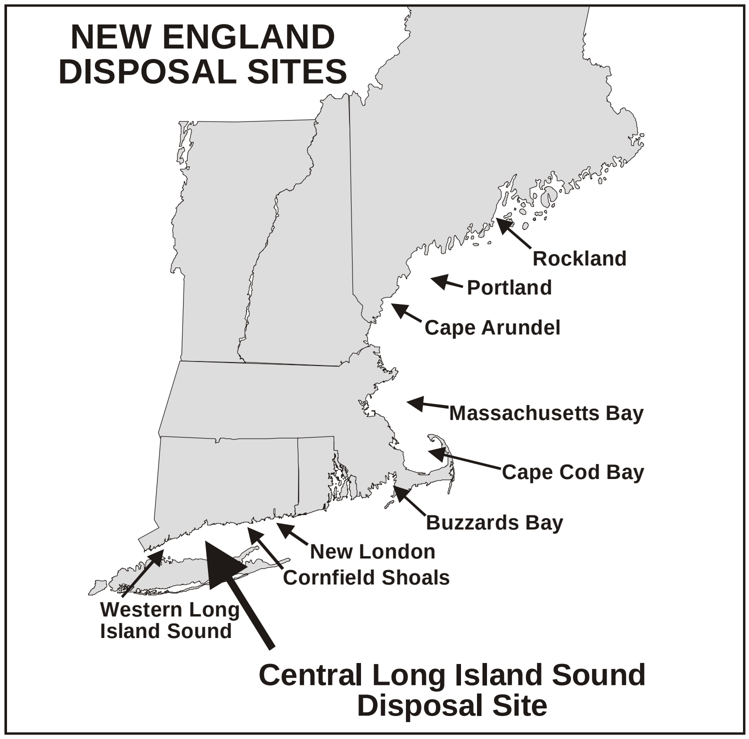
1.0 INTRODUCTION

1.1 Background

The New England District (NAE) of the U.S. Army Corps of Engineers regulates all coastal dredging operations from Eastport, Maine to Byram, Connecticut. In 1977, the Disposal Area Monitoring System (DAMOS) was developed in response to the recognized need for the managed disposal of the volumes of sediment dredged from the ports and harbors of the northeastern United States. The DAMOS Program currently manages ten closely monitored open water disposal sites along coastal New England (Figure 1-1A). These sites are utilized for the cost-effective and environmentally sound disposal of dredged material from the New England and New York Districts (Long Island, Westchester County).

The Central Long Island Disposal Site (CLIS) is one of four regional dredged material disposal sites located in the waters of Long Island Sound (Figure 1-1A). CLIS covers a 6.86 km^2 (2 nmi^2) area centered at 41°08.905´ N, 72°53.073´ W (NAD 83). It is located approximately 10.4 km (5.6 nmi) south of South End Point, East Haven, Connecticut (Figure 1-2). Historically, CLIS has been one of the most active disposal sites in the New England region (Figure 1-1B). Sediments deposited at CLIS have originated from dredging projects in New Haven, Bridgeport, Stamford, and Norwalk Harbors, as well as numerous smaller harbors in the adjacent coastal areas. Since 1982, this site has received nearly 5.3 million cubic meters of sediment, as well as been subject to comprehensive monitoring activity to ensure that the impacts associated with this dredged material placement are minimal (Figure 1-3).

The management strategy at CLIS entails the controlled placement of small to moderate volumes of sediment to form individual deposits or mounds on the seafloor. These discrete disposal mounds are monitored individually to assess mound stability, material thickness, and benthic recolonization status relative to the results of previous monitoring surveys and in comparison to nearby reference areas. Beginning in 1984, this management strategy was modified to include the selection of dredged material placement locations in a manner that would promote the development of rings of disposal mounds. This approach creates a network of mounds, which form artificial containment cells on the seafloor that facilitate subsequent large-scale confined aquatic disposal (CAD) operations. Containment cells tend to limit the lateral spread of unacceptably contaminated dredged material (UDM) and facilitate efficient coverage with capping dredged material (CDM; Fredette 1994).



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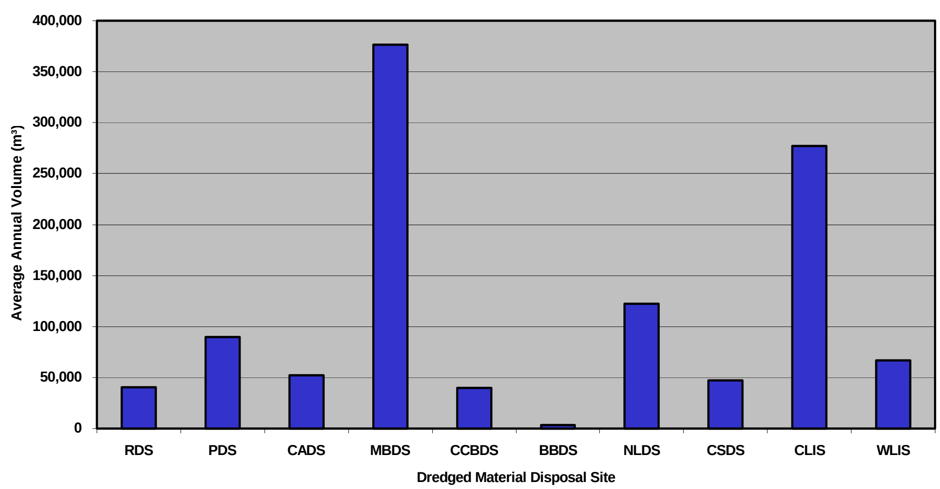

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Figure 1-1. Location of the ten regional disposal sites along the coast of New England regularly monitored by the DAMOS Program (A) and average annual dredged material disposal volumes for the ten New England disposal sites based on the period 1982 to 2000 (B)

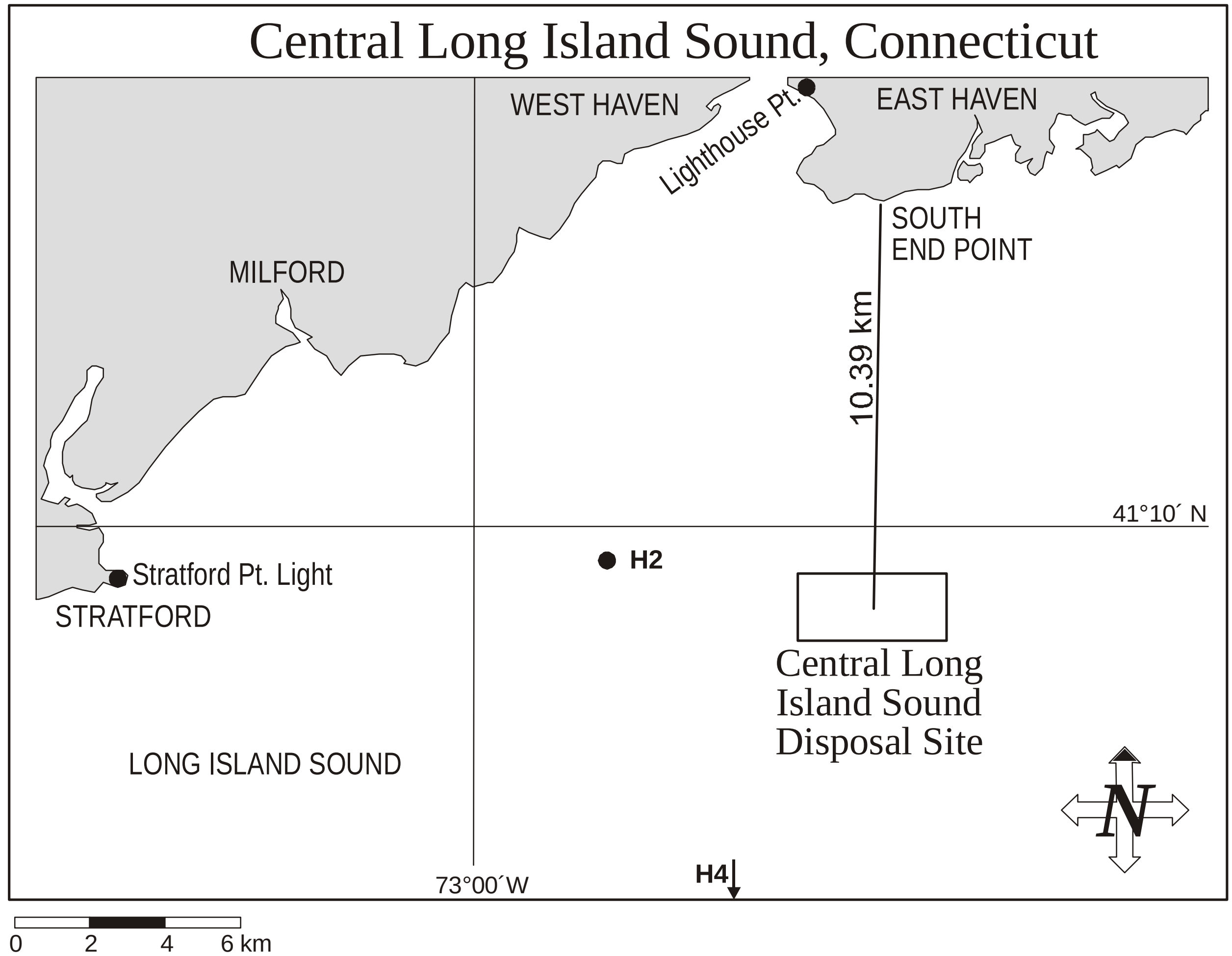


Figure 1-2. Location of the Central Long Island Sound Disposal Site relative to the Connecticut shoreline and shore station benchmarks. The locations of water quality stations H2 and H4 sampled by the Connecticut Department of Environmental Protection also are shown.

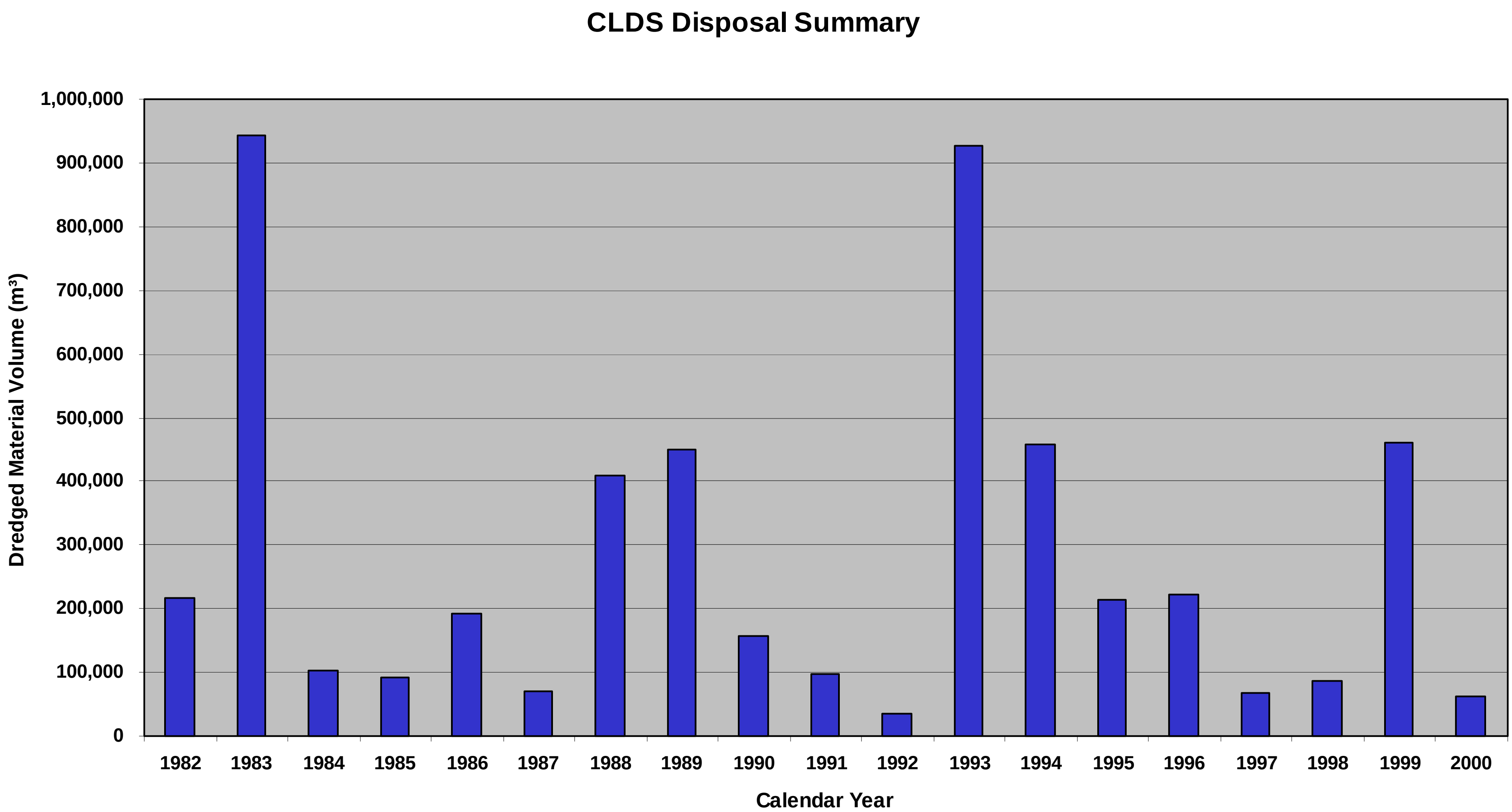


Figure 1-3. Histogram displaying reported volume of dredged material placed at the Central Long Island Sound Disposal Site between 1982 and 2000

The development of the New Haven 1993 (NHAV 93) Mound during the 1993–94 disposal season documented the overall success of this artificial containment cell strategy. From 1984 to 1993, placement of small to moderate volumes of dredged material was controlled to create a ring of disposal mounds to form the first containment cell in the northwestern quadrant of CLIS. During the 1993–94 disposal season, approximately 590,000 m^3 of UDM dredged from the inner New Haven Harbor was deposited within the center of this containment cell. The UDM deposit was then capped to a thickness of 0.5 m to 1.0 m with 569,000 m^3 of CDM, yielding a CDM to UDM ratio of 0.96:1.0 (Morris and Tufts 1997). Based on subsequent monitoring surveys, the completed NHAV 93 Mound was found to be broad, stable, and adequately capped. In the past, CDM to UDM ratios have varied from 2:1 to 6:1 when the capping operations were conducted on a flat or gently sloping area of seafloor. The successful strategy employed within the CLIS containment cell resulted in the formation of the first capped disposal mound composed of a smaller volume of CDM than the underlying UDM deposit (Morris et al. 1996).

Science Applications International Corporation (SAIC) conducted two environmental monitoring surveys at CLIS as part of the 1999/2000 effort. The first survey, from 11 September through 23 September 1999, was a comprehensive field effort documenting the changes in seafloor topography within the active areas of CLIS. As part of this field effort, single-beam bathymetry and REMOTS® sediment-profile imaging surveys were performed over several recent and historic disposal mounds to map the distribution of dredged material on the seafloor and examine trends in benthic recolonization relative to the nearby reference areas. In September 2000, a multibeam bathymetry survey was completed over an 8.6 km^2 area over and around CLIS, yielding complete coverage of the disposal site seafloor (Figure 1-4). The multibeam data confirmed the general findings from previous single-beam bathymetric surveys regarding dredged material distribution and disposal mound morphology. In addition, the high-resolution data set highlighted numerous small-scale features throughout CLIS that were not detected previously in the single-beam data. This report summarizes the findings of the September 1999 and September 2000 data collection efforts over CLIS. Before the 1999 survey, the last full-scale environmental monitoring survey was conducted at CLIS in September 1997 (Figure 1-5). The following sections provide background details about the various disposal mounds surveyed in 1999 and 2000.

1.2 CLIS 99 Mound

The CLIS 99 mound is a bottom feature resulting from the disposal of a moderate volume of dredged material at CLIS during the 1999–2000 disposal season. In September 1999, a disposal buoy identified as CDA 99 was deployed at 41°09.162´ N, 72°52.638´ W (NAD 83) between the historic Stamford-New Haven North (STNH-N)

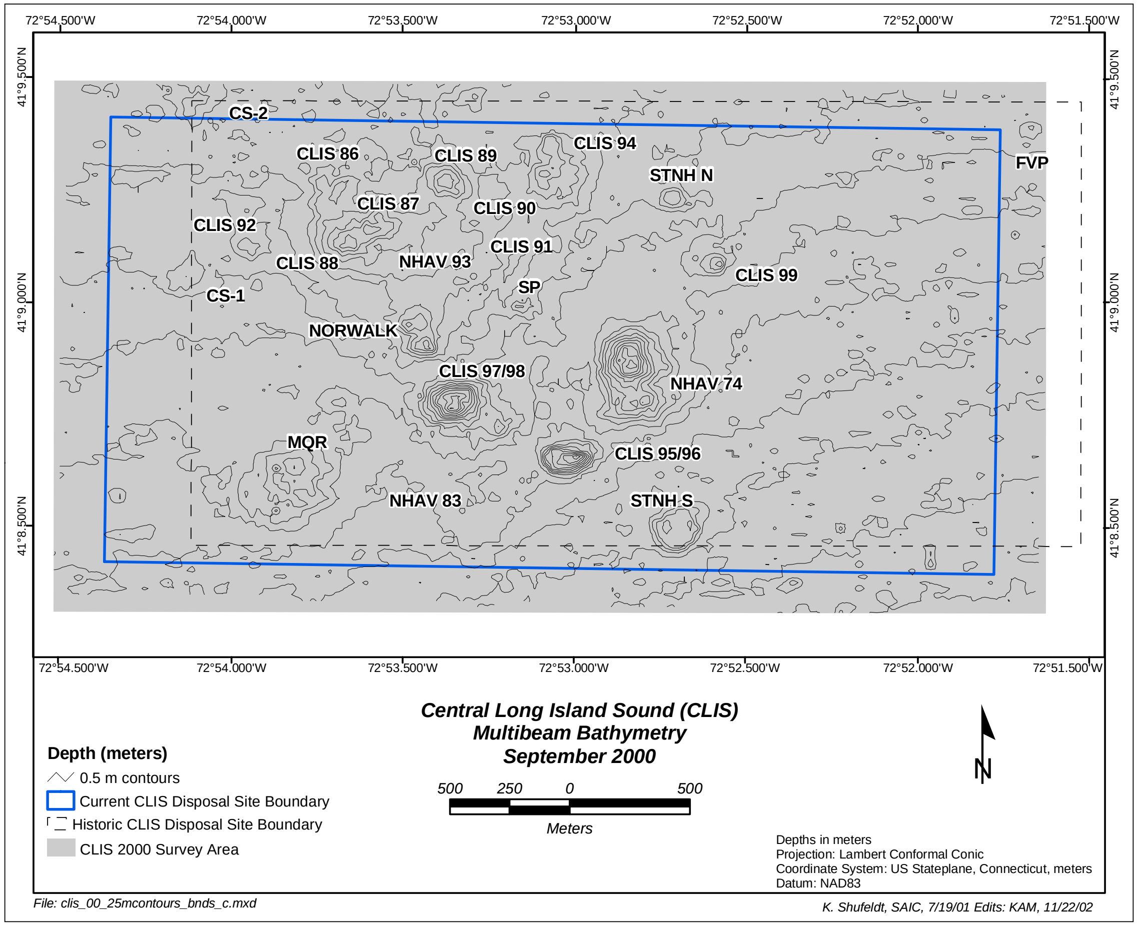


Figure 1-4. Bathymetric chart of the 8.6 km² multibeam bathymetric survey area over CLIS showing the general morphology and location of the various dredged material mounds constructed within the confines of the disposal site. The solid blue line represents the current disposal site boundary, while the dashed line denotes the historic boundary.

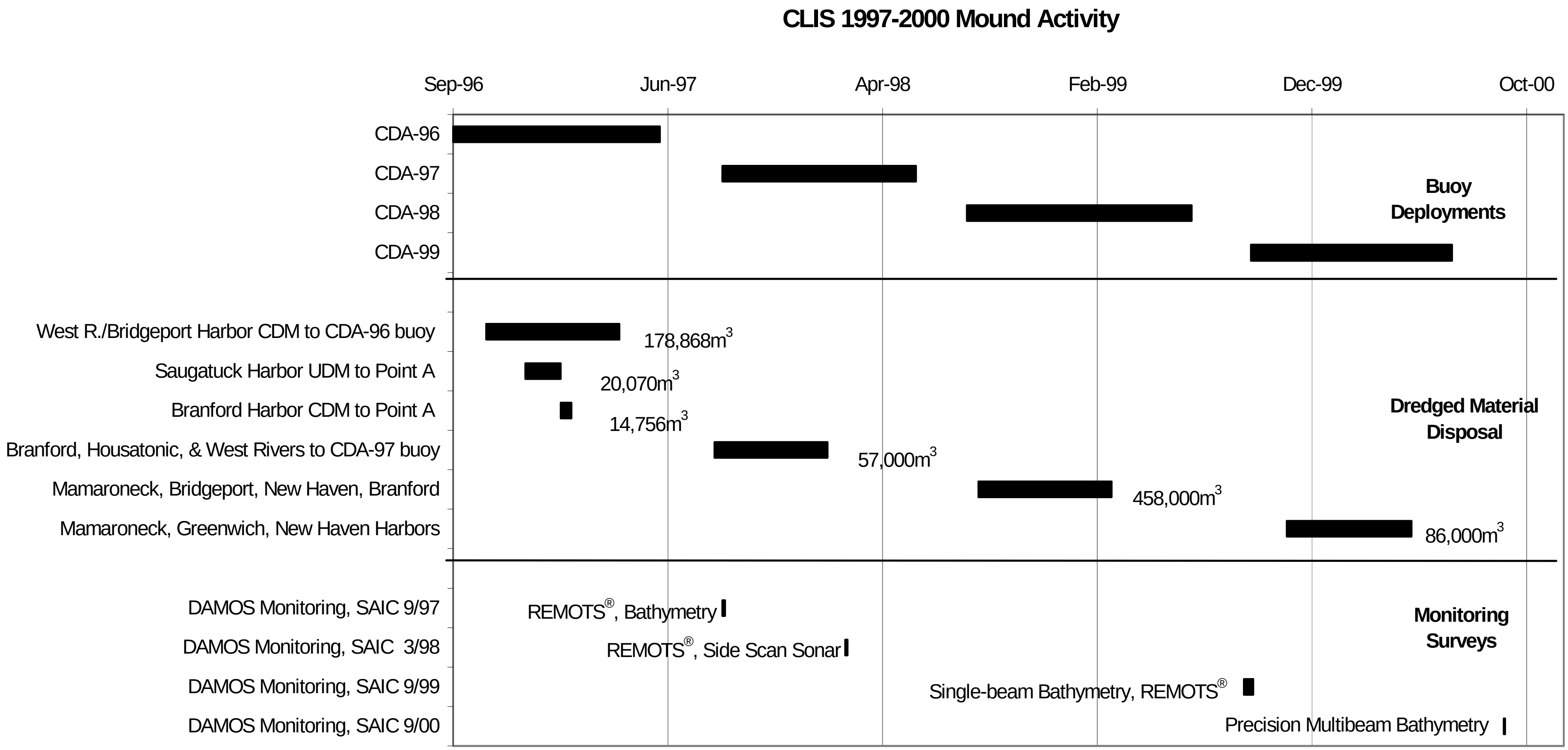


Figure 1-5. Timeline of dredged material placement and environmental monitoring activity at the Central Long Island Sound Disposal Site between 1997 and 2000

and New Haven 1974 (NHAV 74) disposal mounds (Figure 1-6). An estimated barge volume of 86,000 m^3 of sediments dredged from various small-scale projects in New Haven Harbor, Mamaroneck Harbor, Housatonic River, West River, and Greenwich Harbor were deposited at the CDA 99 buoy (Appendix A1). The resulting disposal mound (CLIS 99) was apparent in the September 2000 multibeam survey, but no data pertaining to benthic recolonization have been acquired to date over the CLIS 99 Mound (Figure 1-3).

1.3 CLIS 97/98 Mound Complex

The CLIS 97/98 Mound Complex is an example of a bottom feature formed over multiple disposal seasons. In September 1997, a disposal buoy identified as CDA 97 was deployed at 41°08.736' N, 72°53.213' W (NAD 83), roughly 300 m northwest of the pre-existing CLIS 95/96 Mound complex (Figure 1-6). An estimated barge volume of 57,000 m^3 of sediments from various small-scale dredging projects in the Branford, Housatonic, and West Rivers were disposed at the CDA 97 buoy to form a modest disposal mound (Appendix A2). No bathymetric survey operations were performed at the conclusion of the 1997–98 disposal season to document mound development (Figure 1-3).

In September 1998, the CDA 98 buoy was deployed at 41°08.785' N, 72°53.378' W (NAD 83), 250 m northwest of the CDA 97 buoy position (Figure 1-6). Approximately 460,000 m^3 of material removed from Mamaroneck Harbor in New York, and Bridgeport, New Haven, and Branford Harbors in Connecticut was transported to CLIS and deposited at the CDA 98 buoy (Figure 1-5; Appendix A3). The results presented in this report indicate that the relatively large volume of material deposited at the CDA 98 buoy formed a distinct disposal mound on the CLIS seafloor. The formation of the CLIS 97/98 Mound Complex completes a second containment cell that can be used for a future large-scale CAD project.

1.4 CLIS 95/96 Mound Complex

The CLIS 95/96 Mound Complex is another example of a bottom feature developed over multiple disposal seasons. Deposition of sediment during the 1995–96 disposal season resulted in a small, capped mound originally identified as the CLIS 95 Mound (Morris 1998). From September through October 1995, an estimated barge volume of 16,300 m^3 of UDM removed from Milford and Bridgeport Harbors was deposited at the CDA 95 buoy located at 41°08.666' N, 72°53.015' W (NAD 83) approximately 450 m southwest of the historic NHAV 74 Mound apex (Figure 1-6). Capping operations commenced on 30 October 1995 and continued through 4 March 1996. A total of 50,100 m^3 of CDM generated from dredging projects in the West River

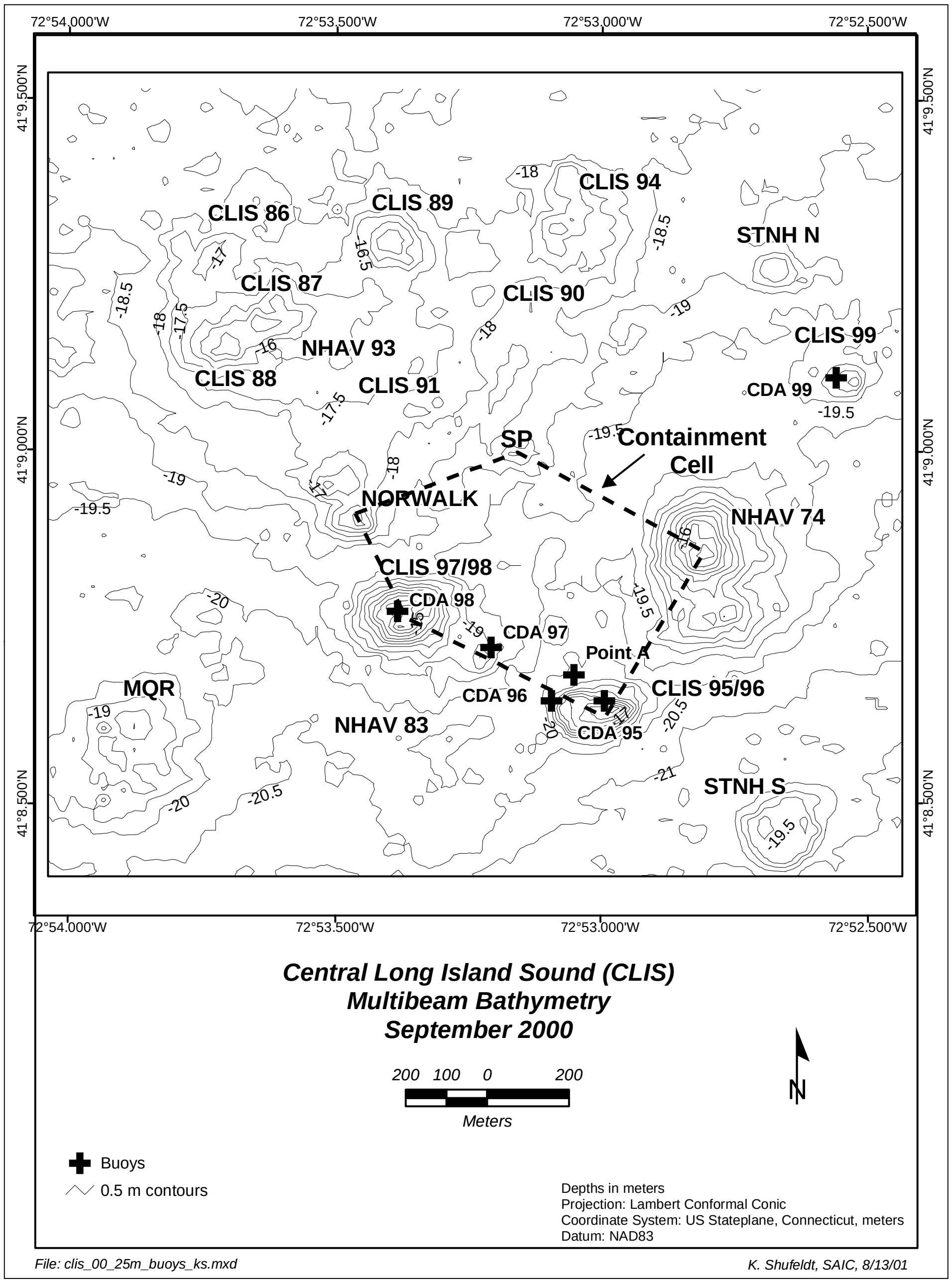


Figure 1-6. Bathymetric chart of the 2100 × 2100 m analysis area over CLIS with plotted DAMOS disposal buoy positions for the 1995-96, 1996-97, 1997-98, 1998-99, and 1999-2000 disposal seasons relative to the existing disposal mounds, September 2000 bathymetry, 0.5 m contour interval

and Bridgeport Harbor was used to completely isolate the UDM deposit, yielding a CDM to UDM ratio of 3.1:1.0 (Morris 1998).

The following year, CLIS 95 was enlarged on the west and northwest sides of the mound by material deposited from additional capping projects to form the CLIS 95/96 complex. In September 1996, the CDA 96 buoy was deployed at 41°08.672' N, 72°53.106' W (NAD 83) approximately 130 m west of the CLIS 95 Mound apex (Figure 1-6). An estimated barge volume of 62,000 m^3 of UDM followed by 193,600 m^3 of CDM was placed at the CDA 96 buoy, as well as a secondary disposal point. A survey performed in September 1997 indicated that the UDM within the complex was completely capped and isolated from the environment and that benthic recolonization over the CLIS 95/96 complex was rapid (Figure 1-4; SAIC 2002).

1.5 NHAV 93 Mound

As stated above, the NHAV 93 Mound is a capped mound constructed during the 1993–94 disposal season. Follow-on monitoring surveys performed near the center of the NHAV 93 Mound have shown a pattern of cyclical recovery and decline of benthic habitat conditions over the surface of the mound, roughly corresponding to the seasonal hypoxia patterns in the central Long Island Sound region. In addition, these survey efforts have attributed the variations in conditions to elevated levels of labile organics, as well as the onset and severity of seasonal hypoxia. Sediment profile images collected over NHAV 93 in the past have displayed degraded benthic habitat conditions during the summer months, with the expectation that the surface sediments will become less susceptible to the effects of seasonal hypoxia over time. The September 1999 survey provided another opportunity to examine the long-term recovery of NHAV 93.

1.6 MQR Mound

The Mill-Quinnipiac River (MQR) Mound is a historic capped mound formed along the southern boundary of CLIS during the 1981–82 and 1982–83 disposal seasons (Figure 1-4). Recommendations for additional cap material were made based on the results of environmental monitoring surveys performed between 1983 and 1992 (Murray 1996). Supplemental cap material from various dredging projects was placed at MQR during the 1993–94 disposal season. A REMOTS® sediment-profile imaging survey and sediment chemistry testing in July 1994 confirmed that the UDM was isolated by the supplemental CDM (Morris and Tufts 1997). A follow-up sediment-profile imaging survey was conducted over this mound as part of the September 1999 monitoring effort to assess the status of benthic recolonization and habitat quality relative to previous survey efforts.

1.7 FVP Mound

The Field Verification Program (FVP) was a joint research effort between NAE and the U.S. Environmental Protection Agency (EPA) to study the environmental impacts associated with various methods of dredged material disposal. The FVP Mound is a historic mound composed of 55,000 m^3 of UDM dredged from Black Rock Harbor and placed in the northeast corner of CLIS in 1983 as part of this program (Figure 1-4). The disposal mound was left uncapped and now serves as a "negative control" in order to observe recolonization rates and stability within the benthic community. Apart from the original FVP study, additional monitoring surveys have been performed in 1991, 1993, and 1995 to document trends in benthic habitat quality. In 1995, a chronic negative response was confirmed, with the FVP Mound showing generally poor benthic habitat conditions and increased susceptibility to benthic disturbance (i.e., seasonal hypoxia).

1.8 CLIS Reference Areas

As part of the DAMOS monitoring protocols, reference area data are collected to provide a baseline against which the results from the dredged material mounds are compared. These areas are free of dredged material and are used to characterize the existing ambient conditions within the central Long Island Sound region during the period that monitoring operations are being conducted. In the past, natural (i.e., hypoxia) and/or anthropogenic (i.e., trawling activity) disturbances found within the reference areas have been an important consideration in the interpretation of the monitoring data within CLIS.

1.9 Objectives and Predictions

The objectives of the September 1999 monitoring survey were to:

- Map the distribution of dredged material deposited at the site during the 1997–98 and 1998–99 disposal seasons
- Examine the benthic recolonization status over the CLIS 95/96 and CLIS 97/98 Mound Complexes
- Assess the benthic habitat conditions over the historic NHAV 93, FVP, and MQR mounds relative to the three CLIS reference areas and results of previous monitoring efforts

The September 1999 survey tested the following predictions:

1) The dredged material placed during the 1997–98 and 1998–99 disposal seasons will result in the formation of one bottom feature, creating a second containment cell on the CLIS seafloor.

2) The sediments of the CLIS 97/98 Mound Complex will be supporting an abundant Stage I population with advancement to Stage II and III over much of the mound. The CLIS 95/96 Mound Complex will be supporting an advanced benthic infaunal community with Stage III organisms present in relative abundance.

3) Several stations over the NHAV 93 Mound will demonstrate increased stress on the benthic community consistent with the cyclical patterns of benthic habitat recovery and decline detected in previous surveys. The FVP Mound is expected to show moderate to poor benthic habitat conditions, confirming the chronic response documented in the 1980s and 1990s. The MQR mound is expected to be supporting a stable and healthy benthic community with advanced successional seres dominating the surficial sediments.

The objectives of the 2000 high-resolution multibeam survey were to:

1) Use multibeam survey technology to develop a high-resolution master bathymetric survey over the entire 8.6 km^2 survey area

2) Investigate the presence and document the morphology of various small-scale features on the CLIS seafloor that may not have been detected by prior single-beam bathymetry

The September 2000 bathymetric survey tested the following predictions:

1) Seafloor features associated with dredged material placement will be contained within the current and/or historic boundaries of the disposal site.

2) The high-resolution and complete bottom coverage of the multibeam bathymetry data will provide information on the existence of many small-scale bottom features typically excluded from single-beam survey results.

2.0 METHODS

2.1 1999 Field Operations

2.1.1 Single-Beam Bathymetric Survey

In order to fulfill the objectives of the 1999 CLIS monitoring survey, a bathymetric survey area was defined to examine both the CLIS 95/96 and CLIS 97/98 Mound Complexes. The September 1999 bathymetric survey occupied a 1000 × 1000 m area over CLIS, centered at 41°08.990' N, 72°53.272' W (NAD 27) [41°08.996' N, 72°53.245' W (NAD 83)]. A total of 41 survey lanes at 25 m lane spacing was required to delineate the topography of the two mound complexes (Figure 2-1). Detailed bathymetric charts were generated for the 1.0 km^2 survey area to accurately quantify the mound height, the lateral spread of dredged material, and consolidation.

In order to provide strong comparisons with previous CLIS data sets, bathymetric data were collected with the use of SAIC's Portable Integrated Navigation and Survey System (PINSS). This system utilizes a Toshiba 3200 series computer to provide real-time navigation, as well as collect position, depth, and time data for later analysis. A Del Norte Trisponder® System provided positioning data to an accuracy of ±3 m in the horizontal control of North American Datum of 1927 (NAD 27). Shore stations were established along the Connecticut coast at the known benchmarks of Stratford Point (41°09.112' N, 72°06.227' W) and Lighthouse Point (41°14.931' N, 72°54.255' W) (Figure 1-2). A detailed description of the navigation system and its operation can be found in the DAMOS Navigation and Bathymetry Reference Report (Murray and Selvitelli 1996).

2.1.2 Single-Beam Bathymetry Data Collection and Processing

An ODOM DF3200 Echotrac® Survey Fathometer with a narrow beam, 208 kHz transducer measured individual depths to a resolution of 3.0 cm (0.1 ft.) as described in the DAMOS Navigation and Bathymetry Reference Report (Murray and Selvitelli 1996). For the 1999 CLIS survey, data from the National Oceanic and Atmospheric Administration (NOAA) tide station in Bridgeport Harbor, CT (8467150) were used for generating tidal correctors. The NOAA 6-minute tide data were downloaded in the Mean Lower Low Water (MLLW) datum, adjusted to local time, and then corrected for tidal differences based on the entrance to New Haven Harbor, CT.

A Seabird Instruments, Inc. SEACAT SBE 19-01 Conductivity, Temperature, and Depth (CTD) probe was used to obtain sound velocity measurements at the start, midpoint, and end of each survey day. The data collected by the CTD probe were bin-averaged to

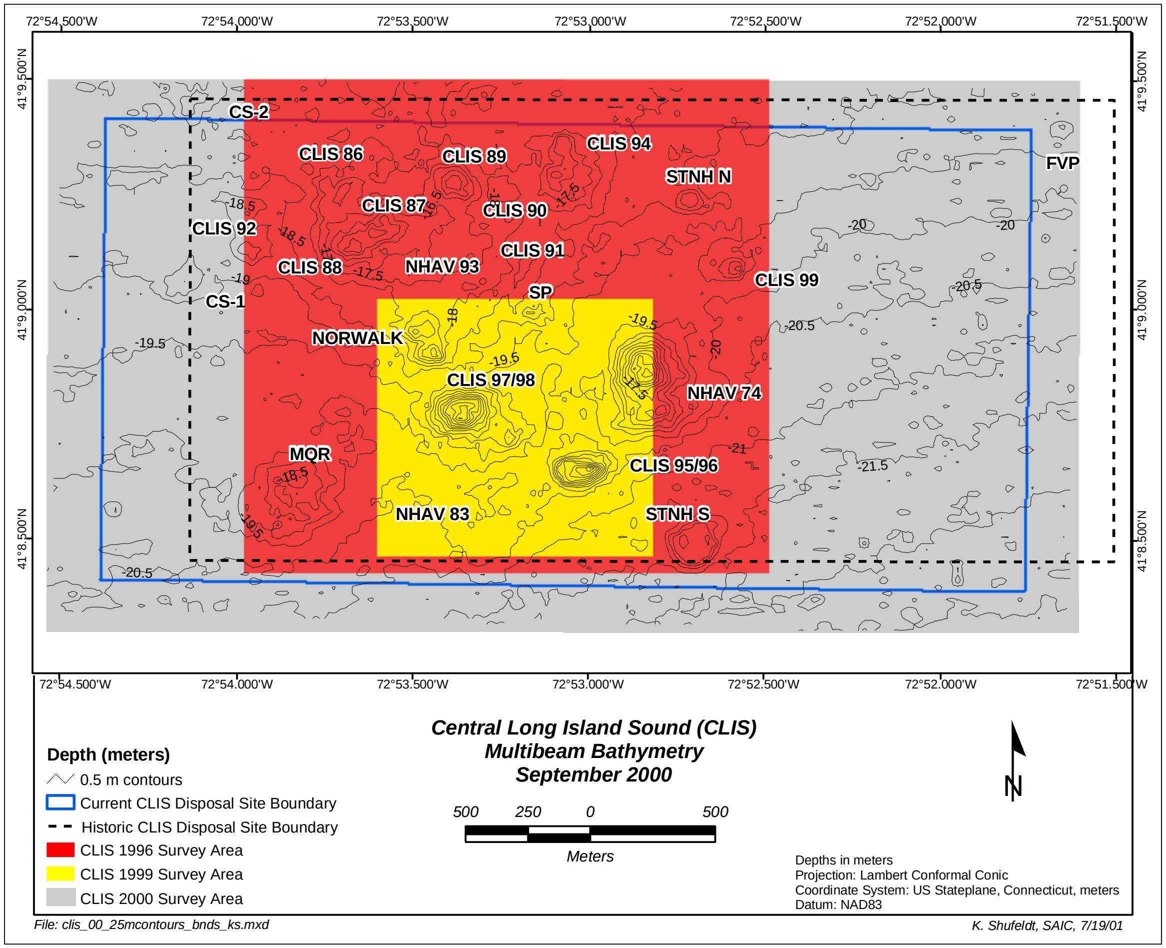


Figure 2-1. Configuration of the 1996 (red), 1999 (yellow), and 2000 (gray) bathymetric survey areas relative to the current (blue) and historic (dashed) disposal site boundaries and existing disposal mounds on the CLIS seafloor

one-meter depth intervals to account for any pycnoclines, rapid changes in density that create distinct layers within the water column. Sound velocity correction factors were then calculated using the bin-averaged values.

The bathymetric data were analyzed using SAIC's Hydrographic Data Analysis System (HDAS), Version 1.03. Raw bathymetric data were imported into HDAS, corrected for sound velocity, and standardized to mean lower low water using the NOAA observed tides. The bathymetric data were then used to construct depth models of the surveyed area. A detailed discussion of the bathymetric analysis technique is provided in the DAMOS Bathymetry and Navigation Reference Report (Murray and Selvitelli 1996).

2.1.3 REMOTS® Sediment-Profile Imaging Survey

Remote Ecological Monitoring of the Seafloor (REMOTS®) is a benthic sampling technique used to detect and map the distribution of thin ($<$20 cm) dredged material layers, map benthic disturbance gradients, and monitor the process of benthic recolonization at dredged material disposal mounds. 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 2-2). 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 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). OSI values may range from −10 (azoic with low sediment dissolved oxygen and/or the 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 based on the apparent RPD depth, successional status, and any indicators of sediment methane or low sediment oxygen. Standard 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).

In order to maximize the efficiency of survey operations at CLIS, differential Global Positioning System (DGPS) data in conjunction with SAIC's PINSS were used to position the survey vessel over the September 1999 REMOTS® camera stations. A Trimble 4000 DSi GPS receiver and a Trimble NavBeacon XL differential beacon receiver provided

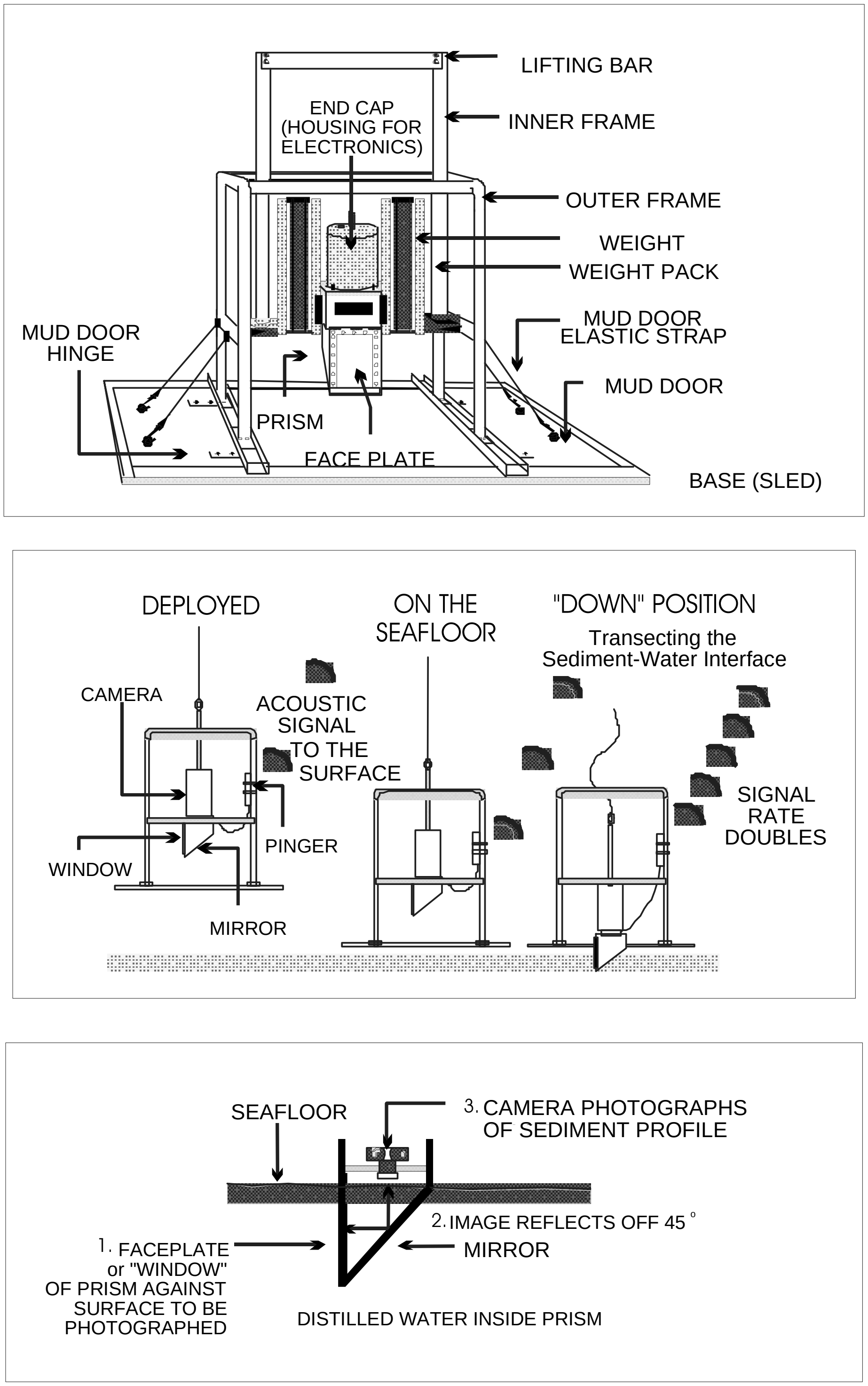


Figure 2-2. Schematic diagram of a Benthos Inc. Model 3731 REMOTS® sediment-profile camera and sequence of operation on deployment

DGPS positioning data to PINSS in the horizontal control of North American Datum of 1983 (NAD 83) to an accuracy of ±5 m. The U.S. Coast Guard beacon broadcasting from Moriches, NY (293 kHz) was used for satellite corrections due to its geographic position relative to CLIS. The target REMOTS® station locations were calculated in NAD 27, then converted to NAD 83 for real-time navigation with the use of the U.S. Army Topographic Engineering Center's CORPSCON version 4.12.

The 1999 REMOTS® survey at CLIS was used to characterize sediment composition, benthic recolonization status, and general habitat conditions over several mounds (CLIS 95/96, CLIS 97/98, NHAV 93, MQR, and FVP) at the disposal site (Figure 2-3). Three reference areas surrounding CLIS (CLISREF, 4500E, 2500W) were also sampled to provide adequate comparison between the habitat qualities of the disposal mounds relative to conditions within the ambient sediment (Figure 2-3). Where feasible, the 1999 REMOTS® sampling stations were established to correspond with stations sampled during earlier (1996 and 1997) REMOTS® survey efforts. Three replicate photographs were collected at each station for analysis and comparison with previous data sets.

A composite grid consisting of 57 stations spaced 100 m apart, referred to as the CLIS 95-98 grid, covered both the CLIS 97/98 and CLIS 95/96 Mound Complexes, as well as the "mound apron" area surrounding both bottom features (Figure 2-4; Table 2-1). The standard cross-shaped grids over mound centers usually employed for DAMOS monitoring were not used due to significant overlap of stations. Stations were assigned based on a system of rows and columns analogous to a rectangular survey grid (Figure 2-4). This composite grid was successful at maximizing spatial coverage over the recent dredged material deposits, while minimizing station overlap.

The REMOTS® survey performed over the NHAV 93 mound was centered at 41°09.128' N, 72°53.426' W (NAD 83), and consisted of five stations with station spacing at 200 m over a cross-shaped grid (Figure 2-3; Table 2-2). The other historic mounds (FVP and MQR) were surveyed using a traditional 13-station cross-grid, duplicating previous monitoring efforts. The FVP sampling grid was centered at 41°09.396' N, 72°51.723' W (NAD 83), and the MQR grid was centered at 41°08.643' N, 72°53.832' W (NAD 83; Figure 2-3; Table 2-2).

Data from three reference areas (2500W, 4500E, and CLISREF) were used for comparison of ambient central Long Island Sound sediments relative to the sediments deposited at CLIS through disposal operations. Reference areas 2500W (41°09.260' N, 72°55.542' W) and 4500E (41°09.260' N, 72°50.538' W) were sampled at four randomly

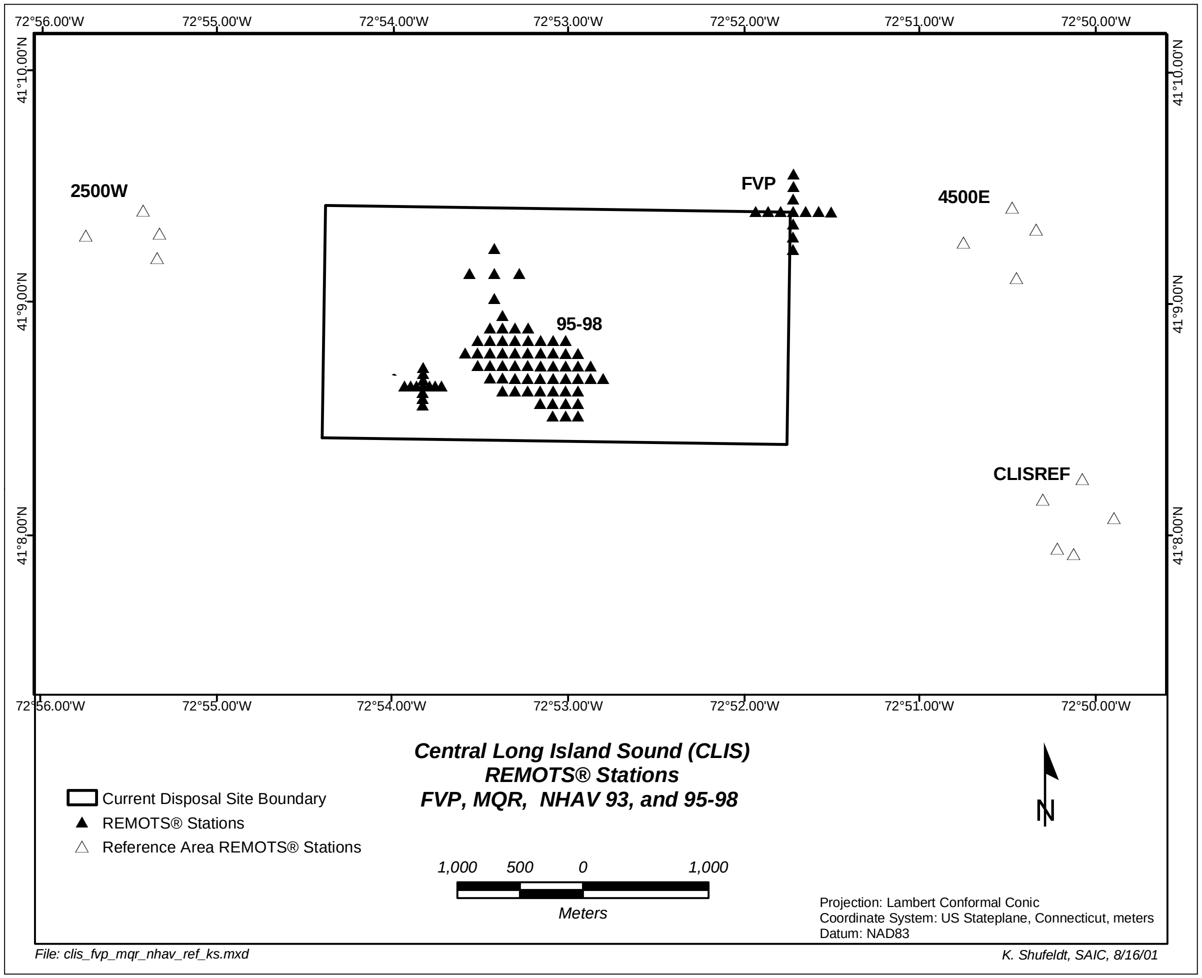


Figure 2-3. REMOTS® sediment-profile photography stations occupied over the NHAV 93, MQR, and FVP Mounds, as well as the CLIS Reference Areas (2500W, 4500E, and CLISREF) during the September 1999 survey

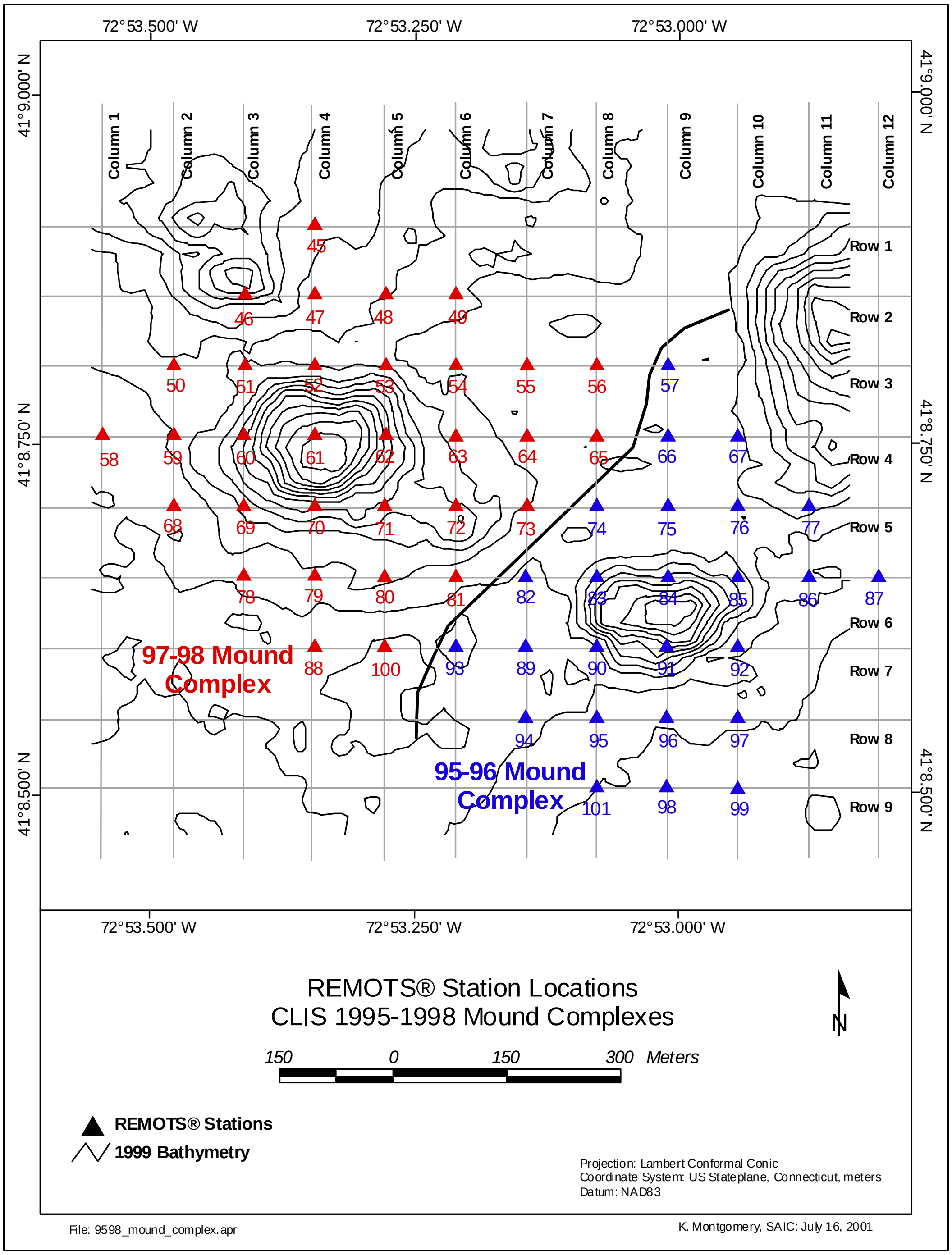


Figure 2-4. Distribution of the 1999 REMOTS® sediment-profile photography stations over the CLIS 97/98 and CLIS 95/96 Mound Complexes

Table 2-1.

REMOTS® Station Locations over the CLIS 95/96 and CLIS 97/98 Mound Complexes

Area	Station Grid	Station Number	Latitude	Longitude	Latitude	Longitude
CLIS 95-98 Grid	R - Row C - Column		NAD 83		NAD 27	
	R1C4	45	41° 08.947´ N	72° 53.378´ W	41° 08.941´ N	72° 53.405´ W
	R2C3	46	41° 08.893´ N	72° 53.449´ W	41° 08.887´ N	72° 53.476´ W
	R2C4	47	41° 08.893´ N	72° 53.378´ W	41° 08.887´ N	72° 53.405´ W
	R2C5	48	41° 08.893´ N	72° 53.306´ W	41° 08.887´ N	72° 53.333´ W
	R2C6	49	41° 08.893´ N	72° 53.235´ W	41° 08.887´ N	72° 53.262´ W
	R3C2	50	41° 08.839´ N	72° 53.520´ W	41° 08.833´ N	72° 53.548´ W
	R3C3	51	41° 08.839´ N	72° 53.449´ W	41° 08.833´ N	72° 53.476´ W
	R3C4	52	41° 08.839´ N	72° 53.378´ W	41° 08.833´ N	72° 53.405´ W
	R3C5	53	41° 08.839´ N	72° 53.306´ W	41° 08.833´ N	72° 53.333´ W
	R3C6	54	41° 08.839´ N	72° 53.235´ W	41° 08.833´ N	72° 53.262´ W
	R3C7	55	41° 08.839´ N	72° 53.163´ W	41° 08.833´ N	72° 53.190´ W
	R3C8	56	41° 08.839´ N	72° 53.092´ W	41° 08.833´ N	72° 53.119´ W
	R3C9	57	41° 08.839´ N	72° 53.020´ W	41° 08.833´ N	72° 53.047´ W
	R4C1	58	41° 08.785´ N	72° 53.592´ W	41° 08.779´ N	72° 53.619´ W
	R4C2	59	41° 08.785´ N	72° 53.520´ W	41° 08.779´ N	72° 53.548´ W
	R4C3	60	41° 08.785´ N	72° 53.449´ W	41° 08.779´ N	72° 53.476´ W
	R4C4	61	41° 08.785´ N	72° 53.378´ W	41° 08.779´ N	72° 53.405´ W
CLIS 97/98	R4C5	62	41° 08.785´ N	72° 53.306´ W	41° 08.779´ N	72° 53.333´ W
	R4C6	63	41° 08.785´ N	72° 53.225´ W	41° 08.779´ N	72° 53.262´ W
	R4C7	64	41° 08.785´ N	72° 53.163´ W	41° 08.779´ N	72° 53.190´ W
	R4C8	65	41° 08.785´ N	72° 53.092´ W	41° 08.779´ N	72° 53.119´ W
	R4C9	66	41° 08.785´ N	72° 53.020´ W	41° 08.779´ N	72° 53.047´ W
	R4C10	67	41° 08.785´ N	72° 52.949´ W	41° 08.779´ N	72° 52.976´ W
	R5C2	68	41° 08.731´ N	72° 53.520´ W	41° 08.725´ N	72° 53.548´ W
	R5C3	69	41° 08.731´ N	72° 53.449´ W	41° 08.725´ N	72° 53.476´ W
	R5C4	70	41° 08.731´ N	72° 53.378´ W	41° 08.725´ N	72° 53.405´ W
	R5C5	71	41° 08.731´ N	72° 53.306´ W	41° 08.725´ N	72° 53.333´ W
	R5C6	72	41° 08.731´ N	72° 53.235´ W	41° 08.725´ N	72° 53.262´ W
	R5C7	73	41° 08.731´ N	72° 53.163´ W	41° 08.725´ N	72° 53.190´ W
	R6C3	78	41° 08.677´ N	72° 53.449´ W	41° 08.671´ N	72° 53.476´ W
	R6C4	79	41° 08.677´ N	72° 53.378´ W	41° 08.671´ N	72° 53.405´ W
	R6C5	80	41° 08.677´ N	72° 53.306´ W	41° 08.671´ N	72° 53.333´ W
	R6C6	81	41° 08.677´ N	72° 53.235´ W	41° 08.671´ N	72° 53.262´ W
	R6C7	82	41° 08.677´ N	72° 53.163´ W	41° 08.671´ N	72° 53.190´ W
	R7C4	88	41° 08.623´ N	72° 53.378´ W	41° 08.617´ N	72° 53.405´ W
	R7C5	100	41° 08.623´ N	72° 53.306´ W	41° 08.617´ N	72° 53.333´ W
	R5C8	74	41° 08.731´ N	72° 53.092´ W	41° 08.725´ N	72° 53.119´ W
	R5C9	75	41° 08.731´ N	72° 53.020´ W	41° 08.725´ N	72° 53.047´ W
	R5C10	76	41° 08.731´ N	72° 52.949´ W	41° 08.725´ N	72° 52.976´ W
	R5C11	77	41° 08.731´ N	72° 52.877´ W	41° 08.725´ N	72° 52.905´ W
	R6C8	83	41° 08.677´ N	72° 53.092´ W	41° 08.671´ N	72° 53.119´ W
	R6C9	84	41° 08.677´ N	72° 53.020´ W	41° 08.671´ N	72° 53.047´ W
	R6C10	85	41° 08.677´ N	72° 52.949´ W	41° 08.671´ N	72° 52.976´ W
CLIS 95/96	R6C11	86	41° 08.677´ N	72° 52.877´ W	41° 08.671´ N	72° 52.905´ W
	R6C12	87	41° 08.677´ N	72° 52.806´ W	41° 08.671´ N	72° 52.833´ W
	R7C6	93	41° 08.623´ N	72° 53.235´ W	41° 08.617´ N	72° 53.262´ W
	R7C7	89	41° 08.623´ N	72° 53.163´ W	41° 08.617´ N	72° 53.190´ W
	R7C8	90	41° 08.623´ N	72° 53.092´ W	41° 08.617´ N	72° 53.119´ W
	R7C9	91	41° 08.623´ N	72° 53.020´ W	41° 08.617´ N	72° 53.047´ W
	R7C10	92	41° 08.623´ N	72° 52.949´ W	41° 08.617´ N	72° 52.976´ W
	R8C7	94	41° 08.569´ N	72° 53.163´ W	41° 08.563´ N	72° 53.190´ W
	R8C8	95	41° 08.569´ N	72° 53.092´ W	41° 08.563´ N	72° 53.119´ W
	R8C9	96	41° 08.569´ N	72° 53.020´ W	41° 08.563´ N	72° 53.047´ W
	R8C10	97	41° 08.569´ N	72° 52.949´ W	41° 08.563´ N	72° 52.976´ W
	R9C8	101	41° 08.515´ N	72° 53.092´ W	41° 08.509´ N	72° 53.119´ W
	R9C9	98	41° 08.515´ N	72° 53.020´ W	41° 08.509´ N	72° 53.047´ W
	R9C10	99	41° 08.515´ N	72° 52.949´ W	41° 08.509´ N	72° 52.976´ W

Table 2-2.

REMOTS® Station Locations over the Historic Disposal Mounds

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)	Area	Station	Latitude (NAD 27)	Longitude (NAD 27)
	CTR	41° 09.128´ N	72° 53.426´ W		CTR	41° 09.122´ N	72° 53.453´ W
NHAV 93	200N	41° 09.236´ N	72° 53.426´ W	NHAV 93	200N	41° 09.230´ N	72° 53.453´ W
41º 09.128´ N	200S	41° 09.020´ N	72° 53.426´ W	41º 09.122 N	200S	41° 09.014´ N	72° 53.453´ W
72º 53.426´ W	200E	41° 09.128´ N	72° 53.283´ W	72º 53.453´ W	200E	41° 09.122´ N	72° 53.310´ W
	200W	41° 09.128´ N	72° 53.569´ W		200W	41° 09.122´ N	72° 53.596´ W
	CTR	41° 09.396´ N	72° 51.723´ W		CTR	41° 09.390´ N	72° 51.750´ W
	100N	41° 09.450´ N	72° 51.723´ W		100N	41° 09.444´ N	72° 51.750´ W
	200N	41° 09.504´ N	72° 51.723´ W		200N	41° 09.498´ N	72° 51.750´ W
	300N	41° 09.558´ N	72° 51.723´ W		300N	41° 09.552´ N	72° 51.750´ W
FVP	100S	41° 09.342´ N	72° 51.723´ W	FVP	100S	41° 09.336´ N	72° 51.750´ W
41º 09.396´ N	200S	41° 09.288´ N	72° 51.723´ W	41º 09.390´ N	200S	41° 09.282´ N	72° 51.750´ W
72º 51.723´ W	300S	41° 09.234´ N	72° 51.723´ W	72º 51.750´ W	300S	41° 09.228´ N	72° 51.750´ W
	100E	41° 09.396´ N	72° 51.651´ W		100E	41° 09.390´ N	72° 51.679´ W
	200E	41° 09.396´ N	72° 51.580´ W		200E	41° 09.390´ N	72° 51.607´ W
	300E	41° 09.396´ N	72° 51.508´ W		300E	41° 09.390´ N	72° 51.536´ W
	100W	41° 09.396´ N	72° 51.794´ W		100W	41° 09.390´ N	72° 51.821´ W
	200W	41° 09.396´ N	72° 51.866´ W		200W	41° 09.390´ N	72° 51.893´ W
	300W	41° 09.396´ N	72° 51.937´ W		300W	41° 09.390´ N	72° 51.964´ W
	CTR	41° 08.643´ N	72° 53.832´ W		CTR	41° 08.637´ N	72° 53.859´ W
	50E	41° 08.643´ N	72° 53.796´ W		50E	41° 08.637´ N	72° 53.823´ W
	100E	41° 08.643´ N	72° 53.761´ W		100E	41° 08.637´ N	72° 53.788´ W
	150E	41° 08.643´ N	72° 53.725´ W		150E	41° 08.637´ N	72° 53.752´ W
MQR	50N	41° 08.670´ N	72° 53.832´ W	MQR	50N	41° 08.664´ N	72° 53.859´ W
41º 08.643´ N	100N	41° 08.697´ N	72° 53.832´ W	41º 08.637´ N	100N	41° 08.691´ N	72° 53.859´ W
72º 53.832´ W	150N	41° 08.724´ N	72° 53.832´ W	72º 53.859´ W	150N	41° 08.718´ N	72° 53.859´ W
	50S	41° 08.616´ N	72° 53.832´ W		50S	41° 08.610´ N	72° 53.859´ W
	100S	41° 08.589´ N	72° 53.832´ W		100S	41° 08.583´ N	72° 53.859´ W
	150S	41° 08.562´ N	72° 53.832´ W		150S	41° 08.556´ N	72° 53.859´ W
	50W	41° 08.643´ N	72° 53.868´ W		50W	41° 08.637´ N	72° 53.895´ W
	100W	41° 08.643´ N	72° 53.903´ W		100W	41° 08.637´ N	72° 53.930´ W
	150W	41° 08.643´ N	72° 53.939´ W		150W	41° 08.637´ N	72° 53.966´ W

selected stations. CLISREF (41°08.091' N, 72°50.082' W; NAD 83) was sampled at five stations, four of which were randomly selected stations (Figure 2-3; Table 2-3).

2.2 2000 Multibeam Bathymetric Survey

Since its inception in 1977, the DAMOS Program has utilized single-beam bathymetry as a primary monitoring tool to document changes in seafloor topography resulting from the deposition of dredged sediments. Using one acoustic transducer, depth measurements are collected along a series of tightly spaced (25 meters), parallel survey lines to yield multiple depth profiles within a survey area. Because single-beam bathymetry typically covers only a small percentage of the total seafloor area (less than 5%), a large degree of interpolation between survey lines is required to generate a representation of the seafloor. As a result, single-beam bathymetry products (e.g., 3-D surface models and contour plots) have the potential to distort smaller features that may have only been detected by a few data points along a single track-line. Additionally, any small features that happen to fall entirely between survey lines will not be detected at all.

In 1998, multibeam bathymetry was introduced to the DAMOS Program for use at disposal sites with rocky and irregular bottom topography (i.e., Portland Disposal Site and Cape Arundel Disposal Site) in order to obtain a more accurate representation of the seafloor. Multibeam bathymetric survey systems employ a specialized transducer array comprised of multiple, narrow acoustic beams that are capable of completely ensonifying an area that is up to seven times the surrounding water depths. For example, in water depths of 20 m, a multibeam survey line can provide full bottom coverage over a swath of up to 140 m. The swath coverage provided by the multibeam systems allows higher resolution surveys to be completed in a shorter amount of time. A detailed explanation pertaining to multibeam bathymetry and the configuration of the survey system employed at CLIS during the September 2000 survey is presented in Appendices B through D.

2.2.1 Survey Area

The September 2000 multibeam bathymetric survey performed at CLIS consisted of 48 primary survey lines run over an 8.6 km^2 rectangular-shaped area (Figure 2-1). The survey lines were each 4100 m in length, oriented in the east/west direction (91° azimuth) and spaced at 45 m intervals to provide greater than 150% sounding coverage of the seafloor. The survey lines covered both the historical site boundaries (depicted by black dotted lines) and the current disposal site boundaries (represented by solid blue line; Figure 2-1). Three cross-lines, 2150 m in length, were run at an azimuth of 182° to serve as reference checks to the processed multibeam data.

Table 2-3.

REMOTS® Locations over the CLIS Reference Areas

Area	Station	Latitude	Longitude	Area	Station	Latitude	Longitude
		NAD 83				NAD 27	
	STA 1	41° 09.288´ N	72° 55.753´ W		STA 1	41° 09.282´ N	72° 55.780´ W
2500W	STA 2	41° 09.397´ N	72° 55.428´ W	2500W	STA 2	41° 09.391´ N	72° 55.456´ W
41° 09.260´ N	STA 3	41° 09.191´ N	72° 55.348´ W	41° 09.254´ N	STA 3	41° 09.185´ N	72° 55.375´ W
72° 55.542´ W	STA 4	41° 09.296´ N	72° 55.333´ W	72° 55.569´ W	STA 4	41° 09.290´ N	72° 55.360´ W
	STA 5	41° 09.112´ N	72° 50.451´ W		STA 5	41° 09.106´ N	72° 50.478´ W
4500E	STA 6	41° 09.416´ N	72° 50.475´ W	4500E	STA 6	41° 09.411´ N	72° 50.503´ W
41° 09.260´ N	STA 7	41° 09.266´ N	72° 50.752´ W	41° 09.254´ N	STA 7	41° 09.026´ N	72° 50.780´ W
72° 50.538´ W	STA 8	41° 09.321´ N	72° 50.339´ W	72° 50.565´ W	STA 8	41° 09.031´ N	72° 50.367´ W
	STA 9	41° 08.245´ N	72° 50.075´ W		STA 9	41° 08.239´ N	72° 50.103´ W
CLISREF	STA 10	41° 07.923´ N	72° 50.124´ W	CLISREF	STA 10	41° 07.917´ N	72° 50.151´ W
41° 08.091´ N	STA 11	41° 08.159´ N	72° 50.300´ W	41° 08.085´ N	STA 11	41° 08.153´ N	72° 50.327´ W
72° 50.082´ W	STA 12	41° 08.079´ N	72° 49.895´ W	72° 50.109´ W	STA 12	41° 08.073´ N	72° 49.922´ W
	STA 13	41° 07.945´ N	72° 50.216´ W		STA 13	41° 07.939´ N	72° 50.244´ W

2.2.2 Survey Vessel Positioning

The R/V *Ocean Explorer* was used as the survey platform for multibeam survey operations conducted at CLIS. This specialized survey vessel is specifically designed and outfitted for high speed (~11 knots) swath bathymetry data collection. Precision navigation, helmsman display, and data integration from the multitude of sensors aboard the survey vessel were accomplished with the use of SAIC's Integrated Survey System 2000 (ISS-2000). Real-time navigation, data time tagging, and data logging were controlled by the ISS-2000 in a Windows NT 4.0 environment.

Positioning information was recorded from multiple independent Global Positioning System (GPS) receiver networks in the North American Datum of 1983 (NAD 83). Two linked GPS receivers embedded within a TSS POS/MV 320, 3-axis Inertial Motion compensation Unit (IMU) were used as the primary source for vessel position and attitude correctors applied to the multibeam data. The POS/MV IMU was interfaced with a Trimble Probeacon Differential Beacon Receiver to improve the positioning data to an accuracy of ±5 m. Correctors to the satellite information broadcast from the U.S. Coast Guard differential station at Moriches, NY (293 kHz) were applied to the satellite data. The ISS-2000 monitored horizontal dilution of precision (HDOP; quality of the signal); number of satellites, elevation of satellites, and age of correctors to ensure the resulting bathymetric positioning errors did not exceed five meters at the 95% confidence level.

2.2.3 Multibeam System Configuration

A RESON 8101 shallow water, multibeam system was employed for the acquisition of sounding data over the CLIS survey area. The RESON 8101 was mounted on the keel of the survey vessel, and utilizes 101 individual narrow beam (1.5°) transducers capable of yielding a total swath coverage of 150° (75° per side). Acoustic returns from the seafloor are detected by the transducer array and raw depth values are transmitted to the RESON 6042 topside control unit. The RESON 6042 then applies a series of real-time corrections (i.e., sound velocity, attitude, predicted tides, draft, squat, etc.) to the raw soundings before transmitting them to the ISS-2000 for position stamps and data storage.

The quality and accuracy of the multibeam data (particularly in the outer beams) is highly dependent upon the precise measurement of the position, motion, and attitude of the survey vessel (e.g., heading, heave, pitch, and roll). Real-time heading and attitude compensation were accomplished in the multibeam system based on the data output by the POS/MV GPS-aided inertial navigation system. The POS/MV heading, heave, pitch, and roll data were transferred to the RESON 6042, which applied corrections to the raw soundings before they were transmitted to the ISS-2000 and stored for post processing.

Density profiles were obtained at approximately two-hour intervals during the CLIS survey in order to document changing water column characteristics. A Brooke Ocean Technology Ltd., Moving Vessel Profiler-30 (MVP) sound velocity profiling system was used to determine water column speed of sound. After examining the records, the data are sent to the RESON 6042 topside control unit. Within the RESON 6042, a beam refraction model was computed from the speed of sound data, and beam angle correctors are applied to the raw multibeam sounding data received from the RESON 8101 transducer.

Raw soundings collected by the RESON 8101 multibeam system reference depth values to the transducer mounted on the underside of the survey vessel. At the beginning and end of each survey day, static draft measurements were made on the port and starboard sides of the survey vessel. Static draft values were applied to the raw soundings as well as correctors based on settlement and squat of the survey vessel will in motion.

2.2.4 Tidal Corrections

For the 2000 CLIS survey, data from the NOAA tide station in Bridgeport Harbor, CT (8467150) were used for generating final tidal correctors. The NOAA 6-minute tide data were downloaded in the MLLW datum, adjusted to local time, and then corrected for tidal differences based on the entrance to New Haven Harbor, CT. The local tide zone correctors applied to the Bridgeport tide data were +2 minutes for time difference and 98% for height.

3.0 RESULTS

3.1 September 2000 Master Bathymetric Survey

The 4100 × 2100 m multibeam bathymetric survey depicted the seafloor topography of CLIS at the resolution of 1 m^2. The survey extended approximately 200 m beyond the current disposal site boundaries to incorporate two mounds originally developed within the historic disposal site boundaries (CS-2 and FVP; Figure 3-1). Water depths over the survey area ranged from a minimum of 13.9 m over the CLIS 97/98 Mound Complex to a maximum of 23.6 m in the southeast corner of the survey area. Based on the high-resolution depth model, a total of 22 man-made bottom features (disposal mounds and mound complexes) are readily visible within the region. In general, the multibeam September 2000 survey confirmed the findings of the previous single-beam bathymetric surveys.

By applying hill shading and color to the 1 × 1 m grid, small-scale seafloor features become apparent in the swath bathymetry (Figure 3-2). Many small-scale, circular features with a vertical relief of 10 cm to 20 cm are noticeable within the multibeam data set. These features are concentrated over and around each dredged material disposal mound and each represents an individual disposal event. The relatively new bottom features (CLIS 99 and CLIS 97/98) display a high concentration of these disposal features. In contrast, these same features are less pronounced over the surface of the older mounds (NHAV 74, STNH-N), suggesting a gradual reduction in relief over time. The larger rings (~100 m in diameter) are attributable to material deposited by large 3,050 m^3 to 4,600 m^3 barges, while the smaller rings (~50 m in diameter) are likely the result of material deposited via smaller 380 m^3 barges. Small rings that seem to be linked are likely the products of sequential pockets being opened on the drifting disposal barges. Similar features have been seen in other swath data (i.e., side-scan sonar) obtained over many disposal sites in New England waters.

In addition to the small, circular features associated with past disposal activity, many long, narrow bottom features were also visible in the hill-shaded bathymetry (Figure 3-2). Previously identified in side-scan sonar and sub-bottom profile data acquired by the U.S. Geological Survey (USGS), the furrows were reported to have an average width of 9.2 m and average relief of 0.4 m. These longitudinal features are oriented along a west-southwest to east-northeast axis and are a naturally occurring feature thought to result from tidal and storm-induced, near-bottom currents in Long Island Sound (Poppe et al.1998). Although CLIS is located in a depositional environment, these sedimentary furrows are the result of gradual sediment transport. The normally weak bottom-current regimes in the region suggest these furrows are only intermittently active (Knebel et al. 1999,

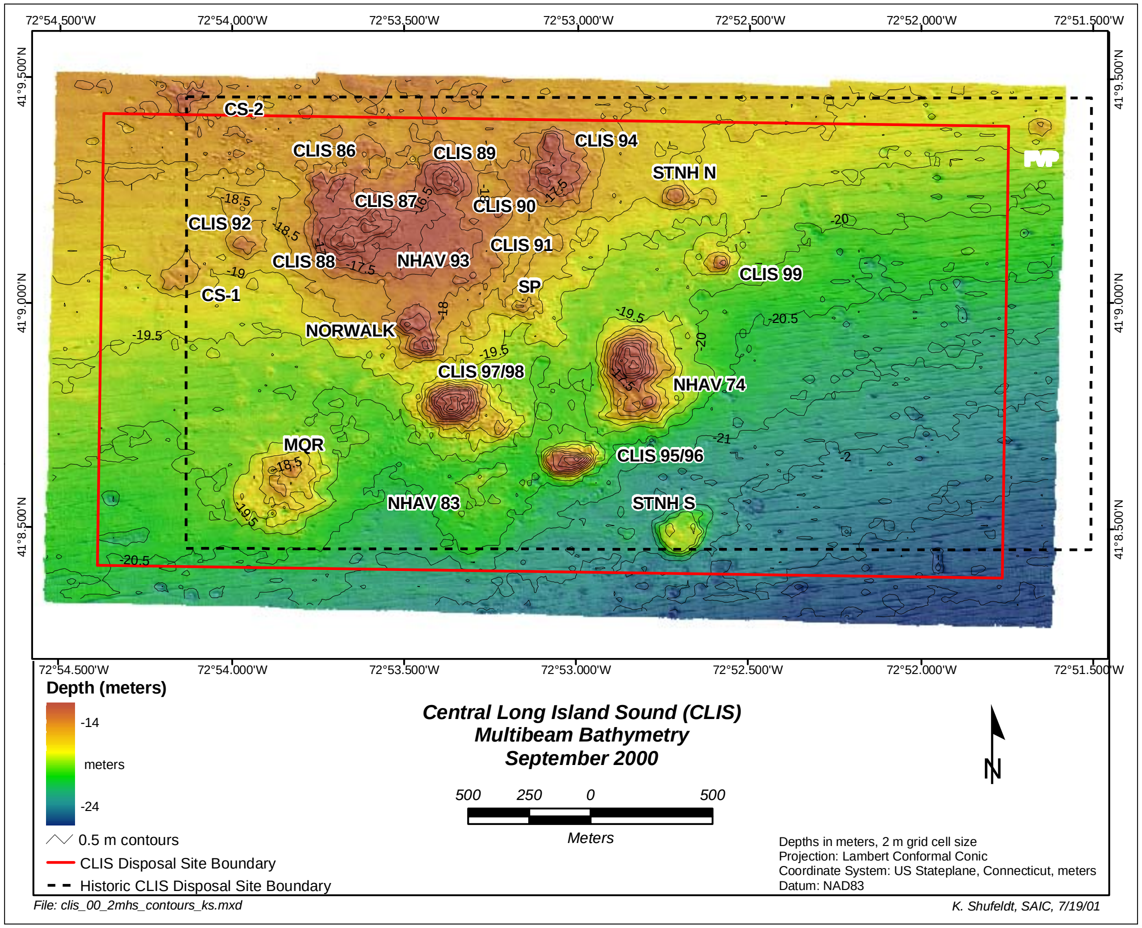


Figure 3-1. Bathymetric chart of the 4100 × 2100 m multibeam survey area occupied in September 2000, relative to the current (red) and historic (dashed) disposal site boundaries and existing disposal mounds on the CLIS seafloor, 0.5 m contour interval

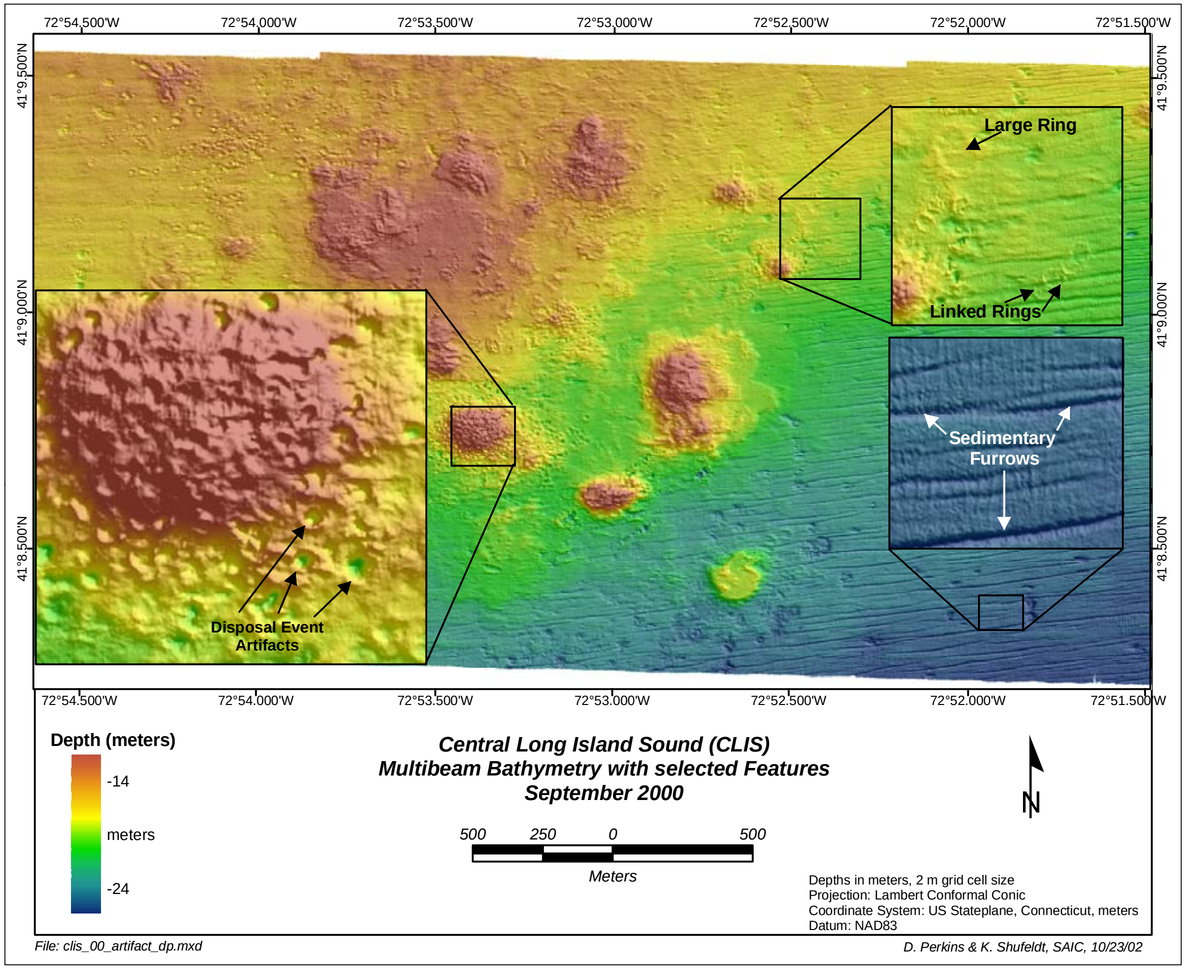


Figure 3-2. Colored and hill shaded bathymetry displaying various types of small-scale features visible within the high-resolution multibeam data set

Signell et al. 1998). Furthermore, the absence of these features in areas of CLIS subjected to dredged material disposal indicates they require a significant amount of time to form.

Depth difference comparisons made between the new 2000 master bathymetric survey and the 1996 single-beam survey documented the formation of several disposal mounds on the CLIS seafloor. In order to facilitate this comparison, the 2000 bathymetric data were re-processed to produce a depth model comparable to the July 1996 data set (Figure 3-3). The 1996 data show the modest CLIS 95 Mound lying between the NHAV 74 and NHAV 83 disposal mounds (Figure 3-4). Over the course of four years, an estimated barge volume of 860,000 m^3 of sediment was strategically placed at CLIS to form three prominent dredged material disposal mounds (CLIS 95/96, CLIS 97/98, and CLIS 99; Figure 3-5).

In addition to the prominent positive differences associated with the recent placement activity, the depth difference results in Figure 3-5 also show some areas with small-scale and consistent negative difference values. Due to the location and morphology of these areas, the apparent reductions in mound heights are likely attributable to disposal mound consolidation over the NHAV 93 and CLIS 94 disposal mounds (Morris 1998). A result of pore water extrusion within the various layers of deposited sediments, disposal mound consolidation is often substantial within one year of dredged material placement and usually continues at a much slower rate over the next several years. However, subsidence within the underlying ambient sediments due to the weight of the deposited sediments contributes to apparent loss in mound height over the long term (Poindexter-Rollings 1990; Brandes et al. 1991).

3.2 Morphology of the CLIS 99 Mound

At the time of the September 2000 survey, the CLIS 99 mound was the newest bottom feature on the CLIS seafloor (Figure 3-3). Composed of nearly 86,000 m^3 of dredged material, the CLIS 99 Mound displayed a height of 2.25 m at the apex and diameter of approximately 200 m (Figure 3-5). Developed between the NHAV 74 and STNH-N Mounds, the CLIS 99 Mound begins to close a third artificial containment cell within the confines of CLIS (Figure 3-3). Due to the relatively small volume of dredged material and likelihood of future dredged material placement operations in the immediate area, no sediment-profile imaging was performed over the CLIS 99 Mound during the September 2000 field operation.

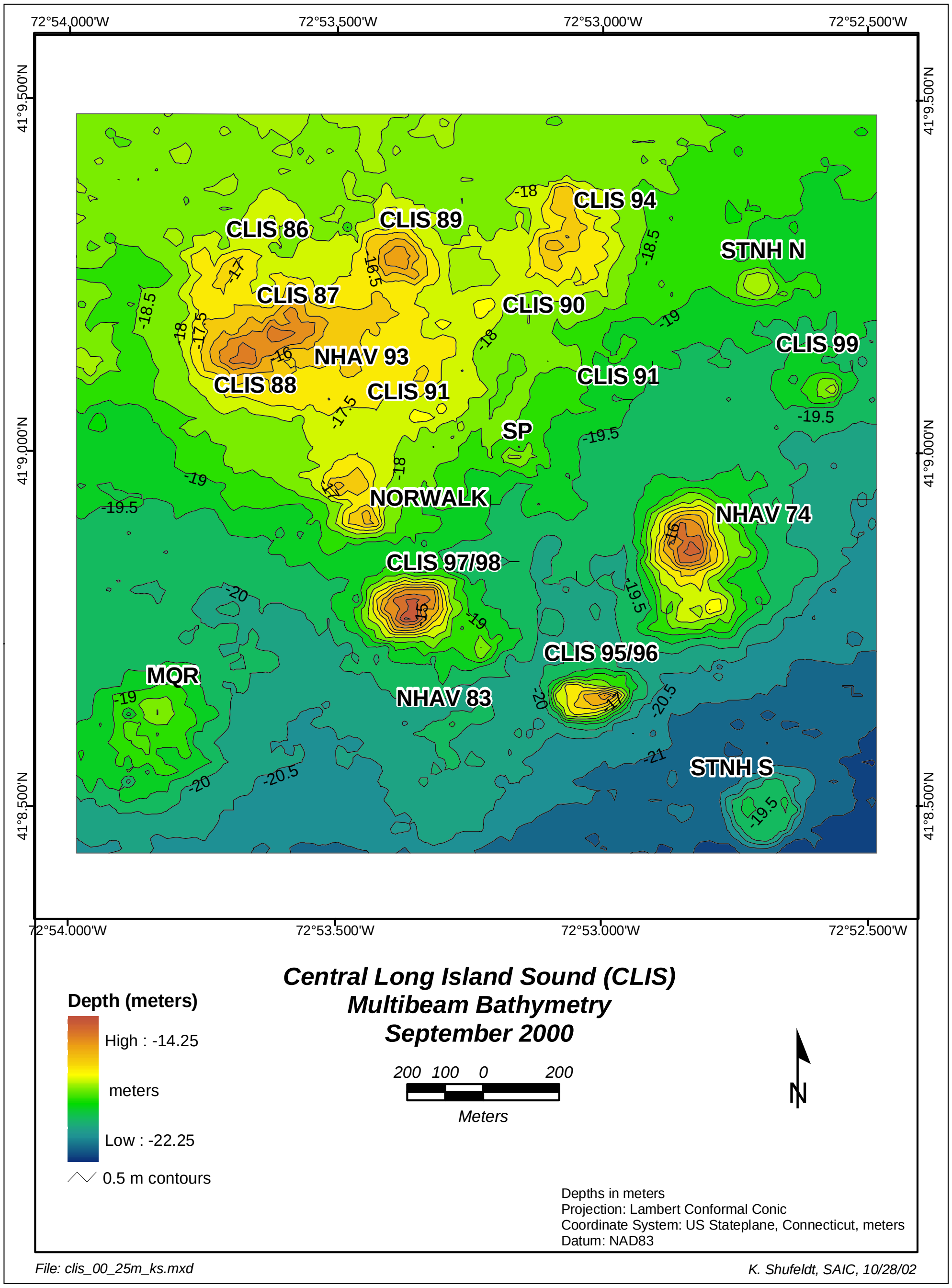


Figure 3-3. Bathymetric chart of the September 2000 multibeam bathymetry data regridded to 25 × 25 m grid cells and confined to a 2100 × 2100 m analysis area to facilitate depth difference comparison with the July 1996 survey, 0.5 m contour interval

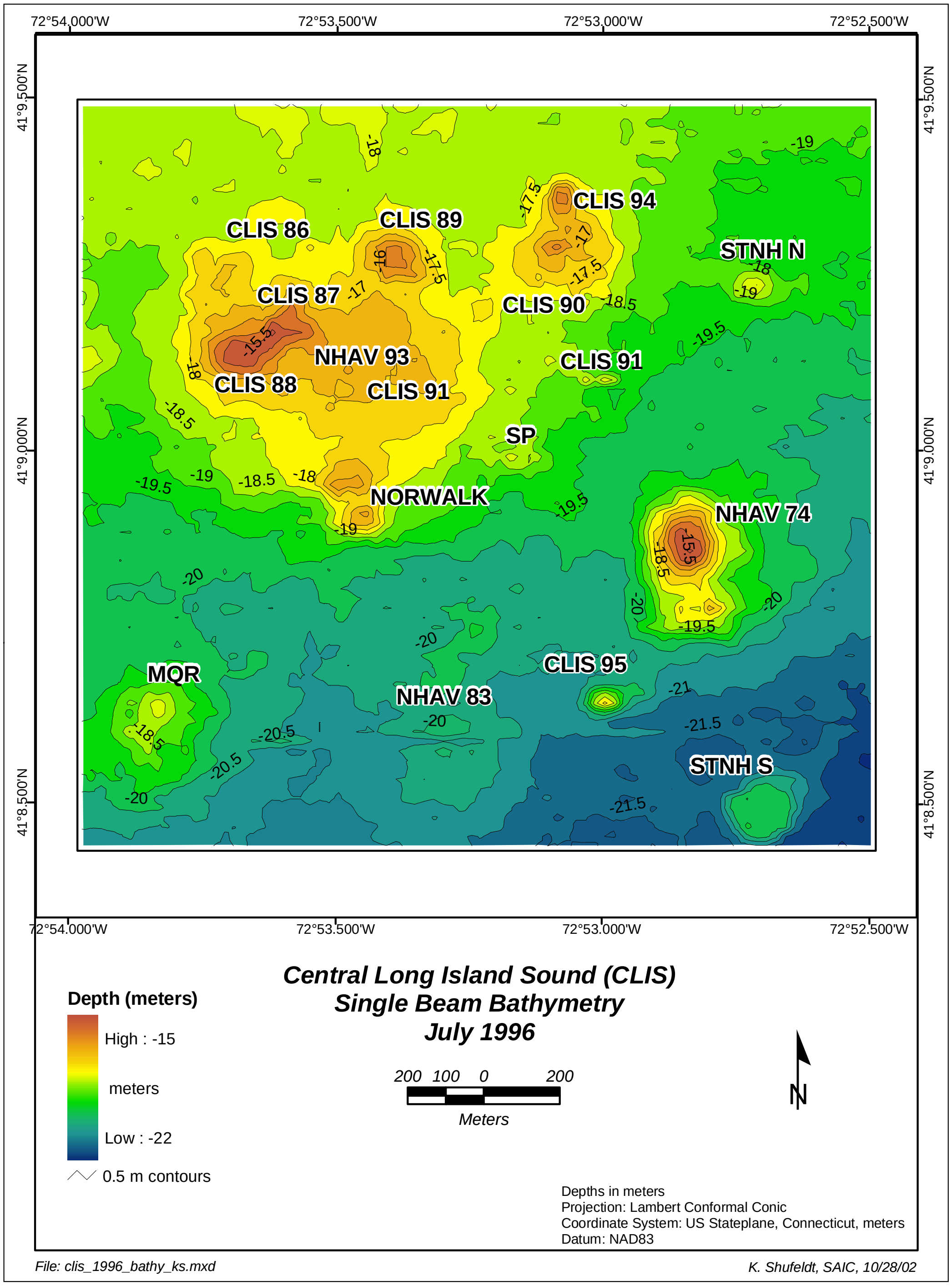


Figure 3-4. Bathymetric chart of the 2100 × 2100 m area surveyed in July 1996, 0.5 m contour interval

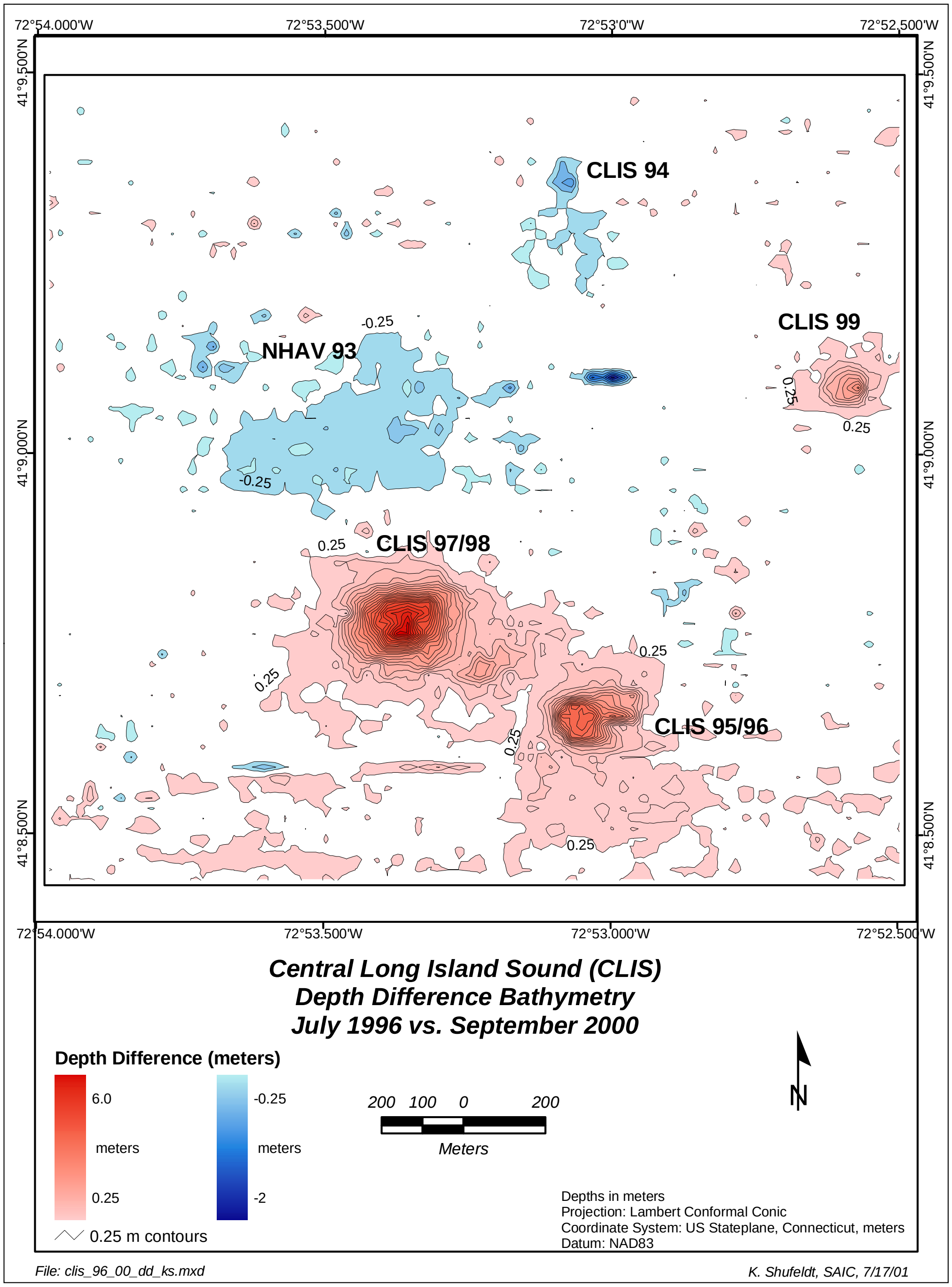


Figure 3-5. Depth difference plot of the September 2000 vs. the July 1996 bathymetric data, 0.25 m contour interval. Dredged material accumulation is shown in red and consolidation/subsidence is shown in blue.

3.3 September 1999 Survey

3.3.1 Single-Beam Bathymetry

The September 1999 single-beam bathymetric survey at CLIS covered a 1000 × 1000 m area encompassing both the CLIS 97/98 and the CLIS 95/96 Mound Complexes (Figure 3-6). Water depths for the 1999 single-beam survey ranged from a minimum of 14.5 m over the apex of the CLIS 97/98 Mound Complex to a maximum of 21.5 m in the southeast corner of the survey area. The 1999 bathymetry data also show the neighboring historic disposal mounds NHAV 74 to the east and the Norwalk Mound to the northwest (Figure 3-6).

The 1999 survey overlapped with a significant portion of the September 1997 bathymetric survey. A 950 × 950 m analysis area was defined within each data set (see Figures 3-7 and 3-8) to facilitate depth difference calculations and document changes in the seafloor topography resulting from the deposition of nearly 460,000 m^3 of dredged material in the period between the two surveys. The depth difference plot shows a large accumulation of sediment detected in close proximity to the CDA 97 and CDA 98 disposal buoy positions representing the material placed at CLIS during the 1997–98 and 1998–99 disposal seasons (Figure 3-9). The dredged material deposit developed around the CDA 98 buoy, composed of an estimated barge volume of 460,000 m^3 of dredged material, is by far the largest of the recent disposal mounds. This mound displayed a height of 6 m and a diameter of roughly 400 m along its north-south axis (Figure 3-9). Composed of an estimated barge volume of 58,000 m^3 of dredged material, the CDA 97 deposit is much smaller in height (1.25 m) and diameter (200 m; Figure 3-9).

The comparison between the 1997 and 1999 surveys also displays an area of consolidation over the surface of the CLIS 95/96 Mound Complex. The depth difference calculations indicate an approximate 2 m reduction in disposal mound height corresponding to the CDA 96 dredged material deposit (Figure 3-9). Although disposal mound consolidation is common in large dredged material deposits, the degree of the consolidation detected over the CLIS 95/96 Mound Complex may be enhanced by localized survey artifacts associated with the slopes of this bottom feature. Similar slope-induced artifacts are also visible in the northeastern corner of the analysis area and correspond to the relatively steep sides of the NHAV 74 mound.

The depth difference comparison between the September 1999 and September 2000 surveys provides information pertaining to consolidation within the CLIS 97/98 Mound Complex over the course of one year. As anticipated, disposal mound consolidation was significant within the CDA 98 deposit, with a 1.6 m reduction in mound height at the

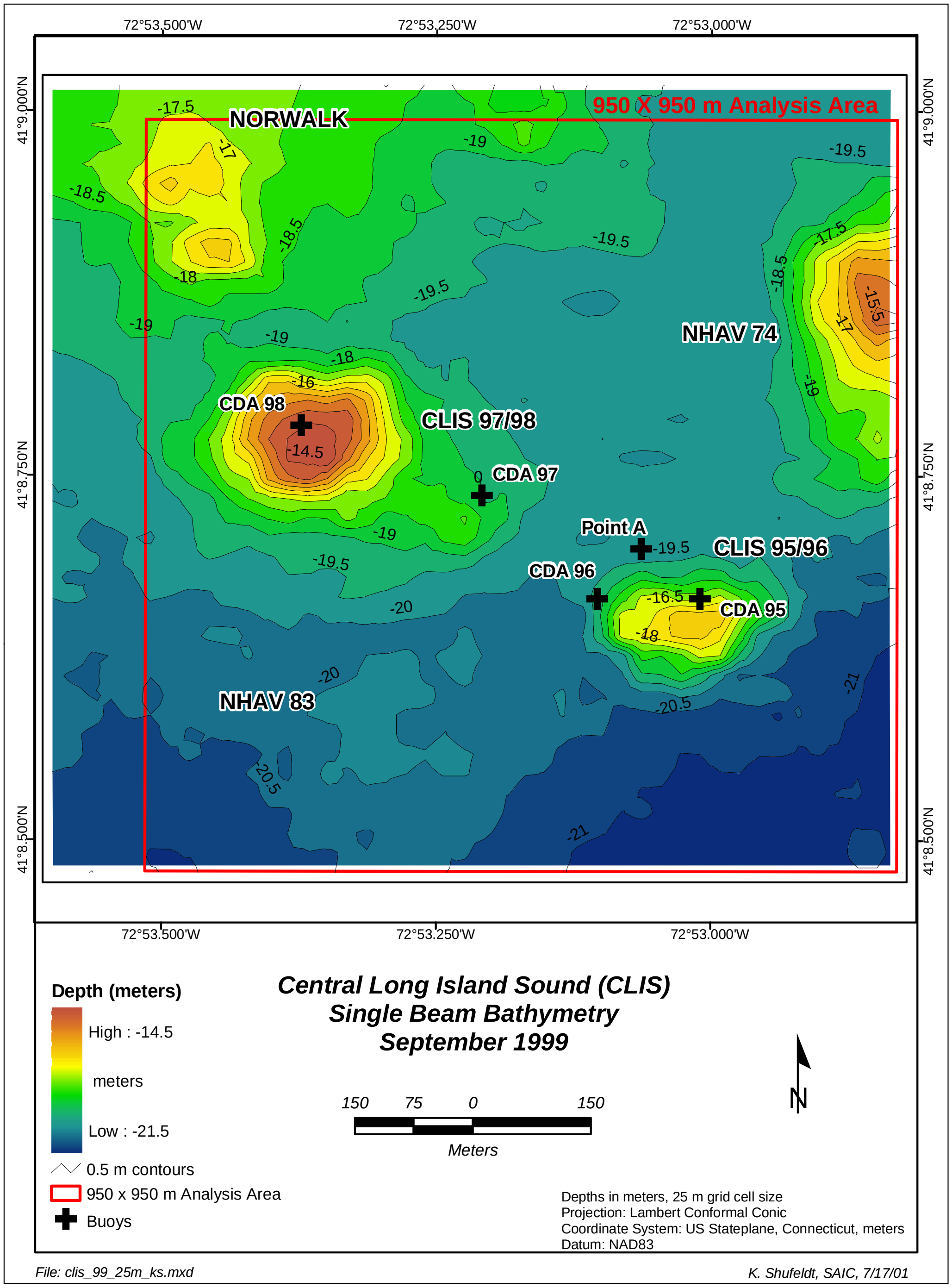


Figure 3-6. Bathymetric chart of the 1200 × 1000 m area surveyed in September 1999, 0.5 m contour interval. A 950 × 950 m analysis area is plotted in red.

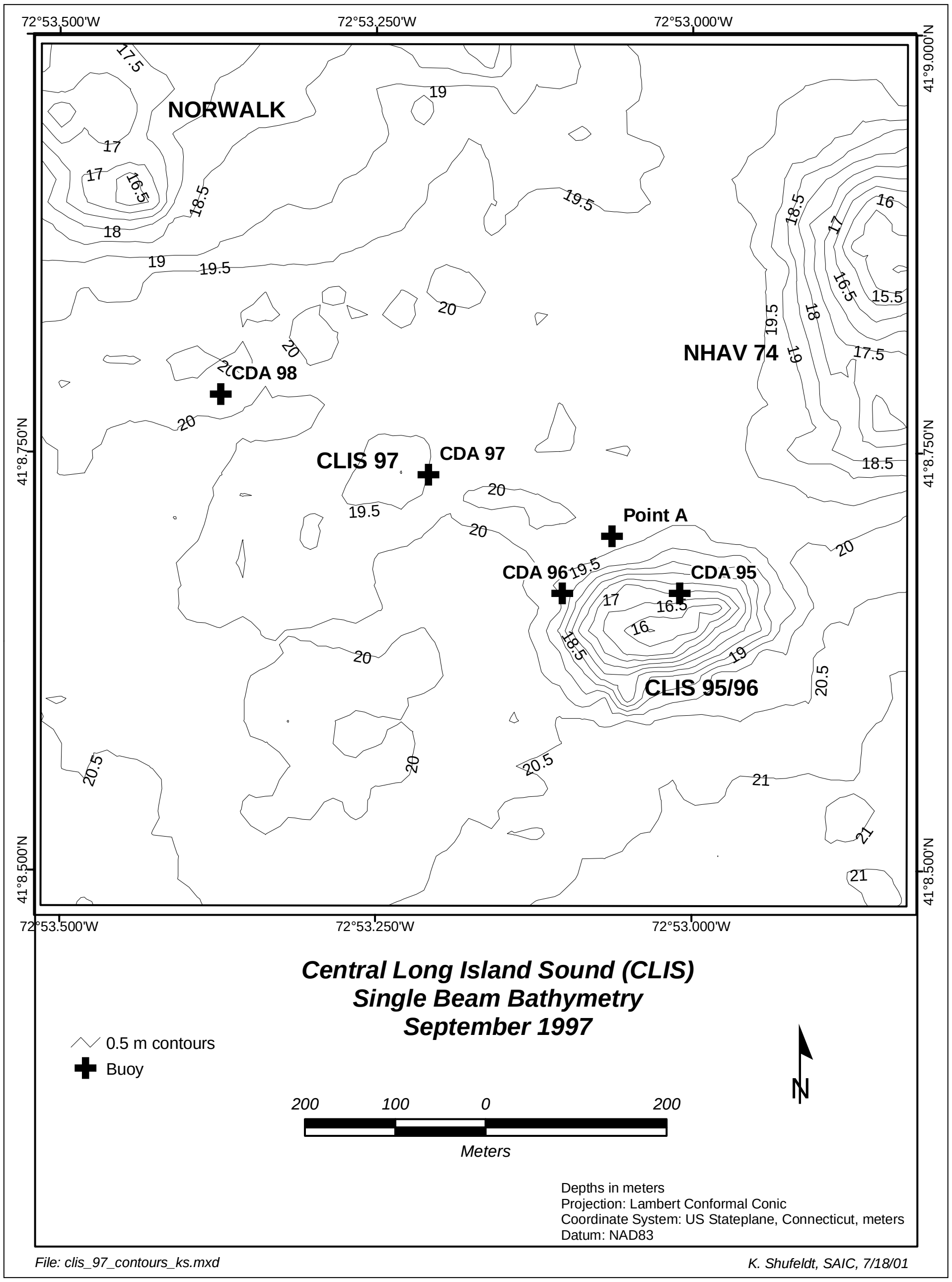


Figure 3-7. Bathymetric chart of the seafloor within the 950 × 950 m analysis area based on the September 1997 survey, 0.5 m contour interval. The position of the DAMOS disposal buoys for the 1995–96, 1996–97, 1997–98, and 1998–99 disposal seasons are plotted for reference.

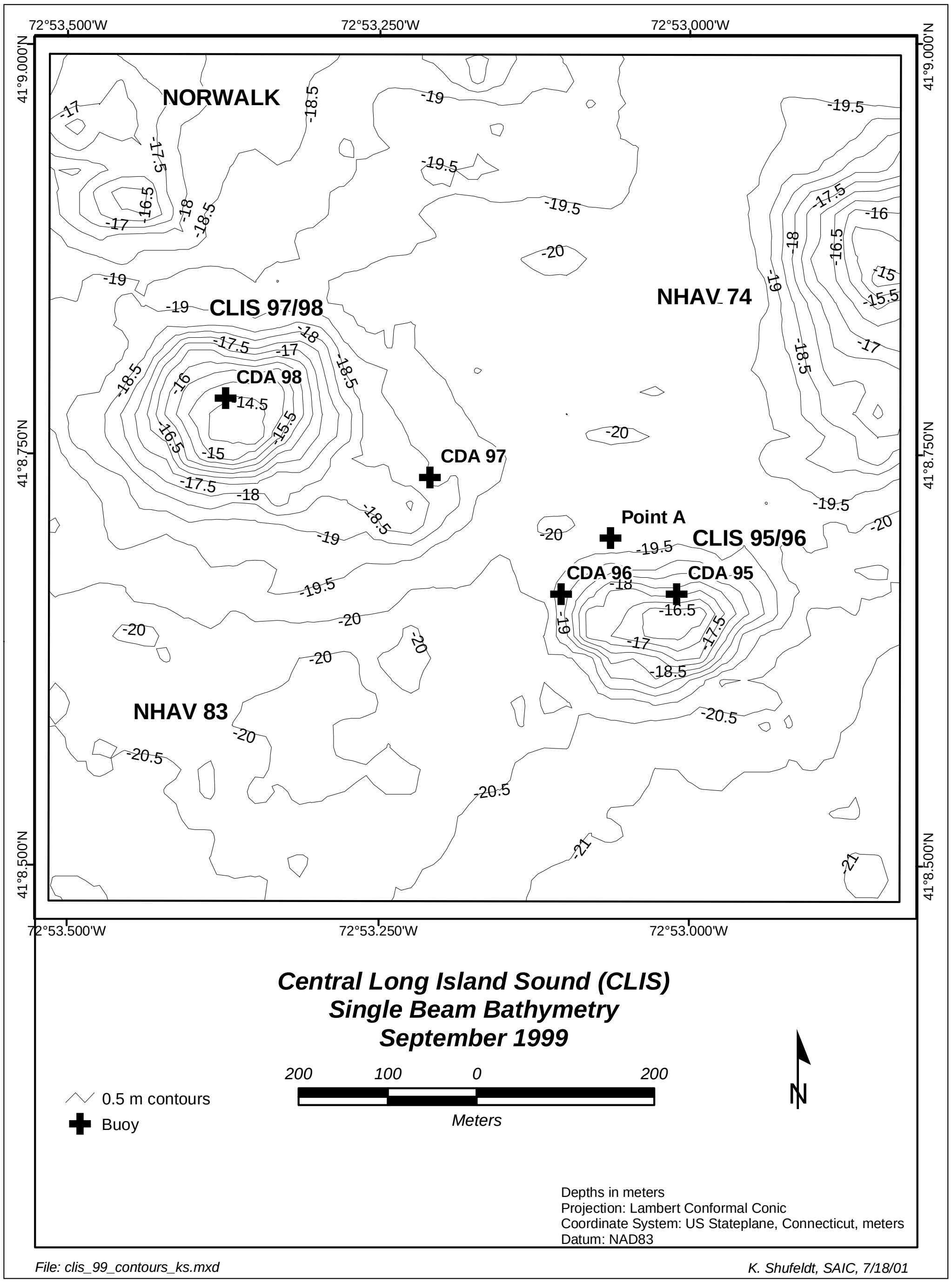


Figure 3-8. Bathymetric chart of the seafloor within the 950 × 950 m analysis area based on the September 1999 survey, 0.5 m contour interval. The position of the DAMOS disposal buoys for the 1995–96, 1996–97, 1997–98, and 1998–99 disposal seasons are plotted for reference.

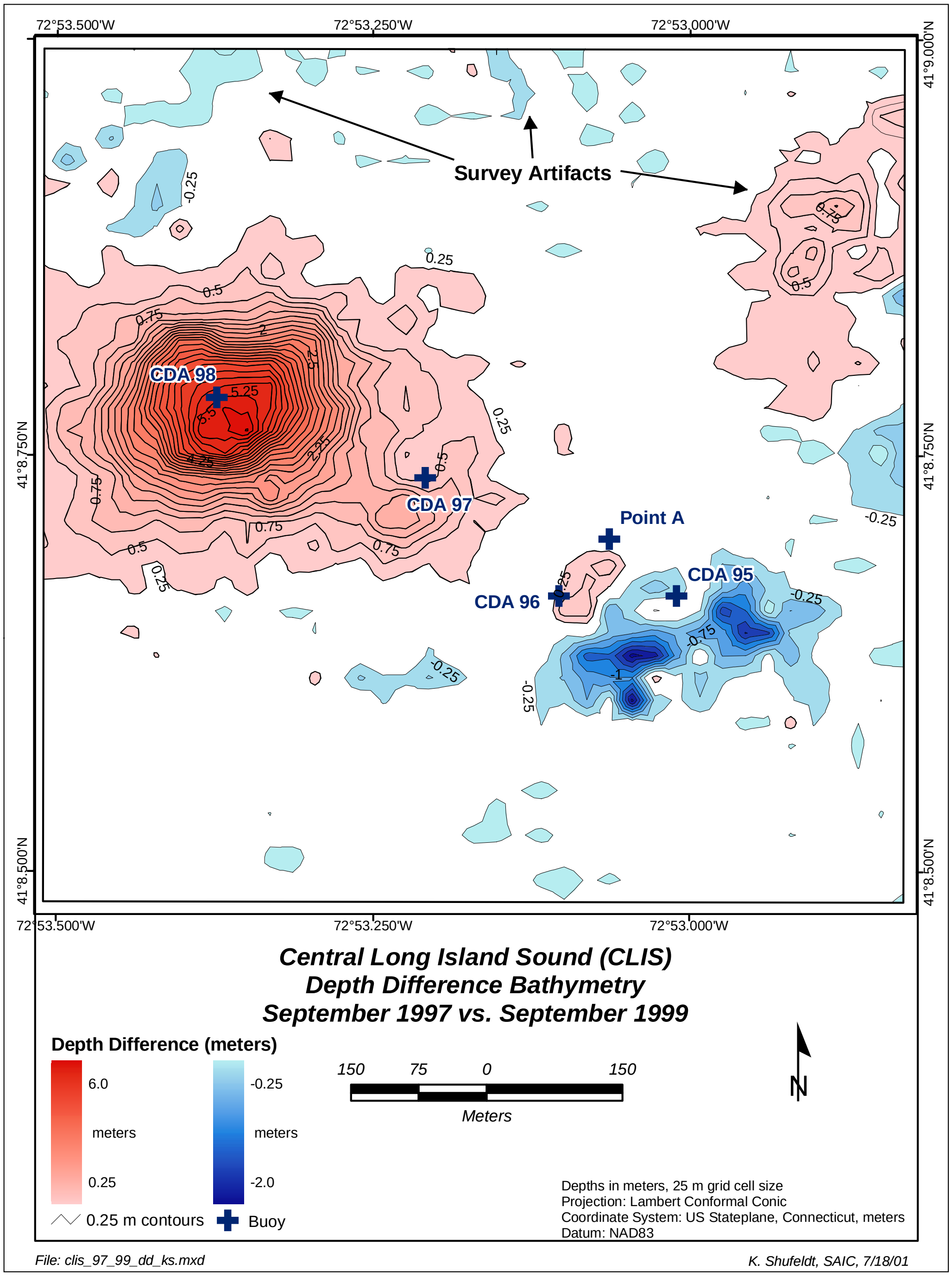


Figure 3-9. Depth difference plot of the September 1999 vs. September 1997 single-beam bathymetry data, 0.25 m contour interval. Dredged material accumulation is shown in red and consolidation is shown in blue.

apex (Figure 3-10). Limited consolidation ranging from 0.25 to 0.75 m was also detected within the CDA 97 and CDA 96 dredged material deposits as well. Once again, a variety of slope-induced survey artifacts were evident in the depth difference comparisons, the most significant of which corresponded to the NHAV 74 Mound.

3.3.2 REMOTS® Sediment-Profile Imaging

The REMOTS® results for the September 1999 survey were used primarily to assess the benthic recolonization status within the surface sediments over multiple disposal mounds on the CLIS seafloor. A complete set of REMOTS® image analysis results for the disposal site and reference area stations are provided in Appendix E. These results are summarized in the series of tables appearing below.

3.3.2.1 CLIS 97/98 Mound Complex

Dredged Material Distribution and Physical Sediment Characteristics

As previously described, a 57-station REMOTS® survey grid was completed over the area of most recent disposal at the time of the September 1999 field operation. A total of 32 stations were assigned to the CLIS 97/98 Mound Complex to evaluate sediment composition and benthic conditions over this bottom feature. Replicate-averaged camera penetration depths over this bottom feature varied from 4.8 cm at Station 71 to 19.4 cm at Station 51, with an overall average of 14.5 cm (Table 3-1). The shallower camera penetration depths were usually associated with stations displaying increased sand content in the surface sediment layers.

The CLIS 97/98 Mound Complex was developed in an area of the disposal site heavily influenced by both recent and historic dredged material placement activity. As anticipated, dredged material (fresh or historic) was detected and classified as greater than the penetration (i.e., imaging) depth of the sediment-profile camera in all replicate images acquired over CLIS 97/98 stations. However, the thickness of dredged material was reported only if evidence of fresh material from the most recent 1998–99 disposal season was detected (Table 3-1). Fresh dredged material, characterized as layers of low reflectance (organic-rich) sediment with a chaotic fabric and anomalous grain size distributions, was detected at 16 of the 28 stations and found to be primarily within a 200 m radius of the CDA 98 buoy location (Figures 3-11 and 3-12A). Layering of dredged material (fresh over historic) was noted at several stations, while historic dredged material (higher reflectance, better sorted) was detected at the sediment-water interface at 16 stations on the periphery of the CDA 98 deposit (Figures 3-12B and 3-12C).

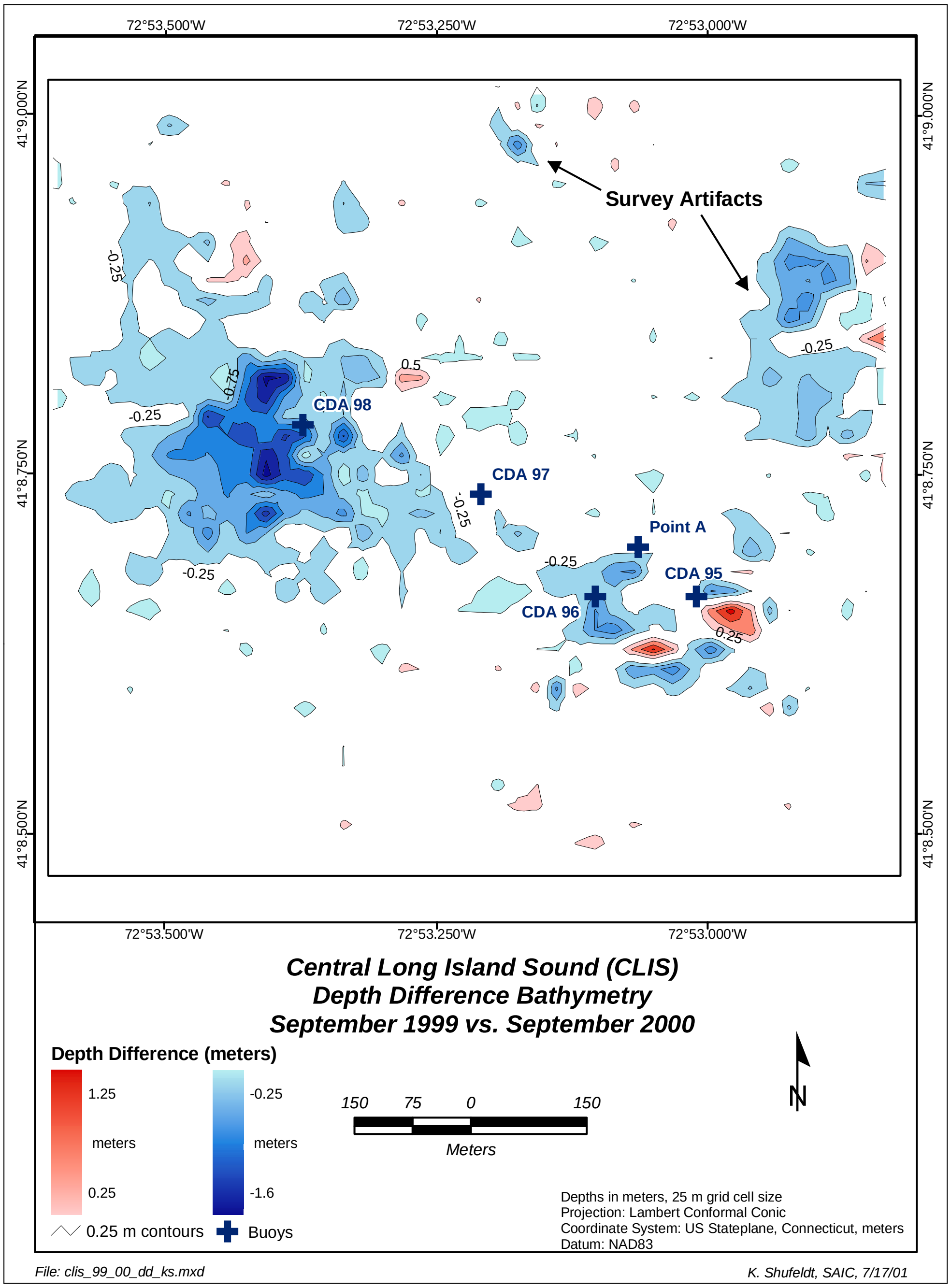


Figure 3-10. Depth difference plot of the September 2000 multibeam vs. September 1999 single-beam bathymetric surveys over the active area of disposal, 0.25 m contour interval. Apparent dredged material accumulation is shown in red and consolidation is shown in blue.

Table 3-1.

Summary of REMOTS® Results for Stations over the CLIS 97/98 Mound Complex

Associated Mound	Station (grid)	Station (waypoint)	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Fresh 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)
CLIS 97/98	R1C4	45	14.46	0.00	0	0.98	I,III	ST_III	>4	NO	5.67	7	0.83
CLIS97/98	R2C3	46	16.25	0.00	0	1.18	I,III	ST_I_ON_III	>4	NO	4.33	3	0.88
CLIS97/98	R2C4	47	18.06	0.00	0	1.52	I,III	ST_I_ON_III	>4	NO	5.00	4	0.72
CLIS97/98	R2C5	48	18.80	10.02	2	1.59	I,III	ST_III	>4	NO	5.00	4	0.40
CLIS97/98	R2C6	49	18.60	0.20	1	1.51	I	ST_I	>4	NO	3.67	4	0.56
CLIS97/98	R3C2	50	17.47	0.00	0	1.68	I,III	ST_I_ON_III	>4	NO	5.67	5	0.53
CLIS97/98	R3C3	51	19.38	0.00	0	1.88	I	ST_I	>4	NO	4.00	4	0.43
CLIS97/98	R3C4	52	9.50	9.53	3	1.95	I	ST_I	>4	NO	4.33	4	1.06
CLIS97/98	R3C5	53	13.79	>13.46	3	2.19	I,III	ST_III	>4	NO	5.67	5	1.06
CLIS97/98	R3C6	54	17.27	>16.79	3	1.62	I,III	ST_I_ON_III	>4	NO	6.00	7	0.96
CLIS97/98	R3C7	55	15.23	4.99	3	1.73	I,III	ST_III	>4	NO	5.00	4	1.13
CLIS97/98	R3C8	56	15.86	0.00	0	1.58	I,III	ST_III	>4	NO	4.67	3	0.66
CLIS97/98	R4C1	58	18.86	0.00	0	2.06	I,III	ST_I_ON_III	>4	NO	5.67	5	0.49
CLIS97/98	R4C2	59	12.76	10.31	2	1.26	I,III	ST_III	>4	NO	8.00	8	2.49
CLIS97/98	R4C3	60	8.43	8.18	3	2.40	I,III	ST_III	4 to 3	NO	7.50	7.5	1.18
CLIS97/98	R4C4	61	13.09	>13.14	3	1.29	I,III	ST_III	>4	NO	6.00	7	1.44
CLIS97/98	R4C5	62	7.76	7.68	3	2.40	I,III	ST_I_ON_III	>4	NO	6.33	5	1.04
CLIS97/98	R4C6	63	13.58	8.57	2	2.04	I,III	ST_III	>4	NO	8.33	8	1.35
CLIS97/98	R4C7	64	14.42	0.34	1	1.75	I,III	ST_I_ON_III	>4	NO	7.00	7	1.00
CLIS97/98	R4C8	65	17.55	0.00	0	2.17	I	ST_I	>4	NO	4.33	4	1.28
CLIS97/98	R5C2	68	15.47	>15.34	3	1.26	I,III	ST_I_ON_III	>4	NO	5.67	7	0.86
CLIS97/98	R5C3	69	12.97	>12.75	3	1.98	I	ST_I	4 to 3	NO	4.33	4	0.95
CLIS97/98	R5C4	70	6.88	>6.78	3	1.92	I,III	ST_III	4 to 3	NO	6.67	8	0.70
CLIS97/98	R5C5	71	4.78	>4.62	3	4.37	I	ST_I	3 to 2	NO	6.67	7	0.57
CLIS97/98	R5C6	72	10.91	0.00	0	2.62	I,III	ST_III	>4	NO	7.33	9	0.69
CLIS97/98	R5C7	73	18.50	0.00	0	2.15	I,III	ST_I_ON_III	>4	NO	5.33	4	0.28
CLIS97/98	R6C3	78	17.36	0.00	0	4.12	I,III	ST_I_ON_III	>4	NO	11.00	11	0.98
CLIS97/98	R6C4	79	18.28	0.00	0	2.55	I,III	ST_I_ON_III	>4	NO	6.33	5	1.62
CLIS97/98	R6C5	80	12.31	0.00	0	3.14	I,III	ST_III	>4	NO	7.33	6	1.22
CLIS97/98	R6C6	81	14.88	0.00	0	2.47	I,III	ST_III	>4	NO	8.67	9	0.96
CLIS97/98	R7C4	88	15.65	0.00	0	3.97	I,III	ST_I_ON_III	>4	NO	9.00	9	1.82
CLIS97/98	R7C5	100	16.22	0.00	0	3.63	I,III	ST_I_ON_III	>4	NO	9.00	10	0.87
CLIS97/98		AVG	14.54	2.39	1.28	2.16					6.23	6.08	0.97
Stations		MIN	4.78	0.00	0.00	0.98					3.67	3	0.28
		MAX	19.38	>16.79	3.00	4.37					11.00	11	2.49

Values shown are means for n = 3 replicate images obtained and analyzed at each station. If dredged material exceeded the prism penetration depth, then the mean value shown is a minimum estimate of dredged material layer thickness (indicated by the > sign)

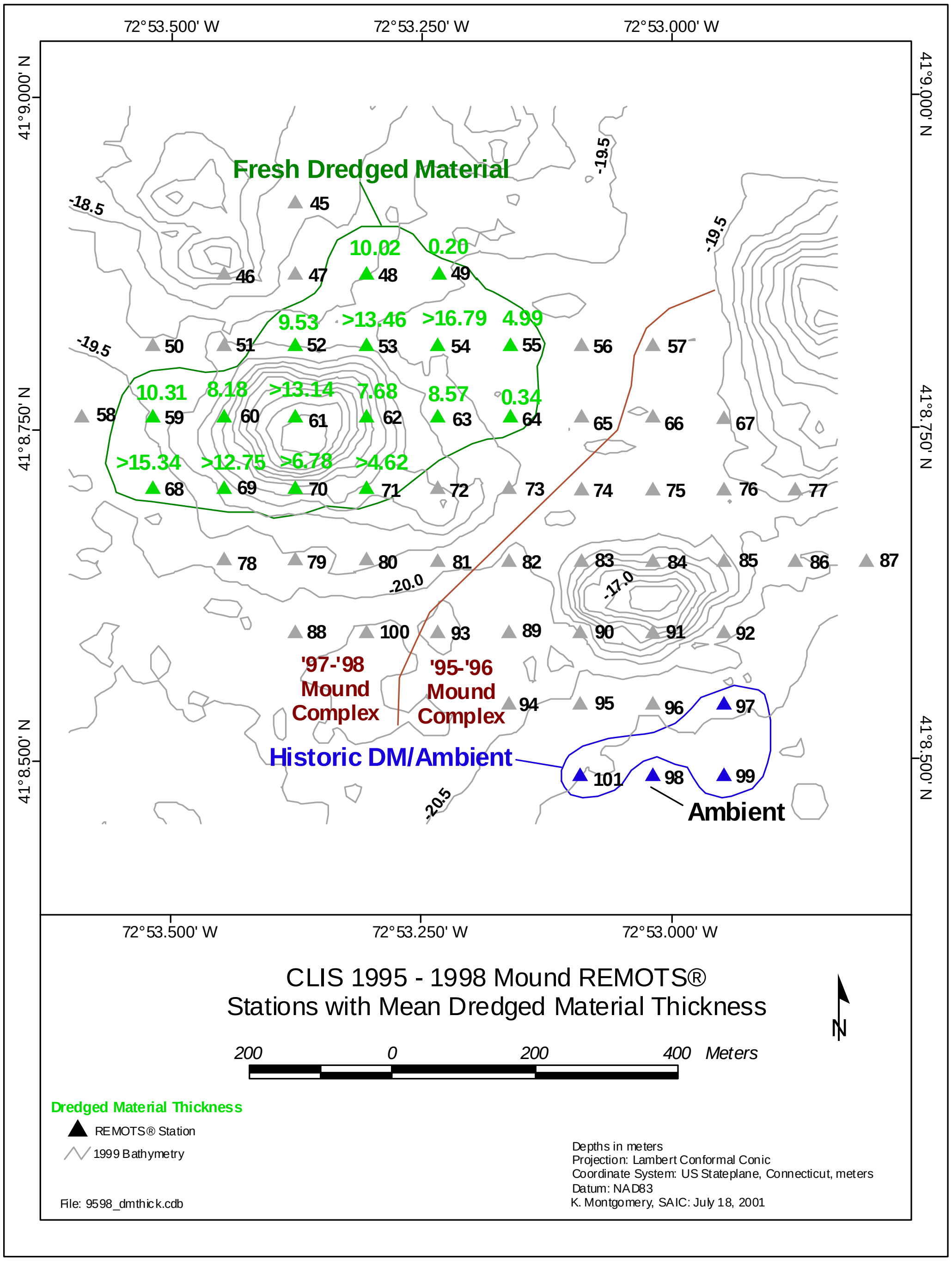


Figure 3-11. Distribution and thickness of fresh dredged material (green), historic dredged material (gray), and ambient sediment (blue) at the sediment-water interface over the CLIS 97/98 and CLIS 95/96 Mound Complexes

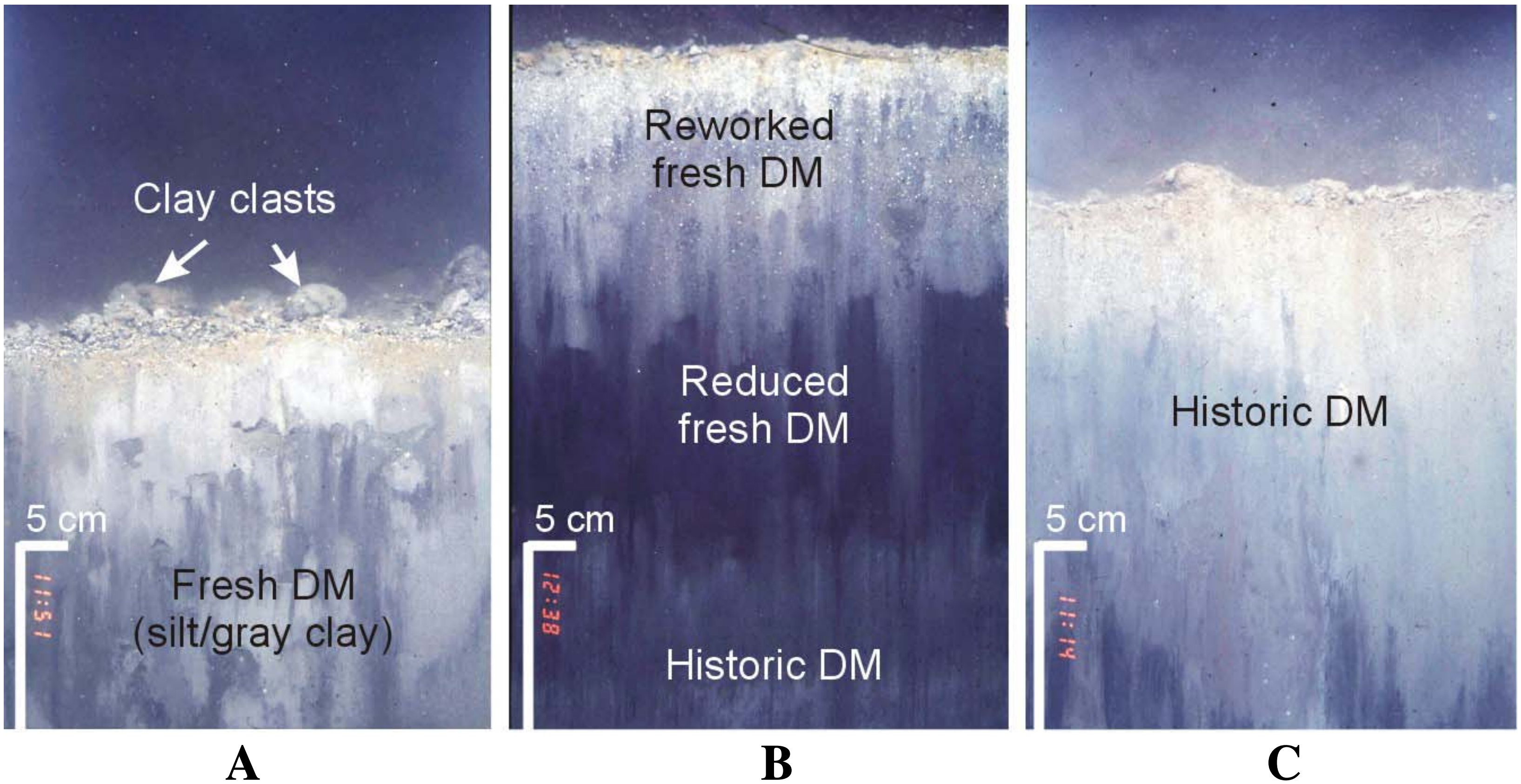


Figure 3-12. REMOTS® images collected at Stations 61 (A), 49 (B), 65 (C) displaying the visual characteristics of fresh dredged material (A), layering of fresh over historic dredged material (B), and historic dredged material greater than penetration (C)

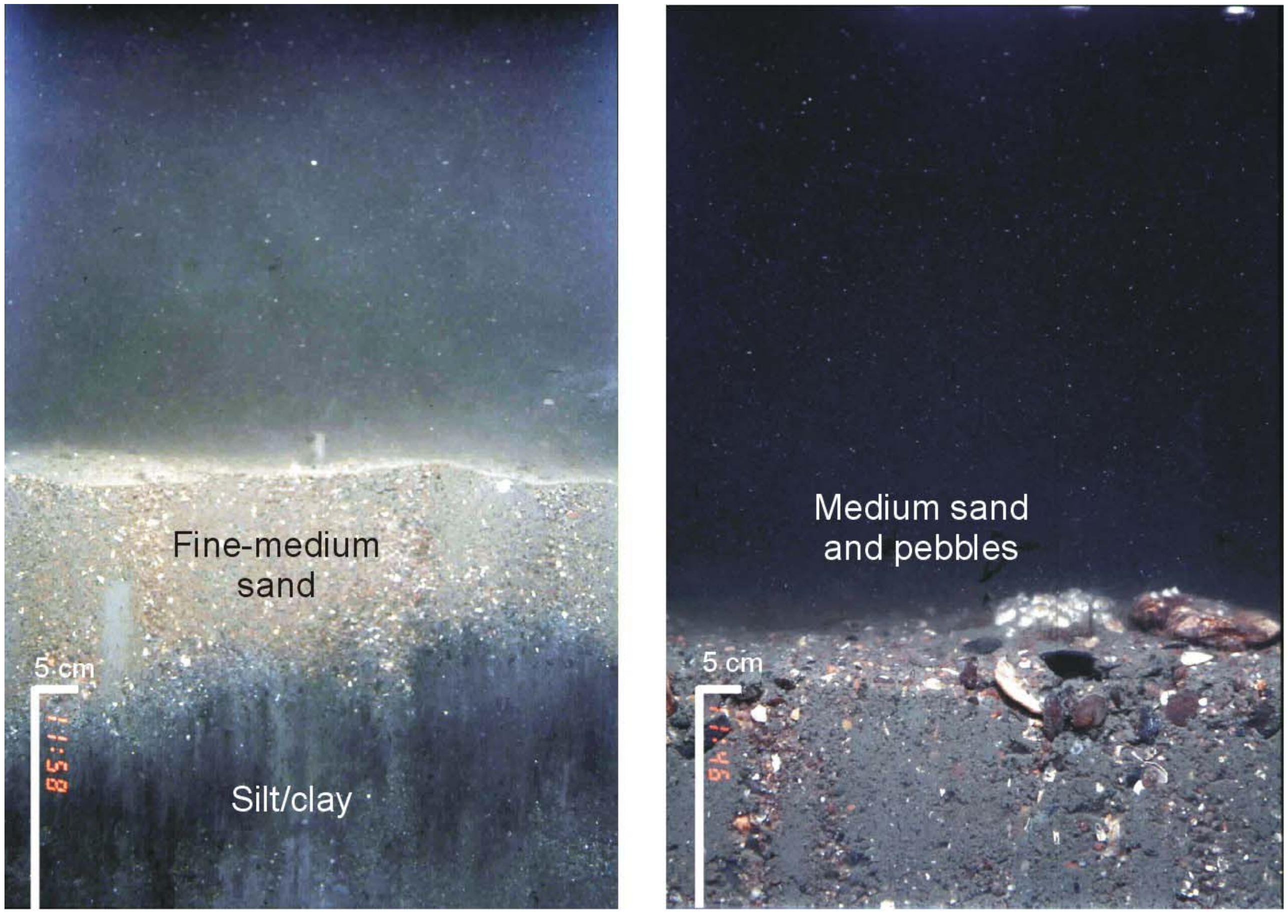
The major modal grain size of the surficial sediments over most of the CLIS 97/98 complex was classified as fine-grained (>4 phi; silt/clay), similar to the reference areas. However, very fine to medium-grained sand (4 to 1 phi) was detected in several of the replicate images collected (Figure 3-13A). In fact, several stations south and west of the mound apex (60, 69, 70, and 71) had sufficient sand content to classify the major modal grain size as 4 to 3 phi, or coarser (Figure 3-13B; Table 3-1). Boundary roughness values at the sediment-water interface varied from 0.3 cm to 2.5 cm, also tracking very close to the results of the CLIS reference areas (Table 3-2). The source of seafloor roughness over CLIS 97/98 was attributed to a combination of both physical disturbance as a result of sediment placement and biological activity.

Biological Conditions and Benthic Recolonization

Three parameters were used to assess the benthic recolonization rate and overall health of the CLIS 97/98 sediment deposit, relative to the reference areas. The apparent RPD depth, OSI, and infaunal successional status were mapped on station location plots to outline the biological conditions at each station (Figures 3-14 and 3-15).

The RPD is measured on each image to establish the apparent penetration of oxygen into the sediment. The RPD value is an indicator of near bottom dissolved oxygen conditions, as well as the incorporation of molecular oxygen (O_2) in the surface sediments. The replicate-averaged RPD depths over the CLIS 97/98 Mound Complex ranged from 1 cm at Station 45 to 4.4 cm at Station 71, with an average value of nearly 2.2 cm (Figure 3-14; Table 3-1). Most of the lower RPD values were located to the north of CLIS 97/98 (Stations 46–49) near the historic Norwalk Mound and on the southeastern apron of the deposit (Stations 45, 68, and 56; Table 3-1). As expected, RPD depths tended to be deeper over the CDA 97 sediment deposit and reference areas. No low dissolved oxygen conditions, redox rebounds, or methane bubbles were observed in any of the replicate images from this dredged material deposit.

The seafloor surrounding the CLIS 97/98 sediment deposit appeared to be recolonizing as anticipated after a recent benthic disturbance. Stage I surface tube-dwelling polychaetes and evidence of Stage III activity in the subsurface sediments were detected in the majority of the stations sampled. Stations 49, 51, 52, 65, 69, and 71 appeared to be in the initial stages of benthic recolonization with only Stage I organisms present (Figure 3-15). As anticipated, Stage III organisms tended to be more abundant at stations displaying dredged material layering or only historic dredged material.



A **B**

Figure 3-13. REMOTS® images collected at Stations 60 (A) and 71 (B) displaying sand over mud layering (A) and shells/pebbles in a fine-medium sand matrix (B)

Table 3-2.

Summary of REMOTS® Results for Stations over the CLIS Reference Areas

Reference Area	Station	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material	RPD Mean	Successional Stages Present	Highest Successional Stage	Grain Size Major Mode (Phi)	Methane Present	OSI Mean	OSI Median	Boundary Roughness
2500W	1	15.61	0	0	2.80	I,III	ST_I_ON_III	>4	NO	8.00	8	1.62
	2	13.25	0	0	2.29	I,III	ST_III	>4	NO	8.67	8	2.10
	3	15.72	0	0	1.47	I,III	ST_I_ON_III	>4	NO	7.67	8	1.41
	4	16.70	0	0	2.90	I,III	ST_III	>4	NO	9.33	8	0.66
4500E	5	15.60	0	0	2.80	I,III	ST_I_ON_III	>4	NO	7.67	9	0.77
	6	15.29	0	0	3.58	I,III	ST_III	>4	NO	8.33	9	0.91
	7	15.57	0	0	2.34	I,III	ST_I_ON_III	>4	NO	8.67	9	0.59
	8	13.31	0	0	2.84	I,III	ST_I_ON_III	>4	NO	7.00	6	0.35
CLISREF	9	15.31	0	0	3.98	I,III	ST_I_ON_III	>4	NO	10.33	11	0.54
	10	17.08	0	0	4.40	I,III	ST_I_ON_III	>4	NO	10.33	11	0.54
	11	14.00	0	0	3.99	I,III	ST_III	>4	NO	10.00	11	0.63
	12	12.62	0	0	4.51	I,III	ST_III	>4	NO	9.33	11	0.38
	13	13.78	0	0	4.66	I,III	ST_I_ON_III	>4	NO	8.00	7	0.54
AVG		14.91	0	0	3.27					8.72	8.92	0.85
MIN		12.62	0	0	1.47					7.00	6	0.35
MAX		17.08	0	0	4.66					10.33	11	2.10

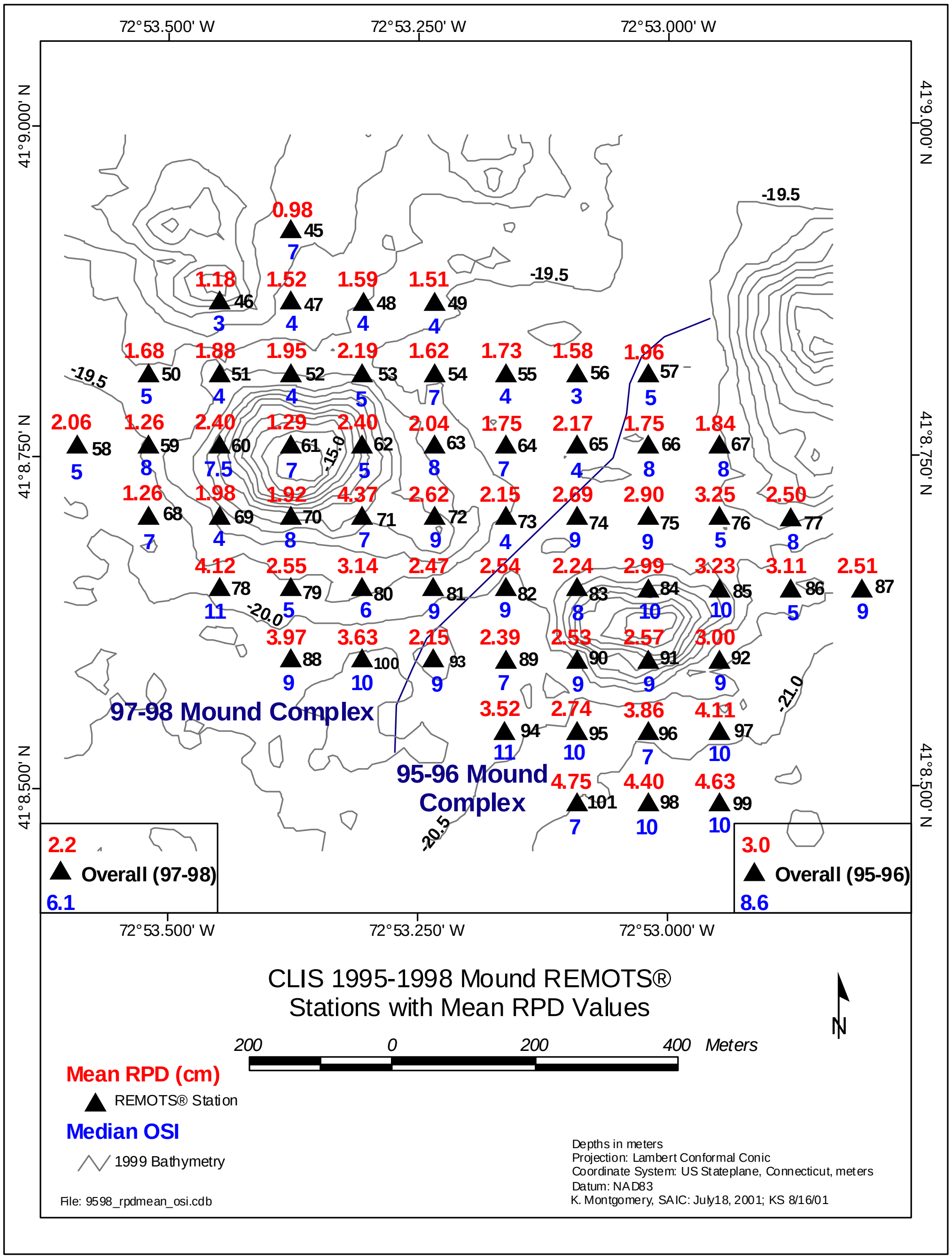


Figure 3-14. Replicate-averaged RPD (red) and median OSI values (blue) calculated for the REMOTS® stations established over the CLIS 97/98 and CLIS 95/96 Mound Complexes

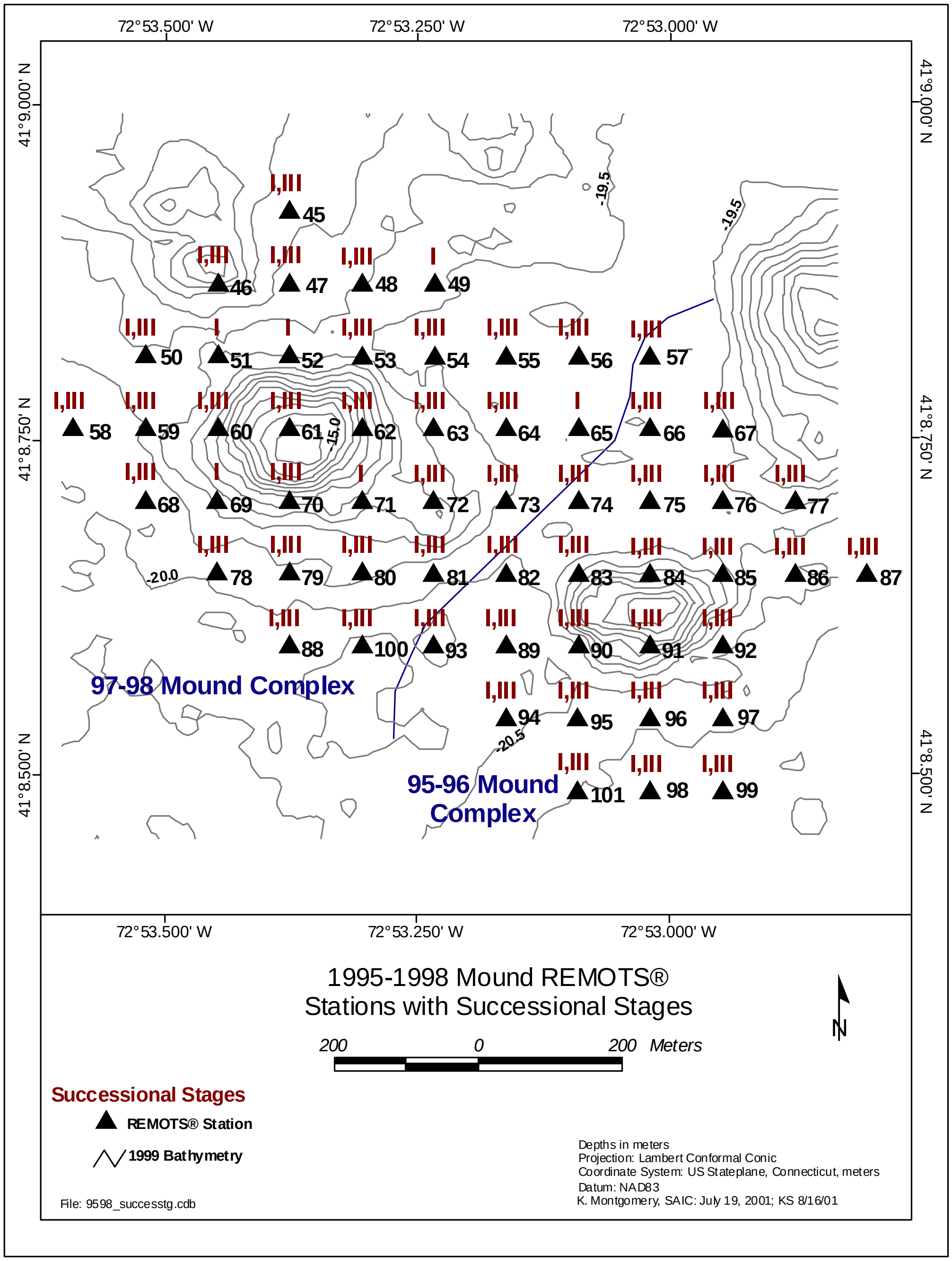


Figure 3-15. Successional stage status for the REMOTS® stations established over the CLIS 97/98 and CLIS 95/96 Mound Complexes

The median OSI values over the surface of the CLIS 97/98 Mound Complex ranged from +3 to +11 and averaged +6.1, less than the reference area OSI value of +8.9 (Tables 3-1 and 3-2). Due to shallow RPD depths, many of the lowest values were seen along the northern fringe of the survey grid (Figure 3-14). However, the stations over the southern portion of the CLIS 97/98 Mound Complex yielded OSI values comparable to those at the CLIS reference areas.

3.3.2.2 CLIS 95/96 Mound Complex

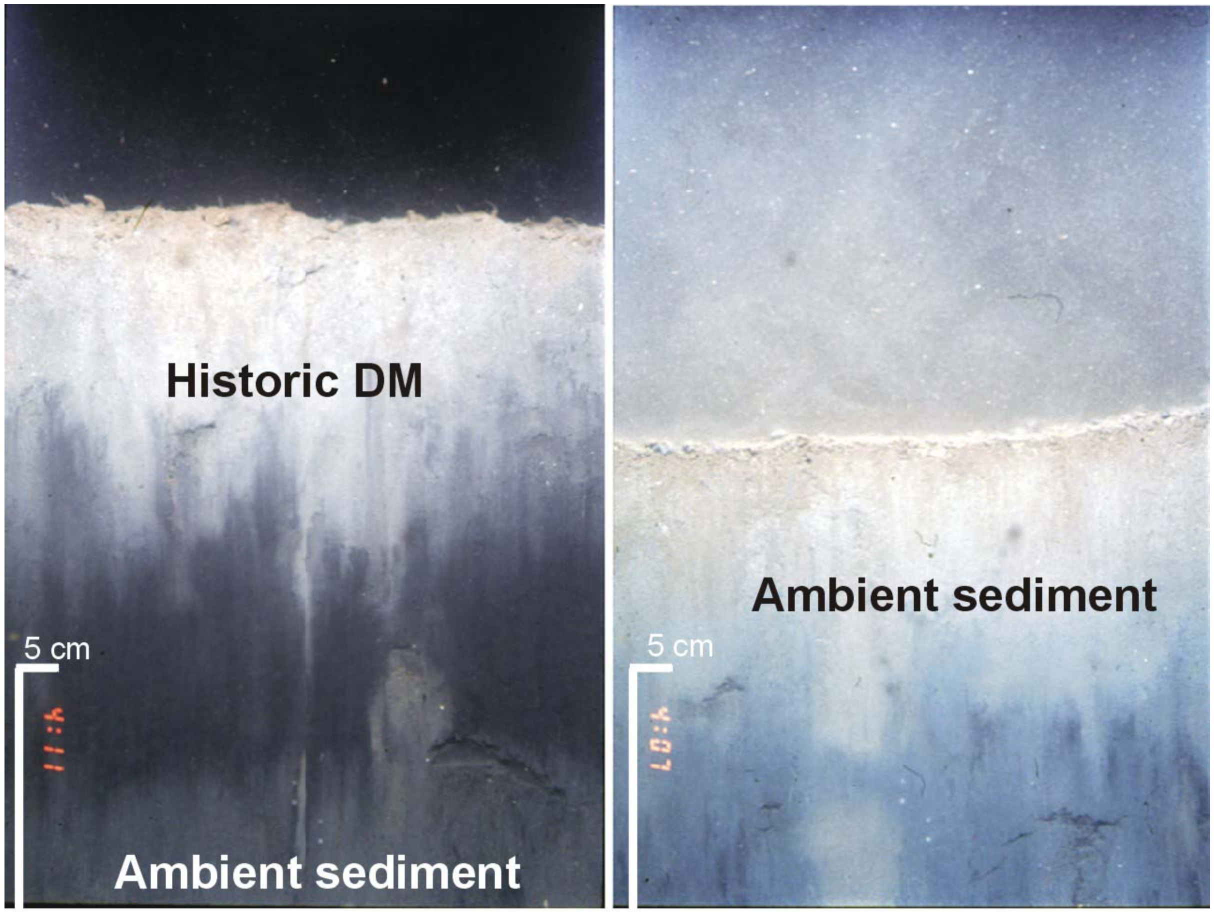
Dredged Material Distribution and Physical Sediment Characteristics

Twenty-five stations were sampled over the CLIS 95/96 Mound Complex, and historic dredged material was detected and classified as having a thickness greater than camera penetration depth in all but a few replicate images. Layering of historic dredged material over ambient sediment was observed in several photographs collected along the southern periphery of the survey grid (Stations 97, 99, and 101), while ambient Long Island Sound material was detected at the sediment-water interface at Station 98 (Figures 3-11 and 3-16A and B). Replicate-averaged camera penetration depths over the CLIS 95/96 Mound Complex ranged from 11.7 to 16.7 cm during the September 1999 survey, with no apparent spatial trends.

Similar to the CLIS reference areas, the CLIS 95/96 Mound Complex and the surrounding area consisted primarily of fine-grained sediments (silt/clay), yielding a major modal grain size of >4 phi for all stations (Table 3-3). Boundary roughness values were similar to both CLIS 97/98 and the reference areas, ranging from 0.3 to 2.6 cm, with an overall average of 0.9 cm (Tables 3-3 and 3-2). Surface disturbances at the sediment-water interface were attributed to a combination of physical and biological activity.

Biological Conditions and Benthic Recolonization

In general, RPD depths over the CLIS 95/96 Mound Complex were slightly deeper than the RPDs measured over the CLIS 97/98 Mound Complex. The replicate-averaged RPD depths ranged from 1.8 cm at Stations 66 and 67 to 4.8 cm at Station 101, with an overall average of 3 cm (Figure 3-11; Table 3-3). The deepest RPDs were detected well south of the detectable mound where layering of historic dredged material and ambient sediment was observed (Figures 3-14 and 3-16). Reference area RPD values were slightly higher relative to the results obtained from CLIS 95/96 Mound Complex, with an overall average of 3.3 cm. No low dissolved oxygen conditions, redox rebounds, or methane bubbles were observed in any of the replicate images from this region.



A B

Figure 3-16. REMOTS® images collected at Stations 99 (A) and 98 (B) showing layering of historic dredged material over ambient sediments (A) and ambient Long Island Sound sediments at the sediment-water interface (B)

Table 3-3.

Summary of REMOTS® Results for Stations over the CLIS 95/96 Mound Complex

Associated Mound	Station (grid)	Station (waypoint)	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Fresh 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)
CLIS95/96	R3C9	57	13.70	0.00	0	1.96	I,III	ST_III	>4	NO	5.67	5	0.62
CLIS95/96	R4C9	66	15.25	0.00	0	1.75	I,III	ST_III	>4	NO	6.67	8	0.78
CLIS95/96	R4C10	67	15.10	0.00	0	1.84	I,III	ST_III	>4	NO	6.67	8	0.91
CLIS95/96	R5C8	74	11.73	0.00	0	2.69	I,III	ST_III	>4	NO	7.67	9	0.70
CLIS95/96	R5C9	75	12.22	0.00	0	2.90	I,III	ST_I_ON_III	>4	NO	8.00	9	0.35
CLIS95/96	R5C10	76	16.69	0.00	0	3.25	I,III	ST_III	>4	NO	6.67	5	1.27
CLIS95/96	R5C11	77	15.26	0.00	0	2.50	I,III	ST_III	>4	NO	7.33	8	0.85
CLIS95/96	R6C7	82	14.77	0.00	0	2.54	I,III	ST_I_ON_III	>4	NO	7.67	9	0.40
CLIS95/96	R6C8	83	15.82	0.00	0	2.24	I,III	ST_III	>4	NO	7.33	8	0.33
CLIS95/96	R6C9	84	14.85	0.00	0	2.99	I,III	ST_III	>4	NO	9.67	10	0.84
CLIS95/96	R6C10	85	12.67	0.00	0	3.23	I,III	ST_III	>4	NO	10.00	10	2.13
CLIS95/96	R6C11	86	14.93	0.00	0	3.11	I,III	ST_I_ON_III	>4	NO	7.00	5	0.82
CLIS95/96	R6C12	87	12.91	0.00	0	2.51	I,III	ST_III	>4	NO	7.67	9	0.54
CLIS95/96	R7C7	89	14.82	0.00	0	2.39	I,III	ST_I_ON_III	>4	NO	7.00	7	2.61
CLIS95/96	R7C8	90	15.27	0.00	0	2.53	I,III	ST_I_ON_III	>4	NO	9.00	9	0.85
CLIS95/96	R7C9	91	14.50	0.00	0	2.57	I,III	ST_I_ON_III	>4	NO	9.00	9	0.65
CLIS95/96	R7C10	92	15.05	0.00	0	3.00	I,III	ST_I_ON_III	>4	NO	8.33	9	0.64
CLIS95/96	R7C6	93	11.78	0.00	0	2.15	I,III	ST_III	>4	NO	8.67	9	1.01
CLIS95/96	R8C7	94	13.21	0.00	0	3.52	I,III	ST_I_ON_III	>4	NO	10.33	11	1.05
CLIS95/96	R8C8	95	14.68	0.00	0	2.74	I,III	ST_III	>4	NO	9.33	10	0.80
CLIS95/96	R8C9	96	13.87	0.00	0	3.86	I,III	ST_I_ON_III	>4	NO	7.67	7	0.94
CLIS95/96	R8C10	97	16.52	0.00	0	4.11	I,III	ST_III	>4	NO	9.00	10	1.20
CLIS95/96	R9C9	98	15.55	0.00	0	4.40	I,III	ST_I_ON_III	>4	NO	9.33	10	1.02
CLIS95/96	R9C10	99	16.67	0.00	0	4.63	I,III	ST_I_ON_III	>4	NO	10.33	10	1.42
CLIS95/96	R9C8	101	15.27	0.00	0	4.75	I,III	ST_I_ON_III	>4	NO	8.33	7	0.70
CLIS95/96 Stations		AVG	14.29	0.00	0.00	2.89					8.28	8.58	0.95
		MIN	11.73	0.00	0.00	2.15					6.67	5	0.33
		MAX	16.69	0.00	0.00	4.11					10.33	11	2.61
All Stations		AVG	**9.61**	**0.80**	**0.43**	**1.68**					**4.84**	**4.89**	**0.64**
		MIN	**4.78**	**0.00**	**0.00**	**0.98**					**3.67**	**3**	**0.28**
		MAX	**19.38**	**10.31**	**3.00**	**4.63**					**11.00**	**11**	**2.61**

As anticipated, the successional stage was more advanced over CLIS 95/96 in comparison to the CLIS 97/98 Mound Complex. Stage III individuals were much more abundant over the older sediment deposit, with every station within the survey grid displaying evidence of a mature benthic assemblage (Figure 3-15; Table 3-3). In response to the deeper RPDs and the density of Stage III organisms, the station median OSI values were fairly high, ranging from +5 to +11 with an overall average of +8.6 (Table 3-3). The lowest median OSI values over CLIS 95/96 were found at three stations (Stations 57, 76, and 86) located on the north side of the mound complex (Figure 3-14). Overall, benthic habitat quality over the CLIS 95/96 Mound Complex appeared to be quite comparable to the CLIS reference areas, which displayed an average OSI value of +8.9 (Table 3-2). These findings suggest the three-year-old sediment deposit is recovering from the benthic disturbance, as anticipated.

3.3.2.3 NHAV 93 Mound

Dredged Material Distribution and Physical Sediment Characteristics

Since its completion in the spring of 1994, the NHAV 93 Mound has displayed a cyclical pattern of benthic recovery and decline, suggesting an increased susceptibility to regional disturbance (i.e., seasonal hypoxia) relative to the CLIS reference areas and surrounding disposal mounds (Morris 1998). Due to the origin of the CDM and lack of toxicity in a well-oxygenated environment, the instability in the benthic habitat is likely related to labile organics within the deposited sediment and sediment oxygen demand (Morris and Tufts 1996). The 1999 survey represents the sixth sediment-profile photography survey performed over this disposal mound, focusing on areas of concern located near the center of the capped mound.

Five stations were sampled over the NHAV 93 Mound, with historic dredged material detected and classified as greater than penetration in all replicate photographs (Table 3-4). The surface sediment was predominantly fine-grained material, displaying a major modal grain size of >4 phi (silt/clay) and indicating no detectable coarsening (winnowing) relative to previous surveys. Camera penetration depths ranged from 14.2 to 16.1 cm with boundary roughness values varying from 0.7 to 1.7 cm. Surface disturbances were primarily physical in nature.

Biological Conditions and Benthic Recolonization

The replicate-averaged RPD values measured over the NHAV 93 Mound varied from 1.8 cm at Station 200W to 2.5 cm at Station CTR (Figure 3-17; Table 3-4). Although low dissolved oxygen conditions were not apparent in any of the images, two

Table 3-4.

Summary of REMOTS® Results for Stations over the NHAV 93 Mound

Station	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material Present	RPD Mean	Successional Stages Present	Highest Successional Stage	Grain Size Major Mode	Methane Present	OSI Mean	OSI Median	Boundary Roughness
CTR	15.49	>15.41	3	2.46	I,III	ST_I_ON_III	>4	YES	7.67	8	1.72
200N	15.94	>15.86	3	2.39	I,III	ST_I_ON_III	>4	NO	8.33	8	1.27
200E	14.82	>14.48	3	2.41	I,III	ST_I_ON_III	>4	NO	7.33	9	0.84
200S	14.22	>13.80	3	2.02	I,III	ST_I_ON_III	>4	NO	5.67	4	0.65
200W	16.14	>15.47	3	1.77	I,III	ST_I_ON_III	>4	NO	6.67	7	0.90
AVG	15.32	>15.00	3	2.21					7.13	7.20	1.08
MIN	14.22	>13.80	3	1.77					5.67	4	0.65
MAX	16.14	>15.86	3	2.46					8.33	9	1.72

Values shown are means for n = 3 replicate images obtained and analyzed at each station. If dredged material exceeded the prism penetration depth, then the mean value shown is a minimum estimate of dredged material layer thickness (indicated by the > sign)

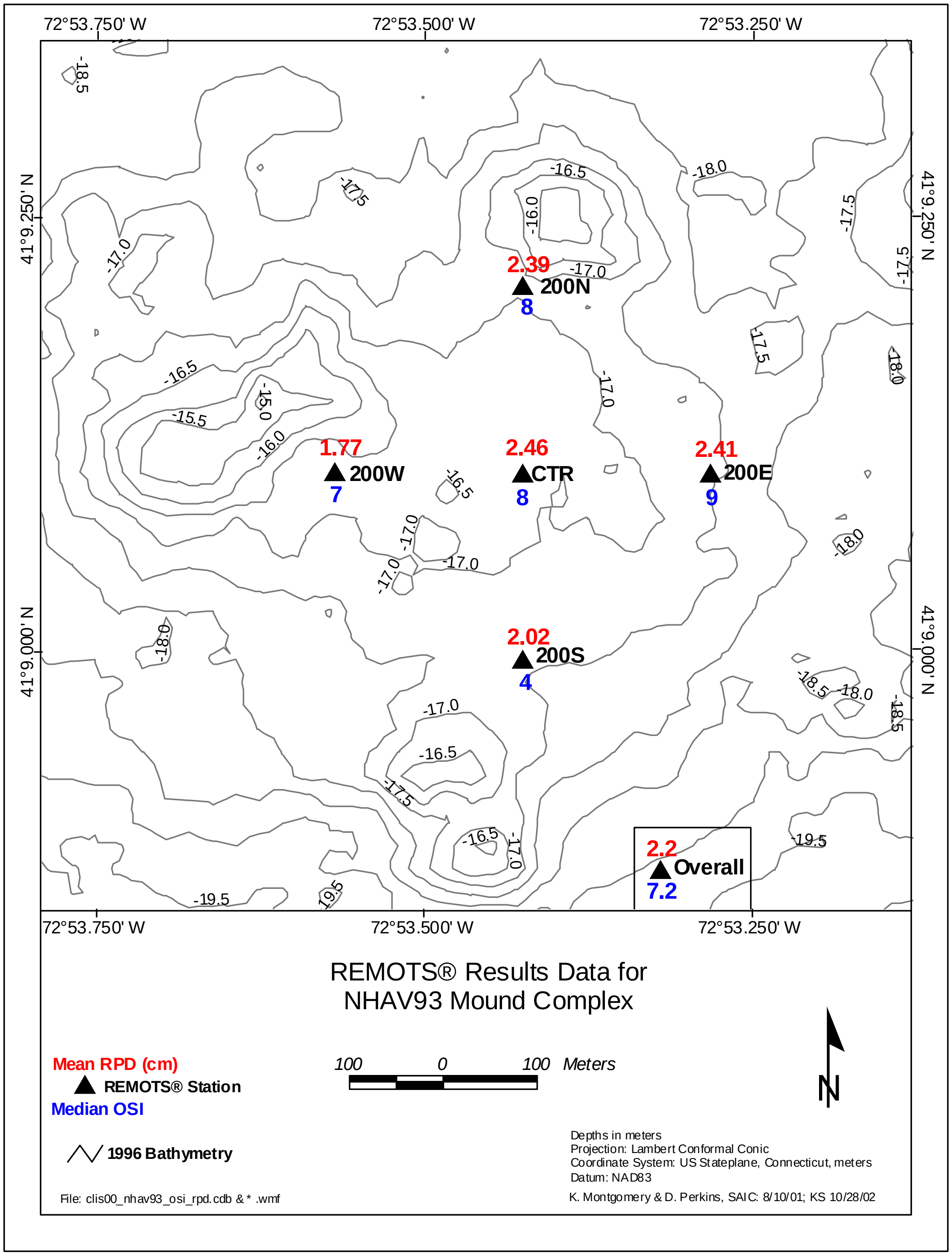


Figure 3-17. Replicate-averaged RPD (red) and median OSI values (blue) calculated for the REMOTS® stations established over the NHAV 93 Mound

replicates from the center station did show methane bubbles (a product of anaerobic decomposition of organic matter) in the sediments (Figure 3-18). Furthermore, the underlying sediments in many images were described as reduced (low reflectance) at depth, likely due to an elevated organic load. No visible redox rebound layers were observed in the images collected over the NHAV 93 Mound.

The center portion of the NHAV 93 Mound displayed an advanced successional stage with evidence of Stage III activity detected in 11 of the 15 replicate images. Stage I tubes were present at the sediment-water interface in all replicates from all stations and each station was classified as having a Stage I population over a Stage III assemblage (Figure 3-19). In general, the 1999 REMOTS® results show improvement in benthic habitat conditions in comparison to earlier surveys. The station median OSI values ranged from +4 at Station 200S to +9 at Station 200E, with an average over the mound of +7.2, lower than the reference area value of +8.9 (Figure 3-17). Station 200S has been one of the areas of concern on the NHAV 93 Mound over the past six years. The low OSI value calculated for Station 200S as part of the 1999 survey results was primarily due to lack of Stage III activity and shallow RPD depths in two of the three photographs collected (Figure 3-20A). The third replicate displayed a fairly deep RPD with small Stage I surface tubes at the sediment-water interface and active Stage III feeding voids at depth and an OSI value of +9 (Figure 3-20B). This suggests variability in benthic conditions exist within the 25 m sampling radius of Station 200S.

Similar variability occurred at Stations 200E, where one of the three replicates had an OSI value of +4, due to the lack of Stage III activity and slightly shallower RPD depths than the other two replicates from that station (with OSI values of +9; Appendix E). One of three replicate images at Station 200W also had an OSI value of +4 due to the same factors, while the other two replicates from that station had OSI values of +7 and +9. More consistent results were found among the replicate images acquired at stations CTR and 200N, with OSI values of +6, +8, and +9 for the three replicate images at CTR, and OSI values of +8, +8, and +9 for the three replicate images at 200N. Both CTR and 200N displayed evidence of Stage III activity in all replicates, and the slight deviations in OSI values were attributable to minor differences in RPD depths.

3.3.2.4 MQR Mound

Dredged Material Distribution and Physical Sediment Characteristics

A 13-station REMOTS® survey grid was occupied over the historic MQR Mound to evaluate benthic habitat conditions relative to the results of previous surveys. All of the dredged material observed in the REMOTS® images was described as historic,

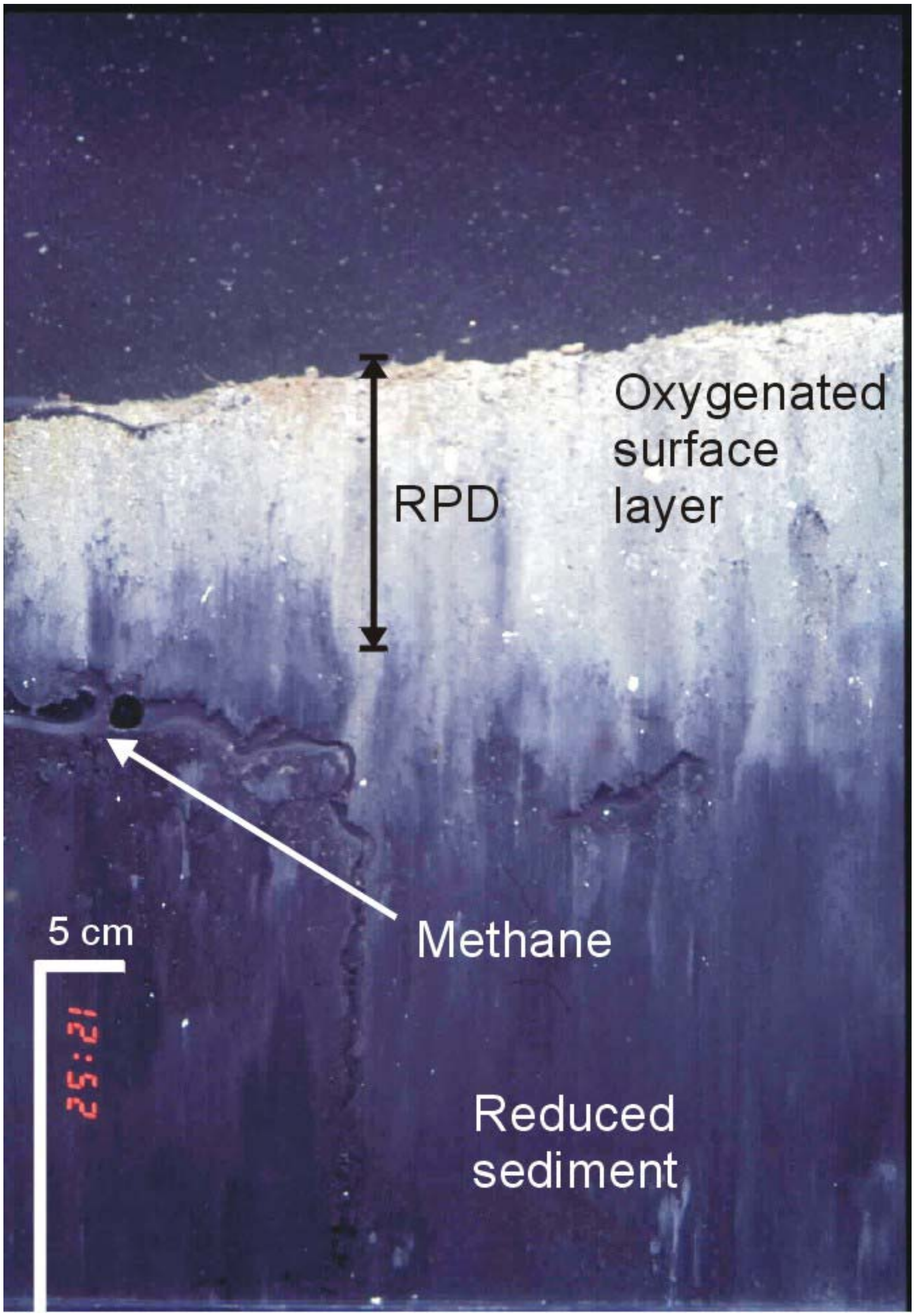


Figure 3-18. REMOTS® image collected at NHAV 93 Station CTR showing a relatively deep RPD, reduced sediments at depth, and methane gas bubbles entrained within the subsurface sediments

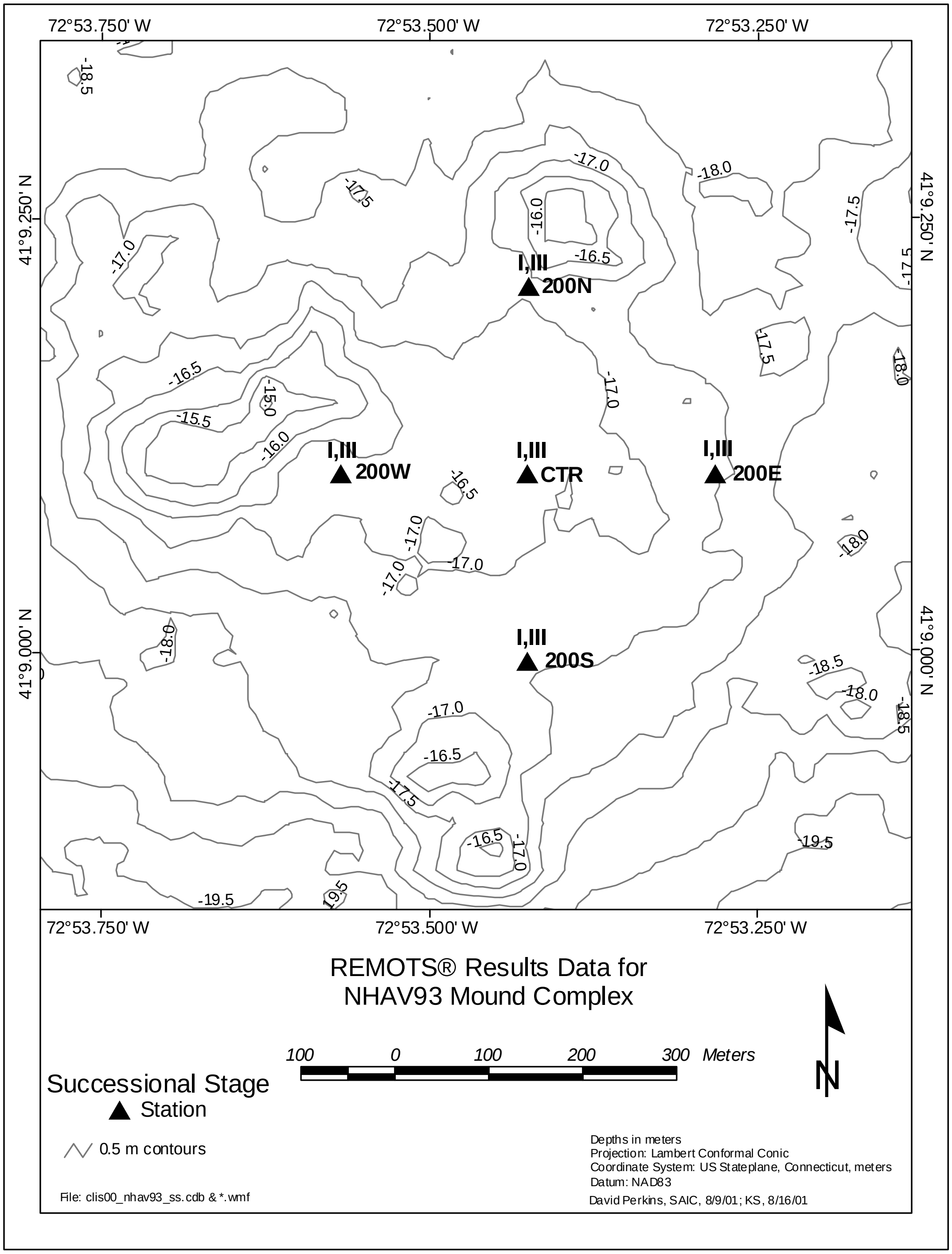
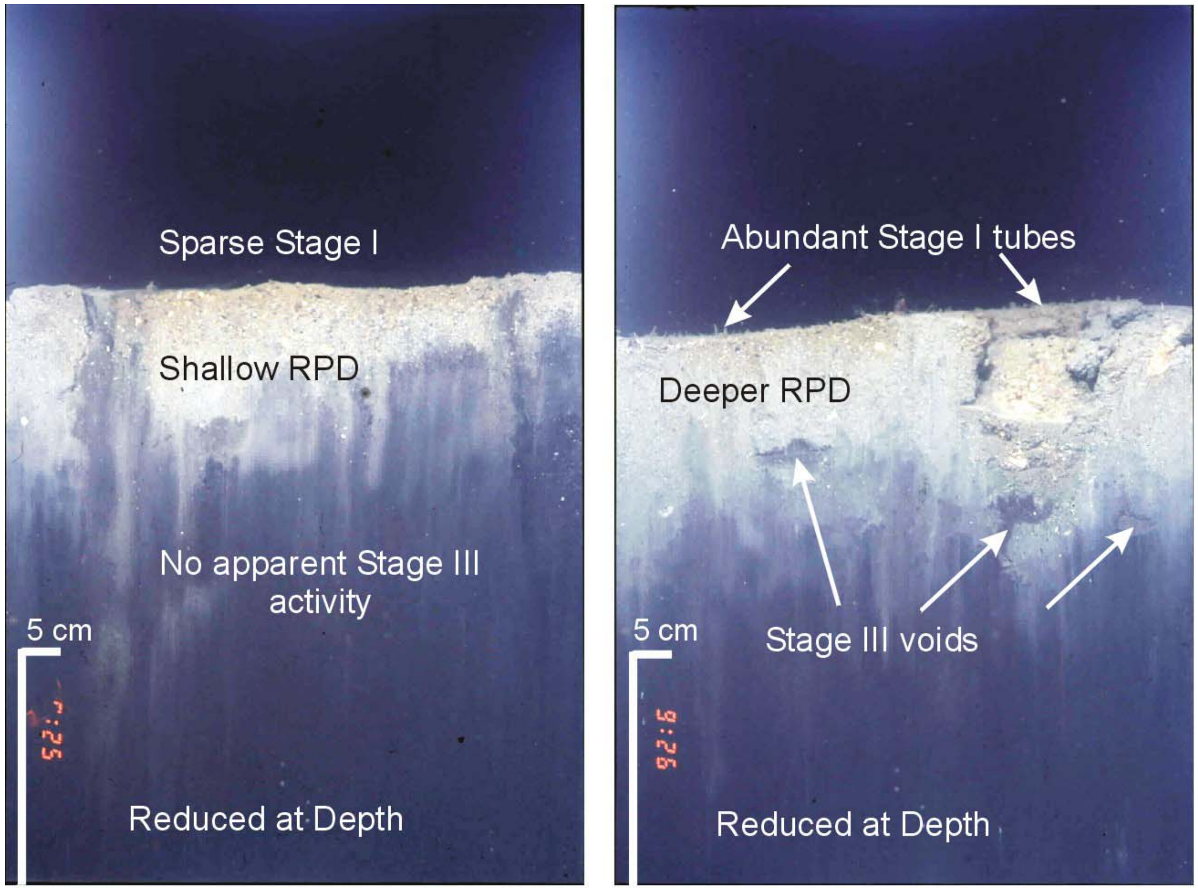


Figure 3-19. Successional stage status for the REMOTS® stations established over the NHAV 93 Mound



A **B**

Figure 3-20. REMOTS® images collected at NHAV 93 Station 200S showing variability in benthic habitat conditions within the 25 m sampling radius with thicknesses determined to be greater than the camera penetration depth (Figure 3-21A). However, several of the replicate images collected on the southern and western arms of the survey grid displayed low reflectance, reduced sediments (an indicator of organically enriched dredged material) at depth (Figure 3-21B).

The surface sediments over most of this historic disposal mound consisted of fine-grained sediments, with a major modal grain size of >4 phi (silt/clay). Coarser grained material (fine to medium sand) was noted in many replicate images, and sufficient sand was detected at Station 150S to yield a major modal grain size of 4 to 3 phi (Table 3-5). Replicate-averaged camera penetration ranged from 10.5 cm at Station 100E to 16.2 cm at Station 50S, with an overall average of 13.0 cm. Average boundary roughness values for each station ranged from 0.8 to 1.9 cm. Biological activity was responsible for surface disturbances at Stations 50W and 100W, while boundary roughness was described as physical in nature over the remainder of the disposal mound. A number of small mud clasts were observed on the sediment surface at Stations 50E, 100E, 150E, 50W, and 150N, suggesting some minor physical disturbance in the recent past (i.e., trawling).

Biological Conditions and Benthic Recolonization

The replicate-averaged RPD values ranged from 1.7 at Stations 150E and 150S to 3.3 cm at Station 50W (2.5 cm overall average; Figure 3-22; Table 3-5). The RPD depths over the MQR Mound were generally shallower in comparison to the data acquired from the CLIS reference areas. However, none of the images collected over the MQR Mound in September 1999 displayed low dissolved oxygen conditions, methane bubbles, or visible redox rebounds. One replicate image from Station 50N had a very shallow RPD depth of 0.18 cm, which was attributed to a recent physical benthic disturbance based upon the presence of a large surface mud clast (Figure 3-23A).

The successional status over most of the MQR Mound appeared to be advanced, with evidence of Stage III activity detected in 29 out of 39 replicate photographs (Figure 3-24). Most of the images also displayed dense aggregations of Stage I tubes visible at the sediment-water interface. Large *Chaetopterus* tubes were seen in two replicates obtained from Station 50S (Figure 3-23B). The OSI values over the MQR stations were lower, but comparable to the CLIS reference area results. Median OSI values ranged from +4 to +10, with an overall average of +7.9 (Figure 3-22; Table 3-5). These results suggest undisturbed benthic habitat quality exists over most of the disposal mound. However, Stations 100S and 150S had lower median OSI values of +4, primarily due to the relatively low abundance of Stage III organisms at these two stations.

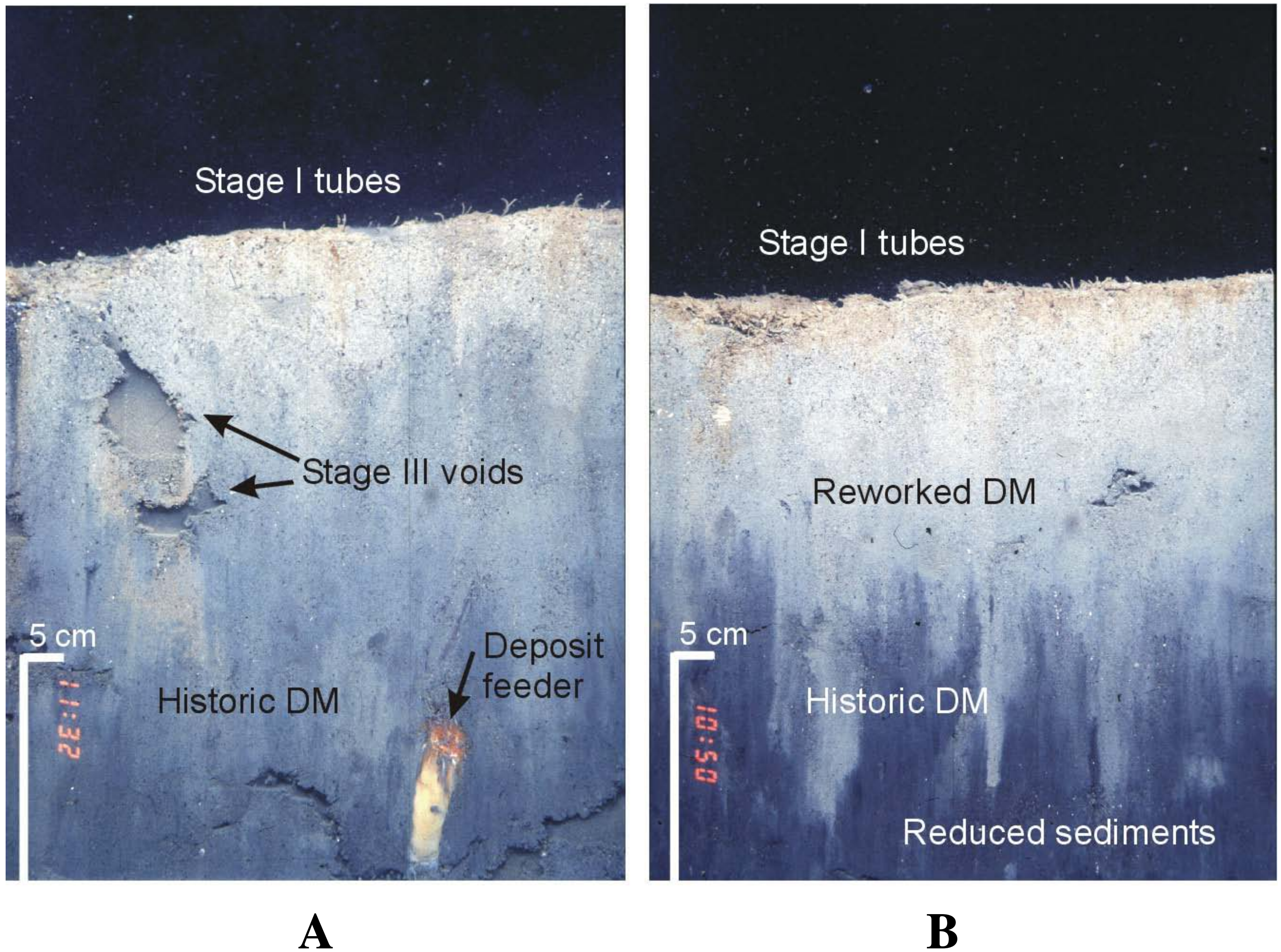


Figure 3-21. REMOTS® images collected at MQR Stations 100N (A) and 50W (B) showing variability in the appearance of historic dredged material

Table 3-5.

Summary of REMOTS® Results for Stations over the MQR Mound

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
CTR	13.86	>10.69	3	1.86	I,III	ST_I_ON_III	>4	NO	6.67	7	0.99
50N	14.59	>14.62	3	2.11	I,III	ST_III	>4	NO	8.67	10	1.50
50E	12.39	>12.15	3	2.73	I,III	ST_I_ON_III	>4	NO	9.00	9	1.18
50S	16.15	>16.13	3	3.19	I,III	ST_I_ON_III	>4	NO	9.67	10	1.87
50W	13.14	>13.16	3	3.34	I,III	ST_III	>4	NO	10.00	10	0.91
100N	14.52	>14.46	3	2.94	I,III	ST_I_ON_III	>4	NO	8.00	9	0.94
100E	10.48	>10.86	3	3.19	I,III	ST_III	>4	NO	10.00	10	1.18
100S	12.20	>12.12	3	2.10	I,III	ST_I_ON_III	>4	NO	5.67	4	0.80
100W	10.81	>10.84	3	2.27	I,III	ST_I_ON_III	>4	NO	7.33	8	0.85
150N	11.58	>11.69	3	2.35	III	ST_III	>4	NO	8.67	8	1.10
150E	14.82	>14.97	3	1.68	I,III	ST_I_ON_III	>4	NO	5.33	5	0.78
150S	10.58	>10.23	3	1.72	I,III	ST_III	4 to 3	NO	5.33	4	0.89
150W	13.71	>13.64	3	2.62	I,III	ST_I_ON_III	>4	NO	7.67	9	0.82
AVG	12.99	>12.74	3	2.47					7.85	7.92	1.06
MIN	10.48	>10.69	3	1.68					5.33	4	0.78
MAX	16.15	>16.13	3	3.34					10.00	10	1.87

Values shown are means for n = 3 replicate images obtained and analyzed at each station. If dredged material exceeded the prism penetration depth, then the mean value shown is a minimum estimate of dredged material layer thickness (indicated by the > sign)

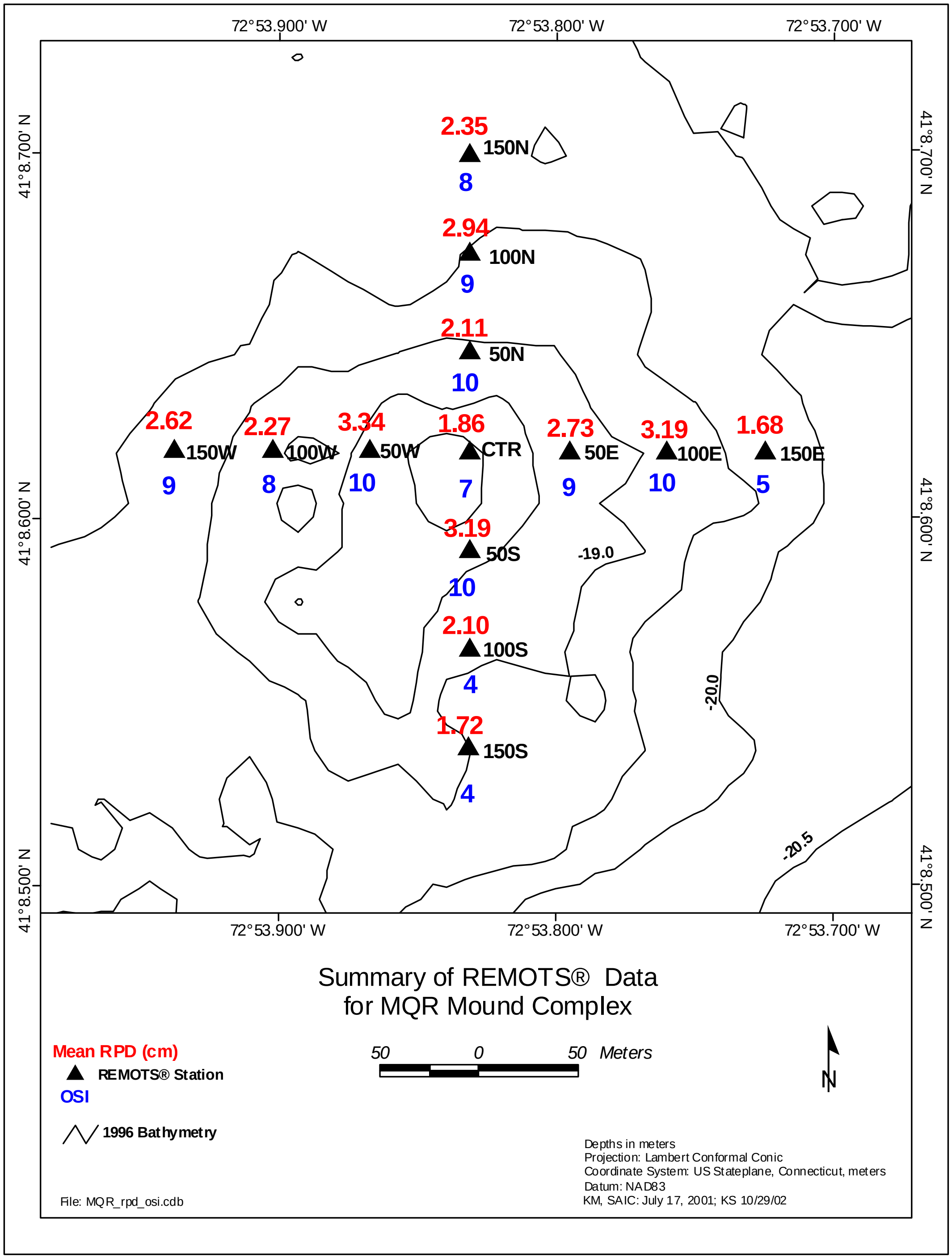
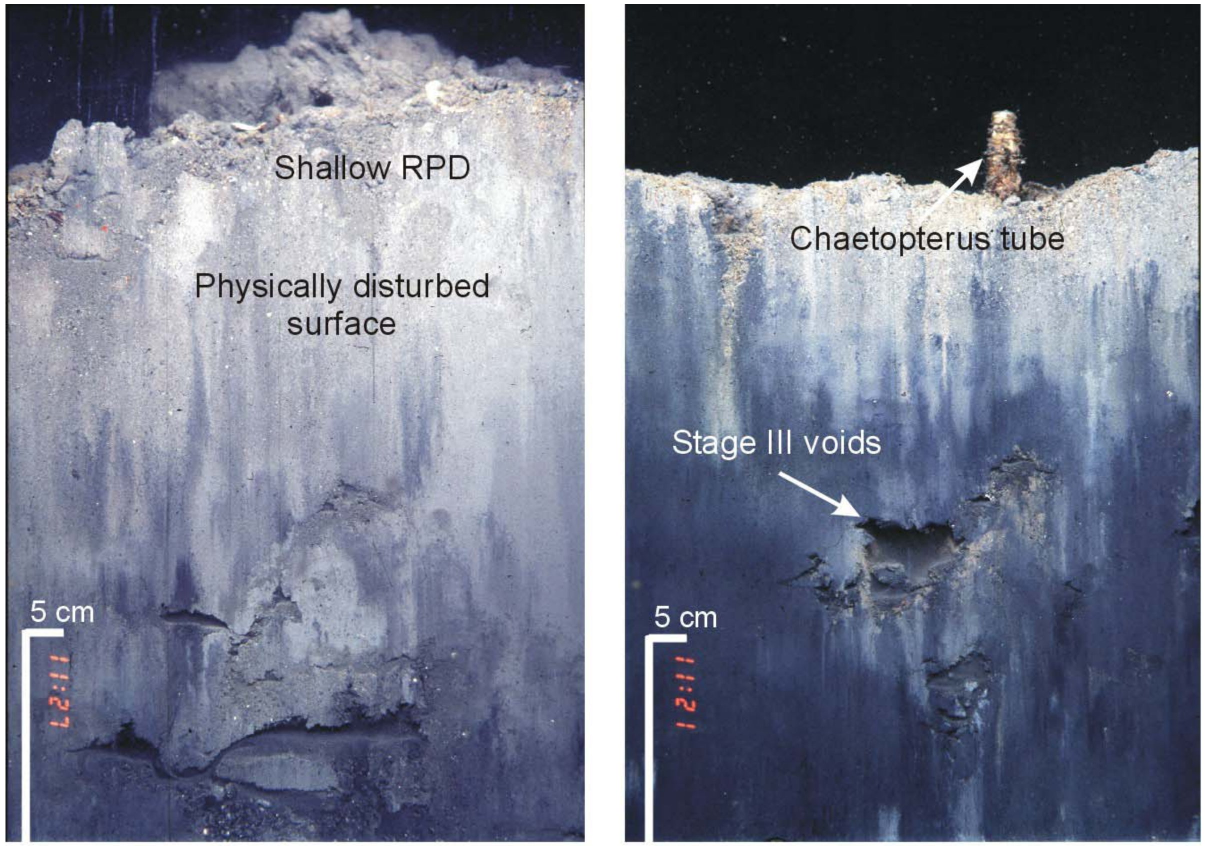


Figure 3-22. Replicate-averaged RPD (red) and median OSI values (blue) calculated for the REMOTS® stations established over the MQR Mound



A B

Figure 3-23. REMOTS® images collected over MQR Stations 50N (A) and 50S (B) showing disturbed surface layer with a large mudclast (A) and a recovering area of seafloor with a large *Chaetopterus* tube at the sediment-water interface with Stage III feeding voids at depth (B)

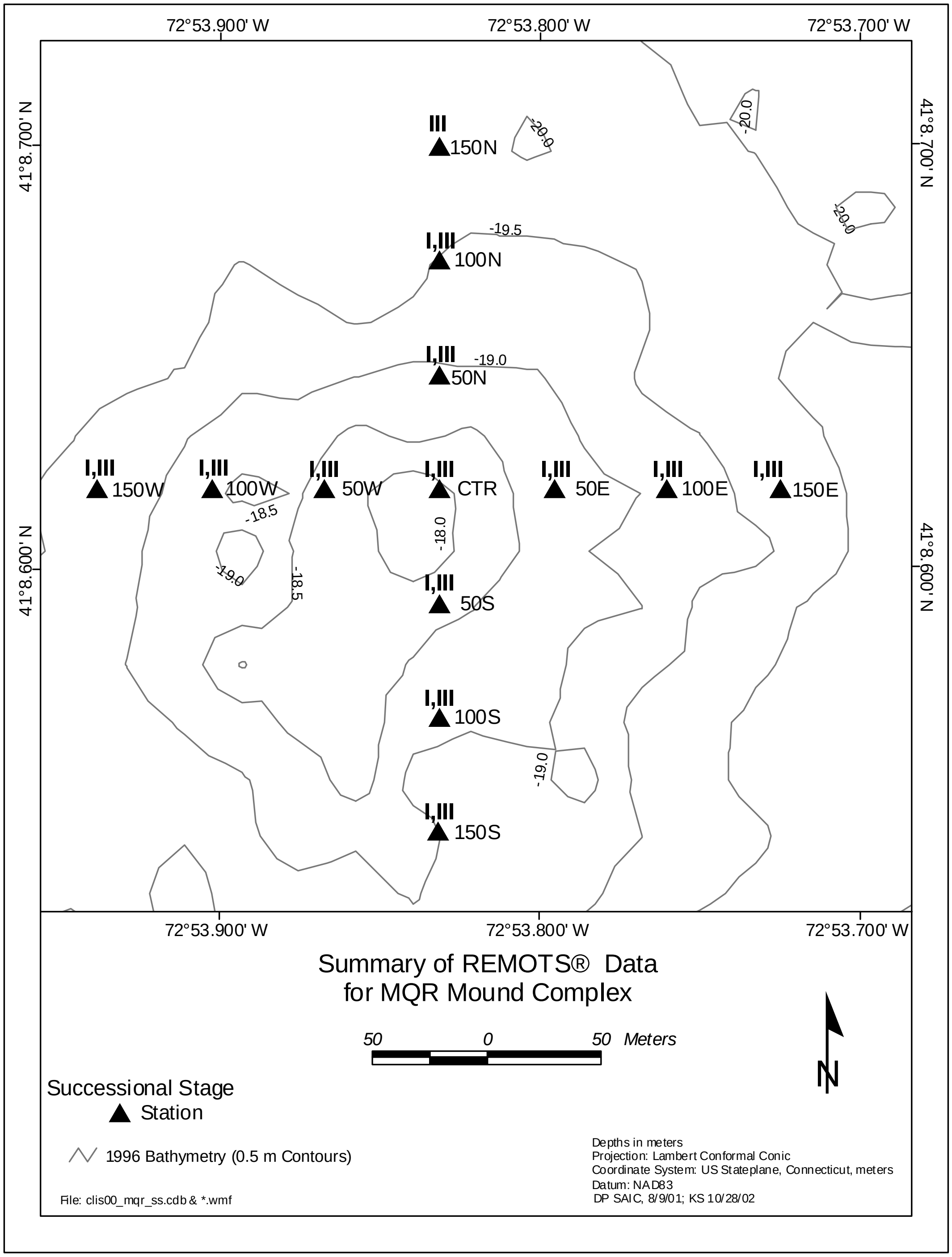


Figure 3-24. Successional stage status for the REMOTS® stations established over the MQR Mound

3.3.2.5 FVP Mound

Dredged Material Distribution and Physical Sediment Characteristics

The FVP Mound was developed in the northeastern corner of CLIS during the 1982–83 disposal season; it consists of a relatively small volume of UDM originating from Black Rock Harbor. The UDM deposit was left uncapped and monitored intensively from 1983 through 1986 to evaluate the effects on the benthic environment. The FVP Mound was then monitored periodically during the 1990s (1991, 1993, and 1995) to examine long-term trends in benthic community structure (Wiley and Charles 1995 and Morris 1997). Over the years, the results have indicated the benthic infaunal community inhabiting the sediments of FVP is more susceptible to the impacts of seafloor disturbances (i.e., regional hypoxia) relative to other disposal mounds and the CLIS reference areas. The September 1999 survey effort represents the latest evaluation of the FVP Mound.

As in previous monitoring surveys, the surficial sediments over the FVP Mound consist of fine-grained material (>4 phi, silt/clay). Sediments displaying the characteristics of historic dredged material were detected at seven of the thirteen REMOTS® stations, and essentially confined within 200 m of Station CTR (Table 3-6). Camera penetration depths over the FVP Mound ranged from 13 to 17.2 cm, with an overall average penetration depth of 15.6 cm. Replicate-averaged boundary roughness values ranged from 0.5 to 1.2 cm, with no significant difference between stations with or without historic dredged material. Surface roughness was attributed to a combination of physical disturbance and biological activity. Many small mud clasts were noted at the sediment-water interface, although no spatial pattern was evident.

Biological Conditions and Benthic Recolonization

In general, the benthic habitat quality over the FVP Mound was better than anticipated, with relatively deep RPD depths (3.4 cm average) over the historic dredged material deposit and the surrounding ambient sediments (Figure 3-25). The replicate-average RPD depths ranged from 2.8 cm at Station 300N to 4.1 cm at Station 100N (Table 3-6). Overall, sediment oxygenation levels, as reflected in the RPD measurements, appeared to be consistently deeper over the FVP Mound compared to the CLIS reference areas (Table 3-2). No low dissolved oxygen conditions, methane bubbles, or redox rebounds were apparent in any of the replicate photographs.

The successional status at FVP was advanced and comparable to that observed at the reference areas, with evidence of Stage III activity observed in 32 out of 39 replicate images distributed among all 13 stations (Figure 3-26). In addition, dense patches of

Table 3-6.

Summary of REMOTS® Results for Stations over the FVP Mound

Station	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material Present	RPD Mean	Successional Stages Present	Highest Successional Stage	Grain Size Major Mode (Phi)	Methane Present	OSI Mean	OSI Median	Boundary Roughness Mean (cm)
CTR	17.12	>16.83	3	3.30	III	ST_III	>4	NO	10.00	10	0.63
100N	16.07	>16.25	3	4.14	I,III	ST_I_ON_III	>4	NO	11.00	11	0.68
100E	14.31	>14.07	3	3.38	I,III	ST_III	>4	NO	7.00	7	0.85
100S	17.23	>17.09	3	2.93	I,III	ST_I_ON_III	>4	NO	8.00	7	0.59
100W	15.93	>15.67	3	3.19	I,III	ST_III	>4	NO	9.67	10	0.68
200N	13.03	>9.87	3	3.01	I,III	ST_III	>4	NO	6.67	6	1.09
200E	15.12	>14.78	3	4.06	I,III	ST_I_ON_III	>4	NO	9.00	10	0.94
200S	15.74	0.00	0	3.07	I,III	ST_III	>4	NO	9.67	10	0.79
200W	15.20	0.00	0	3.73	I,III	ST_I_ON_III	>4	NO	10.33	11	0.54
300N	15.29	0.00	0	2.78	I,III	ST_I_ON_III	>4	NO	9.33	9	0.90
300E	15.24	0.00	0	3.45	I,III	ST_III	>4	NO	10.33	10	0.82
300S	15.85	0.00	0	3.66	I,III	ST_III	>4	NO	9.00	10	1.16
300W	16.22	0.00	0	3.40	I,III	ST_III	>4	NO	9.67	11	1.01
AVG	15.57	>14.94	1.62	3.39					9.21	9.38	0.82
MIN	13.03	0.00	0	2.78					6.67	6.00	0.54
MAX	17.23	>17.09	3	4.14					11.00	11.00	1.16

Values shown are means for n = 3 replicate images obtained and analyzed at each station. If dredged material exceeded the prism penetration depth, then the mean value shown is a minimum estimate of dredged material layer thickness (indicated by the >sign)

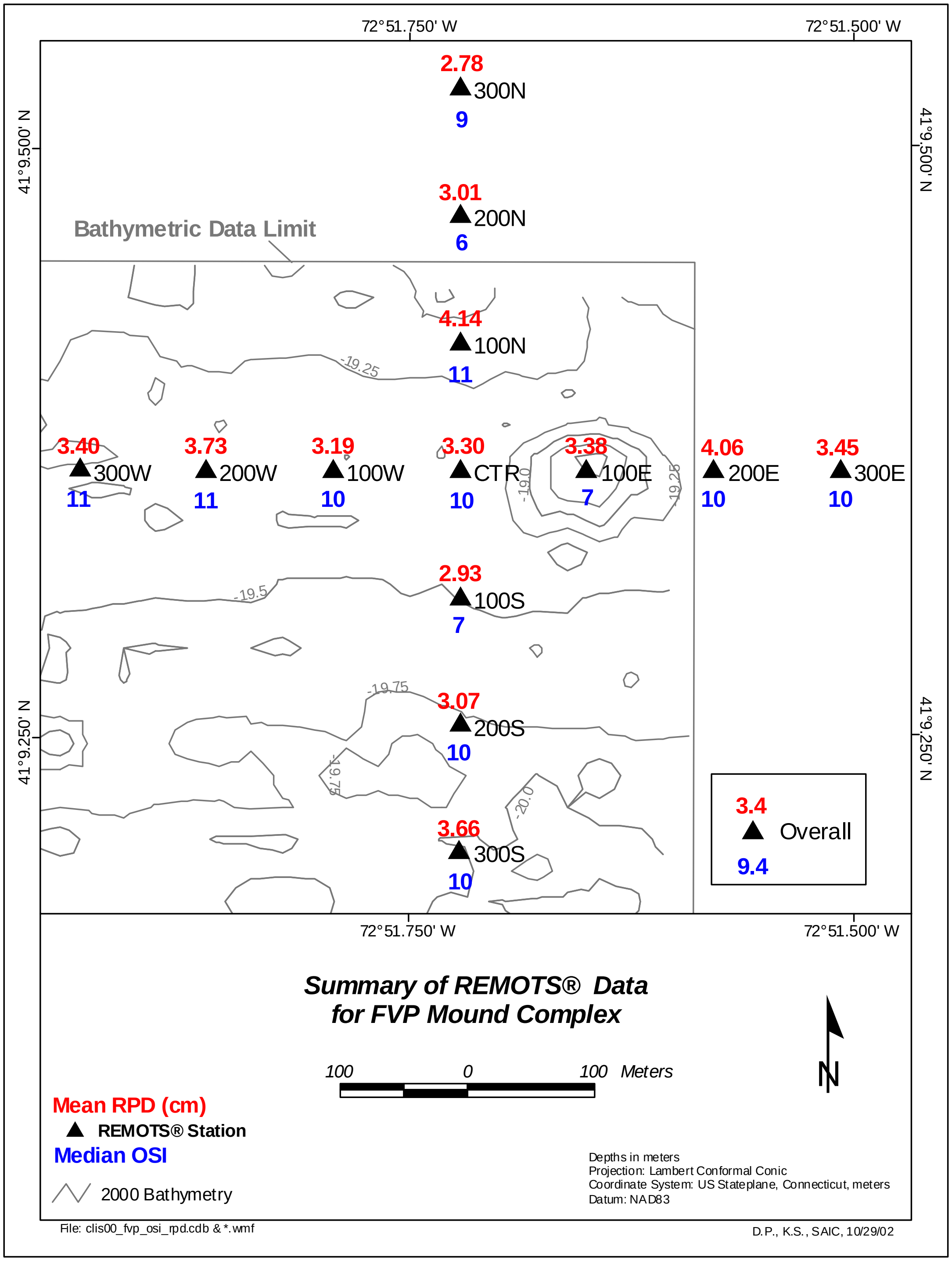


Figure 3-25. Replicate-averaged RPD (red) and median OSI values (blue) calculated for the REMOTS® stations established over the FVP Mound

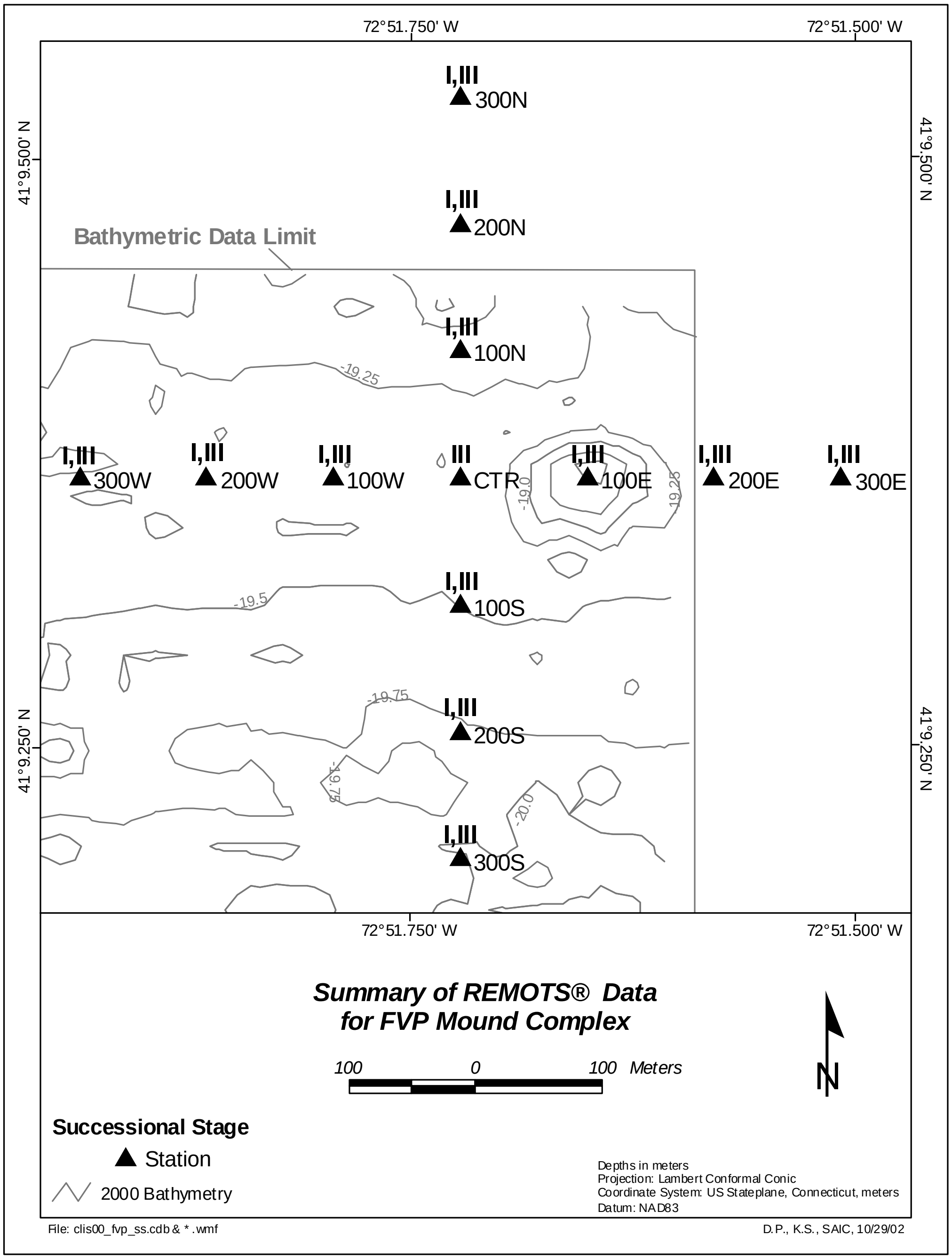


Figure 3-26. Successional stage status for the REMOTS® stations established over the MQR Mound

Stage I tubes were also visible at the sediment-water interface in many of the photographs collected over FVP (Figure 3-27A). Relatively small *Chaetopterus* tubes were detected in photos collected from Stations 100E, 100W, and 200S, suggesting recent recruitment of this polychaete into the benthic community at this mound (Figure 3-27B). As a result of the deep RPDs and the presence of an advanced successional stage, the average station median OSI was relatively high at +9.4 (Table 3-6). Median OSI values ranged from +6 at Station 200N to +11 at Stations 100N, 200W and 300W (Figure 3-25). The range of OSI values was narrower at the CLIS reference areas, but the overall average (+8.9) was actually lower relative to FVP.

3.3.2.6 CLIS Reference Areas

Thirteen stations were distributed between the three CLIS reference areas (2500W, 4500E, and CLISREF) and sampled with the REMOTS® sediment-profile camera. As with the disposal mound stations, three replicate photographs were collected at each reference station. Data from the reference areas were compiled to serve as a basis of comparison for the results obtained from the dredged material disposal mounds.

All of the replicate images were characterized as displaying ambient sediment, with no indications of dredged material placement or anthropogenic activity. Each of the reference area images also displayed a consistent major modal grain size of >4 phi, indicating a seafloor comprised of fine-grained sediment (silt/clay). Replicate-averaged camera penetration values ranged from 12.6 to 17.1 cm, with an overall average 14.9 cm for the reference areas (Table 3-2). Boundary roughness values were low for most stations sampled, ranging from 0.4 to 2.1 cm (average 0.8 cm), with physical factors being the predominant cause of surface roughness. While higher boundary roughness values were measured at Stations 1, 2, and 3 over 2500W, no indications of recent physical disturbance were apparent. The minor roughness in photographs collected from 4500E and CLISREF was likely caused by the resident biota.

Replicate-averaged RPD depths for all of the reference area stations ranged from 1.5 to 4.7 cm, with an overall average of 3.3 cm, indicating a well-oxygenated surficial sediment layer (Table 3-2). No redox rebound intervals were identified in any reference area photographs. In addition, there were no indications of low dissolved oxygen or methane at any of the three CLIS reference areas.

As anticipated, the successional stage status at the reference areas indicated an abundance of Stage III activity, with active feeding voids, burrows, or deposit feeding worms detected in 31 of 39 replicate images (Figure 3-28A; Table 3-2). Stage I tubes were also seen at the sediment-water interface in many of the photographs, prompting the

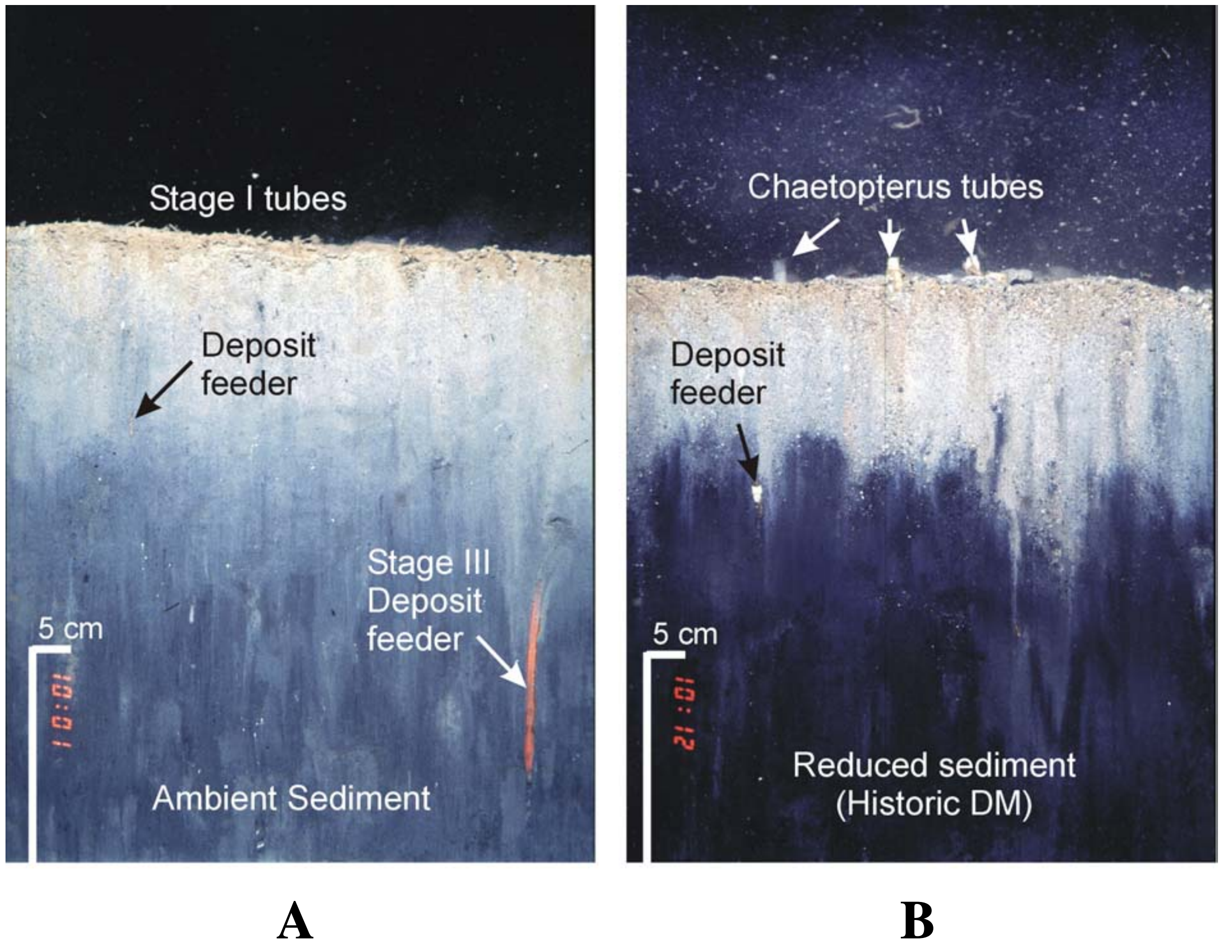
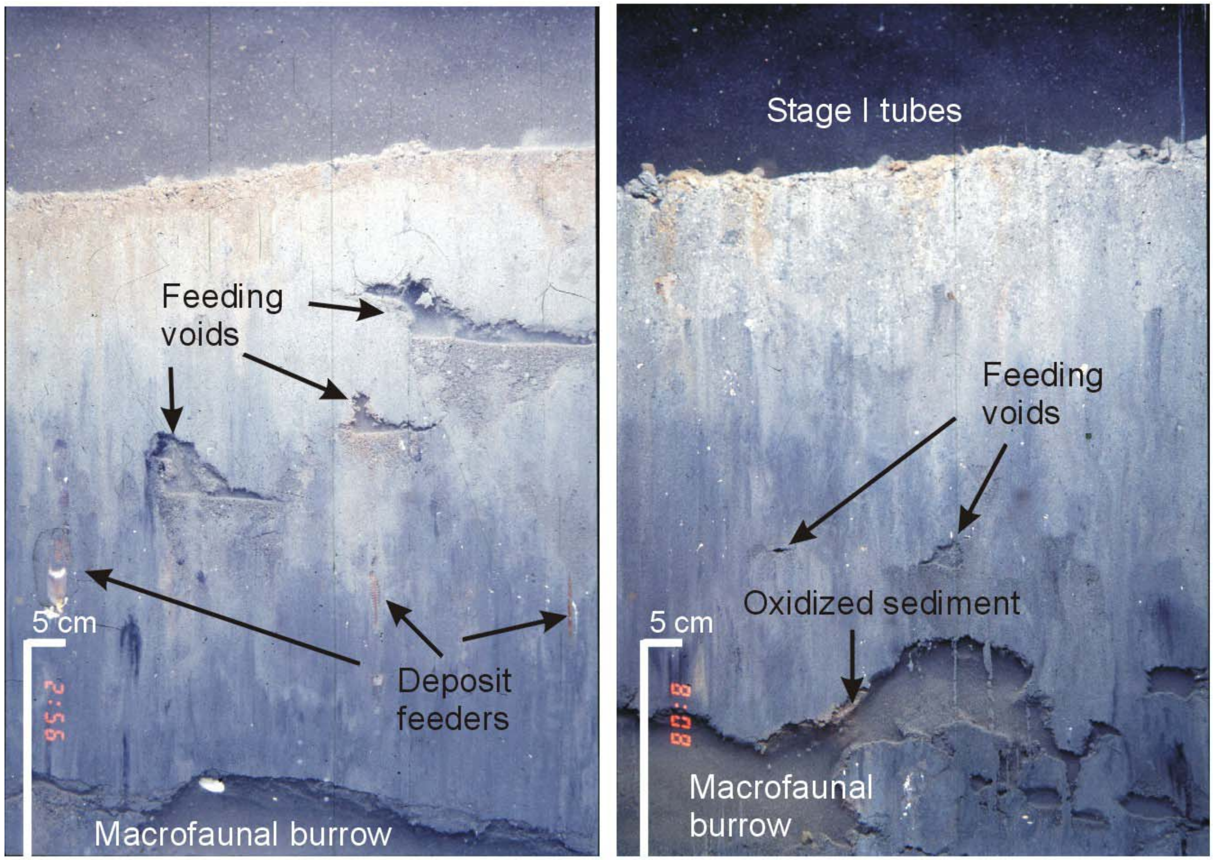


Figure 3-27. REMOTS® images collected at FVP Stations 300E (A) and 100E (B) as examples of benthic habitat conditions over the uncapped UDM deposit



A **B**

Figure 3-28. REMOTS® images collected at Station 11 from CLISREF (A) and Station 3 from 2500W (B) showing evidence of Stage III activity, as well as large-scale macrofaunal burrows at depth classification of Stage I on III at the majority of the stations sampled (Figure 3-28B). Macrofaunal (potentially juvenile lobster) burrows were also observed at a depth of 15 to 20 cm in multiple replicates collected from all three reference areas. The station median OSI values for the CLIS reference areas ranged from +6 to +11, with an overall average of +8.9. All three reference areas appeared free of any benthic disturbance, with CLISREF displaying the best conditions as four of the five stations displayed median OSI values of +11 (Table 3-2).

4.0 DISCUSSION

4.1 Seafloor Topography

Dredged material placement operations at CLIS entail directing disposal barges to a single taut-wire disposal buoy during each disposal season in order to form discrete dredged material deposits (disposal mounds) on the seafloor. This management strategy was employed to efficiently utilize the capacity of the disposal site, while preserving the capability to monitor each mound individually. Disposal logs and the results of the September 2000 multibeam bathymetric survey of the entire site indicate that disposal activity at CLIS historically has been concentrated within the northern and western portions of the disposal site. However, isolated disposal mounds (FVP, MQR, and STNH-S) exist in other areas of CLIS.

Over the past 16 years, disposal buoys have been located in a manner that promoted the formation of a circular pattern of disposal mounds on the CLIS seafloor. These rings of disposal mounds eventually will serve as containment basins for large-scale projects that require confined aquatic disposal. The artificial containment cells will limit the lateral spread of the initial UDM deposit on the seafloor and facilitate more efficient coverage with layers of CDM. Between 1984 and 1992, deposition of small to moderate volumes of dredged material was controlled to form a ring of mounds in the northwestern region of CLIS. In 1993, the artificial contaminant cell was filled with approximately 1.16 million cubic meters of dredged material, forming the NHAV 93 Mound (Figure 4-1; Morris and Tufts 1996). A second artificial containment cell (A) incorporating the CLIS 97/98 and 95/96 Mound Complexes, as well as the NHAV 74, SP, and NORWALK Mounds, is currently nearing completion to the southeast of NHAV 93 (Figure 4-1). Although small gaps exist between the CLIS 97/98, NHAV 74, and CLIS 95/96 Mounds, the ring of disposal mounds is sufficient to function as a containment basin, while still enabling discrete and independent monitoring of each of these bottom features.

In addition, a third cell (B) is being constructed to the east of the NHAV 93 Mound, which utilizes the flanks of the SP, CLIS 91, CLIS 94, STNH-N, CLIS 99, and NHAV 74 Mounds (Figure 4-1). Containment cell B is nearing completion with the recent construction of the CLIS 99 Mound. During the 2000/2001disposal season, approximately 71,000 m^3 of dredged material was placed at a disposal buoy deployed to the southwest of the CLIS 99 Mound. This sediment deposit will form the CLIS 2000 Mound and will aid in closing containment cell B. It is recommended that future disposal be directed to a position between the CLIS 94 and STNH-N Mounds to complete this containment cell (Figure 4-1).

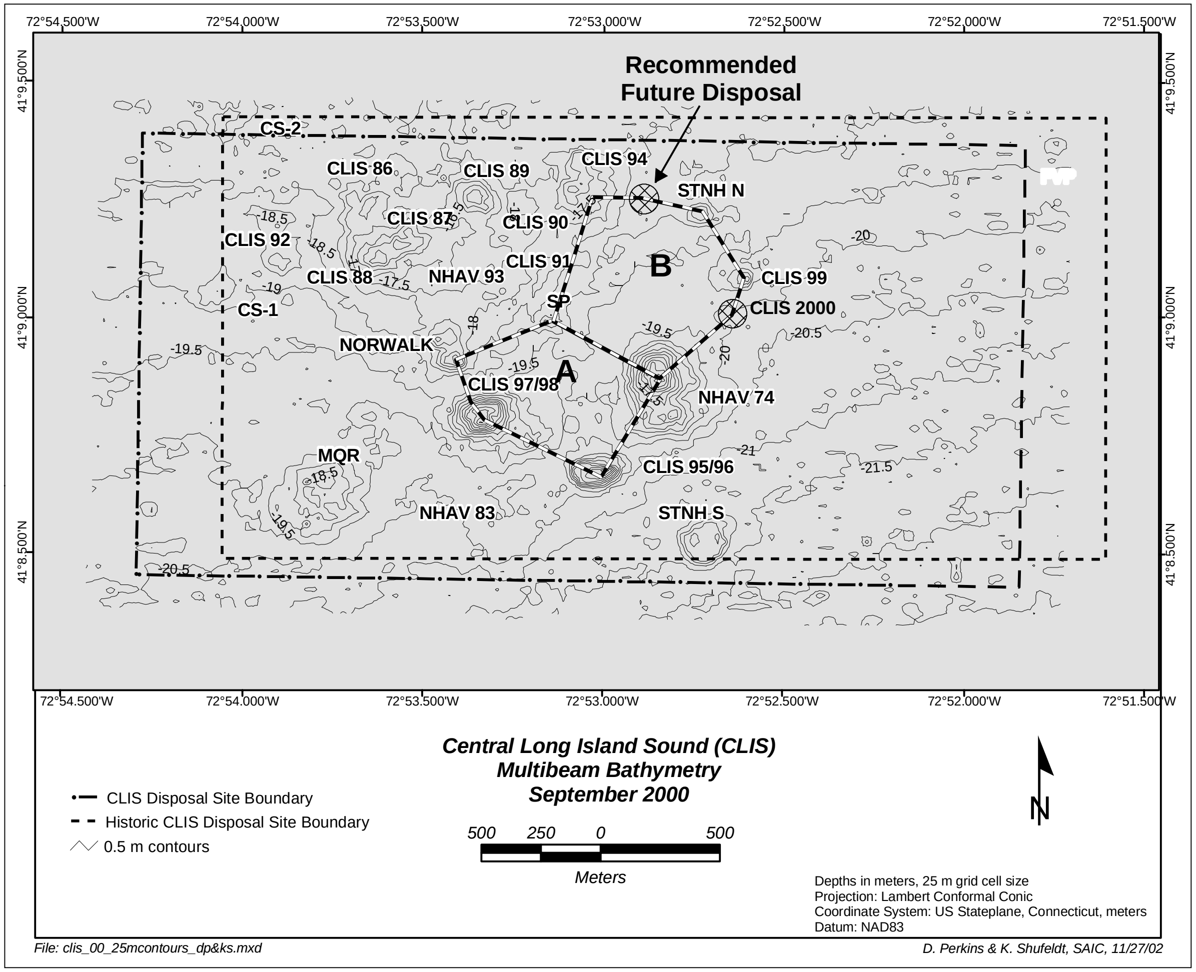


Figure 4-1. Bathymetric chart of CLIS based on the September 2000 multibeam survey showing the configuration of two artificial containment cells (A and B) on the seafloor of the disposal site

The depth difference results between the 2000 multibeam bathymetric survey and previous single-beam surveys showed that the detectable changes in seafloor topography at CLIS were the result of dredged material placement activity and disposal mound consolidation. Since the 1996 bathymetric survey, the small CLIS 95 Mound has received nearly 256,000 m^3 of additional material during the 1996–97 disposal season to form the CLIS 95/96 Mound Complex. Furthermore, an estimated barge volume of 517,000 m^3 was placed on the CLIS seafloor over the course of two disposal seasons (1997–98 and 1998–99) to form the CLIS 97/98 Mound Complex. The CLIS 99 Mound was created during the 1999–2000 disposal season by the placement of 86,000 m^3 of dredged material. All three of these mounds and/or mound complexes are prominent new features in the depth difference comparisons between the 1996 and 2000 bathymetric surveys (Figures 3-5 and 3-9).

The depth difference comparisons between the 1999 and 2000 surveys also indicated a sizable reduction in mound height over the apex of the CLIS 97/98 Mound Complex (Figure 3-10). Similar results for other mounds were seen in comparisons of the 1996 and 2000 surveys, as well as the 1997 and 1999 surveys (Figures 3-5 and 3-9). Disposal logs and REMOTS® sediment-profile images indicate the CDA 98 dredged material deposit is composed of 460,000 m^3 of various types of sediment (sand, silt, and clay) originating from multiple dredging projects in the Long Island Sound region and placed at a single disposal point. Although sand and pebbles were identified at the sediment-water interface at several stations, the REMOTS® images show no evidence of erosion (i.e., bedforms, lack of an oxidized surface layer, etc.) over the surface of the CDA 98 deposit, suggesting the apparent loss in mound height detected in the depth difference comparison was a product of sediment consolidation. Furthermore, these changes in mound height were confined primarily to the central portions of recently formed mounds, where relatively rapid rates of consolidation are known to occur.

The consolidation of dredged material disposal mounds over time is an expected and well-documented occurrence (Poindexter-Rollings 1990; Brandes et al. 1994; Morris 1998). As recent sediment deposits settle due to gravity, the interstitial spaces between sediment grains gradually close, causing the extrusion of pore water and a reduction in mound height. The rate of consolidation is dependent on many factors including the size and height of the mound, the type of material used to create the mound, and the length of time that has passed since the mound was formed. At roughly three months post disposal, the September 1999 survey documented the formation of a discrete disposal mound 6 m high and 400 m wide. The September 2000 survey indicated a major reduction in mound height (1.6 m) over the CDA 98 deposit within a 12-month period (15 months post disposal). It is anticipated that the rate of consolidation within the dredged material deposit will decrease during subsequent years as the interstitial spaces close and the mound reaches equilibrium. However, the added weight of a dredged material deposit on the CLIS seafloor will also cause the compression of the underlying ambient sediments and the gradual subsidence of the natural bottom (Poindexter-Rollings 1990).

Subsidence of the ambient seafloor occurs over the long term (5 to 10 years) and can be seen in comparisons of data sets that span several years. The smaller negative depth difference areas identified between the July 1996 and September 2000 surveys corresponded to the NHAV 93 and the CLIS 94 Mounds (Figure 3-5). These reductions in mound height are likely the result of a combination of small-scale consolidation within the disposal mound, as well as the subsidence of the underlying ambient seafloor. The July 1996 survey was completed two to three years after the initial creation of NHAV 93 and CLIS 94. Sequential bathymetric surveys performed in 1994, 1995, and 1996 had already captured the majority of the consolidation that had occurred within these disposal mounds (Morris 1998). Subsequent bathymetric surveys performed over the NHAV 93 and CLIS 94 Mounds in the next several years will likely be useful in documenting the degree of subsidence in the ambient sediments underlying these disposal mounds.

4.2 Benthic Habitat Assessment

At the time of the September 1999 REMOTS® survey, benthic habitat conditions over most of the disposal mounds, as well as within the ambient sediments of the central Long Island Sound region, appeared well within expectations. OSI values were generally higher at the various disposal mounds and the reference areas relative to the September 1997 survey. This general increase was a product of both deeper RPD depths and a higher apparent abundance of Stage III organisms. Over the past few years, a relationship was identified between benthic habitat conditions and the onset and severity of seasonal hypoxia in the region. Based on the findings of previous surveys, the improvement in benthic conditions documented in 1999 is likely attributable to higher dissolved oxygen concentrations within the regional bottom waters during the weeks preceding the 1999 survey effort, resulting in reduced stress within the benthos.

Since 1995, bottom water dissolved oxygen concentrations in the central Long Island Sound region have been used to qualify the sediment-profile photography results for CLIS (Morris 1997). Water quality data obtained from the Connecticut Department of Environmental Protection (CTDEP) for Stations H2 and H4 (see Figure 1-2) in 1999 showed that the September REMOTS® survey was completed while bottom water dissolved oxygen concentrations were relatively high (6.5 $mg \cdot l^{-1}$; Figure 4-2). The continuous records for Stations H2 and H4 indicate dissolved oxygen concentrations were quite high throughout the winter and early spring, then decreased as the waters of Long Island Sound

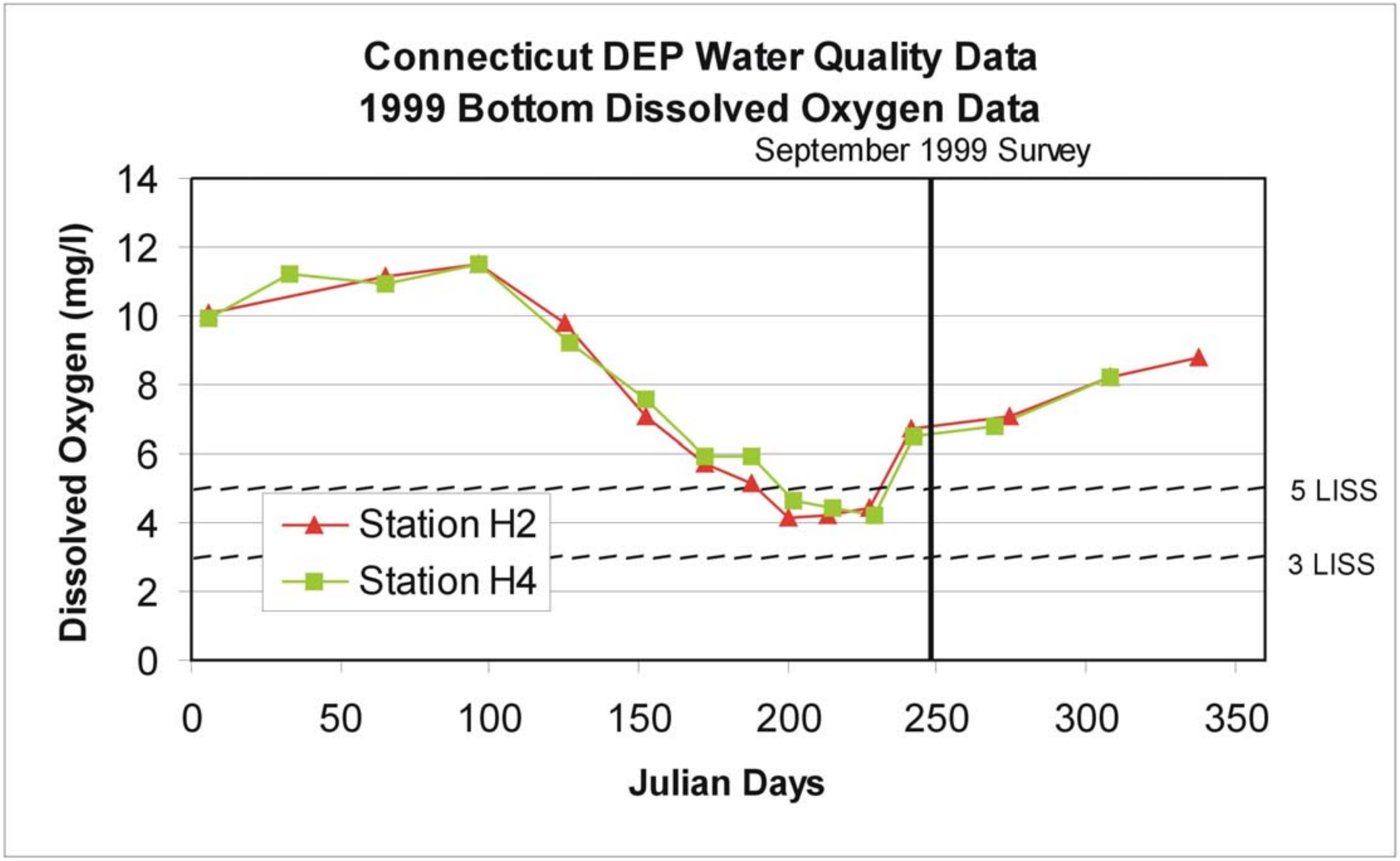


Figure 4-2. Observed changes in bottom water dissolved oxygen concentrations at the Connecticut Department of Environmental Protection dissolved oxygen sampling stations H2 (red) and H4 (green) for 1999. The dashed lines represent the dissolved oxygen thresholds for impacts on benthic organisms (5 $mg \cdot l^{-1}$) and hypoxia (3 $mg \cdot l^{-1}$) as recognized by the Long Island Sound Study (LISS).

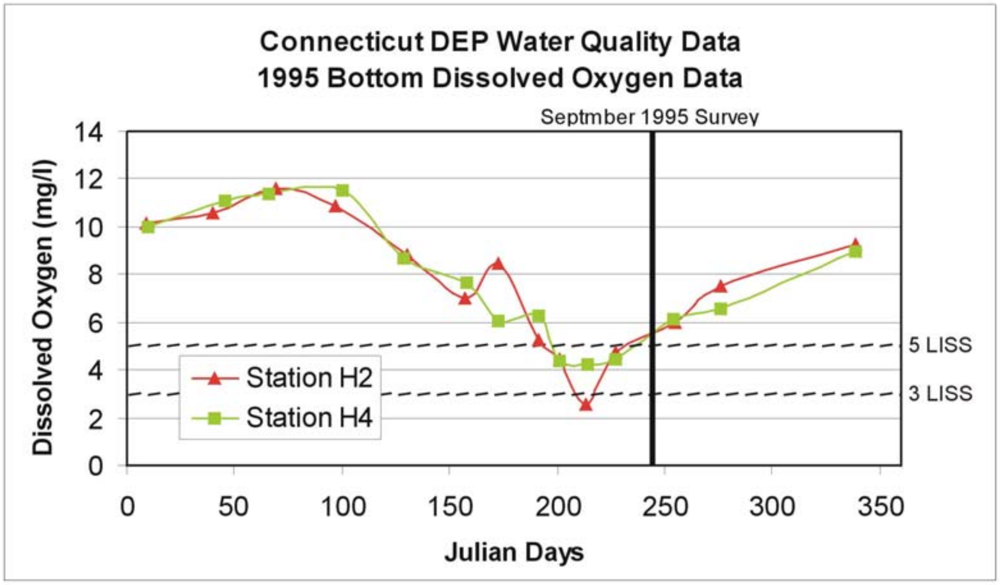
began to warm and oxygen demand increased during the month of May (Julian Days 121–151). Molecular oxygen (O_2) concentrations lingered around 4 $mg \cdot l^{-1}$ from mid-July through mid-August (Julian Days 200–231), but remained above hypoxic levels (3 $mg \cdot l^{-1}$). Oxygen concentrations increased significantly in late August, allowing approximately two weeks for recovery before the September 1999 survey event.

The 1997 and 1999 surveys occurred in the same basic time frame (Julian Day 250), with bottom water dissolved oxygen concentrations showing a minimum of approximately 4.0 $mg \cdot l^{-1}$ during both years (Figures 4-2 and 4-3). Although bottom water oxygen concentrations in the region never reached truly hypoxic levels, the decrease in available oxygen would tend to increase stress within the benthic community and cause a reduction in RPD depths. The continuous record for 1997 indicates the seasonal reduction in dissolved oxygen was delayed relative to 1999, but lasted well into the month of September (Figure 4-3). As a result, the 1997 REMOTS® survey was performed at a time that would reflect the impacts associated with a more prolonged reduction in molecular oxygen (SAIC 2002).

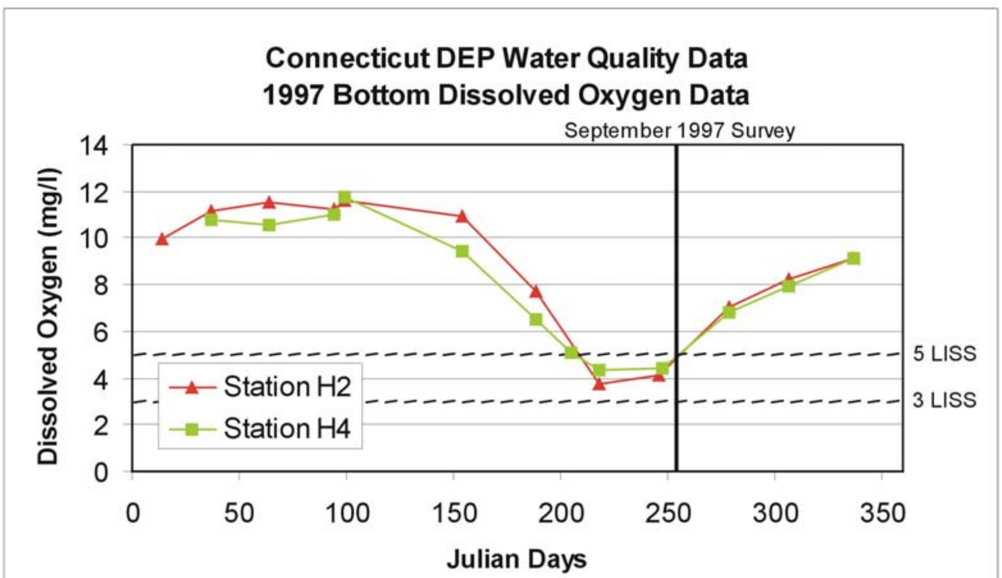
4.2.1 CLIS 97/98 Mound Complex

The CLIS 97/98 complex is composed of sediments deposited over the course of two disposal seasons. Fresh dredged material from the 1998–99 disposal season was detected at the majority of stations established over CLIS 97/98. Based on its location relative to the CDA 98 deposit, portions of the CDA 97 deposit were impacted by disposal activity at the CDA 98 buoy. Layering of fresh dredged material over historic dredged material deposited during the 1997–98 disposal was detected in multiple replicate sediment profile images. The deposition of new sediment layers over a recovering disposal mound tends to impact the sessile Stage I organisms inhabiting the sediment-water interface of a historic dredged material deposit. However, Stage I species are defined as opportunistic, and tend to recover quickly from such a physical disturbance. Barring further disturbance, a new population of pioneering polychaetes will begin to exploit the competition-free space over a layer of fresh dredged material within one to two weeks of a disposal event. Errant polychaetes comprising the Stage III population that inhabit the underlying sediments are capable of migrating through relatively thin layers of new dredged material (10 cm) to reestablish a connection with the sediment-water interface and maintain a supply of oxygen from the bottom waters (Germano et al. 1994).

At three months post completion, the surface of the newer CDA 98 sediment deposit was supporting a stable Stage I community with evidence of progression to Stage III at many stations. Median OSI values in the northern portion of the REMOTS® grid were



A



B

Figure 4-3. Observed changes in bottom water dissolved oxygen concentrations at the Department of Environmental Protection dissolved oxygen sampling stations H2 (red) and H4 (green) for 1995 and 1997. The dashed lines represent the dissolved oxygen thresholds for impacts on benthic organisms (5 $mg \cdot l^{-1}$) and hypoxia (3 $mg \cdot l^{-1}$) as recognized by the Long Island Sound Study (LISS).

lower (+3 to +4) than the values calculated for the remainder of the stations over the mound complex. However, these lower OSI values were primarily a function of RPD depths less than 2 cm, and indicative of an area ofseafloor that was in the early stages of recovering from a recent benthic disturbance. Future monitoring surveys should detect deeper RPD depths in subsequent years as the organic load is consumed by the resident benthic infauna and bioturbation acts to mix oxygen downward into the sediment.

The benthic community recovery within the now historic material deposited at the CDA 97 buoy during the 1997–98 disposal season also appears to be following expectations. At 15 months post disposal, the images collected over this deposit indicated deep RPDs and an abundance of Stage III activity in most of the surficial sediments. As a result, the median OSI values for the stations were quite high over this subtle bottom feature, as well as over the apron of the deposit. Overall, the REMOTS® sediment-profile imaging survey performed over the CLIS 97/98 Mound Complex indicated that the sediment deposit was recovering as anticipated. Periodic monitoring of this bottom feature is recommended over the next several years to verify that habitat conditions continue to improve as the benthic infauna exploit the deposited sediments as a habitat and food source.

4.2.2 CLIS 95/96 Mound Complex

Although the results of the September 1997 survey were generally comparable, the September 1999 survey over the CLIS 95/96 Mound Complex indicated continued improvement in benthic habitat conditions. Stage III activity was detected at all stations occupied over the mound complex, and relatively deep RPD depths were common throughout the survey area. The deeper RPD depths and increased Stage III activity resulted in generally higher OSI values relative to the 1997 survey (+8.6 average versus +7.5 average; SAIC 2001a). This general improvement in benthic conditions may be due to the three to four weeks of benthic recovery time following the seasonal reduction in dissolved oxygen concentrations. In addition, the sediments comprising CLIS 95/96 have been left undisturbed for an additional two years, allowing the further recruitment of Stage III organisms via reproduction. As the successional stage data suggest, the surface sediments to a depth of 3 to 4 cm appear to be reworked by the bioturbational activity of the benthic infauna. The deeper sediment layers display a slightly higher reflectance indicating the consumption of organic matter held within the silt/clay matrix. Over time, the dredged material composing the CLIS 95/96 Mound Complex is expected to become more difficult to distinguish from the ambient sediments detected in the southern portion of the survey area. Although these results indicate that continued intensive monitoring of this region is not necessary, periodic monitoring to verify continued recovery over this mound complex is advised over the next several years.

4.2.3 NHAV 93 Mound

Over the years, benthic recolonization of the NHAV 93 Mound has shown a cyclical recovery and decline roughly corresponding to the seasonal hypoxia patterns in the central Long Island Sound region. The CLIS reference areas also show some evidence of responses to these seasonal events, although the NHAV 93 Mound appears to exhibit a more pronounced response. This is likely due to the elevated labile organic content of the CDM on the surface of the NHAV 93 Mound, which has been apparent in monitoring surveys by the continued presence of low-reflectance, sulfidic sediment at depth (Morris and Tufts 1997). Aerobic conditions promote the chemical breakdown of organic material over time (through chemical oxidation), and consumption via foraging activity of the benthic infauna (bioturbation). As a result, total sediment oxygen demand (SOD), a function of biological oxygen demand (BOD) and chemical oxygen demand (COD), is often significantly higher in sediments with elevated organic content. A higher SOD makes an area of seafloor more susceptible to disturbance during periods of time when bottom water dissolved oxygen concentrations are low (seasonal hypoxic events). Oftentimes, the decrease in available oxygen impacts the benthic community inhabiting organically enriched dredged material, triggering a reduction in resident infauna and limiting bioturbation. Chemical oxidation of organic matter will continue in the deposited sediments until the supply of molecular oxygen is exhausted, causing a rapid decrease in RPD depths (measured as a redox rebound layer).

Organic material is also consumed in an anaerobic environment as bacterial action breaks down complex molecules to yield methane gas and sulfides as the end products. As the methane is produced in the subsurface sediments, gas bubbles percolate through the various layers of sediment and escape through fractures at the sediment–water interface. On occasion, methane gas bubbles are imaged by the REMOTS® camera and serve to identify areas of seafloor having high inventories of organic matter at depth. Methane gas bubbles were detected in two replicate photographs obtained from Station CTR during the September 1999 survey, confirming the presence of elevated levels of organic matter. Station CTR also displayed methane gas during the 1997 survey along with Station 200E (SAIC 2002). Methane bubbles were absent from the three photographs collected at Station 200E in 1999, which may be due to a decrease in organics at depth or a result of spatial variability.

In 1997, the timing of the low dissolved oxygen event in the central Long Island Sound region was such that benthic habitat conditions were degraded over the NHAV 93 Mound during the September survey, with numerous replicate images lacking evidence of Stage III organisms. The images collected from the CLIS reference areas during the 1997 survey showed a similar response at this time as well, with many stations displaying OSI values below +6 (SAIC 2002). In comparison, the seasonal low dissolved oxygen event occurred earlier in 1999 and was shorter in duration (Figures 4-2 and 4-3). This may have contributed to the improved conditions in 1999, which were evident in higher median OSI values over NHAV 93 (+7.2 average) relative to the 1997 survey (+5.2 average; SAIC 2001a). The increased OSI values in the 1999 survey were principally due to the higher abundance of Stage III organisms below the sediment-water interface, because the replicate-averaged RPD depths were nearly identical (2.2 cm average) between the two surveys. Additionally, the reference areas showed a marked improvement in 1999, with no station displaying an OSI value lower than +6 and many with median OSI values of +11 (Table 3-2). These findings suggest that the Stage III communities inhabiting the majority of the NHAV 93 sediments may fluctuate from year to year at least partly in response to the occurrence and/or severity of hypoxic conditions, and that the effects are likely to be more dramatic over the NHAV 93 Mound than the reference areas.

Despite the improved conditions detected over the majority of the NHAV 93 Mound in the 1999 survey results, there continued to be patchy occurrences of lower than expected OSI values for a five-year-old dredged material deposit. Although the replicate-averaged RPD depths were within normal parameters, Stage III organisms continue to be scarce at Station 200S (lacking in 2 of 3 replicate images), and less abundant at Stations 200E and 200W (lacking in 1 of 3 replicate images at each of these stations). Since July 1994, the results of periodic monitoring surveys have not indicated significant improvement in benthic habitat conditions at Station 200S (Table 4-1). The March 1998 sampling event indicated median OSI values approaching +6, likely due to higher bottom water dissolved oxygen concentrations, but the median OSI values calculated for summer survey efforts (i.e., September 1997 and 1999) have generally remained low.

The spatial variability and persistence of low OSI values for some replicate images acquired over NHAV 93 prompted the incorporation of additional information regarding the suitability of the cap material to determine if an alternative management approach (i.e., comprehensive testing, cap augmentation, etc.) may be required. Results from sediment toxicity testing and sediment quality triad analyses conducted as part of the Long Island Sound Environmental Impact Statement (EIS) effort for EPA designation of dredged material disposal sites in the Long Island Sound were used to supplement the 1999 REMOTS® sediment profile imaging data (ENSR 2000; ENSR 2001). The field sampling activity was conducted in February 2000, and the strategy for this effort consisted of targeting active disposal mounds, historical disposal mounds, non-impacted reference areas, and down-current areas that could potentially have been impacted by disposal activities in the region. A total of seven stations at CLIS were sampled and tested, including the NHAV 93 Mound, which was included in the CLIS sampling plan as an active disposal mound. Other CLIS stations included the FVP and NHAV 74 Mounds

Table 4-1.

Summary of REMOTS® Results for NHAV 93 Station 200S (1994 through 1999)

Survey	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number of Reps w/ Dredged Material Present	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	Grain Size Major Mode	Methane Present	OSI Mean	OSI Median	Boundary Roughness
July 1994	19.66	>19.58	3	2.04	I	ST_I	>4	NO	3	3	0.13
September 1995	17.33	>17.09	3	1.24	I	ST_I_ON_III	>4	NO	4.67	4	0.48
July 1996	16.74	>16.5	3	1.45	I, III	ST_I_ON_III	>4	NO	4.67	3	0.49
September 1997	14.77	>14.71	3	1.6	I	ST_I	>4	NO	2.5	2.5	1.07
March 1998	15.76	>16.35	3	1.67	I, III	ST_III	>4	NO	5.5	5.5	0.81
September 1999	14.22	>13.80	3	2.02	I, III	ST_I_ON_III	>4	NO	5.67	4	0.65

(historic), reference areas 2500W and CLISREF site, as well as far-field (down-current) sites 2000 m and 1000 m west of the western boundary of CLIS.

Sediment toxicity was evaluated using 10-day acute exposure assays with amphipods in accordance with accepted test procedures. Test results were evaluated by comparing percent survival to control tests and reference controls. The NHAV 93 sediment samples were all collected at or immediately north of the CTR Station. As such, they do not add information to assist in the interpretation of observed conditions at individual stations (200S, 200E, and 200W). However, the results indicate a general lack of sediment toxicity over NHAV 93, as well as the remainder of the CLIS stations.

As anticipated, bulk sediment chemistry data derived from the surface of the NHAV 93 Mound indicated chemical concentrations of the analytes evaluated for the sediment quality triad exceeded the relatively conservative ecological benchmarks, specifically marine Effects Range-Low (ER-L) benchmarks (ENSR 2001, Long et al. 1995). At concentrations below ERL levels, potential toxic effects are deemed unlikely. The ER-L values for copper (Cu), mercury (Hg), nickel (Ni), silver (Ag), total PCBs, and dioxins were exceeded in NHAV 93 sediment; however, the reported values in the February 2000 data set were consistently below the Probable Effects Limits (PEL) for each of the respective compounds (Table 4-2; MacDonald 1994). In addition, the February 2000 chemistry results appear to be consistent with the values derived from the Outer New Haven Harbor channel sediments as part of the 1993 sediment characterization effort (Morris et al. 1996). Prior to dredging, these in-place sediments were determined to be suitable for unconfined open water disposal and were used as cap material over the surface of the NHAV 93 Mound.

The benthic community analysis from the sediment quality triad indicated no significant differences in conditions over the center of the NHAV 93 Mound relative to the other CLIS stations and reference areas sampled (comparison of number of species, organism density, diversity, and evenness measures to reference values; ENSR 2001). The lack of toxicity at all CLIS stations, and lack of evidence of any adverse benthic community impacts at each of the target stations (active, historical, reference, and down-current sites) suggests that suitability of cap material is not the basis for the instability in the benthic community documented over the past five years. As a result, the other environmental factors mentioned above (i.e., organic loading) are likely the reasons for the lack of a consistent, advanced benthic community dominated by end-member, Stage III organisms over portions of the NHAV 93 mound.

Despite the lack of toxic effects from the sediment over the central portion of the NHAV 93 Mound, as well as the general similarities in the benthic community structure when compared to the reference areas, factors favor a recommendation for additional environmental monitoring and management measures at the NHAV 93 Mound. These factors include continued instability within the benthic community resulting from the pronounced effects of seasonal hypoxia at several of the NHAV 93 stations (most notably at 200S). A conservative management approach would be to continue monitoring the surface of the NHAV 93 Mound to determine the amount of time required to dissipate the organic load within the CDM through natural (chemical and biological) processes. However, the full recovery of the seafloor surrounding Station 200S may be expedited by directing a small volume of additional sediment to Station 200S. Ideally, this material would be suitable for unconfined open water disposal and display a relatively low organic load. This management approach would facilitate the formation of more favorable benthic habitat conditions by covering the organically enriched sediment, reduce biological stress levels within the resident benthos, and decrease the overall susceptibility of the benthic community to the effects of seasonal hypoxia.

4.2.4 MQR Mound

The MQR Mound was first developed on the CLIS seafloor during the 1981/82 disposal season. This small, capped mound consisted of 42,000 m^3 of UDM removed from Mill River that was capped by 133,000 m^3 of CDM from the Quinnipiac River. Additional layers of UDM (67,000 m^3) and CDM (400,000 m^3) were added to the original mound during the 1982/83 disposal season (SAIC 1995). Based on the results of multiple survey efforts, an estimated barge volume of 65,000 m^3 of supplemental CDM was added to the MQR Mound during the 1993–94 disposal season (Morris and Tufts 1997). A survey performed in July 1994 detected evidence of benthic community recovery with increasing presence of advanced successional stages (Stage II and Stage III) following the placement of supplemental CDM. However, OSI values were fairly low over the MQR Mound in 1994 due to shallow RPD depths (Morris and Tufts 1997).

The September 1999 survey, conducted five years later, provided evidence of improved benthic conditions relative to 1994. The RPD depths increased from a mound average of 0.91 cm in 1994 to 2.5 cm in 1999, with the OSI values increasing significantly (+3.9 in 1994 to +7.9 in 1999) in response to the deeper RPDs. One replicate image collected at Station 50N was described as fresh dredged material during initial analysis, because of the apparent high boundary roughness and shallow RPD. However, this image likely represents historical dredged material in an area that was subject to a recent physical disturbance (i.e. fishing activity).

Two stations on the southern arm of the 1999 survey grid (100S and 150S) both displayed relatively low OSI values of +4, which indicates less favorable benthic habitat

Table 4-2.
Concentrations of Various Environmental Contaminants over NHAV 93, FVP, and Reference Areas

	Sampling Areas			Benchmarks				
ANALYTE	**NHAV 93**	**FVP**	**REFERENCE**	Effect Range Low (ER-L)a	Effect Range Medium (ER-M)a	Threshold Effects Limit (TEL)b	Probable Effects Limit (PEL)b	Apparent Effects Threshold (AET)c
Trace Metals	parts per million (mg/kg)							
Ar	7.4	5.8	6.3	8.2	70	7.24	41.6	
Cd	0.59	0.91	0.13	1.2	9.6	0.68	4.21	
Cr	80	103.5	53.2	81	370	52.3	160	
Cu	76		44.6	34	270	18.7	108	
Pb	44.6	41.5	29.4	46.7	218	30.2	112	
Hg	0.2	0.25	0.12	0.15	0.71	0.13	0.69	
Ni	23	24.1	23.7	20.9	51.6	15.9	42.8	
Ag	1.33	1.25	0.6	1	3.7	0.73	1.7	
Zn	140	129	109	150	410	124	271	
SEM/AVS Ratio	0.1412	0.0713	1.729					
Organics	parts per billion (ug/kg)							
Total PAHs	1036	1447	783	4022	44792	1684	16770	
Tot PCBs	59		16	22.7	180	21.6	189	
Dioxins	**421**	0.00132	0.00044	NA	NA	NA	NA	0.0036

Recreated from ENSR 2001

**Reference values represent composite results from CLISREF and 2500W

a. Long et al. 1993
b. MacDonald 1994
c. Barrick et al. 1988

conditions in the southern area of the mound. Despite relatively deep RPD depths, two of the three replicate images collected from each station lacked evidence of Stage III activity, impacting the reported OSI values. Future monitoring surveys over MQR should focus on the southern portion of the disposal mound to verify the development of a stable Stage III population.

4.2.5 FVP Mound

Composed of 55,000 m^3 of uncapped UDM, the FVP Mound has served as a "negative control" showing the response of the benthic community inhabiting the surficial sediments to changing environmental conditions or disturbance. Benthic habitat conditions over the FVP Mound have been periodically evaluated with the use of sediment-profile imaging since the development of this bottom feature in 1983. The survey performed over FVP as part of the September 1999 field effort represented the twentieth environmental monitoring event. The FVP Mound has displayed a range of habitat conditions during different surveys, including undisturbed benthic environment, as well as episodes of apparent benthic community regression from regional seafloor disturbances (i.e., seasonal hypoxia). The stations within a 100 m radius of the center have been of particular interest over the past decade and useful in tracking the benthic conditions over this dredged material deposit.

Research into conditions at the FVP Mound over time has shown that the sampling grids have varied in both number and distribution of stations. Comparisons between the station distribution for the more recent surveys (1995 and 1999) indicates a 100 m westerly offset exists within the 1995 and 1999 sampling grids, relative to historic survey efforts (Figures 3-25 and 3-26). Although this sampling grid is valid for assessing the habitat conditions at FVP and the surrounding seafloor, direct comparisons between stations occupied prior to September 1995 were restricted to the east-west axis and required limited modification in station designations. For the purpose of comparison, the name Station A was assigned to the sampling locations directly over the disposal mound, while Stations B and C designate the sampling locations 100 m to the west and east of the mound, respectively (Figure 4-4).

The FVP Mound was surveyed in June 1991 as part of routine monitoring efforts evaluating benthic habitat conditions within the surficial sediment layers. Data collected from the 13-station grid indicated the seafloor conditions surrounding the FVP Mound were comparable to reference areas, as replicate-averaged RPD depths ranged from 1.8 to 4.2 cm and evidence of Stage III activity was widespread (Wiley and Charles 1995). Median OSI values were greater than +6 at 11 of the 13 stations, with five of those stations displaying the maximum OSI value of +11. The center station (Station A) over

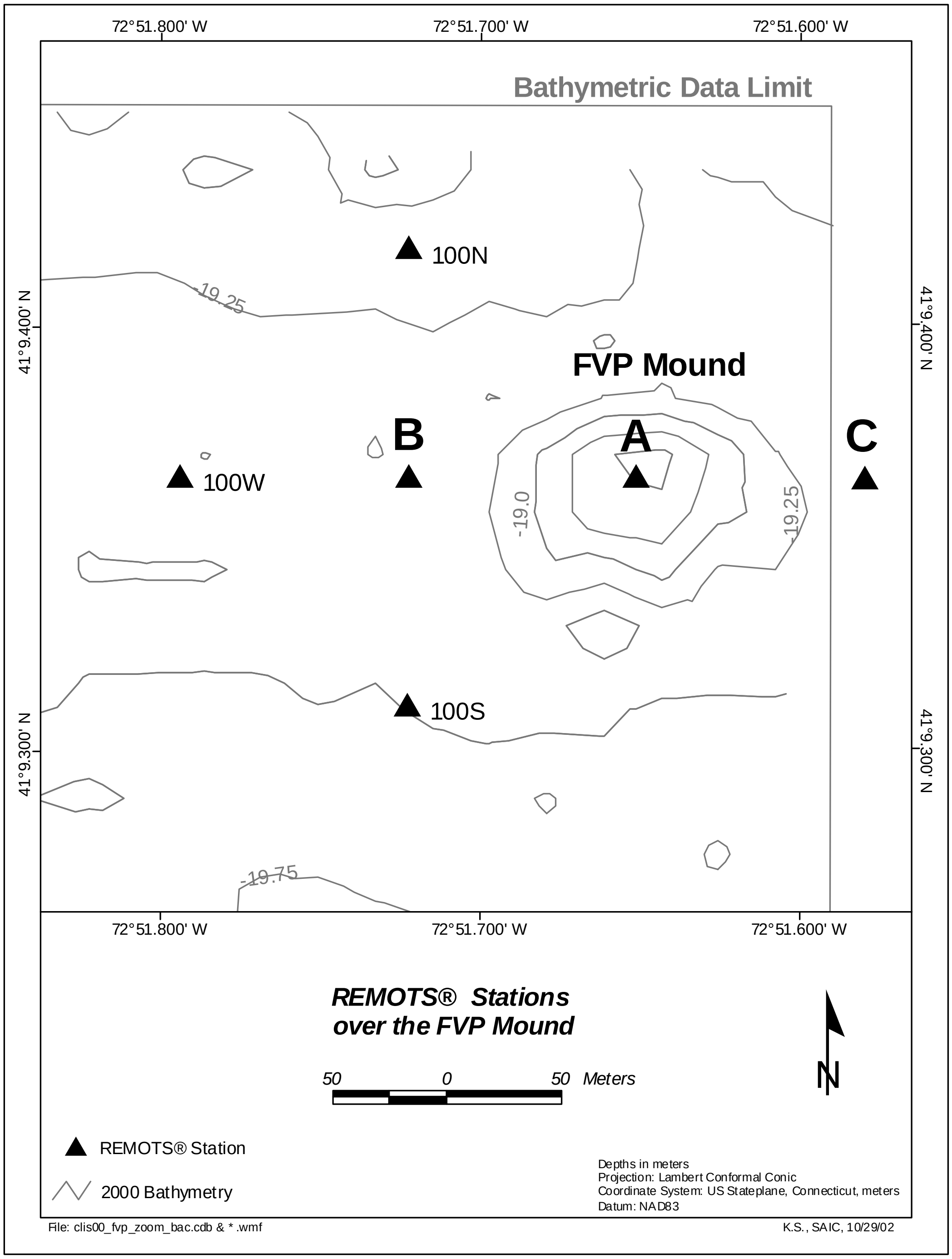


Figure 4-4. Location of the sediment profile imaging locations re-designated as Stations A, B, and C for the purpose of comparison between surveys

FVP displayed a deep RPD and the presence of an advanced benthic community composed of Stage III organisms. Despite the presence of methane gas in one replicate image, a median OSI value +5 was calculated for Station A from the June 1991 data set (Table 4-3A). Stations B and C, located on the western and eastern flanks of the mound, generally displayed undisturbed benthic habitat conditions with OSI values of +10.5 and +8, respectively (Tables 4-3 B and 4-3C).

The September 1993 survey primarily focused on the interior portions of the FVP Mound. The results from a series of nine stations distributed within a 100 m radius of the center (Station A) indicated benthic habitat conditions had degraded somewhat relative to June 1991. Replicate-averaged RPDs were shallow (<2 cm) and evidence of Stage III activity was scarce, with one of the 27 replicate images collected over FVP displaying feeding voids at depth. These factors combined to yield OSI values ranging from +3 to +5 over the survey grid, the lowest of which corresponded to Station A over the center of the mound (Table 4-3A). In addition, the results obtained over Stations B and C indicated a sharp decrease in median OSI values relative to 1991. No reference area data were collected as part of the 1993 survey effort to determine if the decline in benthic habitat conditions was isolated to FVP or the product of a regional disturbance.

Follow-on monitoring conducted over FVP in September 1995 displayed a slight improvement over most of the mound as both the abundance of Stage III organisms and RPD depths increased relative to 1993, resulting in a minor increase in OSI values. Station B showed a 2-point increase in OSI, while the median value for Station C was unchanged despite deeper replicate-averaged RPD depths and evidence of Stage III activity (Tables 4-3B and 4-3C). However, a shallow RPD (1.1 cm) and the appearance of methane gas bubbles at Station A further diminished median OSI values at this station (Table 4-3A). Data obtained from the reference areas, as well as other disposal mounds surveyed as part of the September 1995 monitoring effort suggested that a low dissolved oxygen event had affected benthic habitat conditions throughout the central Long Island Sound region.

The findings of the 1993 and 1995 REMOTS® surveys over FVP indicate the continued persistence of degraded benthic habitat conditions over the mound center (Morris 1997). The infaunal community appeared to be more susceptible to seafloor disturbance and tended to recover at a slower rate relative to the CLIS reference areas and the surface of other CLIS disposal mounds. This evidence of environmental stress was thought to be related to characteristics of the uncapped UDM comprising the FVP Mound, in conjunction with seasonal low dissolved oxygen events in the bottom waters. The added biological stress associated with each low dissolved oxygen event was expected to have negative impacts on the resident benthos of FVP, with severe or prolonged hypoxia events yielding

Table 4-3.

Summary of Benthic Habitat Assessment Results for
Central Stations over the FVP Mound (1991 through 1999)

Station A

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	Methane Present	OSI Mean	OSI Median
June 1991	3.14	I, III	ST_III	YES	5.7	5
September 1993	1.23	I	ST_I	NO	2.7	3
September 1995	1.08	I, III	ST_I_ON_III	YES	3	2
September 1999	3.38	I, III	ST_III	NO	7	7

Station B

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	Methane Present	OSI Mean	OSI Median
June 1991	2.8	I, III	ST_I_ON_III	NO	10.5	10.5
September 1993	1.71	I	ST_I	NO	4	4
September 1995	2.36	I, III	ST_I_ON_III	NO	6	6
September 1999	3.3	III	ST_III	NO	10	10

Station C

Survey	RPD Mean (cm)	Successional Stages Present	Highest Successional Stage	Methane Present	OSI Mean	OSI Median
June 1991	1.84	I, III	ST_I_ON_III	NO	8	8
September 1993	1.24	I	ST_I	NO	3.7	4
September 1995	2.84	I, III	ST_I_ON_III	YES	5.7	4
September 1999	4.06	I, III	ST_I_ON_III	NO	9	10

significant degradation in benthic habitat conditions. Given that hypoxia occurs on an annual basis, and the FVP Mound appeared to exhibit more dramatic benthic community responses to these events.

However, the results of the September 1999 survey revealed benthic habitat conditions over the yet uncapped FVP Mound were better than anticipated, exceeding the conditions detected within the ambient sediments of the CLIS reference areas. The 1999 images revealed the presence of an advanced Stage III population at all stations sampled, with an abundance of Stage I individuals at the sediment-water interface. In addition, RPD depths were quite deep, averaging 3.4 cm over the surface of the disposal mound. With OSI values ranging from +6 to +11, the benthic habitat in the surficial sediments showed marked improvement over the results of the September 1995 survey (Morris 1997). The September 1999 survey results for Stations A, B, and C exceed the June 1991 findings, despite the difference in season (spring versus late summer) and the passage of the annual, summer low dissolved oxygen event in the central Long Island Sound region several weeks prior to the 1999 survey.

Additional evidence of comparable conditions to reference areas at the FVP Mound is provided in the sediment quality triad results (ENSR 2001). This study included stations sampled within roughly 30 m (biota samples) and 40 m (sediment chemistry samples) of the mound center in February 2000, approximately five months after the 1999 sediment profile imaging survey. The results indicated no sediment toxicity in the FVP Mound samples, and no differences in benthic community structure (number of individuals, number of species, diversity, and evenness) when compared to the reference areas occupied as a part of that study. The results were comparable to reference despite chemical concentrations 3 to 4 times the concentrations detected at the reference areas.

Sediment chemistry results in the sediment quality triad analyses also included a comparison to ecological benchmarks (ENSR 2001). While the concentrations of copper (Cu) and nickel (Ni) exceeded ER-L benchmarks for all CLIS stations in this study, the concentration of copper exceeded the PEL (Probable Effects Limit) value at FVP. Additionally, the concentrations of chromium (Cr) mercury (Hg), silver (Ag), and total PCBs exceeded the ER-L value at the FVP Mound, but remained below their respective PEL values. These results were anticipated given the type and concentrations of various organic and inorganic contaminants identified in the Black Rock Harbor sediments during the initial characterization performed as part of the Field Verification Project in 1983 (Rogerson et al. 1985).

Marine organisms inhabiting the benthos display different tolerance levels for copper, but elevated concentrations of this trace metal have been known to interfere with reproduction and larval development in polychaetes worms and echinoderms (Reish 1964, Young and Nelson 1974). However, the low Simultaneous Extracted Metals (SEM) to Acid Volatile Sulfide (AVS) ratio reported in the ENSR data set suggests the majority of the copper detected in the bulk sediment chemistry is bound to sulfides and exists as non-bioavailable metal sulfide compounds (Table 4-2). The SEM/AVS samples were typically collected from the oxidized surface layer of sediment, the zone inhabited by the majority of the resident benthic infauna. As a result, bioavailablity of copper and other trace metals appears to be quite low. Therefore, concentrations of the ionic form of these contaminants would not reach levels capable of triggering acute toxicity in an aerobic environment.

In addition, the concentration of total Polychlorinated Biphenyls (PCBs) in the FVP sediments is similar to the ER-M levels (Table 4-2). Although the concentrations of PCBs within the FVP sediments was not sufficient to cause acute toxicity during the 10-day amphipod test, this class of chemical contaminants possesses a high potential to bioaccumulate. These compounds are considered highly lipophilic and are usually found in the fat (lipid) stores of marine and aquatic organisms at concentrations greater than or equal to sediment concentrations (Pruell et al. 1986, Neff 1984). Several studies have shown a tendency for biomagnification of PCBs due to low rates of elimination from aquatic and marine organisms (Kay 1984, USACE 1995).

Although the FVP sediments were not found to be toxic to test animals in an aerobic environment, the net result from the combined effects of the environmental contaminants and organic load may serve to increase biological stress and susceptibility of the resident benthic infauna to seafloor disturbance (i.e., seasonal hypoxia), as well as delay seafloor recovery over the FVP Mound. The basis for the improvement in benthic habitat conditions over FVP in the 1999 survey is not associated with a change in surface sediment characteristics, as there has been no placement of CDM over the past four years and the sedimentary characteristics described in photographs obtained in 1999 are identical to those of earlier sampling efforts. Low reflectance, organically enriched sediment is common under the oxidized surface layer at stations on the eastern arm of the survey grid, as well as within 100 m of Station CTR (Figure 3-27B). This suggests no accumulation of new material over the mound, except through natural deposition of Long Island Sound sediments.

The timing of the 1993, 1995, and 1999 surveys was similar (early September); however, comparisons in bottom water dissolved oxygen concentrations did display some differences between the 1995 and 1999 (Figure 4-2 and 4-3). Unfortunately, no dissolved oxygen data were available for 1993 to determine if bottom water dissolved oxygen concentrations were a factor in the findings of that survey. As stated in Section 4.2 above, the seasonal reduction in dissolved oxygen within the region in 1999 appeared to follow the typical pattern, with a gradual decline in dissolved oxygen as water temperatures warmed during the spring and early summer. Oxygen levels within the bottom waters fell below 5 $mg \cdot l^{-1}$ in mid-July (Julian Day 185) and remained at concentrations of approximately 4 $mg \cdot l^{-1}$ for one month before rebounding to 6.5 $mg \cdot l^{-1}$ two weeks prior to the 1999 survey (Figure 4-2).

The continuous record of bottom water dissolved oxygen concentrations for 1995 displayed substantial variability between the data acquired at Stations H2 and H4 prior to the sediment-profile imaging survey (Figure 4-3). Station H2, the closer of the two stations to CLIS (7 km northwest), displayed strong fluctuations in molecular oxygen concentrations, with levels falling from 8.5 $mg \cdot l^{-1}$ to 2.5 $mg \cdot l^{-1}$ in less than six weeks. Dissolved oxygen levels then increased gradually over the next four weeks, reaching approximately 5.5 $mg \cdot l^{-1}$ at the time of the September 1995 survey. The data from Station H4, located in deeper water approximately 9 km south of CLIS, did not show these strong fluctuations in dissolved oxygen concentrations, suggesting a localized occurrence.

The effects of the summer 1995 hypoxia event were apparently sufficient to profoundly impact the benthic habitat conditions over the surface of the FVP Mound, while the seasonal reduction in dissolved oxygen in 1999 appeared quite benign (Figure 4-2). Although the most recent REMOTS® survey indicated stable benthic conditions exist over the FVP Mound, capping of this exposed UDM deposit should continue to be considered. This area has shown a great deal of improvement since 1995, which provides useful insight into the effects of UDM in the marine environment. However, as a conservative management action, it is recommended that the mound now be considered for isolation from the marine environment. Furthermore, benthic habitat conditions are not expected to be resistant to the potentially significant benthic disturbance related to the passage of a significant hypoxia event. Since the long-term study of this exposed UDM area has been carried out for 18 years, it is recommended that this area, which has served as a "negative control," now be capped with a layer of CDM greater than 0.5 m in thickness. This management approach would facilitate the formation of more favorable benthic habitat conditions by reducing biological stress levels over the surface of the mound, in turn decreasing the overall susceptibility of the resident benthic community to future seafloor disturbance.

5.0 CONCLUSIONS

The September 2000 multibeam survey at CLIS was performed to provide a high-resolution bathymetric data set documenting the effects of more than 25 years of dredged material placement on the seafloor topography. The swath bathymetry data provided extraordinary detail pertaining to disposal mound morphology and distribution of dredged material, confirming the findings of previous single-beam bathymetric surveys. The high-resolution multibeam survey also highlighted numerous small-scale features that were not visible with the use of single-beam bathymetric survey techniques. In addition, this data set will serve as the new baseline to which future single-beam and multibeam bathymetric surveys will be compared.

Since 1984, the management strategy at CLIS entailed the deposition of small to moderate volumes of dredged material in a manner that would form rings of disposal mounds to serve as artificial containment cells on the seafloor. The September 2000 multibeam survey confirmed that two additional artificial containment cells capable of accepting large volumes of UDM in future CAD operations are nearing completion on the CLIS seafloor. Strategic placement of the CDA buoy over the next two to three disposal seasons should close two rings of disposal mounds, thereby completing these containment basins.

The 2000 multibeam data were also compared against the 1996, 1997, and 1999 single-beam bathymetric surveys to evaluate the consistency of the survey results and document changes in the seafloor topography. Several bottom features have been formed since the large-scale, single-beam bathymetric survey was performed in 1996. The CLIS 95/96 and CLIS 97/98 Mound Complexes represent the products of dredged material placement from September 1995 through June 1999. The CLIS 1999 Mound is a small-scale dredged material disposal mound developed during the 1999–2000 disposal season.

A benthic recolonization survey has yet to be completed over the CLIS 1999 Mound. However, the September 1999 survey effort examined the benthic habitat conditions over several recent (CLIS 97/98) and historic (CLIS 95/96, NHAV 93, MQR, and FVP) disposal mounds. In general, benthic habitat conditions within CLIS and the reference areas showed significant improvement relative to the findings of earlier surveys. Traditionally, the results of benthic habitat assessments performed in August or September reflect the impacts associated with the passage of the seasonal hypoxia event within the central Long Island Sound region. However, data obtained from the CTDEP for 1999 indicated the seasonal reduction in bottom water dissolved oxygen concentrations was relatively mild and short in duration. As a result, the impacts on the benthos were not as profound as those detected in previous years.

Benthic recolonization over the CLIS 97/98 Mound Complex is proceeding as anticipated. The newest sediment deposit (CDA 98 deposit) supports a Stage I community with progression into Stage III at many stations. OSI values were lower in the area immediately north of the CDA 98 deposit, but within expectations for a new bottom feature. Higher OSI values, a product of deeper RPD depths and an abundance of Stage III activity, were detected over the CDA 97 deposit. The CDA 97 deposit was formed about 12 months before the CDA 98 deposit, but was impacted somewhat by the deposition of new material due to its location. Layered sediments comprised of fresh dredged material over historic dredged material were detected at many stations. Dense populations of Stage I individuals were identified over the recently placed material with Stage III organisms present at depth.

The sediment-profile imaging stations occupied over the now historic CLIS 95/96 Mound Complex indicated continued recovery and general improvement in benthic conditions relative to the September 1997 survey. Stage III organisms and deep RPDs were detected at each station established over CLIS 95/96, resulting in high OSI values. The surficial sediments have been reworked by the benthic infauna and now display the characteristics of historic dredged material. Periodic monitoring over the next five years is recommended to confirm continued progression to near-ambient conditions.

The NHAV 93 Mound is a five-year-old CAD mound that has been monitored since its completion in 1994. The September 1999 survey indicates a stable benthic community has been established over the majority of this disposal mound. Despite the improved conditions detected over most of the NHAV 93 Mound, Stations 200S, 200W, and 200E continue to exhibit spatial variability and some images with lower than expected OSI values. Stage III organisms continue to be scarce at some locations, suggesting the sediments are not yet capable of supporting a stable benthic community due to a high inventory of labile organics and correspondingly high SOD. An alternative management approach (i.e., cap augmentation) might be considered in the near future to isolate the surface sediments, particularly along the southern flank of the mound.

Supplemental capping material was placed over the MQR mound during the 1993–94 disposal season as part of a cap augmentation effort. Benthic habitat conditions on the surface of the MQR mound have shown a significant improvement over the past five years. Most of the stations sampled during the September 1999 survey displayed benthic conditions with advanced successional stages present in relative abundance and generally deep RPDs. However, two Stations (100S and 150S) had less advanced successional stages in comparison to the remainder of the MQR Mound, as well as the CLIS reference areas. Future monitoring surveys should focus on these two stations to verify that conditions within the surficial sediments improve over time.

Since the September 1993 survey, a general trend of poor benthic conditions (shallow RPDs and low OSI values) have been detected near the center of the FVP Mound. This was a predictable response for the small, uncapped UDM deposit due to the elevated levels of environmental contaminants and resulting stress on the infaunal community inhabiting the surficial sediments. However, the benthic habitat conditions detected over the FVP Mound during the September 1999 REMOTS® survey were unexpectedly good, as deep RPDs and high OSI values were calculated for the entire mound. Additionally, the 1999 sediment toxicity tests (ENSR 2000) of the mound indicated no toxicity associated with the sediments despite elevated levels of some chemical constituents, and no apparent adverse impacts on benthic community structure compared to reference areas. With no placement of CDM over FVP reported since the last monitoring effort, the basis for this improvement in habitat conditions is currently unknown. Although the results of the 1999 survey do not necessarily warrant capping of the FVP mound, isolation of the contaminants contained within the UDM deposit is still recommended as this sediment deposit has demonstrated susceptibility and slow recovery to benthic disturbance. Capping this UDM deposit will isolate the contaminants from the marine environment and return this area of seafloor to near ambient conditions. This process will in turn reduce biological stress within the benthos and promote the formation of a stable benthic community over the cap material.

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Appendix A
1999–2000 Disposal Logs

Appendix B
Multibeam System Configuration

MULTIBEAM SYSTEM CONFIGURATION

Background

Single-beam bathymetric survey techniques entail using one acoustic transducer to collect depth measurements along a series of tightly spaced (25 meters), parallel survey lines to yield multiple depth profiles within a survey area. The depth profiles are edited and reduced to MLLW and then merged together during post-processing. A grid system is then defined over the survey area of interest, typically based on the track-line spacing for the survey. For track-lines spaced at 25 m intervals, a grid cell size of 12.5 m (along-track) by 25 m (cross-track) would be used to ensure sufficient data coverage to fill each cell. After the individual data points are corrected for tidal variation and water column sound velocity, a gridding routine averages all of the single-beam data points that fall within each cell, to generate a single depth value for each cell. The end result of this process is a matrix of depth values that define a three-dimensional surface model of the survey area.

Because the single-beam bathymetry typically covers only a small percentage of the total seafloor area (less than 5%), a large cross-track cell size must be specified in order to ensure that actual data points fall within each defined cell. As a result of the large cell size requirement, single-beam bathymetry products (e.g., 3-D surface models and contour plots) tend to distort smaller features that may have only been detected by a few data points along a single track-line. Additionally, any small features that happen to fall entirely between survey lines will not be detected at all. The only way to improve the resolution (or reduce the cell size) of the single-beam data models is to use much tighter line spacing over a grid-type survey pattern.

Multibeam sounding systems employ a specialized transducer array comprised of multiple, narrow acoustic beams that are capable of ensonifying an area that is up to seven times the surrounding water depths. For example, in water depths of 20 m, a multibeam survey line can provide full bottom coverage over a swath of up to 140 m. The swath coverage provided by the multibeam systems allows full bottom coverage surveys to be completed in a shorter amount of time, relative to single-beam surveys that provide less than five percent bottom coverage. The higher density of the multibeam data sets enables the generation of 3-D surface models that are based on grid cells that are as small as 1×1 m. Even at this small cell size, the multibeam systems will provide redundant data points in each cell, thereby enabling data quality comparisons to be made. Relative to a single-beam survey, a multibeam survey will provide a far more complete and much higher resolution representation of the seafloor topography. Multibeam bathymetry was first introduced to the DAMOS Program in 1998 as a means to better characterize the rocky, irregular seafloor topography within the Portland and Cape Arundel Disposal sites in waters of southern Maine.

Survey Area

The September 2000 multibeam bathymetric survey performed at CLIS consisted of 48 primary survey lines run over an 8.6 km^2 rectangular-shaped area (Figure 2-1). The survey lines were each 4100 m in length, oriented in the east/west direction (91° azimuth) and spaced at 45 m intervals to provide greater than 150% sounding coverage of the seafloor. The survey lines covered both the historical site boundaries (depicted by black dotted lines) and the current disposal site boundaries (represented by solid blue line; Figure 2-1). Three cross-lines, 2150 m in length, were run at an azimuth of 182° to serve as reference checks to the processed multibeam data.

Survey Vessel Positioning

The R/V *Ocean Explorer* was used as the survey platform for multibeam survey operations conducted at CLIS. This specialized survey vessel is specifically designed and outfitted for high speed (~11 knots) swath bathymetry data collection. The main cabin of the vessel serves as the data collection and first-order-processing center. Upon completion of the survey, all data were delivered to the Data Processing Center for post-processing. Table B-1 provides a list of characteristics for the R/V *Ocean Explorer*. Precision navigation, helmsman display, and data integration from the multitude of sensors aboard the survey vessel were accomplished with the use of SAIC's Integrated Survey System 2000 (ISS-2000). Real-time navigation, data time tagging, and data logging were controlled by the ISS-2000 in a Windows NT 4.0 environment.

Positioning information was recorded from multiple independent Global Positioning System (GPS) receiver networks in the North American Datum of 1983 (NAD 83). Two linked GPS receivers embedded within a TSS POS/MV 320, 3-axis Inertial Motion compensation Unit (IMU) were used as the primary source for vessel position and attitude correctors applied to the multibeam data. The POS/MV IMU was interfaced with a Trimble Probeacon Differential Beacon Receiver to improve the positioning data to an accuracy of ±5 m. Correctors to the satellite information broadcast from the U.S. Coast Guard differential station at Moriches, NY (293 kHz) were applied to the satellite data. The ISS-2000 monitored horizontal dilution of precision (HDOP; quality of the signal); number of satellites, elevation of satellites, and age of correctors to ensure the resulting bathymetric positioning errors did not exceed five meters at the 95% confidence level.

The second GPS system served as a source of position confidence checks and a real-time monitor to verify the navigation information provided by the POS/MV IMU. The secondary system consisted of a Trimble 7400 RSi GPS receiver interfaced with a Leica MX41R Differential Beacon Receiver. Differential correctors broadcast from the U.S. Coast Guard station in Sandy Hook, NJ (286 kHz) were applied to the satellite data.

The real-time monitor within ISS-2000 raised an alarm when the two DGPS positions differed by more than 10 m horizontally. All positioning confidence checks were well within the allowable inverse distance of 5 m.

Multibeam System Configuration

Because of the swath acoustic coverage provided by multibeam systems, there are several external data sensors that must be incorporated into any multibeam survey. In addition to the position, depth, and water column sound velocity typically required for a single-beam survey, multibeam surveys must also have sensors to accurately measure vessel heading, heave, pitch, and roll. The sensor configuration on R/V *Ocean Explorer* during the CLIS survey is depicted in Figure B-1 and the sensor offsets relative to top centerline of the POS/MV IMU are shown in Table B-2.

Depth Soundings

A RESON 8101 shallow water, multibeam system was employed for the acquisition of sounding data over the CLIS survey area (Table B-3). The RESON 8101 was mounted on the keel of the survey vessel, and utilizes 101 individual narrow beam (1.5°) transducers capable of yielding a total swath coverage of 150° (75° per side). The actual width of coverage is adjustable through range scale settings with a maximum equivalent to 7.4 times the water depth. The RESON 8101 transducer can transmit up to 12 high frequency (240 kHz) sound pulses, or pings per second, though that number may be reduced in deeper water where sound travel times are greater. This rapid ping rate provides dense along-track data coverage and allows the survey boat to be operated at higher speeds. During the CLIS survey, vessel speed was controlled to yield average along-track coverage of 2.5 pings/m^2 of seafloor. The RESON 8101 horizontal range scale was set at 100 meters to optimize the efficiency of the survey in the 14–23 m water depths.

Acoustic returns from the seafloor are detected by the transducer array and raw depth values are transmitted to the RESON 6042 topside control unit. The RESON 6042 then applies a series of real-time corrections (i.e., sound velocity, attitude, predicted tides, draft, squat, etc.) to the raw soundings before transmitting them to the ISS-2000 for position stamps and data storage. An ODOM DF 3200 Echotrac single-beam echosounder was also operated to provide a real-time quality check of the RESON 8101 data (Table B-3).

Table B-1.

Survey Vessel Characteristics

Vessel Name	LOA (Ft)	Beam (Ft)	Draft (Ft)	Gross Tonnage	Power (Hp)	Registration Number
R/V *Ocean Explorer*	61’	16’4”	3’3”	56	1100	US905425

Table B-2.

R/V *Ocean Explorer* Antenna and Transducer Locations Relative to the POS/MV IMU Vessel Reference Point, Measurements in Meters

Sensor	Offset in ISS2000		POS/MV IMU	
Multibeam RESON 8101 Transducer Hull Mount			X	-1.63
			Y	0.00
			Z	0.70
ODOM Single-beam Transducer	X	-2.04		
	Y	-.018		
	Z	0.80		
Trimble 7400 Antenna	X	-5.70		
	Y	0.00		
	Z	-7.43		
POS/MV GPS Master Antenna			X	-5.70
			Y	-1.00
			Z	-7.44

Table B-3.

The R/V *Ocean Explorer* System Components

Subsystem	Components
Positioning	TSS-POS/MV Model 320 Position and Orientation System (Dual GPS receivers and IMU)
Vessel Position Quality Monitoring	Trimble 7400 GPS Receiver (Quality Monitoring) Trimble DGPS Beacon Receiver
Integrated Navigation System	SAIC ISS2000
Survey Autopilot	Robertson AP9 Mk II
Multibeam Sonar	RESON 8101 240 kHz Multibeam Depth Sounder
Motion Sensor	TSS-POS/MV Model 320 Position and Orientation System
Data Acquisition and Display	Windows NT Computer running ISS2000 Integrated Survey System Software
Sound Velocity Profiler	Brooke Ocean Technology MVP 30, Moving Vessel Profiler (SVP System)

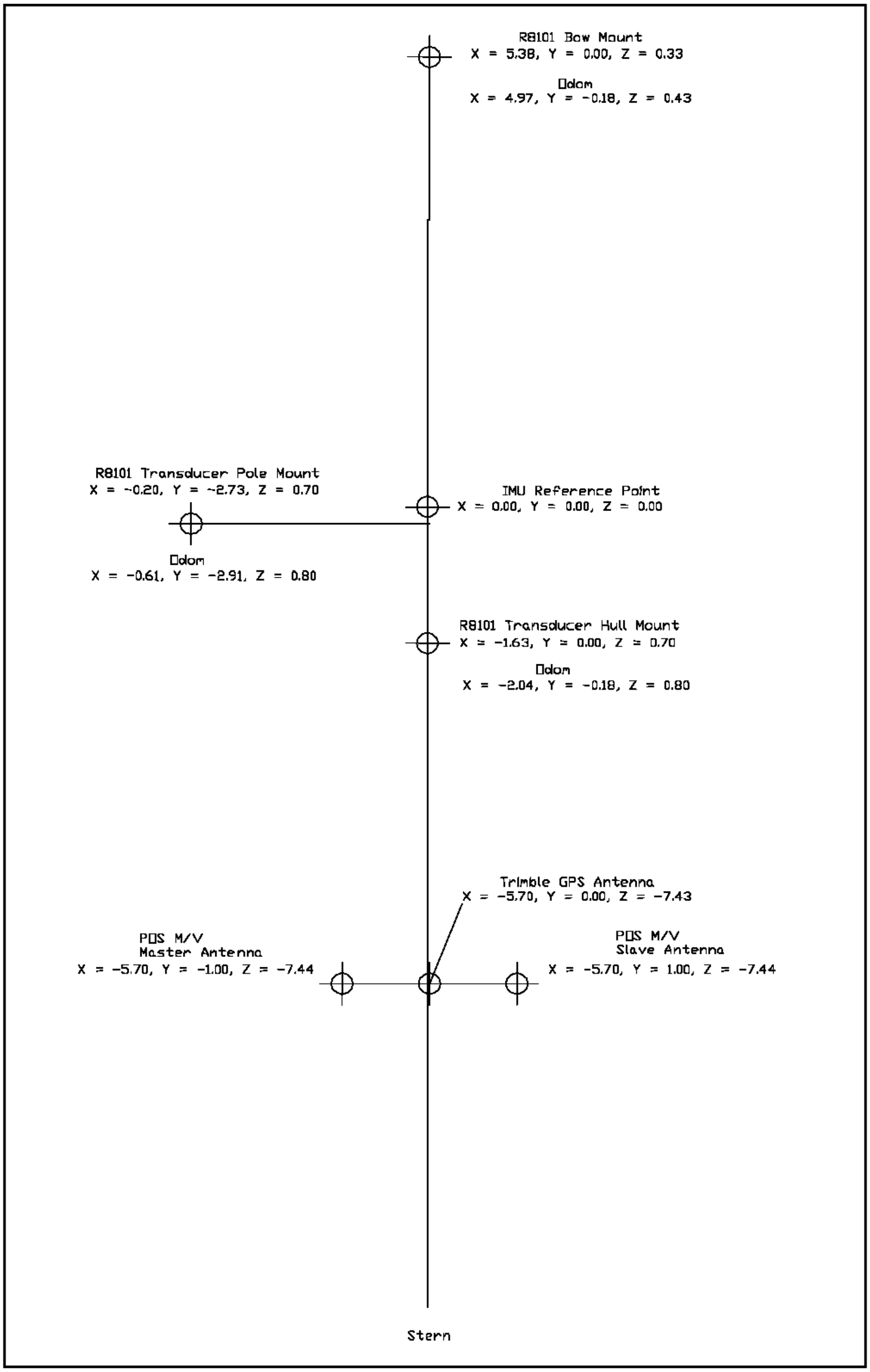

Figure B-1. Configuration of R/V Ocean Explorer during survey operations

Attitude and Heading Compensation

Each individual multibeam swath extends a great distance perpendicular to the precise aspect of the transducer at the time of the transmit pulse. As a result, the quality and accuracy of the multibeam data (particularly in the outer beams) is highly dependent upon the precise measurement of the position, motion, and attitude of the survey vessel (e.g., heading, heave, pitch, and roll). Real-time heading and attitude compensation were accomplished in the multibeam system based on the data output by the POS/MV GPS-aided inertial navigation system (Table B-3). The primary positioning unit (POS/MV IMU) was mounted on the vessel centerline just forward and above the RESON 8101 transducer to minimize positional offsets (Figure B-1). The POS/MV heading, heave, pitch, and roll data were transferred to the RESON 6042, which applied corrections to the raw soundings before they were transmitted to the ISS-2000 and stored for post processing.

With the vessel underway, the azimuth accuracy of the POS/MV system is $\pm 0.05°$, one order of magnitude better than a gyrocompass. The accuracy of the system for heave was 5% of 1 m or 5 cm, and $\pm 0.10°$ dynamic accuracy for roll and pitch ($\pm 0.05°$ static accuracy for roll and pitch). Heading, roll, and pitch biases were determined in a series of patch tests performed in Narragansett Bay during the Sea Acceptance Test. These biases are required to account for any minor misalignment between the mounting of the 8108 transducer and the POS/MV IMU. A complete description of the POS/MV calibration procedure and resulting bias calculations are presented in Appendix C.

Sound Velocity

Any acoustic echosounder (single or multibeam) computes a depth by precisely measuring the travel time of a sound pulse that originates from the transducer, reflects off the seafloor, and returns back to the transducer. The acoustic travel time is multiplied by the speed of sound within the water column, and then divided in half to obtain a depth value. As a result, the accurate determination of the speed of sound within the water column is required for the correct calculation of depth during the survey operation.

Sound velocity in seawater is a function of density, a variable characteristic controlled by water temperature and salinity. A variety of tools exist for the determination of an average water column speed of sound that satisfies the requirements of a single-beam system, where the acoustic signal is transmitted straight down through the water column. However, because multibeam systems generate numerous acoustic beams angled off the vertical, strong water column density gradients, or pycnoclines, can have a greater impact on multibeam data (particularly in the outer beams). When the non-vertical multibeam pings encounter pycnoclines, they tend to be refracted by the change in speed, causing them to strike the seafloor at a different location relative to those traveling through a well-mixed water column. The effects of pycnoclines on multibeam data are corrected in real-time during multibeam surveys by generating refraction models that are based on periodic density profiles for the entire water column.

In addition to strong pycnoclines in the central Long Island Sound region during the summer months, the semi-diurnal tidal cycle promotes significant changes in seawater properties within a survey day. Density profiles were obtained at approximately two-hour intervals during the CLIS survey in order to document changing water column characteristics. A Brooke Ocean Technology Ltd., Moving Vessel Profiler-30 (MVP) sound velocity profiling system was used to determine water column speed of sound (Table B-3). After examining the records, the data are sent to the RESON 6042 topside control unit. Within the RESON 6042, a beam refraction model was computed from the speed of sound data, and beam angle correctors are applied to the raw multibeam sounding data received from the RESON 8101 transducer.

Static Draft of the Survey Vessel

Raw soundings collected by the RESON 8101 multibeam system reference depth values to the transducer mounted on the underside of the survey vessel. In order to adjust the depth values to the water's surface, a draft corrector was applied to the raw soundings in the RESON 6042 topside control unit. Depth of the transducer below the vessel's main deck (3.07 m) was determined from measurements made during a dry dock period in May 2000. This measurement remains constant as both the deck and the keel are fixed structures on the survey vessel. However, daily draft measurements were made between the main deck and the still water level to compensate for changes in vessel draft due to fuel and water consumption.

At the beginning and end of each survey day, static draft measurements were made on the port and starboard sides of the survey vessel. The height of the vessel's main deck above the still water level was subtracted from 3.07 m to yield actual draft of the transducer array (Figure B-2). The draft measured for the CLIS 2000 survey was 1.43 m, which in turn was added to the raw soundings.

Settlement and Squat

The configuration of the R/V *Ocean Explorer* allows the collection of high-quality swath bathymetry data at speeds approaching 11 knots. The displacement of water by the survey vessel's hull allows the boat to settle into the water slightly. The faster the hull moves through the water, the greater the volume of water displaced, promoting further settlement. In addition, higher speeds and the resulting increased shaft revolutions per minute (RPMs) also cause the bow of the survey vessel to rise higher in the water and the

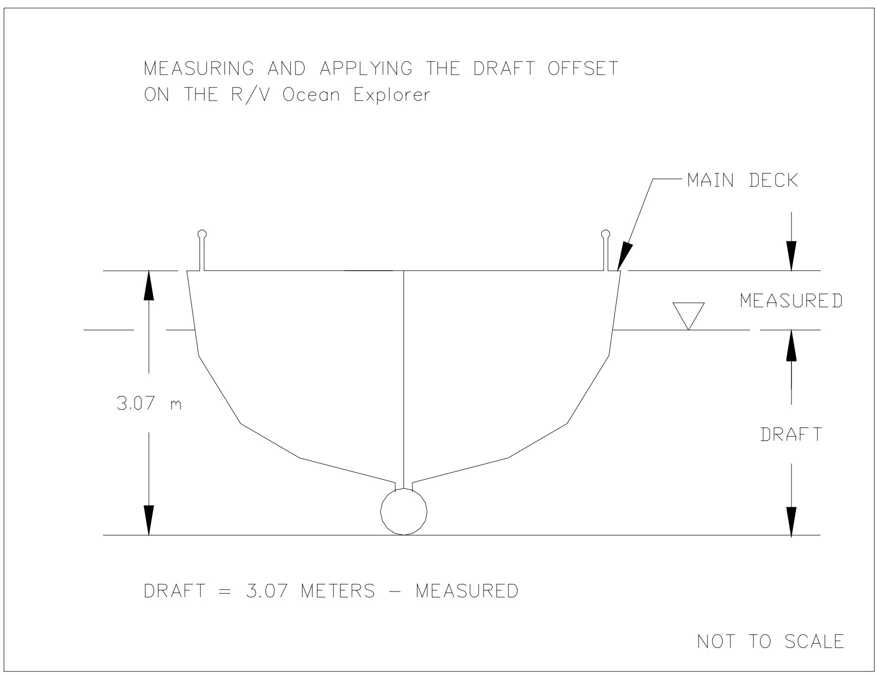

Figure B-2. R/V Ocean Explorer and draft determination stern to dip further into the water. This apparent change in vessel's vertical position, relative to the water line, is capable of impacting the hydrographic data set unless settlement and squat correctors are applied.

Measurements of settlement and squat for the R/V *Ocean Explorer* were conducted on 13 May 2000 (Julian day 134), in Narragansett Bay, RI over an area of seafloor 18 m below the water's surface. As expected, the correction values increase proportionally with the vessel's speed over ground. A complete description of the measurement procedure is presented in Appendix D.

Tidal Corrections

For the 2000 CLIS survey, data from the National Oceanic and Atmospheric Administration (NOAA) tide station in Bridgeport Harbor, CT (8467150) were used for generating final tidal correctors. The NOAA 6-minute tide data were downloaded in the MLLW datum, adjusted to local time, and then corrected for tidal differences based on the entrance to New Haven Harbor, CT. The local tide zone correctors applied to the Bridgeport tide data were +2 minutes for time difference and 98% for height.

Data Acquisition

Multibeam depth data were collected by the RESON 8101/6042 system in the Generic Sensor Format (GSF). The GSF file format allows flags to be set as an indication of the validity of each ping or beam within the bathymetric data. These flags can be set in real-time either during acquisition or later during post processing of the data. The GSF combined with history records inserted into the files in real-time and during post processing provides complete tracking of all correctors and processing steps that were applied to the data. Thus, the original GSF file is continually updated without creating multiple redundant multibeam files; no data are deleted, they are only flagged and ignored in the final processing routines.

Multibeam Data Processing

All multibeam data processing was conducted using the SAIC ISS2000 system. Initial navigation quality control was done on the vessel shortly after the data was collected. Where time allowed, multibeam data were edited onboard the vessel using the geoswath editor, which provides both plan and profile views of each beam in its true geographic position and depth. At the end of each day, both the raw and processed data were backed up onto 4 mm tape and shipped to the Data Processing Center in Newport, RI.

In the processing center, manual data editing was completed and reviewed by an ACSM-certified Hydrographer. Verified data from the NOAA tide station at Bridgeport, CT were applied to the multibeam data during this phase of the post-processing. The data collected along the three cross lines were compared to soundings obtained from the same locations along the mainscheme survey lines as a quality control tool. Any questionable data were noted and later evaluated by the lead Hydrographer.

During data acquisition, a cutoff beam angle of 56° was applied to restrict the use of the data from the outer beams. However, after all corrections were applied to the data, it was determined that the length of the lead-in at the start of each survey line was not adequate to allow the POS/MV IMU heave value to properly settle to the true vertical datum. In order to fill in the gaps for the first 400 meters of these lines, the swath angle was opened up to 70° for the last 400 meters of the adjacent survey lines. A further review of this wider beam angle data found no discrepancies between overlapping data.

Once the data were fully processed and reviewed, the depth data were gridded into 1×1 m, 5×5 m, 10×10 m, and 25×25 m cells. Each cell contained a single depth value derived from averaging all of soundings that fell within that cell. When large differences were detected between soundings within the same cell, the edited multibeam files were re-examined and re-edited as needed. The resulting gridded data sets were used to evaluate coverage and quality, as well as facilitate comparison with older single-beam bathymetric data sets. The 1 m gridded dataset provided a high-resolution representation of the CLIS seafloor and was used for generating the preliminary interpretive results. For later analysis and comparisons with the previously collected single-beam datasets, the 1 m grid was re-sampled to a 625 m^2 (25×25 m) grid. This re-sampling was accomplished using a combination of ESRI Arcinfo and Arcview® to spatially re-position and average the data to fit within the required cell bins.

Depth Difference Comparisons

The 625 m^2 gridded data from the 1999 single-beam survey and the 2000 multibeam survey were imported into Arcview® for spatial analysis and comparisons. In addition, the single-beam bathymetric dataset from a 1996 monitoring survey was also gridded at a 625 m^2 interval and imported into Arcview® for additional analysis. Because both the 1999 and 1996 datasets covered a smaller area than the 2000 dataset, depth difference values could only be computed over the common areas for each of the survey combinations. Within Arcview®, depth difference matrices were generated by calculating the differences between values in corresponding grid cells between the different surveys. The resulting matrices were then reviewed within Arcview® to aid in the interpretation of the observed differences in topography that were evident between the 1996, 1999, and 2000 surveys.

Appendix C
Heave, Pitch, Roll Biases

The POS/MV IMU was used for heave, roll, pitch, and heading. The accuracy of the sensor was 5 cm for heave, ±0.10° dynamic accuracy (±0.05° static) for roll and pitch. The dynamic heading accuracy of the unit is ±0.05°.

Heading, roll, and pitch biases were determined in a series of tests performed in the Narragansett Bay during the Sea Acceptance Test. Before conducting any of the tests, an SVP was collected by the MVP-30 and entered into the RESON system. Initially, the roll, pitch, and heading biases were set to 0° in the RESON system.

SAIC used a combination of the geoswath editor and a spreadsheet to compute the roll bias between the POS/MV IMU and the transducer. This technique was developed and used on the Gulf of Mexico project for roll bias determination over flat bottom. Because the bottom is seldom truly flat, the test is accomplished by running the same line in opposite directions over a smooth bottom. An area is selected for the measurements, and an equal number of port and starboard depth pairs is measured from each direction. The apparent port to starboard slope of the bottom is computed for each pair of measurements. Averaging the equal number of slopes from each direction removes the bottom slope and leaves the roll bias. If a roll bias was in the system at the time of the test, it is added algebraically to the apparent slope to compute the values to be averaged. On 11 May 2000 (Julian day 132), three separate determinations of roll bias were made and then averaged for a bias value of 0.18. Roll bias results are shown in Table C-1.

After the roll bias was calculated and entered into the RESON system, timing latency test and then pitch bias tests were conducted. Timing latency testing was conducted by running the same line in the same direction, at slow speeds then at fast speed, over distinct rocks on the bottom. The geoswath editor was used to measure the positions of the rocks from data taken at the two speeds. Differences in positions of the rocks were less than 1 m and were both positive and negative in sign as well as across track. This indicated no timing latency, only the scatter associated with DGPS positioning.

Pitch bias testing was conducted by running the same line as for timing latency, but in the opposite direction at the same speed. Positioning of the rocks was similar to the timing results, indicating no pitch bias. Since there was no discernable timing latency or pitch bias as a result of these tests, a bias of 0.0° was kept in the system for the survey.

Following the roll and pitch bias tests, a heading bias test was conducted by running parallel lines in opposing directions so that the outer beams of adjacent swaths ensonified the same rocks used for timing and pitch. Positioning of the rocks was similar to the results of the timing and pitch tests, indicating no heading bias. Therefore, a heading bias of 0.0° was kept in the system for this survey. Table C-1 contains the results of the Accuracy test conducted on 13 May 2000 (Julian day 134). Roll, pitch, and heading biases applied in the CLIS survey are shown in Table C-2.

Table C-1.

Roll Bias Results for R/V *Ocean Explorer*

	Roll Bias Determination		Julian Day:	132	date:	11 May 2000
	File numbers:	132.d06 & 132.d08				
	from geoswath		from geoswath	apparent	bias already	bias to enter
#	depth port m.	depth stbd m.	swath width m.	slope	in ISS2000	in ISS2000
1	40.33	37.36	105.30	0.81	0.00	0.81
2	40.38	37.45	105.30	0.80	0.00	0.80
3	40.25	37.41	105.30	0.77	0.00	0.77
4	40.16	37.74	105.30	0.66	0.00	0.66
5	40.20	38.11	105.30	0.57	0.00	0.57
6	40.74	38.29	105.30	0.67	0.00	0.67
7	40.34	38.16	105.30	0.59	0.00	0.59
8	40.25	38.09	105.30	0.59	0.00	0.59
9	40.36	37.97	105.30	0.65	0.00	0.65
10	40.36	38.02	105.30	0.64	0.00	0.64
11	39.27	40.20	105.30	-0.25	0.00	-0.25
12	39.36	40.27	105.30	-0.25	0.00	-0.25
13	39.41	40.40	105.30	-0.27	0.00	-0.27
14	39.47	40.81	105.30	-0.36	0.00	-0.36
15	39.34	40.29	105.30	-0.26	0.00	-0.26
16	39.13	40.13	105.30	-0.27	0.00	-0.27
17	38.98	39.86	105.30	-0.24	0.00	-0.24
18	38.84	39.77	105.30	-0.25	0.00	-0.25
19	38.63	39.83	105.30	-0.33	0.00	-0.33
20	38.56	39.77	105.30	-0.33	0.00	-0.33
			mean bias to enter in ISS2000			0.20
			standard deviation first direction			0.09
			standard deviation second direction			0.04

Table C-1. (continued)

	Roll Bias Determination		Julian Day:	132	date:	11 May 2000
	File numbers:		132.d05 & 132.d10			
	from geoswath		from geoswath	apparent	bias already	bias to enter
#	depth port m.	depth stbd m.	swath width m.	slope	in ISS2000	in ISS2000
1	37.11	37.81	105.30	-0.19	0.00	-0.19
2	37.09	37.88	105.30	-0.21	0.00	-0.21
3	37.20	37.98	105.30	-0.21	0.00	-0.21
4	37.20	38.36	105.30	-0.32	0.00	-0.32
5	37.43	38.65	105.30	-0.33	0.00	-0.33
6	37.84	38.82	105.30	-0.27	0.00	-0.27
7	38.11	38.84	105.30	-0.20	0.00	-0.20
8	38.16	38.91	105.30	-0.20	0.00	-0.20
9	37.11	37.79	105.30	-0.18	0.00	-0.18
10	37.08	37.77	105.30	-0.19	0.00	-0.19
11	39.98	37.59	105.30	0.65	0.00	0.65
12	39.83	37.54	105.30	0.62	0.00	0.62
13	39.75	37.50	105.30	0.61	0.00	0.61
14	39.70	37.52	105.30	0.59	0.00	0.59
15	39.59	37.50	105.30	0.57	0.00	0.57
16	39.54	37.50	105.30	0.55	0.00	0.55
17	39.45	37.41	105.30	0.55	0.00	0.55
18	39.56	37.30	105.30	0.61	0.00	0.61
19	39.27	36.84	105.30	0.66	0.00	0.66
20	39.31	36.75	105.30	0.70	0.00	0.70
			mean bias to enter in ISS2000			0.19
			standard deviation first direction			0.05
			standard deviation second direction			0.05

Table C-1. (continued)

	Roll Bias Determination		Day:	132	date:	11-May-00
	File numbers:		132.d04 & .d09			
	from geoswath		from geoswath	apparent	bias already	bias to enter
#	depth port m.	depth stbd m.	swath width m.	slope	in ISS2000	in ISS2000
1	37.68	36.04	105.30	0.45	0.00	0.45
2	37.68	36.13	105.30	0.42	0.00	0.42
3	37.70	36.16	105.30	0.42	0.00	0.42
4	37.70	36.18	105.30	0.41	0.00	0.41
5	37.77	36.11	105.30	0.45	0.00	0.45
6	37.75	36.11	105.30	0.45	0.00	0.45
7	37.79	36.13	105.30	0.45	0.00	0.45
8	37.81	36.09	105.30	0.47	0.00	0.47
9	37.84	36.09	105.30	0.48	0.00	0.48
10	37.91	36.11	105.30	0.49	0.00	0.49
11	36.84	37.24	105.30	-0.11	0.00	-0.11
12	36.83	37.29	105.30	-0.13	0.00	-0.13
13	36.88	37.31	105.30	-0.12	0.00	-0.12
14	36.86	37.34	105.30	-0.13	0.00	-0.13
15	36.83	37.31	105.30	-0.13	0.00	-0.13
16	36.86	37.27	105.30	-0.11	0.00	-0.11
17	36.86	37.36	105.30	-0.14	0.00	-0.14
18	36.83	37.43	105.30	-0.16	0.00	-0.16
19	36.84	37.34	105.30	-0.14	0.00	-0.14
20	36.86	37.27	105.30	-0.11	0.00	-0.11
			Mean bias to enter in ISS2000			0.16
			Standard deviation first direction			0.03
			Standard deviation second direction			0.02
Average of three tests			***Mean bias to enter in ISS2000***			***0.18***

Table C-2.

Roll, Pitch, and Heading Bias for the R/V *Ocean Explorer*

Bias	**Value**
Roll	0.18
Pitch	0.00°
Heading	0.00°

Appendix D
Settlement and Squat Calculations for the R/V *Ocean Explorer*

Measurements of settlement and squat were conducted near 41°31’ 56” N, 71°19’ 30” W on 13 May 2000 (Julian day 134), in 18 meters of water off the end of the Coddington Cove breakwater, Narragansett Bay, RI. The following procedures were used to determine the settlement correctors:

Measurement by Surveyor’s Level and Rod, the preferred method when the attitude sensor (IMU) and the transducer are not co-located.

1. Used a surveyor’s level and a level rod with target, or a stadia board to measure the elevation of a spot above the attitude sensor (IMU) on the survey boat as the boat was operated at different shaft RPMs.
2. Selected a location to set up a surveyor’s level (“level”) overlooking adequate water for the survey vessel to run a survey line at various speeds, including full speed. Established communication between “level” and the boat.
3. Selected the “static” point for initial measurements, which was the point at which the vessel was to hold station.
4. Planned the “settlement and squat” survey line through “static.” The vessel ran this line at various shaft RPM settings to make settlement and squat measurements. The line ran more nearly toward the “level” than across in front of it. This made it more likely that the observer was able to focus on and read, or direct the reading, of the level rod on the boat. For this reason, a breakwater end was chosen.
5. Marked a spot on the vessel above the attitude sensor (IMU) so that the level rod was always held at the same point on the boat.
6. Stopped the vessel at “static” with the starboard side toward “level.”
   A. Held the rod on mark with face toward “level.”
   B. Adjusted the rod target according to signals from “level.”
   C. On signal from “level,” recorded time and rod reading from target.
   D. Repeated the reading at least three times.
   E. The NOAA water level gauge at Newport was used to record water levels.
7. On a signal from the surveyor at “level,” made way on “settlement and squat” survey lines at predetermined shaft RPM.
   A. On survey track, held rod on mark with face toward “level.”
   B. Adjusted rod target according to signals from “level.”
   C. On signal from “level,” recorded time and rod reading from target. Readings were taken as nearly as possible at “static” to reduce errors from level instrument adjustment and earth curvature.
   D. Repeated the reading at least three times.
   E. The NOAA water level gauge at Newport was used to record water levels.
8. Increased speed to the predetermined shaft RPM settings up to and including full speed, and reran “settlement and squat” tests as described in Step 7.
9. Computed the settlement and squat correctors:

A. Computed the water level correctors from the time of the “static” reading to the time of each of the shaft RPM observations. (Water level during shaft RPM pass minus water level “static”).
B. Applied the water level corrector to each of the shaft RPM rod observations.
C. Subtracted the corrected rod reading at each shaft RPM from the rod reading at “static.” These differences are the settlement and squat correctors to be applied when operating at the corresponding shaft RPM.
D. Constructed a lookup table of shaft RPM and settlement and squat correctors so that the computer may interpolate a corrector based upon the shaft RPM entered into the system during the survey.
E. Entered these values in the ISS2000 *.cfg file.

All results are reported in Table D-1.

Table D-1.

Settlement Results for the R/V/ Ocean Explorer

Engine RPM	Speed Knots*	Settlement Meters
0	0	0.00
600	5	0.01
800	7	0.02
1100	10	0.03
1300	11	0.04
1500	12	0.08
1900	15	0.22

*** NOTE:** The speeds in knots listed in Table D3-1 were not used in the Settlement and Squat Lookup Table, but are given here as approximate average values.

Appendix E
1999 REMOTS® Survey Results

Appendix E1.

REMOTS® Results for the CLIS 97/98 Mound Complex

Station	Rep	Date	Time	Analyst	Latitude	Longitude	Successional Stage	Grain Size (phi) Min	Max	Major Mode	Mudclast Count	Diameter	Camera Penetration Min	Max	Range	Mean	Dredged Material Thickness Area	Min	Max	Mean
45	D	9/14/1999	9:29	MSC	41 08.946N	072 53.382W	ST_I	>4	2	>4	0	0	12.37	13.74	1.37	13.05	0	0.00	0.00	0.00
45	E	9/14/1999	9:30	MSC	41 08.946N	072 53.382W	ST_III	>4	2	>4	0	0	15.21	15.95	0.74	15.58	0	0.00	0.00	0.00
45	F	9/14/1999	9:30	MSC	41 08.937N	072 53.380W	ST_III	>4	1	>4	0	0	14.58	14.95	0.37	14.76	0	0.00	0.00	0.00
46	D	9/14/1999	9:34	MSC	41 08.893N	072 53.452W	ST_I_ON_III	>4	2	>4	0	0	14.11	14.63	0.53	14.37	0	0.00	0.00	0.00
46	E	9/14/1999	9:35	MSC	41 08.890N	072 53.457W	ST_I	>4	2	>4	0	0.29	16.89	17.42	0.53	17.16	0	0.00	0.00	0.00
46	F	9/14/1999	9:36	MSC	41 08.888N	072 53.457W	ST_I	>4	2	>4	0	0	16.42	18	1.58	17.21	0	0.00	0.00	0.00
47	D	9/14/1999	9:39	MSC	41 08.894N	072 53.383W	ST_I_ON_III	>4	2	>4	0	0	18.26	19	0.74	18.63	0	0.00	0.00	0.00
47	E	9/14/1999	9:39	MSC	41 08.890N	072 53.378W	ST_I	>4	2	>4	0	0	15.37	16.16	0.79	15.76	0	0.00	0.00	0.00
47	F	9/14/1999	9:40	MSC	41 08.884N	072 53.377W	ST_I	>4	2	>4	0	0	19.47	20.11	0.63	19.79	0	0.00	0.00	0.00
48	G	9/23/1999	12:34	MSC	41 08.890N	072 53.307W	ST_I	>4	2	>4	0	0	19.9	20.21	0.32	20.05	0	19.90	20.21	20.06
48	H	9/23/1999	12:35	MSC	41 08.887N	072 53.292W	ST_I	>4	2	>4	3	0.83	18.32	18.79	0.47	18.55	0	9.00	10.50	10.00
48	I	9/23/1999	12:36	MSC	41 08.890N	072 53.283W	ST_III	>4	2	>4	0	0	17.58	18	0.42	17.79	0	0.00	0.00	0.00
49	D	9/14/1999	9:49	MSC	41 08.892N	072 53.236W	ST_I	>4	2	>4	6	1.16	18.32	18.84	0.53	18.58	0	0.00	0.00	0.00
49	E	9/14/1999	9:50	MSC	41 08.891N	072 53.235W	ST_I	>4	2	>4	0	0	17.58	17.95	0.37	17.76	0	0.00	0.00	0.00
49	G	9/23/1999	12:38	MSC	41 08.899N	072 53.231W	ST_I	>4	2	>4	13	0.29	19.05	19.84	0.79	19.45	9.23	0.16	0.95	0.59
50	D	9/14/1999	10:07	MSC	41 08.839N	072 53.533W	ST_I	>4	2	>4	0	0	18.39	18.96	0.57	18.67	0	0.00	0.00	0.00
50	E	9/14/1999	10:08	MSC	41 08.831N	072 53.535W	ST_I	>4	2	>4	0	0	18.67	19.1	0.43	18.88	0	0.00	0.00	0.00
50	F	9/14/1999	10:08	MSC	41 08.826N	072 53.530W	ST_I_ON_III	>4	2	>4	0	0	14.57	15.16	0.59	14.87	0	0.00	0.00	0.00
51	D	9/14/1999	10:15	MSC	41 08.839N	072 53.449W	ST_I	>4	2	>4	0	0	19.1	19.63	0.53	19.36	0	0.00	0.00	0.00
51	E	9/14/1999	10:15	MSC	41 08.836N	072 53.448W	ST_I	>4	2	>4	0	0	20.48	20.74	0.27	20.61	0	0.00	0.00	0.00
51	F	9/14/1999	10:16	MSC	41 08.827N	072 53.452W	ST_I	>4	2	>4	0	0	17.93	18.4	0.48	18.16	0	0.00	0.00	0.00
52	D	9/14/1999	10:20	MSC	41 08.841N	072 53.383W	ST_I	>4	2	>4	0	0	7.82	9.84	2.02	8.83	124.25	5.74	9.79	8.76
52	E	9/14/1999	10:21	MSC	41 08.840N	072 53.384W	ST_I	>4	2	>4	0	0	11.91	11.97	0.05	11.94	165.86	8.83	11.97	11.77
52	H	9/23/1999	12:31	MSC	41 08.849N	072 53.374W	ST_I	>4	1	>4	6	0.55	7.18	8.3	1.12	7.74	114.83	8.08	8.19	8.06
53	D	9/14/1999	10:26	MSC	41 08.840N	072 53.307W	ST_I	>4	2	>4	1	3.87	14.1	14.95	0.85	14.52	198.64	13.99	14.52	14.06
53	E	9/14/1999	10:27	MSC	41 08.839N	072 53.308W	ST_I	>4	2	>4	0	0	11.49	12.77	1.28	12.13	174.61	11.65	12.87	12.21
53	F	9/14/1999	10:27	MSC	41 08.839N	072 53.308W	ST_III	>4	3	>4	1	1.09	14.2	15.27	1.06	14.73	198.89	11.28	15.11	14.12
54	D	9/14/1999	10:33	MSC	41 08.842N	072 53.233W	ST_I	>4	4	>4	0	0	16.38	16.81	0.42	16.6	233.94	4.10	17.13	16.48
54	E	9/14/1999	10:33	MSC	41 08.837N	072 53.236W	ST_I_ON_III	>4	4	>4	0	0.45	15.58	17.18	1.6	16.38	229.09	15.43	17.07	16.26
54	F	9/14/1999	10:34	MSC	41 08.834N	072 53.241W	ST_I_ON_III	>4	2	>4	0	0	18.4	19.25	0.85	18.83	245.29	13.54	18.59	17.64
55	D	9/14/1999	10:39	MSC	41 08.841N	072 53.166W	ST_III	>4	2	>4	15	0.69	13.72	15.43	1.7	14.57	14.52	0.53	1.76	0.98
55	E	9/14/1999	10:40	MSC	41 08.840N	072 53.169W	ST_I	>4	2	>4	0	0	16.7	17.18	0.48	16.94	0	0.00	0.00	0.00
55	F	9/14/1999	10:41	MSC	41 08.834N	072 53.179W	ST_I	>4	4	>4	6	1	13.56	14.79	1.22	14.18	197.82	11.17	14.95	13.98
56	D	9/14/1999	10:46	MSC	41 08.883N	072 53.093W	ST_I	>4	2	>4	0	0	15.58	16.06	0.48	15.82	0	0.00	0.00	0.00
56	E	9/14/1999	10:47	MSC	41 08.837N	072 53.095W	ST_I	>4	4	>4	2	0.79	14.79	15.16	0.37	14.97	0	0.00	0.00	0.00
56	F	9/14/1999	10:48	MSC	41 08.836N	072 53.101W	ST_III	>4	2	>4	0	0	16.22	17.34	1.12	16.78	0	0.00	0.00	0.00
58	D	9/14/1999	12:10	MSC	41 08.789N	072 53.594W	ST_I_ON_III	>4	2	>4	0	0	16.89	17.53	0.63	17.21	0	0.00	0.00	0.00
58	E	9/14/1999	12:11	MSC	41 08.790N	072 53.594W	ST_I	>4	4	>4	0	0	18.63	19.1	0.47	18.87	0	0.00	0.00	0.00
58	F	9/14/1999	12:11	MSC	41 08.791N	072 53.592W	ST_I	>4	2	>4	0	0	20.32	20.68	0.37	20.5	0	0.00	0.00	0.00
59	D	9/14/1999	12:01	MSC	41 08.781N	072 53.464W	ST_III	>4	3	4 to 3	0	0	5.26	7.37	2.11	6.32	0	0.00	0.00	0.00
59	E	9/14/1999	12:06	MSC	41 08.786N	072 53.535W	IND	>4	2	>4	0	0	13	17.84	4.84	15.42	204.96	12.74	17.58	14.58
59	F	9/14/1999	12:07	MSC	41 08.794N	072 53.536W	ST_I_ON_III	>4	2	>4	2	0.83	16.26	16.79	0.53	16.53	231.74	8.11	16.95	16.35
60	D	9/14/1999	11:55	MSC	41 08.778N	072 53.438W	ST_III	>4	1	>4	0	0	10.84	12.21	1.37	11.53	160.56	10.74	12.11	11.34
60	E	9/14/1999	11:55	MSC	41 08.775N	072 53.455W	IND	>4	1	4 to 3	0	0	2.95	4.37	1.42	3.66	47.58	2.89	4.58	3.32
60	F	9/14/1999	11:58	MSC	41 08.780N	072 53.464W	ST_I	>4	1	4 to 3	0	0	9.74	10.47	0.74	10.11	137.72	9.47	10.26	9.88
61	H	9/14/1999	11:50	MSC	41 08.787N	072 53.366W	ST_III	>4	2	>4	0	0	14.47	16.1	1.63	15.29	212.91	8.05	16.16	15.22
61	I	9/14/1999	11:51	MSC	41 08.789N	072 53.376W	ST_III	>4	2	>4	0	1.72	10.79	11.21	0.42	11	158.08	8.79	11.84	11.23
61	J	9/14/1999	11:52	MSC	41 08.792N	072 53.380W	ST_I	>4	2	>4	0	0	11.84	14.1	2.26	12.97	182.08	10.58	14.21	12.97
62	D	9/14/1999	11:46	MSC	41 08.787N	072 53.299W	ST_I	>4	1	4 to 3	0	0	5.42	6.74	1.32	6.08	82.54	5.32	6.58	5.76
62	E	9/14/1999	11:47	MSC	41 08.789N	072 53.309W	ST_I	>4	1	>4	0	0	7.42	7.95	0.53	7.68	108.61	7.37	8.05	7.70
62	F	9/14/1999	11:48	MSC	41 08.791N	072 53.320W	ST_I_ON_III	>42	1	>4	0	0	8.89	10.16	1.26	9.53	134.85	7.11	10.00	9.57
63	D	9/14/1999	11:39	MSC	41 08.777N	072 53.224W	ST_I_ON_III	>4	2	>4	0	0	14.29	15.55	1.26	14.92	0	0.00	0.00	0.00
63	E	9/14/1999	11:41	MSC	41 08.785N	072 53.239W	ST_I_ON_III	>4	2	>4	0	0	13.42	13.84	0.42	13.63	191.25	13.32	13.79	13.36
63	F	9/14/1999	11:42	MSC	41 08.775N	072 53.240W	ST_III	>4	2	>4	0	0	11	13.37	2.37	12.18	174.15	10.32	13.10	12.36
64	D	9/14/1999	11:29	MSC	41 08.786N	072 53.170W	ST_I	>4	2	>4	20	0.74	12.34	13.72	1.38	13.03	14.81	0.37	1.86	1.01
64	E	9/14/1999	11:30	MSC	41 08.784N	072 53.183W	ST_I_ON_III	>4	2	>4	0	0	15.05	15.47	0.42	15.26	0	0.00	0.00	0.00
64	F	9/14/1999	11:31	MSC	41 08.780N	072 53.197W	ST_I_ON_III	>4	2	>4	0	0	14.37	15.58	1.21	14.97	0	0.00	0.00	0.00
65	D	9/14/1999	11:07	MSC	41 08.775N	072 53.096W	ST_I	>4	2	>4	0	0	16.17	17.98	1.81	17.08	0	0.00	0.00	0.00
65	E	9/14/1999	11:10	MSC	41 08.780N	072 53.109W	ST_I	>4	>2	>4	0	0	19.31	20.32	1.01	19.81	0	0.00	0.00	0.00
65	F	9/14/1999	11:14	MSC	41 08.782N	072 53.101W	ST_I	>4	2	>4	3	0.67	15.27	16.28	1.01	15.77	0	0.00	0.00	0.00
68	D	9/14/1999	12:19	MSC	41 08.733N	072 53.514W	ST_I	>4	2	>4	10	0.62	15.05	15.79	0.74	15.42	212.47	14.74	15.58	15.09
68	E	9/14/1999	12:20	MSC	41 08.737N	072 53.516W	ST_I_ON_III	>4	2	>4	0	0	16.72	16.87	0.16	16.8	232.57	8.56	17.33	16.83
68	F	9/14/1999	12:21	MSC	41 08.739N	072 53.522W	ST_I_ON_III	>4	2	>4	0	0	13.33	15.03	1.69	14.18	194.2	13.23	15.40	14.11
69	D	9/14/1999	12:26	MSC	41 08.730N	072 53.441W	ST_I	>4	2	4 to 3	0	0	14.02	15.45	1.43	14.74	200.74	11.16	15.08	14.33
69	E	9/14/1999	12:27	MSC	41 08.730N	072 53.441W	ST_I	>4	2	4 to 3	0	0	12.12	12.86	0.74	12.49	176.64	4.60	12.86	12.44
69	F	9/14/1999	12:28	MSC	41 08.729N	072 53.440W	ST_I	>4	2	>4	0	0	11.32	12.01	0.69	11.67	162.95	4.29	11.90	11.47
70	D	9/14/1999	12:32	MSC	41 08.731N	072 53.365W	ST_III	>4	2	4 to 3	0	0	5.4	6.24	0.85	5.82	80.61	5.05	6.06	5.66
70	E	9/14/1999	12:33	MSC	41 08.729N	072 53.364W	ST_I	>4	1	4 to 3	0	0	7.94	8.31	0.37	8.12	116.9	7.94	8.31	8.13
70	F	9/14/1999	12:34	MSC	41 08.723N	072 53.367W	ST_III	>4	2	>4	0	0	6.25	7.13	0.89	6.69	91.2	2.40	6.98	6.56
71	D	9/14/1999	12:38	MSC	41 08.872N	072 53.300W	ST_I	4	1	3 to 2	0	0	2.92	3.91	0.99	3.41	49.46	3.28	4.11	3.58
71	H	9/23/1999	11:46	MSC	41 08.732N	072 53.301W	ST_I	>4	0	3 to 2	0	0	5.57	6.1	0.52	5.83	77.18	5.36	5.88	5.53
71	I	9/23/1999	11:47	MSC	41 08.873N	072 53.292W	ST_I	>4	0	3 to 2	0	0	5	5.21	0.21	5.1	66.99	4.01	5.57	4.76
72	D	9/14/1999	13:05	MSC	41 08.725N	072 53.231W	ST_I	4	1	>4	0	0	13.07	13.8	0.73	13.44	0	0.00	0.00	0.00
72	E	9/14/1999	13:06	MSC	41 08.721N	072 53.243W	ST_III	>4	1	>4	0	0	7.63	8.97	1.34	8.3	0	0.00	0.00	0.00
72	F	9/14/1999	13:06	MSC	41 08.726N	072 53.247W	ST_I_ON_III	>4	2	>4	0	0	10.98	10.98	0	10.98	0	0.00	0.00	0.00
73	D	9/14/1999	13:12	MSC	41 08.729N	072 53.152W	ST_I_ON_III	>4	2	>4	0	0	19.68	19.95	0.26	19.82	0	0.00	0.00	0.00
73	E	9/14/1999	13:13	MSC	41 08.728N	072 53.153W	ST_I	>4	2	>4	1	0.68	15.97	16.23	0.26	16.1	0	0.00	0.00	0.00
73	F	9/14/1999	13:13	MSC	41 08.724N	072 53.159W	ST_I	>4	2	>4	0	0	19.42	19.74	0.31	19.58	0	0.00	0.00	0.00
78	D	9/14/1999	14:42	MSC	41 08.681N	072 53.453W	ST_I_ON_III	>4	2	>4	0	0	17.8	19.16	1.36	18.48	0	0.00	0.00	0.00
78	E	9/14/1999	14:43	MSC	41 08.680N	072 53.459W	ST_I_ON_III	>4	2	>4	0	0	17.8	19.01	1.2	18.4	0	0.00	0.00	0.00
78	F	9/14/1999	14:44	MSC	41 08.680N	072 53.457W	ST_I_ON_III	>4	2	>4	0	0	15.03	15.39	0.37	15.21	0	0.00	0.00	0.00
79	E	9/14/1999	14:37	MSC	41 08.674N	072 53.380W	ST_I	>4	2	>4	0	0	17.91	18.69	0.78	18.3	0	0.00	0.00	0.00
79	F	9/14/1999	14:38	MSC	41 08.673N	072 53.382W	ST_I_ON_III	>4	2	>4	0	0	19.06	19.95	0.89	19.5	0	0.00	0.00	0.00
79	G	9/14/1999	14:39	MSC	41 08.672N	072 53.387W	ST_I	>4	2	>4	1	0.49	15.45	18.64	3.19	17.04	0	0.00	0.00	0.00
80	D	9/14/1999	14:30	MSC	41 08.682N	072 53.312W	ST_III	>4	2	4 to 3	0	0	4.45	7.12	2.67	5.79	0	0.00	0.00	0.00
80	E	9/14/1999	14:30	MSC	41 08.680N	072 53.320W	ST_I	>4	2	>4	5	0.7	14.35	14.87	0.52	14.61	0	0.00	0.00	0.00
80	F	9/14/1999	14:31	MSC	41 08.672N	072 53.321W	ST_I	>4	2	>4	0	0	16.28	16.75	0.47	16.52	0	0.00	0.00	0.00
81	G	9/23/1999	12:22	MSC	41 08.686N	072 53.221W	ST_III	>4	2	>4	6	0.58	13.04	14.61	1.57	13.82	0	0.00	0.00	0.00
81	H	9/23/1999	12:23	MSC	41 08.673N	072 53.212W	ST_III	>4	2	>4	3	0.47	12.57	13.72	1.15	13.14	0	0.00	0.00	0.00
81	I	9/23/1999	12:25	MSC	41 08.682N	072 53.230W	ST_I_ON_III	>4	2	>4	0	0	17.59	17.75	0.16	17.67	0	0.00	0.00	0.00
88	B	9/12/1999	15:33	MSC	41 08.614N	072 53.379W	ST_I	>4	2	>4	0	0	10.05	14.51	4.46	12.28	0	0.00	0.00	0.00
88	D	9/12/1999	15:37	MSC	41 08.625N	075 33.720W	ST_I_ON_III	>4	2	>4	2	0.66	16.56	17.15	0.58	16.85	0	0.00	0.00	0.00
88	H	9/12/1999	15:55	MSC	41 08.634N	072 53.369W	ST_I_ON_III	>4	2	>4	0	0	17.62	18.04	0.42	17.83	0	0.00	0.00	0.00
100	D	9/14/1999	15:52	MSC	41 08.577N	072 53.238W	ST_I_ON_III	>4	2	>4	2	1.17	15.92	16.07	0.16	15.99	0	0.00	0.00	0.00
100	E	9/14/1999	15:53	MSC	41 08.577N	072 53.238W	ST_I	>4	2	>4	4	0.65	14.16	15.52	1.35	14.84	0	0.00	0.00	0.00
100	F	9/14/1999	15:54	MSC	41 08.577N	072 53.239W	ST_I_ON_III	>4	2	>4	0	0	17.28	18.38	1.1	17.83	0	0.00	0.00	0.00

REMOTS® Results for the CLIS 97/98 Mound Complex

Station	Rep	Date	Time	Apparent RPD Thickness				Methane B.	OSI	Surface	Low	Comments	Assoc.
				Area	Min	Max	Mean	Count		Disturbance	D.O.		Mound
45	D	9/14/1999	9:29	10.27	0.32	2.79	0.81	0	3	BIOGENIC	NO	historic dm >pen; reduced at depth; oxy. megafaunal burrows	CLIS97/98
45	E	9/14/1999	9:30	11.69	0.37	1.16	0.8	0	7	BIOGENIC	NO	historic dm>pen;bivalve shell; several voids	CLIS97/98
45	F	9/14/1999	9:30	18.99	0.89	1.79	1.32	0	7	BIOGENIC	NO	historic dm>pen;surface shells; active void	CLIS97/98
46	D	9/14/1999	9:34	18.40	0.58	1.74	1.27	0	7	BIOGENIC	NO	historic dm>pen;voids;stgI tubes;historic layers	CLIS97/98
46	E	9/14/1999	9:35	18.96	0.89	1.68	1.32	0	3	BIOGENIC	NO	historic dm layers>pen;stg I tubes; no voids	CLIS97/98
46	F	9/14/1999	9:36	13.87	0.63	1.26	0.95	0	3	PHYSICAL	NO	historic dm layer>pen;reduced at depth; STGI tubes	CLIS97/98
47	D	9/14/1999	9:39	15.83	0.63	1.58	1.09	0	7	BIOGENIC	NO	historic dm>pen;reduced at depth; voids/worm deep;stg I tubes	CLIS97/98
47	E	9/14/1999	9:39	25.83	1.58	2.42	1.82	0	4	BIOGENIC	NO	historic dm layers>pen;stg I tube matcollapsed void	CLIS97/98
47	F	9/14/1999	9:40	23.95	1.21	2	1.66	0	4	BIOGENIC	NO	historic dm layers>pen;stg I tube reduced at depth	CLIS97/98
48	G	9/23/1999	12:34	15.53	0.2	1.47	0.46	0	2	INDET	NO	fresh dm>pen;clay clast surface layer;shallow rpd;layer dm reduced at depth	CLIS97/98
48	H	9/23/1999	12:35	23.91	1.16	2.05	1.68	0	4	PHYSICAL	NO	fresh dm; clay over reduced historic dm layers	CLIS97/98
48	I	9/23/1999	12:36	37.01	1.68	3.26	2.64	0	9	BIOGENIC	NO	historic dm reduced at depth;relic void	CLIS97/98
49	D	9/14/1999	9:49	23.89	1.32	2.11	1.67	0	4	PHYSICAL	NO	historic dm> pen;clay clasts at surface; layered; reduced at depth	CLIS97/98
49	E	9/14/1999	9:50	23.32	0.37	2	1.63	0	4	PHYSICAL	NO	historic dm>pen;layered; reduced at depth	CLIS97/98
49	G	9/23/1999	12:38	17.78	0.74	1.84	1.24	0	3	INDET	NO	thin surface layer of dm clasts;historic dm >pen;layers; reduced at depth	CLIS97/98
50	D	9/14/1999	10:07	17.06	0.21	2.61	1.4	0	5	BIOGENIC	NO	historic dm>pen;StgI tubes; collapsed voids	CLIS97/98
50	E	9/14/1999	10:08	33.86	0.57	3.33	2.37	0	5	BIOGENIC	NO	historic dm >pen;not reduced; STG I tubes	CLIS97/98
50	F	9/14/1999	10:08	18.72	0.59	1.65	1.28	0	7	BIOGENIC	NO	historic dm >pen;homog.;not reduced; void	CLIS97/98
51	D	9/14/1999	10:15	22.82	0.53	2.23	1.56	0	4	BIOGENIC	NO	historic dm>pen;layered; mottled clay	CLIS97/98
51	E	9/14/1999	10:15	30.86	1.25	3.18	2.18	0	4	BIOGENIC	NO	historic layered dm>pen;not reduced;dense STG I tubes	CLIS97/98
51	F	9/14/1999	10:16	27.53	1.7	2.07	1.89	0	4	BIOGENIC	NO	historic dm>pen;graded bedding.;not reduced; silty surface w STGI	CLIS97/98
52	D	9/14/1999	10:20	39.44	1.81	4.04	2.78	0	5	PHYSICAL	NO	possible dm>pen? tan clay/silt;sloping topography	CLIS97/98
52	E	9/14/1999	10:21	22.52	0.43	2.02	1.53	0	4	PHYSICAL	NO	possible dm>pen;tan cl./silt surf. layer; reduced/oxy at dpt; graded bedding;M/S/M/S	CLIS97/98
52	H	9/23/1999	12:31	22.23	0.53	2.13	1.55	0	4	PHYSICAL	NO	fresh dm>pen;graded bedding; M/S/M/S	CLIS97/98
53	D	9/14/1999	10:26	39.46	0.99	4.84	2.85	0	5	PHYSICAL	NO	fresh dm>pen.large dm clast surface;tan silt/clay over reduced sand/dm	CLIS97/98
53	E	9/14/1999	10:27	22.31	0.96	1.97	1.56	0	4	INDET	NO	fresh dm >pen; sandy dm with clay streaks; oxy/reduced	CLIS97/98
53	F	9/14/1999	10:27	32.02	0.43	3.67	2.17	0	8	PHYSICAL	NO	fresh dm>pen; sandy silt/reduced dm mud;clay clast surface	CLIS97/98
54	D	9/14/1999	10:33	29.09	0.69	2.61	2.01	0	4	PHYSICAL	NO	fresh dm/relict dm; layered	CLIS97/98
54	E	9/14/1999	10:33	19.84	1.12	1.7	1.37	0	7	PHYSICAL	NO	fresh dm layer;possible dm clast surface; historic layered dm>pen;1 void	CLIS97/98
54	F	9/14/1999	10:34	21.59	1.01	2.02	1.49	0	7	PHYSICAL	NO	fresh dm over relic dm>pen;layering	CLIS97/98
55	D	9/14/1999	10:39	19.24	0.9	2.5	2	0	8	PHYSICAL	NO	fresh dm clast surface layer; historic dm>pen;voids	CLIS97/98
55	E	9/14/1999	10:40	16.92	0.36	1.82	1.17	0	3	PHYSICAL	NO	historic dm>pen;silty surface over mottled mud	CLIS97/98
55	F	9/14/1999	10:41	28.43	1.06	3.83	2.02	0	4	PHYSICAL	NO	historic dm>pen; Dm clast surface layer; layers of mottled mud	CLIS97/98
56	D	9/14/1999	10:46	21.25	1.06	2.07	1.45	0	3	BIOGENIC	NO	historic dm>pen;dm layers	CLIS97/98
56	E	9/14/1999	10:47	20.68	0.05	1.91	1.43	0	3	PHYSICAL	NO	historic dm>pen;dm layers	CLIS97/98
56	F	9/14/1999	10:48	27.06	0.9	2.5	1.86	0	8	PHYSICAL	NO	historic dm>pen;void deep;dm layers	CLIS97/98
58	D	9/14/1999	12:10	23.89	0.84	2.37	1.68	0	8	BIOGENIC	NO	historic layered dm>pen;fecal mound;void	CLIS97/98
58	E	9/14/1999	12:11	33.04	1.74	3.05	1.85	0	4	BIOGENIC	NO	historic layered dm>pen;mulinia?	CLIS97/98
58	F	9/14/1999	12:11	23.66	0.84	4.65	2.64	0	5	BIOGENIC	NO	historic layered dm>pen;mulinia shells?	CLIS97/98
59	D	9/14/1999	12:01	24.44	0.05	2.68	1.69	0	8	INDET	NO	pullaway;silty surface layer;clay smears on faceplate	CLIS97/98
59	E	9/14/1999	12:06	0.00	0	0.35	0.2	0	99	PHYSICAL	NO	fresh dm>pen;reduced irregular surface	CLIS97/98
59	F	9/14/1999	12:07	27.17	1.21	2.84	1.89	0	8	BIOGENIC	NO	fresh dm>pen;void;mottled clay;shell;dm clasts	CLIS97/98
60	D	9/14/1999	11:55	22.70	1.05	3.11	1.57	0	8	BIOGENIC	NO	fresh dm>pen;silty w/shellhash over reduced dmmud/clay	CLIS97/98
60	E	9/14/1999	11:55	26.26	1.16	2.89	1.85	0	99	PHYSICAL	NO	fresh dm>pen; sandy;shell frags	CLIS97/98
60	F	9/14/1999	11:58	54.18	3.21	4.16	3.79	0	7	PHYSICAL	NO	fresh dm>pen;sandy/silt over reduced dmmud/clay;	CLIS97/98
61	H	9/14/1999	11:50	17.99	0.37	2.79	0.8	0	7	PHYSICAL	NO	fresh dm >pen; mottled clay; large void	CLIS97/98
61	I	9/14/1999	11:51	20.03	0.53	2.26	1.39	0	7	PHYSICAL	NO	fresh dm >pen; clay clasts surface;shell hash; collpsed void	CLIS97/98
61	J	9/14/1999	11:52	24.14	0.89	2.21	1.67	0	4	PHYSICAL	NO	fresh dm>pen;layer of sand/pebbles? at surface;shell;mottled clay at depth	CLIS97/98
62	D	9/14/1999	11:46	32.30	1.63	3	2.27	0	5	PHYSICAL	NO	fresh dm>pen; sandy w shell frags;clay clasts	CLIS97/98
62	E	9/14/1999	11:47	22.47	0.32	2.95	1.59	0	4	INDET	NO	fresh dm>pen; sandy surface over reduced dm mud;shells /hash	CLIS97/98
62	F	9/14/1999	11:48	48.08	2.32	4.53	3.35	0	10	BIOGENIC	NO	fresh dm>pen;worm tube;void;sandy;shell frags	CLIS97/98
63	D	9/14/1999	11:39	25.22	1.05	3.75	2.16	0	8	BIOGENIC	NO	historic dm>pen	CLIS97/98
63	E	9/14/1999	11:41	23.09	1.11	3.16	2.4	0	9	BIOGENIC	NO	fresh dm>pen; reduced at depth; hetero.;stgI tubes; void	CLIS97/98
63	F	9/14/1999	11:42	28.57	0.42	4.68	1.56	0	8	BIOGENIC	NO	fresh dm>pen;macrofuanal burrow ;oxy. at depth; heterogen.	CLIS97/98
64	D	9/14/1999	11:29	24.96	1.28	2.18	1.75	0	5	PHYSICAL	NO	fresh dm surfacelayer of clasts; historic dm>pen; reduced at depth;shell frags	CLIS97/98
64	E	9/14/1999	11:30	15.83	0.37	1.89	1.08	0	7	BIOGENIC	NO	historic dm >pen;mottled voids	CLIS97/98
64	F	9/14/1999	11:31	19.57	0.89	2.8	2.42	0	9	BIOGENIC	NO	historic dm>pen; void	CLIS97/98
65	D	9/14/1999	11:07	37.33	1.44	3.4	2.56	0	5	INDET	NO	historic dm>pen;mottled clay	CLIS97/98
65	E	9/14/1999	11:10	32.98	1.97	2.66	2	0	4	PHYSICAL	NO	historic dm>pen; historic layering;mottled	CLIS97/98
65	F	9/14/1999	11:14	28.16	1.12	2.93	1.96	0	4	PHYSICAL	NO	historic dm>pen;surface clastsDM?reduced at depth	CLIS97/98
68	D	9/14/1999	12:19	7.23	0.16	0.95	0.47	0	2	PHYSICAL	NO	fresh dm>pen;shallow rpd under dm clasts at surface;reduced at depth	CLIS97/98
68	E	9/14/1999	12:20	26.88	0.53	4.87	1.86	0	8	BIOGENIC	NO	frsh dm>pen?silty surface; macrofauanl burrow well oxygen.;stgI tubes	CLIS97/98
68	F	9/14/1999	12:21	20.49	0.63	1.96	1.44	0	7	BIOGENIC	NO	fresh dm>pen?homogen.silty surface;macrofaunal burrow/voids at depth	CLIS97/98
69	D	9/14/1999	12:26	25.87	1.11	2.38	1.8	0	4	BIOGENIC	NO	fresh dm>pen;sandy dm; Stg I tubes	CLIS97/98
69	E	9/14/1999	12:27	22.00	0.95	2.43	1.53	0	4	BIOGENIC	NO	fresh dm>pen? fine sand dm	CLIS97/98
69	F	9/14/1999	12:28	22.00	0.95	4.03	2.6	0	5	PHYSICAL	NO	fresh dm>pen;silty clay surface over coarser layer	CLIS97/98
70	D	9/14/1999	12:32	27.08	0.43	2.55	1.81	0	8	BIOGENIC	NO	fresh dm>pen;coarser surfeace over reduced /tan clay dm;void	CLIS97/98
70	E	9/14/1999	12:33	28.05	1.65	2.66	1.95	0	4	PHYSICAL	NO	fresh dm>pen;coarser sandymud over reduced clay/sand	CLIS97/98
70	F	9/14/1999	12:34	26.85	0.83	4.27	2.01	0	8	PHYSICAL	NO	fresh dm>pen;coarser surface over grey clay ;void/clay shear;hermit crabs?	CLIS97/98
71	D	9/14/1999	12:38	46.66	2.5	3.8	3.35	0	6	PHYSICAL	NO	fresh dm>pen;coarse sand mixed w/clay fraction;very hard;shell frags;RPD>pen	CLIS97/98
71	H	9/23/1999	11:46	71.05	4.58	5.42	5.04	0	7	PHYSICAL	NO	fresh dm>pen;v.coarse sand;pebble mixed w/clay;poorly sorted;large shell frag	CLIS97/98
71	I	9/23/1999	11:47	67.30	1.72	4.95	4.72	0	7	PHYSICAL	NO	fresh dm>pen;coarse sand;pebble w/clay fraction;poorly sorted;shell frags	CLIS97/98
72	D	9/14/1999	13:05	20.95	0.78	1.98	1.46	0	3	PHYSICAL	NO	historic layered dm>pen;gray/reduced layers;stgI tubes	CLIS97/98
72	E	9/14/1999	13:06	36.77	1.44	4.33	2.81	0	9	BIOGENIC	NO	historic dm>pen;layered oxy/reduced;shell hash	CLIS97/98
72	F	9/14/1999	13:06	40.65	0.46	5.41	3.58	0	10	BIOGENIC	NO	historic dm>pen;deep rpd;well oxy;macrofaunal burrow	CLIS97/98
73	D	9/14/1999	13:12	59.15	2.68	6.49	2.96	0	9	BIOGENIC	NO	historic dm>pen;layered dm	CLIS97/98
73	E	9/14/1999	13:13	21.07	0.84	2.51	1.49	0	3	PHYSICAL	NO	historic dm>pen clay clast surface(dm?)layered dm	CLIS97/98
73	F	9/14/1999	13:13	28.28	1.47	5.39	1.99	0	4	PHYSICAL	NO	historic dm>pen;layered	CLIS97/98
78	D	9/14/1999	14:42	56.40	2.3	6.34	3.97	0	11	PHYSICAL	NO	historic dm>pen;deep rpd;coarsere seds at depth	CLIS97/98
78	E	9/14/1999	14:43	65.78	2.93	6.86	4.63	0	11	PHYSICAL	NO	historic dm>pen;coarser seds at depth	CLIS97/98
78	F	9/14/1999	14:44	52.97	1.88	7.85	3.76	0	11	BIOGENIC	NO	historic dm>pen;deep rpd to active void/rock;dense STG I tubes	CLIS97/98
79	E	9/14/1999	14:37	38.50	1.62	4.76	2.7	0	5	PHYSICAL	NO	historic dm>pen;well oxygen.;soft	CLIS97/98
79	F	9/14/1999	14:38	44.10	1.26	8.12	3.14	0	10	BIOGENIC	NO	historic dm>pen;silty surface over dm muid with pockets v.f.sand	CLIS97/98
79	G	9/14/1999	14:39	52.18	1.41	6.54	1.8	0	4	PHYSICAL	NO	historic dm>pen;coarser seds at depth;stgI tubes	CLIS97/98
80	D	9/14/1999	14:30	42.98	1.2	4.5	3.16	0	10	PHYSICAL	NO	historic dm>pen;v.f.sand w/reduced clay;collapsed void	CLIS97/98
80	E	9/14/1999	14:30	45.82	1.73	6.34	3.19	0	6	PHYSICAL	NO	historic dm>pen;layered dm	CLIS97/98
80	F	9/14/1999	14:31	43.35	1.57	9.95	3.07	0	6	BIOGENIC	NO	historic dm>pen	CLIS97/98
81	G	9/23/1999	12:22	47.50	1.68	4.82	3.48	0	10	PHYSICAL	NO	historic dm>pen;silty surface;reduced at depth;v.small void	CLIS97/98
81	H	9/23/1999	12:23	38.61	1.88	4.61	1.23	0	7	INDET	NO	historic dm>pen;layered	CLIS97/98
81	I	9/23/1999	12:25	38.20	1.47	5.39	2.7	0	9	BIOGENIC	NO	historic dm>pen;layered	CLIS97/98
88	B	9/12/1999	15:33	65.60	2.96	8.73	4.53	0	7	PHYSICAL	NO	historic dm>pen;deep rpd ;burrow at right	CLIS97/98
88	D	9/12/1999	15:37	65.92	0.9	6.88	2.54	0	9	BIOGENIC	NO	historic dm>pen;voids;stgI tubes;layered dm	CLIS97/98
88	H	9/12/1999	15:55	66.63	1.85	6.08	4.85	0	11	PHYSICAL	NO	historic dm>pen;voids;stgI tubes;layered dm	CLIS97/98
100	D	9/14/1999	15:52	65.35	1.57	6.12	3.65	0	10	PHYSICAL	NO	historic dm>pen;void/clay shear reduced at depth;clay clast surface	CLIS97/98
100	E	9/14/1999	15:53	51.82	1.82	5.31	3.84	0	7	PHYSICAL	NO	historic dm>pen;no voids;clay clast surface	CLIS97/98
100	F	9/14/1999	15:54	48.39	1.87	4.95	3.4	0	10	PHYSICAL	NO	historic dm>pen;voids at depth.	CLIS97/98

Appendix E2.

REMOTS® Results for the CLIS 95/96 Mound Complex

Station	Rep	Date	Time	Analyst	Latitude	Longitude	Successional Stage	Grain Size (phi)			Mudclast		Camera Penetration				Dredged Material Thickness			
								Min	Max	Major Mode	Count	Diameter	Min	Max	Range	Mean	Area	Min	Max	Mean
57	D	9/14/1999	10:53	MSC	41 08.839N	072 53.022W	ST_III	>4	2	>4	2	0.42	13.35	14.04	0.69	13.7	0	0.00	0.00	0.00
57	E	9/14/1999	10:54	MSC	41 08.836N	072 53.027W	ST_I	>4	2	>4	3	1.98	12.93	13.3	0.37	13.11	0	0.00	0.00	0.00
57	F	9/14/1999	10:55	MSC	41 08.836N	072 53.027W	ST_I	>4	2	>4	5	0.21	13.88	14.68	0.8	14.28	0	0.00	0.00	0.00
66	D	9/14/1999	11:03	MSC	41 08.787N	072 53.021W	ST_I_ON_III	>4	2	>4	0	0	15.21	15.96	0.75	15.59	0	0.00	0.00	0.00
66	E	9/14/1999	11:04	MSC	41 08.876N	072 53.028W	ST_III	>4	2	>4	0	0	15.16	16.06	0.9	15.61	0	0.00	0.00	0.00
66	F	9/14/1999	11:05	MSC	41 08.786N	072 53.029W	ST_I	>4	2	>4	1	0.59	14.2	14.89	0.69	14.55	0	0.00	0.00	0.00
67	D	9/14/1999	10:59	MSC	41 08.784N	072 52.954W	ST_I	>4	2	>4	1	1.23	12.45	14.04	1.6	13.25	0	0.00	0.00	0.00
67	E	9/14/1999	11:00	MSC	41 08.782N	072 52.955W	ST_III	>4	4	>4	0	0	16.06	16.54	0.48	16.3	0	0.00	0.00	0.00
67	F	9/14/1999	11:00	MSC	41 08.781N	072 53.956W	ST_III	>4	2	>4	0	0	15.43	16.06	0.64	15.74	0	0.00	0.00	0.00
74	D	9/14/1999	13:18	MSC	41 08.729N	072 53.094W	ST_I	>4	2	>4	5	0.91	12.93	13.35	0.42	13.14	0	0.00	0.00	0.00
74	E	9/14/1999	13:19	MSC	41 08.728N	072 53.094W	ST_III	>4	2	>4	2	0.81	9.37	10.31	0.94	9.84	0	0.00	0.00	0.00
74	F	9/14/1999	13:20	MSC	41 08.731N	072 53.088W	ST_III	>4	2	>4	5	0.57	11.83	12.57	0.73	12.2	0	0.00	0.00	0.00
75	D	9/14/1999	13:24	MSC	41 08.731N	072 53.088W	ST_I_ON_III	>4	2	>4	0	0	11.99	12.3	0.31	12.15	0	0.00	0.00	0.00
75	E	9/14/1999	13:24	MSC	41 08.729N	072 53.021W	ST_I	>4	2	>4	2	0.49	12.72	13.46	0.73	13.09	0	0.00	0.00	0.00
75	F	9/14/1999	13:25	MSC	41 08.729N	072 53.017W	ST_I_ON_III	>4	2	>4	0	0	11.41	11.41	0	11.41	0	0.00	0.00	0.00
76	E	9/14/1999	13:29	MSC	41 08.734N	072 52.941W	ST_III	>4	2	>4	0	0	16.49	19.37	2.88	17.93	0	0.00	0.00	0.00
76	F	9/14/1999	13:30	MSC	41 08.734N	072 52.944W	ST_III	>4	2	>4	0	0	14.66	15.18	0.52	14.92	0	0.00	0.00	0.00
76	G	9/14/1999	13:31	MSC	41 08.734N	072 52.949W	ST_I	>4	2	>4	0	0	17.02	17.43	0.42	17.22	0	0.00	0.00	0.00
77	D	9/14/1999	13:35	MSC	41 08.734N	072 52.873W	ST_I	4	2	>4	0	0	15.18	15.29	0.1	15.24	0	0.00	0.00	0.00
77	E	9/14/1999	13:36	MSC	41 08.734N	072 52.881W	ST_I_ON_III	>4	2	>4	3	1.52	15.03	16.75	1.73	15.89	0	0.00	0.00	0.00
77	F	9/14/1999	13:37	MSC	41 08.735N	072 52.889W	ST_III	>4	2	>4	4	0.7	14.29	15.03	0.73	14.66	0	0.00	0.00	0.00
82	E	9/14/1999	14:20	MSC	41 08.673N	072 53.165W	ST_I	>4	2	>4	2	0.86	13.72	13.98	0.26	13.85	0	0.00	0.00	0.00
82	F	9/14/1999	14:20	MSC	41 08.673N	072 53.164W	ST_I_ON_III	>4	2	>4	2	0.37	13.46	13.77	0.31	13.61	0	0.00	0.00	0.00
82	H	9/14/1999	11:52	MSC	41 08.688N	072 53.145W	ST_I_ON_III	>4	2	>4	0	0	16.53	17.16	0.63	16.84	0	0.00	0.00	0.00
83	D	9/14/1999	14:03	MSC	41 08.678N	072 53.091W	ST_I_ON_III	>4	2	>4	0	0	17.07	17.28	0.21	17.17	0	0.00	0.00	0.00
83	E	9/14/1999	14:04	MSC	42 08.674N	072 53.098W	ST_I	>4	2	>4	0	0	14.66	15.24	0.58	14.95	0	0.00	0.00	0.00
83	F	9/14/1999	14:04	MSC	41 08.670N	072 53.100W	ST_III	>4	2	>4	0	0	15.24	15.45	0.21	15.34	0	0.00	0.00	0.00
84	D	9/14/1999	13:59	MSC	41 08.680N	072 53.170W	ST_I_ON_III	>4	2	>4	0	0	17.59	18.43	0.84	18.01	0	0.00	0.00	0.00
84	E	9/14/1999	13:59	MSC	41 08.678N	072 53.026W	ST_III	>4	2	>4	0	0	13.72	14.29	0.58	14.01	0	0.00	0.00	0.00
84	F	9/14/1999	14:00	MSC	41 08.677N	072 53.028W	ST_I_ON_III	>4	2	>4	0	0	11.99	13.09	1.1	12.54	0	0.00	0.00	0.00
85	D	9/14/1999	13:54	MSC	41 08.673N	072 52.958W	ST_I_ON_III	>4	2	>4	0	0	9.63	11.83	2.2	10.73	0	0.00	0.00	0.00
85	E	9/14/1999	13:54	MSC	41 08.671N	072 52.957W	ST_I_ON_III	>4	2	>4	2	0.85	14.82	15.5	0.68	15.16	0	0.00	0.00	0.00
85	F	9/14/1999	13:55	MSC	41 08.670N	072 52.956W	ST_III	>4	2	>4	0	0	10.37	13.87	3.51	12.12	0	0.00	0.00	0.00
86	D	9/14/1999	13:47	MSC	41 08.683N	072 52.896W	ST_I_ON_III	>4	2	>4	0	0	15.03	15.65	0.63	15.34	0	0.00	0.00	0.00
86	E	9/14/1999	13:48	MSC	41 08.678N	072 52.901W	ST_I	>4	2	>4	0	0	14.5	15.92	1.41	15.21	0	0.00	0.00	0.00
86	F	9/14/1999	13:48	MSC	41 08.673N	072 52.887W	ST_I	>4	2	>4	0	0	14.03	14.45	0.42	14.24	0	0.00	0.00	0.00
87	D	9/14/1999	13:42	MSC	41 08.673N	072 52.813W	ST_III	>4	2	>4	3	0.93	14.35	14.56	0.21	14.45	0	0.00	0.00	0.00
87	E	9/14/1999	13:43	MSC	41 08.673N	072 52.811W	ST_III	>4	2	>4	0	0	12.57	13.35	0.79	12.96	0	0.00	0.00	0.00
87	F	9/14/1999	13:43	MSC	41 08.675N	072 52.811W	ST_I	>4	2	>4	0	0	10.99	11.62	0.63	11.31	0	0.00	0.00	0.00
89	D	9/14/1999	14:57	MSC	41 08.631N	072 53.161W	IND	>4	2	>4	0	0	8.01	14.76	6.75	11.39	0	0.00	0.00	0.00
89	E	9/14/1999	14:58	MSC	41 08.632N	072 53.159W	ST_I	>4	2	>4	4	0.37	16.4	16.77	0.36	16.59	0	0.00	0.00	0.00
89	F	9/14/1999	14:59	MSC	41 08.633N	072 53.157W	ST_I_ON_III	>4	2	>4	3	0.83	16.13	16.86	0.73	16.49	0	0.00	0.00	0.00
90	D	9/14/1999	15:03	MSC	41 08.624N	072 53.093W	ST_I_ON_III	>4	2	>4	0	0	15.57	16.14	0.57	15.86	0	0.00	0.00	0.00
90	E	9/14/1999	15:04	MSC	41 08.622N	072 53.101W	ST_I_ON_III	>4	2	>4	0	0	14.14	14.76	0.63	14.45	0	0.00	0.00	0.00
90	F	9/14/1999	15:05	MSC	41 08.622N	072 53.104W	ST_I_ON_III	>4	2	>4	0	0	14.82	16.18	1.36	15.5	0	0.00	0.00	0.00
91	D	9/14/1999	15:11	MSC	41 08.622N	072 53.104W	ST_I_ON_III	>4	2	>4	1	0.47	12.04	12.93	0.89	12.49	0	0.00	0.00	0.00
91	E	9/14/1999	15:12	MSC	41 08.619N	072 53.024W	ST_I_ON_III	>4	2	>4	4	0.42	15.65	16.02	0.37	15.84	0	0.00	0.00	0.00
91	F	9/14/1999	15:12	MSC	41 08.619N	072 53.026W	ST_I_ON_III	>4	2	>4	0	0	14.82	15.5	0.68	15.16	0	0.00	0.00	0.00
92	D	9/14/1999	15:16	MSC	41 08.622N	072 53.947W	ST_I	>4	2	>4	0	0	16.07	16.75	0.68	16.41	0	0.00	0.00	0.00
92	E	9/14/1999	15:17	MSC	41 08.623N	072 53.945W	ST_I_ON_III	>4	2	>4	0	0	13.56	14.08	0.52	13.82	0	0.00	0.00	0.00
92	F	9/14/1999	15:18	MSC	41 08.627N	072 53.940W	ST_I_ON_III	>4	2	>4	0	0	14.56	15.29	0.73	14.92	0	0.00	0.00	0.00
93	D	9/14/1999	14:51	MSC	41 08.629N	072 53.234W	ST_III	>4	2	>4	3	1.49	11.47	11.73	0.26	11.6	0	0.00	0.00	0.00
93	E	9/14/1999	14:51	MSC	41 08.632N	072 53.236W	ST_I_ON_III	>4	2	>4	0	0	12.09	12.51	0.42	12.3	0	0.00	0.00	0.00
93	F	9/14/1999	14:52	MSC	41 08.624N	072 53.228W	ST_I_ON_III	>4	2	>4	5	0.26	10.26	12.62	2.36	11.44	0	0.00	0.00	0.00
94	D	9/14/1999	15:46	MSC	41 08.574N	072 53.162W	ST_I_ON_III	>4	2	>4	0	0	13.46	13.46	0	13.46	0	0.00	0.00	0.00
94	E	9/14/1999	15:46	MSC	41 08.579N	072 53.160W	ST_I_ON_III	>4	2	>4	0	0	13.3	14.35	1.05	13.82	0	0.00	0.00	0.00
94	F	9/14/1999	15:46	MSC	41 08.580N	072 53.160W	ST_I_ON_III	>4	2	>4	0	0	11.31	13.41	2.1	12.36	0	0.00	0.00	0.00
95	D	9/14/1999	15:40	MSC	41 08.571N	072 53.090W	ST_I_ON_III	>4	2	>4	0	0	15.29	16.18	0.89	15.73	0	0.00	0.00	0.00
95	E	9/14/1999	15:41	MSC	41 08.571N	072 53.090W	ST_I_ON_III	>4	2	>4	0	0	13.35	14.24	0.89	13.8	0	0.00	0.00	0.00
95	F	9/14/1999	15:42	MSC	41 08.570N	072 53.090W	ST_III	>4	2	>4	2	1.37	14.19	14.82	0.63	14.5	0	0.00	0.00	0.00
96	D	9/14/1999	15:23	MSC	41 08.571N	072 53.020W	ST_I	>4	2	>4	1	0.74	13.46	14.97	1.52	14.21	0	0.00	0.00	0.00
96	E	9/14/1999	15:24	MSC	41 08.570N	072 53.021W	ST_I_ON_III	>4	2	>4	0	0	13.04	13.93	0.89	13.48	0	0.00	0.00	0.00
96	F	9/14/1999	15:25	MSC	41 08.569N	072 53.024W	ST_I	>4	2	>4	0	0	13.72	14.14	0.42	13.93	0	0.00	0.00	0.00
97	D	9/14/1999	16:17	MSC	41 08.573N	072 52.940W	ST_III	>4	2	>4	0	0	16.77	17.94	1.16	17.35	0	0.00	0.00	0.00
97	E	9/14/1999	16:18	MSC	41 08.577N	072 52.939W	ST_III	>4	2	>4	0	0	17.19	18.2	1.01	17.7	0	0.00	0.00	0.00
97	F	9/14/1999	16:18	MSC	41 08.584N	072 52.942W	ST_I	>4	2	>4	0	0	13.81	15.24	1.43	14.52	0	0.00	0.00	0.00
98	D	9/14/1999	16:05	MSC	41 08.524N	072 53.011W	ST_I_ON_III	>4	2	>4	0	0	16.19	16.88	0.69	16.53	0	0.00	0.00	0.00
98	E	9/14/1999	16:06	MSC	41 08.525N	072 53.002W	ST_I	>4	2	>4	4	1.2	18.36	19.84	1.48	19.1	0	0.00	0.00	0.00
98	F	9/14/1999	14:07	MSC	41 08.512N	072 53.018W	ST_I_ON_III	>4	2	>4	0	0	10.58	11.48	0.9	11.03	0	0.00	0.00	0.00
99	D	9/14/1999	16:11	MSC	41 08.524N	072 52.943W	ST_I_ON_III	>4	2	>4	0	0	16.35	18.04	1.69	17.19	0	0.00	0.00	0.00
99	E	9/14/1999	16:12	MSC	41 08.524N	072 52.943W	ST_I_ON_III	>4	2	>4	0	0	16.09	17.86	1.77	16.98	0	0.00	0.00	0.00
99	F	9/14/1999	16:13	MSC	41 08.526N	072 52.942W	ST_I_ON_III	>4	2	>4	0	0	15.45	16.24	0.79	15.85	0	0.00	0.00	0.00
101	D	9/14/1999	15:58	MSC	41 08.523N	072 53.077W	ST_I_ON_III	>4	2	>4	0	0	14.39	15.18	0.79	14.79	0	0.00	0.00	0.00
101	E	9/14/1999	16:00	HLS	41 08.513N	072 53.077W	ST_I	>4	2	>4	2	0.6	14.92	15.5	0.58	15.21	0	0.00	0.00	0.00
101	F	9/14/1999	16:01	MSC	41 08.514N	072 53.081W	ST_I	>4	2	>4	0	0	15.45	16.19	0.74	15.82	0	0.00	0.00	0.00

Appendix E2. (continued)

REMOTS® Results for the CLIS 95/96 Mound Complex

Station	Rep	Date	Time	Apparent RPD Thickness				Methane B.	OSI	Surface	Low	Comments	Assoc.
				Area	Min	Max	Mean	Count		Disturbance	D.O.		Mound
57	D	9/14/1999	10:53	25.52	1.22	2.87	1.74	0	8	BIOGENIC	NO	historic dm>pen;shell frag center clay clasts surface	CLIS95/96
57	E	9/14/1999	10:54	34.97	1.38	3.3	2.44	0	5	PHYSICAL	NO	historic dm>pen; clay clasts surface possible dm; mottled	CLIS95/96
57	F	9/14/1999	10:55	24.49	1.17	2.29	1.71	0	4	PHYSICAL	NO	historic dm>pen;mottled	CLIS95/96
66	D	9/14/1999	11:03	23.76	0.74	3.88	1.66	0	8	BIOGENIC	NO	historic dm>pen;large voids; mottled clay	CLIS95/96
66	E	9/14/1999	11:04	28.61	1.54	2.29	2	0	8	PHYSICAL	NO	historic dm>pen;mottled clay	CLIS95/96
66	F	9/14/1999	11:05	23.54	1.28	1.86	1.6	0	4	PHYSICAL	NO	historic dm>pen reduced under rpd;reduced at depth	CLIS95/96
67	D	9/14/1999	10:59	24.63	1.01	2.39	1.7	0	4	INDET	NO	historic dm>pen;stick/tube foreground; reduced at depth	CLIS95/96
67	E	9/14/1999	11:00	27.79	0.37	3.94	1.95	0	8	PHYSICAL	NO	historic dm>pen; several voids	CLIS95/96
67	F	9/14/1999	11:00	26.98	1.28	2.39	1.87	0	8	INDET	NO	historic dm>pen void;reduced at depth	CLIS95/96
74	D	9/14/1999	13:18	38.05	1.26	4.03	2.84	0	5	PHYSICAL	NO	historic dm>pen;dm clay \clasts surface;layered DM	CLIS95/96
74	E	9/14/1999	13:19	36.47	0.73	4	2.26	0	9	BIOGENIC	NO	histroic dm>pen;active voids;clay clasts surface	CLIS95/96
74	F	9/14/1999	13:20	40.44	1.78	3.93	2.96	0	9	PHYSICAL	NO	historicdm>pen;layers oxy/reduced dm;clay clasts surface;void	CLIS95/96
75	D	9/14/1999	13:24	45.30	2.57	3.93	3.32	0	10	BIOGENIC	NO	historic dm>pen;layerd;voids	CLIS95/96
75	E	9/14/1999	13:24	38.05	0.89	4.19	2.81	0	5	INDET	NO	historic dm>pen;clay clast surface;layered oxy.reduced	CLIS95/96
75	F	9/14/1999	13:25	34.78	1.15	3.4	2.56	0	9	BIOGENIC	NO	historic dm>pen;layered oxy/reduced void	CLIS95/96
76	E	9/14/1999	13:29	32.53	1.7	5.58	3.65	0	5	PHYSICAL	NO	historic dm>pen;shell frags; voids; rpd area slightly dark	CLIS95/96
76	F	9/14/1999	13:30	44.34	1.01	4.63	3.2	0	10	BIOGENIC	NO	historic dm>pen layers oxy./reduced;shell frags	CLIS95/96
76	G	9/14/1999	13:31	41.65	1.17	3.4	2.9	0	5	PHYSICAL	NO	historic dm>pen;reducedat depth;silty surface layer	CLIS95/96
77	D	9/14/1999	13:35	35.73	1.94	3.66	2.61	0	5	PHYSICAL	NO	historic dm>pen;layered dm	CLIS95/96
77	E	9/14/1999	13:36	27.67	0.89	3.09	1.96	0	8	PHYSICAL	NO	historic dm>pen;large clay clast (DM?;artifact?)at surface	CLIS95/96
77	F	9/14/1999	13:37	38.93	0.42	4.19	2.92	0	9	PHYSICAL	NO	historic dm>pen;clay clasts surface(dm?) reduced at depth	CLIS95/96
82	E	9/14/1999	14:20	26.03	1.05	3.51	1.79	0	4	INDET	NO	historic dm>pen;layered;clay clasts on surface	CLIS97/98
82	F	9/14/1999	14:20	38.86	0.26	4.71	3.05	0	10	BIOGENIC	NO	historic dm>pen;active void;clay clasts on surface	CLIS97/98
82	H	9/14/1999	11:52	42.12	1.79	4.53	2.77	0	9	PHYSICAL	NO	historic dm>pen;active void;shell	CLIS97/98
83	D	9/14/1999	14:03	33.75	1.47	5.86	2.4	0	9	PHYSICAL	NO	historic dm>pen;layered reduced at depth	CLIS95/96
83	E	9/14/1999	14:04	32.91	0.73	4.87	2.34	0	5	PHYSICAL	NO	historic dm>pen;layered; reduced at depth;silty surface	CLIS95/96
83	F	9/14/1999	14:04	28.04	0.68	4.35	1.98	0	8	PHYSICAL	NO	hostoric dm>pen;reduced at depth;silty surface	CLIS95/96
84	D	9/14/1999	13:59	38.02	0.84	8.17	1.75	0	8	PHYSICAL	NO	histroic dm>pen;void at depth;reduced at depth	CLIS95/96
84	E	9/14/1999	13:59	41.19	0.99	5.81	3.08	0	10	BIOGENIC	NO	historic dm>pen;deep rpd;reduced at depth	CLIS95/96
84	F	9/14/1999	14:00	57.30	2.46	5.97	4.14	0	11	BIOGENIC	NO	historic dm>pen;deep rpd;reduced;coarser at depth	CLIS95/96
85	D	9/14/1999	13:54	45.02	1.05	6.44	3.18	0	10	PHYSICAL	NO	historic dm>pen;shell frags;sloping topographyvoids deep	CLIS95/96
85	E	9/14/1999	13:54	40.47	0.21	8.12	3.44	0	10	INDET	NO	historic dm>pen;macro burrow;deep rpd;reduced at depth	CLIS95/96
85	F	9/14/1999	13:55	42.11	0.99	5.24	3.07	0	10	INDET	NO	historic dm>pen;megafaunal burrow;coarser sed deep	CLIS95/96
86	D	9/14/1999	13:47	51.88	1.15	7.28	3.82	0	11	BIOGENIC	NO	historic dm>pen;collapsed voids;deep rpd	CLIS95/96
86	E	9/14/1999	13:48	40.05	0.73	7.64	2.86	0	5	BIOGENIC	NO	historic dm>pen;reduced at depth	CLIS95/96
86	F	9/14/1999	13:48	45.97	2.15	4.61	2.65	0	5	PHYSICAL	NO	historic dm>pen;mottled clay	CLIS95/96
87	D	9/14/1999	13:42	33.22	0.99	3.4	2.34	0	9	INDET	NO	historic dm>pen;clay clasts at surf.;reduced at depth;v.small void	CLIS95/96
87	E	9/14/1999	13:43	42.80	2.41	4.24	3.29	0	10	BIOGENIC	NO	historic dm>pen;graded bedding;shell fragsshallow void	CLIS95/96
87	F	9/14/1999	13:43	26.16	1.26	2.93	1.91	0	4	PHYSICAL	NO	historic dm>pen;graded bedding=m/s/m	CLIS95/96
89	D	9/14/1999	14:57	57.66	0.68	5.96	1.76	0	99	BIOGENIC	NO	historic dm>pen;large megafaunal burrow(lobster?)layered dm	CLIS95/96
89	E	9/14/1999	14:58	26.44	0.52	4.5	3.73	0	6	PHYSICAL	NO	layered historic dm mud; no voids;	CLIS95/96
89	F	9/14/1999	14:59	35.14	1.41	4.29	1.68	0	8	PHYSICAL	NO	historic dm>pen;layered dm;void	CLIS95/96
90	D	9/14/1999	15:03	21.12	0.99	3.19	2.27	0	9	PHYSICAL	NO	historic dm>pen;small void deep;worm?	CLIS95/96
90	E	9/14/1999	15:04	48.15	2.46	4.87	3.7	0	10	PHYSICAL	NO	historic dm>pen;reduced;layered	CLIS95/96
90	F	9/14/1999	15:05	37.48	1.36	5.18	1.63	0	8	PHYSICAL	NO	historic dm>pen;deep rpd;voids/clay shear	CLIS95/96
91	D	9/14/1999	15:11	33.39	0.99	4.71	2.35	0	9	PHYSICAL	NO	historic dm>pen;void at depth;clay clast at surface	CLIS95/96
91	E	9/14/1999	15:12	36.15	0.79	4.14	2.71	0	9	PHYSICAL	NO	historic dm>pen;active feeding void;reduced at depth	CLIS95/96
91	F	9/14/1999	15:12	24.84	0.42	5.76	2.66	0	9	PHYSICAL	NO	historic dm>pen;collapsed void;deep rpd;some reduced seed at surface	CLIS95/96
92	D	9/14/1999	15:16	91.78	1.15	4.1	3.2	0	6	PHYSICAL	NO	historic dm>pen;reduced at depth;layered	CLIS95/96
92	E	9/14/1999	15:17	32.59	0.1	3.51	2.39	0	9	PHYSICAL	NO	historic dm>pen;large active void with fecal pellets;well oxygen.	CLIS95/96
92	F	9/14/1999	15:18	47.52	2.41	8.85	3.42	0	10	PHYSICAL	NO	historic dm>pen;well oxygen;.stgI tubes	CLIS95/96
93	D	9/14/1999	14:51	46.10	1.52	4.92	2.59	0	9	PHYSICAL	NO	historic dm>pen;possible dm clay clasts surface;void with feed	CLIS95/96
93	E	9/14/1999	14:51	22.87	1.3	1.98	1.6	0	8	PHYSICAL	NO	historic dm>pen;voids at depth; reduced;coarser at depth	CLIS95/96
93	F	9/14/1999	14:52	33.31	0.42	3.51	2.27	0	9	PHYSICAL	NO	historic dm>pen;possible dm clay clasts at surface;void	CLIS95/96
94	D	9/14/1999	15:46	50.99	1.68	5.71	3.77	0	11	BIOGENIC	NO	historic dm>pen;dense STGI tubes;active voids	CLIS95/96
94	E	9/14/1999	15:46	76.05	1.21	4.65	2.78	0	9	BIOGENIC	NO	historic dm>pen;active voidw/worm;stgI tubes	CLIS95/96
94	F	9/14/1999	15:46	49.33	0.79	9.53	4.02	0	11	BIOGENIC	NO	historic dm>pen;large active burrow;void right	CLIS95/96
95	D	9/14/1999	15:40	55.15	1.41	6.02	3.12	0	10	PHYSICAL	NO	historic dm>pen;active voids;deep rpd;reduced at depth	CLIS95/96
95	E	9/14/1999	15:41	83.37	1.97	4.97	3.01	0	10	PHYSICAL	NO	historic dm>pen;clay clast at surface(DM?);void	CLIS95/96
95	F	9/14/1999	15:42	37.39	1.62	4.24	2.09	0	8	PHYSICAL	NO	historic dm>pen;large clay clast surface(DM?);large void left	CLIS95/96
96	D	9/14/1999	15:23	52.10	2.25	5.6	3.64	0	6	PHYSICAL	NO	historic dm layer;worm ;clay clast(DM?) on surface	CLIS95/96
96	E	9/14/1999	15:24	51.99	2.76	4.58	3.72	0	10	PHYSICAL	NO	historic dm>pen;deep rpd;voids	CLIS95/96
96	F	9/14/1999	15:25	59.85	3.14	6.54	4.21	0	7	BIOGENIC	NO	historic dm>pen;bisected worm?	CLIS95/96
97	D	9/14/1999	16:17	77.74	2.86	5.57	3.21	0	10	PHYSICAL	NO	historic dm layers/ambient?;coarser material at surface	CLIS95/96
97	E	9/14/1999	16:18	80.42	4.44	6.93	5.69	0	11	INDET	NO	historic dm layer;shallow void;deep rpd;shell frag	CLIS95/96
97	F	9/14/1999	16:18	64.78	2.4	4.84	3.42	0	6	BIOGENIC	NO	historic dm>pen;STgI tubes;deep rpd	CLIS95/96
98	D	9/14/1999	16:05	89.56	2.71	5.72	3.52	0	10	BIOGENIC	NO	ambient;many voids with pellets or clay shear	CLIS95/96
98	E	9/14/1999	16:06	64.84	3.28	5.66	4.56	0	7	PHYSICAL	NO	ambient; clay clasts surface(DM?); pen reduced at depth	CLIS95/96
98	F	9/14/1999	14:07	71.37	3.49	7.46	5.12	0	11	PHYSICAL	NO	ambient;voids/clay shear at depth;deep rpd	CLIS95/96
99	D	9/14/1999	16:11	91.33	4.97	8.09	6.56	0	11	BIOGENIC	NO	discrete historic dm layer;voids ;stg I tubes;deep rpd	CLIS95/96
99	E	9/14/1999	16:12	50.85	1.09	4.53	3.61	0	10	PHYSICAL	NO	historic layered dm>pen;void;STG I tubes	CLIS95/96
99	F	9/14/1999	16:13	77.87	1.31	4.87	3.71	0	10	PHYSICAL	NO	discrete historic dm layer;void	CLIS95/96
101	D	9/14/1999	15:58	66.91	2.27	6.24	4.9	0	11	BIOGENIC	NO	historic dm>pen;deep rpd;reduced mud at depth	CLIS95/96
101	E	9/14/1999	16:00	54.11	1.96	5.03	4.02	0	7	PHYSICAL	NO	discrete historic dm layer;clay clasts surface	CLIS95/96
101	F	9/14/1999	16:01	73.22	2.22	7.2	5.33	0	7	BIOGENIC	NO	historic dm>pen;clay clast surface	CLIS95/96

Appendix E3.

REMOTS® Results for the NHAV 93 Mound

Station	Rep	Date	Time	Analyst	Latitude	Longitude	Successional Stage	Grain Size (phi)			Mudclast		Camera Penetration				Dredged Material Thickness			
								Min	Max	Major Mode	Count	Diameter	Min	Max	Range	Mean	Area	Min	Max	Mean
CTR	G	9/23/1999	12:46	MSC	41 09.139N	072 53.416W	ST_I_ON_III	>4	2	>4	0	0	15.21	17.37	2.16	16.85	237.9	15.21	17.37	16.85
CTR	H	9/23/1999	12:47	MSC	41 09.145N	072 53.417W	ST_I_ON_III	>4	2	>4	0	0	13.98	15.34	1.36	14.66	203.66	14.29	15.13	14.44
CTR	I	9/23/1999	12:52	MSC	41 09.134N	072 53.427W	ST_I_ON_III	>4	1	>4	0	0	14.13	15.77	1.64	14.95	210.94	14.13	15.77	14.95
200N	G	9/12/1999	13:01	MSC	41 09.242N	072 53.421W	ST_I_ON_III	>4	2	>4	0	0	15.13	17.51	2.38	16.32	15.13	17.51	2.38	16.32
200N	H	9/12/1999	13:02	MSC	41 09.248N	072 53.414W	ST_I_ON_III	>4	2	>4	0	0	15.08	16.4	1.32	15.74	216.3	12.12	16.4	15.67
200N	I	9/23/1999	13:04	MSC	41 09.239N	072 53.416W	ST_I_ON_III	>4	2	>4	2	0.47	15.71	15.82	0.11	15.77	219.67	15.55	15.77	15.6
200E	D	9/14/1999	9:19	MSC	41 09.129N	072 53.291W	ST_I_ON_III	>4	1	>4	1	0.36	13.53	14.06	0.53	13.79	176.87	12.68	12.95	12.8
200E	E	9/14/1999	9:19	MSC	41 09.129N	072 53.293W	ST_I_ON_III	>4	2	>4	0	0	15.53	16.89	1.37	16.21	230.66	15.95	17	16.31
200E	F	9/14/1999	9:20	MSC	41 09.128N	072 53.294W	ST_I	>4	2	>4	0	0	14.16	14.79	0.63	14.47	200.63	5.26	14.79	14.34
200S	D	9/14/1999	9:24	MSC	41 09.017N	072 53.431W	ST_I	>4	2	>4	0	0	13.68	14.21	0.53	13.95	188.71	10.42	13.89	13.61
200S	E	9/14/1999	9:25	MSC	41 09.016N	072 53.431W	ST_I	>4	2	>4	0	0	14.53	14.95	0.42	14.74	197.43	7.42	14.84	14.18
200S	F	9/14/1999	9:26	MSC	41 09.911N	072 53.433W	ST_I_ON_III	>4	2	>4	0	0	13.47	14.48	1.00	13.97	187.47	13.21	14.11	13.6
200W	G	9/23/1999	12:56	MSC	41 09.124N	072 53.572W	ST_I_ON_III	>4	2	>4	0	0	15.03	15.98	0.95	15.5	210.13	7.62	15.82	15.01
200W	H	9/23/1999	12:57	MSC	41 09.132N	072 53.571W	ST_I_ON_III	>4	2	>4	0	0	14.44	15.87	1.43	15.16	199.47	7.49	15.45	14.4
200W	I	9/23/1999	12:58	MSC	41 09.140N	072 53.567W	ST_I	>4	2	>4	0	0	17.59	17.91	0.31	17.75	231.83	4.29	17.85	17

Station	Rep	Date	Time	Apparent RPD Thickness				Methane B. Count	OSI	Surface Disturbance	Low D.O.	Comments
				Area	Min	Max	Mean					
CTR	G	9/23/1999	12:46	28.829	0.16	3.30	2.03	2	6	PHYSICAL	NO	historic dm>pen; 2 methane bubbles; voids
CTR	H	9/23/1999	12:47	32.197	1.15	4.24	2.26	0	9	PHYSICAL	NO	historic dm>pen; reduced; void; shell
CTR	I	9/23/1999	12:52	52.617	1.10	4.20	3.10	2	8	PHYSICAL	NO	historic dm>pen; 2 large methane bubbles;void;reduced below deep rpd
200N	G	9/12/1999	13:01	37.947	1.22	6.82	2.88	0	9	BIOGENIC	NO	historic dm>pen; void; feeding halo deep;shell
200N	H	9/12/1999	13:02	58.236	0.52	4.00	2.10	0	8	BIOGENIC	NO	historic dm>pen; burrow edge right
200N	I	9/23/1999	13:04	45.334	0.79	5.08	2.18	0	8	PHYSICAL	NO	historic dm>pen; feeding halo; deep rpd
200E	D	9/14/1999	9:19	29.569	0.32	3.58	2.59	0	9	BIOGENIC	NO	historic dm>pen; macrofauna burrow; some stg I tube
200E	E	9/14/1999	9:19	27.619	1.42	3.47	2.61	0	9	BIOGENIC	NO	historic dm>pen; reduced at depth; tubes
200E	F	9/14/1999	9:20	22.843	0.79	2.56	2.03	0	4	PHYSICAL	NO	historic dm>pen; reduced at depth;
200S	D	9/14/1999	9:24	23.694	0.95	1.95	1.63	0	4	PHYSICAL	NO	historic dm>pen; reduced at depth; shell frags
200S	E	9/14/1999	9:25	14.989	0.21	2.77	2.03	0	4	PHYSICAL	NO	historic dm>pen; reduced at depth
200S	F	9/14/1999	9:26	18.779	0.86	4.16	2.41	0	9	BIOGENIC	NO	historic dm>pen; reduced at depth; STG I tubes; voids; rock pulldown?
200W	G	9/23/1999	12:56	31.199	0.63	4.07	2.26	0	9	PHYSICAL	NO	historic dm>pen; deep rpd; worm at depth; void
200W	H	9/23/1999	12:57	15.999	0.05	2.67	1.35	0	7	PHYSICAL	NO	historic dm>pen; deep rpd
200W	I	9/23/1999	12:58	40.525	0.80	4.87	1.69	0	4	PHYSICAL	NO	historic dm>pen; reduced at depth; shell

Appendix E4.

REMOTS® Results for the MQR Mound

Station	Rep	Date	Time	Analyst	Latitude	Longitude	Successional	Grain Size (phi)			Mudclast		Camera Penetration				Dredged Material Thickness			
							Stage	Min	Max	Major Mode	Count	Diameter	Min	Max	Range	Mean	Area	Min	Max	Mean
CTR	D	9/14/1999	16:42	MSC	41 08.646N	072 53.830W	ST_I_ON_III	>4	2	>4	0	0	12.43	13.97	1.53	13.20	185.58	12.17	14.18	12.98
CTR	E	9/14/1999	16:43	MSC	41 08.647N	072 53.828W	ST_I	>4	2	>4	0	0	14.44	15.40	0.95	14.92	79.00	0.42	6.82	5.76
CTR	F	9/14/1999	16:44	MSC	41 08.647N	072 53.825W	ST_I_ON_III	>4	2	>4	0	0	13.23	13.70	0.48	13.46	191.25	13.23	13.65	13.32
50N	D	9/23/1999	11:26	MSC	41 08.672N	072 53.823W	ST_I_ON_III	>4	2	>4	0	0	12.30	12.88	0.58	12.59	177.10	6.23	12.88	12.48
50N	E	9/23/1999	11:26	MSC	41 08.674N	072 53.841W	ST_I_ON_III	>4	2	>4	0	0	13.88	14.51	0.63	14.19	196.01	6.91	14.55	14.16
50N	F	9/23/1999	11:27	MSC	41 08.672N	072 53.839W	ST_III	>4	2	>4	0	0	15.34	18.64	3.30	16.99	242.17	15.92	18.32	17.22
50E	D	9/14/1999	16:37	MSC	41 08.649N	072 53.790W	ST_I_ON_III	>4	2	>4	2	0.54	11.16	13.28	2.12	12.22	170.31	3.86	13.07	11.83
50E	E	9/14/1999	16:38	MSC	41 08.651N	072 53.789W	ST_I_ON_III	>4	2	>4	0	0	12.38	13.07	0.69	12.72	180.36	12.33	13.07	12.59
50E	F	9/14/1999	16:38	MSC	41 08.652N	072 53.788W	ST_I_ON_III	>4	2	>4	0	0	11.85	12.59	0.74	12.22	170.98	6.14	12.54	12.03
50S	D	9/23/1999	11:21	MSC	41 08.618N	072 53.843W	ST_I_ON_III	>4	2	>4	0	0	15.71	17.02	1.31	16.36	227.78	12.46	16.65	16.14
50S	E	9/23/1999	11:22	MSC	41 08.624N	072 53.836W	ST_I_ON_III	>4	2	>4	0	0	15.81	18.64	2.83	17.22	249.06	6.96	18.69	17.42
50S	F	9/23/1999	11:23	MSC	41 08.628N	072 53.823W	ST_I_ON_III	>4	2	>4	0	0	14.14	15.60	1.46	14.87	207.21	7.70	15.50	14.82
50W	D	9/23/1999	10:50	MSC	41 08.641N	072 53.871W	ST_I_ON_III	>4	2	>4	0	0	12.91	14.02	1.11	13.46	188.84	5.29	14.18	13.68
50W	E	9/23/1999	10:51	MSC	41 08.632N	072 53.876W	ST_III	>4	2	>4	3	1.12	11.96	12.54	0.58	12.25	169.17	11.85	12.64	12.06
50W	G	9/23/1999	13:33	MSC	41 08.644N	072 53.875W	ST_I_ON_III	>4	2	>4	0	0	13.19	14.24	1.05	13.72	190.86	13.19	14.14	13.75
100N	D	9/23/1999	11:30	MSC	41 08.700N	072 53.832W	ST_I_ON_III	>4	2	>4	0	0	15.08	15.55	0.47	15.32	215.86	15.03	15.86	15.42
100N	E	9/23/1999	11:31	MSC	41 08.700N	072 53.832W	ST_I	>4	4	>4	0	0	12.83	13.61	0.79	13.22	185.52	6.60	13.72	13.20
100N	F	9/23/1999	11:32	MSC	41 08.694N	072 53.823W	ST_I_ON_III	>4	2	>4	0	0	14.24	15.81	1.57	15.03	205.27	7.80	15.71	14.75
100E	D	9/14/1999	16:32	MSC	41 08.649N	072 53.756W	ST_III	>4	2	>4	4	0.69	14.97	15.92	0.95	15.45	224.38	12.06	16.24	15.80
100E	E	9/14/1999	16:33	MSC	41 08.651N	072 53.755W	ST_I_ON_III	>4	2	>4	0	0	9.05	10.48	1.43	9.76	141.04	9.15	10.53	9.93
100E	F	9/14/1999	16:34	MSC	41 08.650N	072 53.757W	ST_I_ON_III	>4	2	>4	6	0.5	5.66	6.82	1.16	6.24	98.93	2.54	7.67	6.85
100S	D	9/23/1999	11:16	MSC	41 08.586N	072 53.833W	ST_I_ON_III	>4	2	>4	0	0	11.88	12.57	0.68	12.22	166.92	9.21	12.51	11.87
100S	E	9/23/1999	11:17	MSC	41 08.857N	072 53.840W	ST_I	>4	2	>4	0	0	11.05	12.30	1.26	11.68	165.73	4.50	12.36	11.84
100S	F	9/23/1999	11:18	MSC	41 08.575N	072 53.843W	ST_I	>4	2	>4	0	0	12.46	12.93	0.47	12.70	177.86	12.41	12.83	12.66
100W	D	9/23/1999	10:57	MSC	41 08.638N	072 53.914W	ST_I	>4	2	>4	0	0	9.21	9.90	0.68	9.55	134.71	4.76	9.90	9.66
100W	E	9/23/1999	10:57	MSC	41 08.638N	072 53.914W	ST_I_ON_III	>4	2	4 to 3	0	0	11.47	11.57	0.10	11.52	160.00	5.65	11.68	11.32
100W	G	9/23/1999	13:38	MSC	41 08.642N	072 53.907W	ST_I_ON_III	>4	2	>4	0	0	10.47	12.25	1.78	11.36	161.08	10.42	12.20	11.54
150N	D	9/23/1999	11:35	MSC	41 08.732N	072 53.828W	ST_III	>4	2	>4	3	0.82	13.00	13.94	0.94	13.47	186.33	10.10	14.14	13.39
150N	E	9/23/1999	11:36	MSC	41 08.730N	072 53.816W	ST_III	>4	2	>4	0	0	12.93	14.03	1.10	13.48	197.35	10.26	14.71	13.66
150N	F	9/23/1999	11:38	MSC	41 08.732N	072 53.827W	ST_III	>4	2	>4	0	0	7.18	8.43	1.25	7.80	113.38	7.80	8.48	8.03
150E	D	9/14/1999	16:27	MSC	41 08.647N	072 53.719W	ST_I_ON_III	>4	2	>4	0	0	13.28	13.86	0.58	13.57	194.15	13.28	13.86	13.57
150E	E	9/14/1999	16:28	MSC	41 08.648N	072 53.717W	ST_I	>4	2	>4	6	0.53	13.21	13.47	0.26	13.34	188.53	13.32	13.73	13.54
150E	F	9/14/1999	16:29	MSC	41 08.643N	072 53.719W	ST_I	>4	2	>4	0	0	16.79	18.29	1.50	17.54	248.46	13.73	18.39	17.80
150S	E	9/23/1999	11:12	MSC	41 08.572N	072 53.813W	ST_I	>4	2	4 to 3	0	0	10.05	11.05	0.99	10.55	144.25	10.05	11.05	10.55
150S	F	9/23/1999	11:12	MSC	41 08.554N	072 53.829W	ST_III	>4	2	>4	0	0	10.00	11.04	1.04	10.52	141.52	1.25	10.89	9.79
150S	H	9/23/1999	13:29	MSC	41 08.561N	072 53.833W	ST_I	>4	2	3 to 2	0	0	10.37	10.99	0.63	10.68	144.62	10.16	10.99	10.36
150W	E	9/23/1999	11:04	MSC	41 08.642N	072 53.907W	ST_I_ON_III	>4	2	4 to 3	0	0	11.88	13.09	1.20	12.49	175.51	12.09	13.14	12.46
150W	F	9/23/1999	11:05	MSC	41 08.642N	072 53.927W	ST_I	>4	2	>4	0	0	13.35	14.35	0.99	13.85	196.51	4.14	14.24	13.80
150W	G	9/23/1999	11:05	MSC	41 08.639N	072 53.932W	ST_I_ON_III	>4	2	>4	0	0	14.66	14.92	0.26	14.79	204.46	14.40	15.29	14.67

Station	Rep	Date	Time	Apparent RPD Thickness				Methane B.	OSI	Surface	Low	Comments
				Area	Min	Max	Mean	Count		Disturbance	D.O.	
CTR	D	9/14/1999	16:42	58.82	1.11	6.08	2.52	0	9	PHYSICAL	NO	historic dm>pen active void;well oxygen.
CTR	E	9/14/1999	16:43	58.82	1.11	6.08	1.55	0	4	PHYSICAL	NO	historic dm>pen;shell;well oxygen.
CTR	F	9/14/1999	16:44	79.89	3.60	6.93	1.50	0	7	PHYSICAL	NO	historic dm>pen;large void at depth;well oxygen.
50N	D	9/23/1999	11:26	53.01	2.41	4.97	3.05	0	10	PHYSICAL	NO	historic dm>pen;active voids;well oxy cly/dm mud
50N	E	9/23/1999	11:26	53.64	2.36	5.39	3.10	0	10	PHYSICAL	NO	historic dm>pen;well oxygen.
50N	F	9/23/1999	11:27	12.08	0.05	2.77	0.18	0	6	PHYSICAL	NO	fresh dm>pen;mottled grey clay;shallow rpd;clay at surface
50E	D	9/14/1999	16:37	68.45	3.33	7.04	2.50	0	9	PHYSICAL	NO	historic dm>pen;void;shell
50E	E	9/14/1999	16:38	59.95	2.40	6.51	2.80	0	9	PHYSICAL	NO	historic dm>pen;void;well oxygen
50E	F	9/14/1999	16:38	65.64	2.70	6.45	2.90	0	9	PHYSICAL	NO	historic dm>pen;large void;well oxygen.
50S	D	9/23/1999	11:21	49.23	0.21	6.33	3.20	0	10	INDET	NO	historic dm>pen;chaetoperus? large oxy. burrow ;reduced at depth
50S	E	9/23/1999	11:22	61.49	2.09	9.16	2.82	0	9	BIOGENIC	NO	historic dm>pen;chaetoperus?reduced dm mud at depth
50S	F	9/23/1999	11:23	65.27	0.58	6.65	3.56	0	10	PHYSICAL	NO	historic dm>pen;void deep; reduced at depth;coarser surface
50W	D	9/23/1999	10:50	56.57	2.59	5.13	4.26	0	11	BIOGENIC	NO	historic dm>pen;voids;stgI tubes;reduced at depth
50W	E	9/23/1999	10:51	42.66	2.12	3.92	3.11	0	10	BIOGENIC	NO	historic dm>pen;shell;reduced at depth;significant sand fraction
50W	G	9/23/1999	13:33	34.81	0.52	4.71	2.65	0	9	PHYSICAL	NO	historic dm>pen;coarser at depth;shell frags
100N	D	9/23/1999	11:30	65.42	2.62	6.18	3.68	0	10	PHYSICAL	NO	historic dm>pen;collapsed void;reduced at depthstg I tubes
100N	E	9/23/1999	11:31	30.44	0.47	4.24	2.27	0	5	PHYSICAL	NO	historic dm>pen;stgI tubes;reduced at depth
100N	F	9/23/1999	11:32	62.38	2.57	6.39	2.88	0	9	PHYSICAL	NO	historic dm>pen;anemone;voids with pellets.well oxygen.
100E	D	9/14/1999	16:32	34.17	1.01	3.81	2.52	0	9	PHYSICAL	NO	historic dm>pen;active void at depth;silty surface
100E	E	9/14/1999	16:33	44.56	1.75	4.60	3.20	0	10	PHYSICAL	NO	historic dm>pen;void at depth
100E	F	9/14/1999	16:34	51.02	2.43	6.72	3.84	0	11	PHYSICAL	NO	historic dm>pen;void deep;clay clasts surface(possible DM?)
100S	D	9/23/1999	11:16	51.48	2.46	5.60	2.65	0	9	BIOGENIC	NO	historic dm>pen;active voids;reduced at depth;sand.mud
100S	E	9/23/1999	11:17	45.50	1.30	4.08	2.10	0	4	PHYSICAL	NO	historic dm>pen;STG I tubes;reduced at depth
100S	F	9/23/1999	11:18	39.59	0.37	4.82	1.55	0	4	PHYSICAL	NO	historic dm>pen;silty surface over reduced dm mud
100W	D	9/23/1999	10:57	30.52	0.63	4.35	2.30	0	5	BIOGENIC	NO	historic dm>pen; poss. feeding halos?;coarser at depth
100W	E	9/23/1999	10:57	46.66	1.00	4.00	2.40	0	9	BIOGENIC	NO	historic dm>pen; clay/sand; void
100W	G	9/23/1999	13:38	45.59	1.99	6.07	2.11	0	8	BIOGENIC	NO	historic dm>pen;burrow;feeding voids;reduced at depth
150N	D	9/23/1999	11:35	43.60	0.52	6.01	3.30	0	10	PHYSICAL	NO	historic dm>pen;sandy;voids;clay clast surface
150N	E	9/23/1999	11:36	46.92	0.10	5.81	1.61	0	8	PHYSICAL	NO	historic dm>pen;layered s/m; anemone mid depth
150N	F	9/23/1999	11:38	42.29	1.78	5.39	2.13	0	8	BIOGENIC	NO	historic dm>pen; well oxygen. mud/clay
150E	D	9/14/1999	16:27	50.07	0.26	3.37	1.70	0	8	BIOGENIC	NO	historic dm>pen; void deep rpd
150E	E	9/14/1999	16:28	31.96	1.09	4.30	2.31	0	5	PHYSICAL	NO	historic layers dm>pen;clay clasts surface
150E	F	9/14/1999	16:29	28.12	0.47	3.16	1.02	0	3	PHYSICAL	NO	historic layers dm>pen;STG I tubes
150S	E	9/23/1999	11:12	31.03	1.09	3.02	1.72	0	4	BIOGENIC	NO	historic dm>pen;f.sand w/reduced clay/dm mudvoids/shear?
150S	F	9/23/1999	11:12	20.41	0.68	2.60	1.53	0	8	PHYSICAL	NO	historic dm>pen;S/Mud
150S	H	9/23/1999	13:29	26.14	0.37	3.30	1.90	0	4	PHYSICAL	NO	historic dm>pen;m.sand with oxy/reduced dm clay reduce dat depth
150W	E	9/23/1999	11:04	55.74	2.25	5.81	2.54	0	9	PHYSICAL	NO	historic dm.pen;feeding voids;coarser material;reduced at depth
150W	F	9/23/1999	11:05	55.23	1.47	5.08	2.76	0	5	PHYSICAL	NO	historic dm>pen;coarser;reduced at depth;STg I tubes
150W	G	9/23/1999	11:05	47.90	1.10	5.13	2.56	0	9	PHYSICAL	NO	historic dm>pen;collapsed void;reduced at depth

Appendix E5.

REMOTS® Results for the FVP Mound

Station	Rep	Date	Time	Analyst	Latitude	Longitude	Successional Stage	Grain Size (phi)			Mudclast		Camera Penetration				Dredged Material Thickness			
								Min	Max	Major Mode	Count	Diameter	Min	Max	Range	Mean	Area	Min	Max	Mean
CTR	A	9/23/1999	9:36	MSC	41 09.401N	072 51.720W	ST_III	>4	2	>4	1	0.86	17.79	18.16	0.37	17.97	248.49	17.63	18.31	17.91
CTR	B	9/23/1999	9:37	MSC	41 09.396N	072 51.711W	ST_III	>4	2	>4	0	0	15.95	16.31	0.37	16.13	221.23	15.74	16.47	15.87
CTR	C	9/23/1999	9:38	MSC	41 09.388N	072 51.703W	ST_III	>4	2	>4	0	0	16.68	17.84	1.16	17.26	235.24	2.99	17.83	16.72
100N	A	9/23/1999	9:42	MSC	41 09.441N	072 51.724W	ST_I_ON_III	>4	2	>4	0	0	15.68	15.74	0.05	15.71	200.70	15.68	15.74	15.71
100N	B	9/23/1999	9:43	MSC	41 09.441N	072 51.724W	ST_I_ON_III	>4	2	>4	0	0	16.04	17.03	0.99	16.54	237.75	16.56	17.86	17.03
100N	C	9/23/1999	9:44	MSC	41 09.444N	072 51.706W	ST_I_ON_III	>4	2	>4	0	0	15.47	16.46	0.99	15.96	220.30	15.62	16.72	16.00
100E	A	9/23/1999	10:11	MSC	41 09.407N	072 51.664W	ST_I	>4	2	>4	5	0.32	13.75	14.58	0.83	14.17	192.65	10.21	14.14	13.64
100E	B	9/23/1999	10:12	MSC	41 09.407N	072 51.664W	ST_III	>4	2	>4	0	0	13.80	14.32	0.52	14.06	192.31	10.26	14.27	13.88
100E	C	9/23/1999	10:13	MSC	41 09.480N	072 51.642W	ST_I	>4	2	>4	0	0	14.11	15.31	1.20	14.71	200.86	14.01	15.47	14.69
100S	A	9/23/1999	9:30	MSC	41 09.342N	072 51.735W	ST_I	>4	2	>4	0	0	16.84	17.74	0.89	17.29	243.09	6.42	17.47	16.99
100S	B	9/23/1999	9:31	MSC	41 09.335N	072 51.732W	ST_I_ON_III	>4	2	>4	2	0.62	16.63	17.10	0.47	16.87	237.76	12.79	17.16	16.92
100S	C	9/23/1999	9:31	MSC	41 09.330N	072 51.732W	ST_I_ON_III	>4	2	>4	0	0	17.32	17.74	0.42	17.53	244.09	8.68	17.79	17.37
100W	A	9/23/1999	10:18	MSC	41 09.400N	072 51.795W	ST_III	>4	2	>4	0	0	13.75	14.84	1.09	14.30	195.80	14.01	14.95	14.08
100W	B	9/23/1999	10:18	MSC	41 09.393N	072 51.795W	ST_I_ON_III	>4	2	>4	0	0	15.78	16.30	0.52	16.04	218.47	11.56	16.40	16.04
100W	C	9/23/1999	10:19	MSC	41 09.387N	072 51.789W	ST_I_ON_III	>4	2	>4	0	0	17.24	17.65	0.42	17.45	240.28	4.37	17.71	16.89
200N	A	9/23/1999	9:49	MSC	41 09.507N	072 51.727W	ST_III	>4	2	>4	4	0.45	11.61	12.60	0.99	12.11	43.39	1.41	6.15	3.26
200N	B	9/23/1999	9:49	MSC	41 09.507N	072 51.730W	ST_I	>4	2	>4	0	0	14.69	15.88	1.20	15.29	207.30	14.37	15.36	14.95
200N	C	9/23/1999	9:50	MSC	41 09.504N	072 51.720W	ST_I	>4	2	>4	0	0	11.15	12.24	1.09	11.69	155.06	9.22	12.34	11.45
200E	A	9/23/1999	10:06	MSC	41 09.400N	072 51.585W	ST_I	>4	2	>4	1	1.61	13.33	15.00	1.67	14.17	188.52	6.61	14.63	13.88
200E	B	9/23/1999	10:07	MSC	41 09.395N	072 51.588W	ST_I_ON_III	>4	2	>4	1	1.61	14.11	14.69	0.57	14.40	197.21	5.26	14.32	13.98
200E	C	9/23/1999	10:08	MSC	41 09.389N	072 51.581W	ST_I_ON_III	>4	2	>4	1	1.02	16.51	17.08	0.57	16.80	227.06	8.49	16.98	16.49
200S	A	9/23/1999	9:15	MSC	41 09.282N	072 51.732W	ST_III	>4	2	>4	0	0	14.26	14.69	0.42	14.47	0.00	0.00	0.00	0.00
200S	B	9/23/1999	9:16	MSC	41 09.280N	072 51.719W	ST_I_ON_III	>4	2	>4	0	0	15.47	16.37	0.90	15.92	0.00	0.00	0.00	0.00
200S	C	9/23/1999	9:16	MSC	41 09.280N	072 51.719W	ST_I_ON_III	>4	2	>4	0	0	16.31	17.37	1.05	16.84	0.00	0.00	0.00	0.01
200W	A	9/23/1999	10:23	MSC	41 09.400N	072 51.880W	ST_I_ON_III	>4	2	>4	3	1.18	14.22	14.90	0.68	14.56	0.00	0.00	0.00	0.00
200W	B	9/23/1999	10:23	MSC	41 09.397N	072 51.878W	ST_I_ON_III	>4	2	>4	0	0	15.16	15.88	0.73	15.52	0.00	0.00	0.00	0.00
200W	C	9/23/1999	10:24	MSC	41 09.395N	072 51.868W	ST_I_ON_III	>4	2	>4	0	0	15.42	15.62	0.21	15.52	0.00	0.00	0.00	0.00
300N	A	9/23/1999	9:54	MSC	41 09.955N	072 51.720W	ST_I_ON_III	>4	2	>4	0	0	14.74	15.73	0.99	15.23	0.00	0.00	0.00	0.00
300N	B	9/23/1999	9:55	MSC	41 09.555N	072 51.714W	ST_I_ON_III	>4	2	>4	0	0	13.85	15.16	1.30	14.50	0.00	0.00	0.00	0.00
300N	C	9/23/1999	9:56	MSC	41 09.550N	072 51.718W	ST_I_ON_III	>4	2	>4	1	0.54	15.94	16.35	0.42	16.14	0.00	0.00	0.00	0.00
300E	A	9/23/1999	10:01	MSC	41 09.396N	072 51.520W	ST_I_ON_III	>4	2	>4	0	0	14.95	15.73	0.78	15.34	0.00	0.00	0.00	0.00
300E	B	9/23/1999	10:02	MSC	41 09.388N	072 51.526W	ST_I_ON_III	>4	2	>4	3	0.47	14.53	15.21	0.68	14.87	0.00	0.00	0.00	0.00
300E	C	9/23/1999	10:03	MSC	41 09.389N	072 51.517W	ST_III	>4	2	>4	1	0.7	15.00	15.99	1.00	15.50	0.00	0.00	0.00	0.00
300S	A	9/23/1999	9:10	MSC	41 09.229N	072 51.712W	ST_I	>4	2	>4	0	0	14.71	15.08	0.37	14.90	0.00	0.00	0.00	0.00
300S	B	9/23/1999	9:10	MSC	41 08.922N	072 51.708W	ST_III	>4	2	>4	0	0	14.47	15.95	1.47	15.21	0.00	0.00	0.00	0.00
300S	C	9/23/1999	9:11	MSC	41 08.922N	072 51.710W	ST_I_ON_III	>4	2	>4	0	0	16.63	18.26	1.63	17.45	0.00	0.00	0.00	0.00
300W	A	9/23/1999	10:28	MSC	41 09.398N	072 51.943W	ST_III	>4	2	>4	12	0.78	15.47	15.99	0.52	15.73	0.00	0.00	0.00	0.00
300W	B	9/23/1999	10:28	MSC	41 09.398N	072 51.943W	ST_I_ON_III	>4	2	>4	2	1.02	15.63	17.40	1.77	16.51	0.00	0.00	0.00	0.00
300W	C	9/23/1999	10:29	MSC	41 09.394N	072 51.929W	ST_I_ON_III	>4	2	>4	0	0	16.04	16.77	0.73	16.41	0.00	0.00	0.00	0.00

Station	Rep	Date	Time	Apparent RPD Thickness				Methane B.	OSI	Surface	Low	Comments
				Area	Min	Max	Mean	Count		Disturbance	D.O.	
CTR	A	9/23/1999	9:36	58.22	2.95	6.58	4.30	0	11	PHYSICAL	NO	historic dm >pen;collapsed voids deep rpd w/feeding halos
CTR	B	9/23/1999	9:37	58.69	1.42	5.84	3.10	0	10	PHYSICAL	NO	historic dm >pen;collapsed void;reduced at depth
CTR	C	9/23/1999	9:38	34.59	1.08	4.90	2.50	0	9	BIOGENIC	NO	historic dm>pen;feeding halo;reduced at depth;burrow?
100N	A	9/23/1999	9:42	56.25	1.10	5.03	4.02	0	11	PHYSICAL	NO	historic dm >pen;voids;reduced at depth;shell frag
100N	B	9/23/1999	9:43	61.29	2.76	6.82	4.39	0	11	BIOGENIC	NO	historic dm >pen;STG III tubes;shell frags ;reduced at depth
100N	C	9/23/1999	9:44	51.90	1.51	5.26	4.01	0	11	PHYSICAL	NO	historic dm >pen;deep rpd;well oxygenated;collapsed voids
100E	A	9/23/1999	10:11	30.81	1.41	2.98	2.17	0	4	PHYSICAL	NO	historic dm >pen;clay clasts surface;very reduced below rpd
100E	B	9/23/1999	10:12	33.73	2.60	4.10	3.70	0	10	BIOGENIC	NO	historic dm >pen;very reduced below deep rpd;STG III tubes
100E	C	9/23/1999	10:13	59.87	2.45	5.83	4.26	0	7	PHYSICAL	NO	historic dm >pen;stgI tubes;reduced at depth
100S	A	9/23/1999	9:30	56.06	0.47	6.05	4.29	0	7	PHYSICAL	NO	historic dm >pen;deep rpd STG I tubes
100S	B	9/23/1999	9:31	63.99	0.37	1.10	0.88	0	7	BIOGENIC	NO	historic dm >pen;STG I &III tubes;reduced at depth
100S	C	9/23/1999	9:31	74.58	1.26	7.00	3.63	0	10	BIOGENIC	NO	historic dm >pen;active voids;well oxygenated
100W	A	9/23/1999	10:18	55.91	0.05	6.24	3.04	0	10	BIOGENIC	NO	historic dm >pen deep rpd;worm tubes far field;reduced at depth
100W	B	9/23/1999	10:18	52.20	0.98	5.42	2.91	0	9	PHYSICAL	NO	historic dm >pen
100W	C	9/23/1999	10:19	81.54	1.91	6.86	3.61	0	10	PHYSICAL	NO	historic dm >pen;voids deep;stgI tubes
200N	A	9/23/1999	9:49	45.76	1.41	6.46	2.55	0	9	BIOGENIC	NO	historic dm >pen;shell frags at depth
200N	B	9/23/1999	9:49	50.61	2.55	5.05	3.74	0	6	PHYSICAL	NO	historic dm mud>pen;deep rpd ;reduced at depth
200N	C	9/23/1999	9:50	41.86	1.82	5.05	2.74	0	5	PHYSICAL	NO	historic dm >pen;shell frags stgI tubes;feeding halo
200E	A	9/23/1999	10:06	55.25	0.78	5.17	3.05	0	6	BIOGENIC	NO	historic dm >pen;reduced clay clast surface;feeding halo;shell
200E	B	9/23/1999	10:07	24.74	1.51	5.00	3.13	0	10	BIOGENIC	NO	historic dm >pen;collapsed void;fecal mound;reduced at depth
200E	C	9/23/1999	10:08	81.15	4.48	8.18	5.99	0	11	PHYSICAL	NO	historic dm >pen;voids;clay clast surface
200S	A	9/23/1999	9:15	47.35	0.76	5.16	2.10	0	8	BIOGENIC	NO	ambient;large void
200S	B	9/23/1999	9:16	74.19	1.32	12.58	3.06	0	10	BIOGENIC	NO	ambient;deep rpd;vertical burrow
200S	C	9/23/1999	9:16	74.19	1.32	15.58	4.06	0	11	PHYSICAL	NO	ambient;deep rpd
200W	A	9/23/1999	10:23	55.22	1.07	5.78	2.61	0	9	PHYSICAL	NO	ambient;clay clasts surface;collapsed voids
200W	B	9/23/1999	10:23	60.76	2.03	8.44	4.55	0	11	PHYSICAL	NO	ambient sediments;void at depth
200W	C	9/23/1999	10:24	65.42	1.10	5.03	4.02	0	11	PHYSICAL	NO	ambient;voids deep;STG I tubes
300N	A	9/23/1999	9:54	58.79	1.45	5.09	2.37	0	9	BIOGENIC	NO	ambient; StgI tubes
300N	B	9/23/1999	9:55	40.60	1.68	5.08	2.89	0	9	PHYSICAL	NO	ambient;deep rpd;active void
300N	C	9/23/1999	9:56	43.72	2.30	3.87	3.09	0	10	PHYSICAL	NO	ambient;active void;clay clast surface
300E	A	9/23/1999	10:01	54.68	2.24	5.10	4.04	0	11	BIOGENIC	NO	ambient sediments;worm at depth;STG I
300E	B	9/23/1999	10:02	40.78	0.89	4.58	3.12	0	10	BIOGENIC	NO	ambient;active void;anemone; clay clasts surface
300E	C	9/23/1999	10:03	42.63	1.30	4.74	3.20	0	10	BIOGENIC	NO	ambient;deep void/burrow?;reduced at depth
300S	A	9/23/1999	9:10	41.44	1.20	4.61	3.12	0	6	PHYSICAL	NO	ambient;deep rpd;reduced at depth
300S	B	9/23/1999	9:10	41.35	0.11	6.42	3.17	0	10	PHYSICAL	NO	ambient;some shellfrags
300S	C	9/23/1999	9:11	66.47	3.05	10.42	4.68	0	11	PHYSICAL	NO	ambient sediments;active voids deep;feeding halo
300W	A	9/23/1999	10:28	56.44	0.10	1.80	0.88	0	7	PHYSICAL	NO	ambient sediments;clay clasts cover surface;active voids;worms
300W	B	9/23/1999	10:28	101.66	5.88	10.52	4.05	0	11	PHYSICAL	NO	ambient;deep rpd;feeding halos;anemone?
300W	C	9/23/1999	10:29	69.15	2.50	6.61	5.28	0	11	PHYSICAL	NO	ambient;active voids;

Appendix E6.

REMOTS® Results for the CLIS Reference Areas

Site	Station	Rep	Date	Time	Analyst	Latitude	Longitude	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Major Mode	Mudclast Count	Mudclast Diameter	Camera Penetration Min	Camera Penetration Max	Camera Penetration Range	Camera Penetration Mean	Dredged Material Thickness Area	Dredged Material Thickness Min	Dredged Material Thickness Max	Dredged Material Thickness Mean
2500W	1	D	9/23/1999	7:49	HLS	41 09.283N	072 55.769W	ST_I_ON_III	>4	2	>4	0	0	15.58	16.68	1.11	16.13	0	0	0	0
	1	E	9/23/1999	7:50	HLS	41 09.279N	072 55.767W	ST_I	>4	2	>4	1	0.68	13.63	16.63	3.00	15.13	0	0	0	0
	1	F	9/23/1999	7:50	HLS	41 09.286N	072 55.763W	ST_I_ON_III	>4	2	>4	7	0.32	15.21	15.95	0.74	15.58	0	0	0	0
	2	D	9/23/1999	7:54	MSC	41 09.393N	072 55.741W	ST_III	>4	2	>4	0	0	11.73	13.25	1.52	12.49	0	0	0	0
	2	E	9/23/1999	7:55	MSC	41 09.393N	072 55.737W	ST_III	>4	2	>4	0	0	9.06	12.83	3.77	10.94	0	0	0	0
	2	F	9/23/1999	7:55	MSC	41 09.389N	072 55.734W	ST_I_ON_III	>4	2	>4	0	0	15.81	16.81	1.00	16.31	0	0	0	0
	3	D	9/23/1999	8:07	MSC	41 09.193N	072 55.354W	ST_I_ON_III	>4	2	>4	0	0	14.08	16.18	2.09	15.13	0	0	0	0
	3	E	9/23/1999	8:08	MSC	41 09.192N	072 55.351W	ST_I_ON_III	>4	2	>4	0	0	16.44	17.49	1.04	16.97	0	0	0	0
	3	F	9/23/1999	8:09	MSC	41 09.185N	072 55.346W	ST_I_ON_III	>4	2	>4	0	0	14.50	15.60	1.10	15.05	0	0	0	0
	4	D	9/23/1999	8:02	MSC	41 09.290N	072 55.335W	ST_I_ON_III	>4	2	>4	2	0.47	16.02	16.23	0.21	16.13	0	0	0	0
	4	E	9/23/1999	8:03	MSC	41 09.292N	072 55.331W	ST_III	>4	2	>4	2	0.46	15.92	17.17	1.26	16.54	0	0	0	0
	4	F	9/23/1999	8:03	MSC	41 09.292N	072 55.325W	ST_I_ON_III	>4	2	>4	0	0	17.17	17.70	0.52	17.43	0	0	0	0
4500E	5	A	9/23/1999	8:50	MSC	41 09.112N	072 50.457W	ST_I_ON_III	>4	2	>4	0	0	16.07	16.54	0.47	16.31	0	0	0	0
	5	B	9/23/1999	8:51	MSC	41 09.110N	072 50.445W	ST_I	>4	2	>4	2	1.26	14.92	15.86	0.94	15.39	0	0	0	0
	5	C	9/23/1999	8:51	MSC	41 09.110N	072 50.445W	ST_I_ON_III	>4	2	>4	1	1	14.66	15.55	0.89	15.10	0	0	0	0
	6	A	9/23/1999	8:37	MSC	41 09.411N	072 50.489W	ST_I	>4	2	>4	4	0.68	16.23	17.17	0.94	16.70	0	0	0	0
	6	B	9/23/1999	8:37	MSC	41 09.412N	072 50.481W	ST_III	>4	2	>4	3	0.73	14.03	14.87	0.84	14.45	0	0	0	0
	6	C	9/23/1999	8:38	MSC	41 09.412N	072 50.476W	ST_I_ON_III	>4	2	>4	0	0	14.24	15.18	0.94	14.71	0	0	0	0
	7	A	9/23/1999	8:56	MSC	41 09.271N	072 50.751W	ST_I_ON_III	>4	2	>4	1	0.69	14.82	15.45	0.63	15.13	0	0	0	0
	7	B	9/23/1999	8:57	MSC	41 09.271N	072 50.751W	ST_I_ON_III	>4	2	>4	1	0.3	15.19	16.13	0.94	15.66	0	0	0	0
	7	C	9/23/1999	8:58	MSC	41 09.269N	072 50.739W	ST_I_ON_III	>4	2	>4	0	0	15.81	16.02	0.21	15.91	0	0	0	0
	8	A	9/23/1999	8:42	MSC	41 09.319N	072 50.360W	ST_I_ON_III	>4	2	>4	0	0	13.82	13.82	0.00	13.82	0	0	0	0
	8	B	9/23/1999	8:43	MSC	45 09.317N	072 50.360W	ST_I	>4	2	>4	0	0	13.61	14.45	0.84	14.03	0	0	0	0
	8	C	9/23/1999	8:44	MSC	41 09.310N	072 50.357W	ST_I	>4	2	>4	1	0.58	11.99	12.20	0.21	12.09	0	0	0	0
CLISREF	9	A	9/12/1999	13:37	MSC	41 24.700N	072 50.078W	ST_I_ON_III	>4	2	>4	0	0	15.36	15.83	0.47	15.60	0	0	0	0
	9	C	9/12/1999	13:39	MSC	41 08.243N	072 50.084W	ST_I_ON_III	>4	2	>4	2	0.54	15.97	16.28	0.31	16.13	0	0	0	0
	9	G	9/12/1999	14:11	MSC	41 08.243N	072 50.068W	ST_I_ON_III	>4	2	>4	0	0	13.77	14.61	0.84	14.19	0	0	0	0
	10	B	9/12/1999	14:36	MSC	41 07.924N	072 50.124W	ST_I_ON_III	>4	2	>4	0	0	18.32	18.90	0.58	18.61	0	0	0	0
	10	C	9/12/1999	14:37	MSC	41 07.926N	072 50.122W	ST_I_ON_III	>4	2	>4	0	0	16.96	17.54	0.58	17.25	0	0	0	0
	10	D	9/12/1999	14:38	MSC	41 07.928N	072 50.117W	ST_I_ON_III	>4	2	>4	0	0	15.13	15.60	0.47	15.37	0	0	0	0
	11	A	9/12/1999	14:52	MSC	41 08.166N	072 50.297W	ST_III	>4	2	>4	0	0	12.04	12.93	0.89	12.49	0	0	0	0
	11	B	9/12/1999	14:55	MSC	41 08.164N	072 50.304W	ST_I_ON_III	>4	2	>4	0	0	14.08	14.45	0.37	14.27	0	0	0	0
	11	D	9/12/1999	14:56	MSC	41 08.170N	072 50.288W	ST_III	>4	2	>4	0	0	14.92	15.55	0.63	15.24	0	0	0	0
	12	A	9/12/1999	14:16	MSC	41 08.085N	072 49.883W	ST_I	>4	2	>4	3	0.66	11.20	11.68	0.47	11.44	0	0	0	0
	12	C	9/12/1999	14:20	MSC	41 08.084N	072 49.900W	ST_I_ON_III	>4	2	>4	0	0	13.98	14.19	0.21	14.08	0	0	0	0
	12	E	9/12/1999	14:26	MSC	41 08.072N	072 49.898W	ST_III	>4	2	>4	2	0.8	12.09	12.57	0.47	12.33	0	0	0	0
	13	A	9/12/1999	14:43	MSC	41 07.935N	072 50.222W	ST_I_ON_III	>4	2	>4	0	0	16.23	16.70	0.47	16.47	0	0	0	0
	13	D	9/12/1999	14:46	MSC	41 07.949N	072 50.201W	ST_I	>4	2	>4	0	0	13.87	13.93	0.05	13.90	0	0	0	0
	13	E	9/12/1999	14:46	MSC	41 07.944N	072 50.196W	ST_I	>4	2	>4	0	0	10.42	11.52	1.10	10.97	0	0	0	0

Site	Station	Rep	Date	Time	Apparent RPD Thickness Area	Apparent RPD Thickness Min	Apparent RPD Thickness Max	Apparent RPD Thickness Mean	Methane B. Count	OSI	Surface Disturbance	Low D.O.	Comments
2500W	1	D	9/23/1999	7:49	56.41	2.89	5.16	4.01	0	11	PHYSICAL	NO	ambient;sm st_I tubes;active voids;
	1	E	9/23/1999	7:50	35.13	1.53	3.26	2.51	0	5	PHYSICAL	NO	ambient; active bio reworking of sed;
	1	F	9/23/1999	7:50	27.15	0.95	3.00	1.88	0	8	PHYSICAL	NO	ambient; active bio reworking of sed; voids; burrow?@z
	2	D	9/23/1999	7:54	25.12	0.52	4.35	1.77	0	8	PHYSICAL	NO	ambient;silty surf.;shells;collasped voids
	2	E	9/23/1999	7:55	34.98	0.79	3.98	2	0	8	PHYSICAL	NO	ambient;silty surf.;small void deep;shell frags
	2	F	9/23/1999	7:55	62.06	1.78	5.65	3.1	0	10	PHYSICAL	NO	ambient;silty surf.;active void deep;shell frags;reduced at depth
	3	D	9/23/1999	8:07	55.22	0.99	4.34	1.6	0	8	BIOGENIC	NO	ambient;silty surf.;void;burrow deep;Stg I tubes
	3	E	9/23/1999	8:08	53.59	0.31	3.03	0.78	0	7	BIOGENIC	NO	ambient;silty surf.;large burrow;feeding halos
	3	F	9/23/1999	8:09	65.01	0.47	4.39	2.04	0	8	BIOGENIC	NO	ambient;silty surf.;active voids;STG III;I tubes
	4	D	9/23/1999	8:02	68.77	1.14	4.54	2.65	0	9	PHYSICAL	NO	ambient;clay clast at surf.
	4	E	9/23/1999	8:03	41.16	0.52	4.82	1.64	0	8	PHYSICAL	NO	ambient;active voids;clay clasts on silty surf.
	4	F	9/23/1999	8:03	58.73	3.14	5.81	4.4	0	11	PHYSICAL	NO	ambient;silty surf. w/shell frags;void/burrow at dep
4500E	5	A	9/23/1999	8:50	41.21	2.09	3.82	2.98	0	9	PHYSICAL	NO	ambient;silty surf.;shell;anemone at depth
	5	B	9/23/1999	8:51	37.41	0.26	3.21	2.65	0	5	PHYSICAL	NO	ambient;silty surf.;shell void at depth;clast farfield
	5	C	9/23/1999	8:51	39.07	0.05	3.72	2.76	0	9	PHYSICAL	NO	ambient;large clast farfield?;voids;shell
	6	A	9/23/1999	8:37	67.34	2.83	6.13	5.01	0	7	PHYSICAL	NO	ambient;silty surf. w/clay clasts;shell frags;reduced at depth
	6	B	9/23/1999	8:37	38.34	1.62	4.14	2.89	0	9	PHYSICAL	NO	ambient;silty surf.;bisected shell;clay clast;void
	6	C	9/23/1999	8:38	60.94	1.61	5.39	2.84	0	9	PHYSICAL	NO	ambient;silty surf. w/clay clasts active void
	7	A	9/23/1999	8:56	49.73	1.99	5.13	2.71	0	9	PHYSICAL	NO	ambient;silty surf. clay clast;voids at depth
	7	B	9/23/1999	8:57	31.63	2.07	2.54	2.28	0	9	PHYSICAL	NO	ambient;silty surf.;void at depth;
	7	C	9/23/1999	8:58	30.26	1.47	3.66	2.04	0	8	PHYSICAL	NO	ambient;silty surf.;void;shell frags
	8	A	9/23/1999	8:42	51.27	1.52	5.18	3.08	0	10	PHYSICAL	NO	ambient;silty surf.;active void; reduced at depth
	8	B	9/23/1999	8:43	43.03	0.93	4.56	3.06	0	6	PHYSICAL	NO	ambient;silty surf.;reduced at depth
	8	C	9/23/1999	8:44	33.71	1.10	4.24	2.37	0	5	PHYSICAL	NO	ambient;silty surf. w clay clast;some shell frag
CLISREF	9	A	9/12/1999	13:37	68.51	3.28	6.09	5.09	0	11	BIOGENIC	NO	ambient;large void;burrow;anemones;deep rpd
	9	C	9/12/1999	13:39	34.56	1.05	3.98	2.48	0	9	PHYSICAL	NO	ambient mub;deep rpd due to feeding halos;clay clast surf.
	9	G	9/12/1999	14:11	61.18	3.25	5.65	4.37	0	11	BIOGENIC	NO	ambient;collapsed void;stgI tubes
	10	B	9/12/1999	14:36	88.78	4.45	8.48	6.57	0	11	BIOGENIC	NO	ambient;surf. shell;active void deep
	10	C	9/12/1999	14:37	84.50	1.93	6.8	4.01	0	11	BIOGENIC	NO	ambient;active voids deep
	10	D	9/12/1999	14:38	59.50	1.27	4.33	2.63	0	9	BIOGENIC	NO	ambient;voids at depth;deep rpd due to feeding halos
	11	A	9/12/1999	14:52	56.47	1.15	4.49	2.12	0	8	BIOGENIC	NO	ambient;deep rpd w/feeding halos;clay chips at surf.
	11	B	9/12/1999	14:55	71.67	3.93	6.39	5.38	0	11	BIOGENIC	NO	ambient;anemone at depth;active void;stgI tubes
	11	D	9/12/1999	14:56	61.66	3.14	6.02	4.48	0	11	BIOGENIC	NO	ambient;many active voids;anemone left;worms
	12	A	9/12/1999	14:16	51.65	1.10	6.75	3.68	0	6	BIOGENIC	NO	ambient;clay clasts surf.;feeding halos;shell frags
	12	C	9/12/1999	14:20	76.93	3.82	7.75	5.62	0	11	BIOGENIC	NO	ambient;active void;stg III tubes;shell at surf.
	12	E	9/12/1999	14:26	56.21	1.83	5.81	4.23	0	11	PHYSICAL	NO	ambient;burrowing anemone;clay clasts surf.
	13	A	9/12/1999	14:43	70.78	2.20	6.23	4.99	0	11	PHYSICAL	NO	ambient;worm at depth;shell frag/anemone? at left
	13	D	9/12/1999	14:46	79.82	3.87	8.32	5.96	0	7	BIOGENIC	NO	ambient;deep rpd due to feeding halos;some shell frags at depth
	13	E	9/12/1999	14:46	78.58	1.68	5.51	3.03	0	6	PHYSICAL	NO	ambient;no voids;shell frags at depth;clay chips at sur