RESULTS OF THE SUMMER 2006 SEDIMENT-PROFILE IMAGING AND SUB-BOTTOM PROFILING SURVEY AT THE HISTORIC AREA REMEDIATION SITE

FINAL REPORT

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ACKNOWLEDGEMENTS

This report presents the results of the Summer 2006 survey to evaluate the benthic and physical conditions of the sediment within and around the Historic Area Remediation Site (HARS). This survey was conducted by Science Applications International Corporation (SAIC) of Newport, RI, under a Broad Agency Agreement contract with the U.S. Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC) in Vicksburg, MS. The USACE - New York District (NYD) provided much of the funding support to conduct this work. Scientists from ERDC are conducting a bio-accumulation study focused within the New York Bight and the sediment sampling field operations to support this study were conducted in conjunction with the operations described in this report. Dr. Stephen Knowles was the NYD's manager of technical activities, Dr. Jeff Steevens was ERDC's program manager, and Mr. Tom Waddington served as SAIC's project manager.

Sediment-profile/plan-view imaging, sub-bottom profiling, and sediment grab sampling operations were conducted aboard the *R/V Beavertail*. The crew of the *R/V Beavertail* is commended for their skill in vessel handling while conducting the sampling operations, as well as their dedication during long hours of operation at the HARS. We would also like to thank the U.S. Coast Guard Sandy Hook Station for allowing the *R/V Beavertail* to temporarily dock at the station during the field sampling at the HARS. Our ability to use the Coast Guard facilities helped to improve the efficiency of our field operations. In addition, we would like to thank the USACE Caven Point facility for allowing us to temporarily dock the *R/V Beavertail* there during an extended period of unfavorable weather and sea conditions.

Natasha Pinckard of SAIC coordinated the sediment-profile imaging field activities and was assisted in the field by Michael Cole, Pamela Luey, and Maura Suprenant. Tom Waddington coordinated the sub-bottom profiling field activities and was assisted in the field by Kate Scammell. Mike Cole coordinated the sediment grab sampling operations and was assisted in the field by Natasha Pinckard, Pamela Luey, Maura Suprenant, and Kate Scammell of SAIC, as well as Alan Kennedy, Dan Farrar, Laura Innouye, and William Blackburn of ERDC. Natasha Pinckard conducted the sediment-profile image analyses with technical review provided by Ray Valente of SeaRay Environmental. Kate Scammel conducted the sub-bottom profiling data analyses, with technical review provided by Tom Waddington. Christopher Woods and Greg Berman of SAIC were responsible for data tracking and management, as well as the development of the supporting GIS figures for the study report. Natasha Pinckard, Mike Cole, Ray Valente, and Tom Waddington authored the Study Report with final review provided by Dr. Knowles.

EXECUTIVE SUMMARY

Since the closure of the Mud Dump Site (MDS) in September 1997 and its re-designation as the Historic Area Remediation Site (HARS), placement of remediation dredged material in HARS Priority Remediation Areas (PRAs) 1, 2, 3 and 4 has been ongoing. The HARS Site Management and Monitoring Plan (SMMP) serves as a guideline document for the monitoring of the PRAs during the course of remediation efforts. In addition to routine unconfined placement of dredged material at the site over many years, two capping projects were conducted at the MDS in the 1990s. The 1993 Dioxin Capping Project placed an estimated 585,500 cubic yards of dioxin-contaminated dredged material from berthing facilities in Newark Bay at the MDS in summer 1993 and subsequently capped this material with approximately 1.7 million cubic yards of clean sand. The 1997 Category II Capping Project placed approximately 700,000 cubic yards of dioxin-contaminated dredged material from Newark Bay in the southern portion of the former MDS adjacent to the 1993 Dioxin Mound and subsequently capped this material with approximately 2.4 million cubic yards of clean sand from Ambrose Channel. A comprehensive monitoring effort conducted in 2002 served to demonstrate that the cap material has remained in-place on the seafloor and has been effective at isolating the underlying dioxin-contaminated sediment.

This report presents the results of the 2006 sediment-profile imaging and sub-bottom profiling survey, which was conducted in and around the HARS during late August and early September of 2006. A seafloor camera system was used to obtain sediment-profile images and sediment plan-view images at numerous stations to evaluate benthic recolonization status and overall benthic habitat quality in and around the HARS. The sediment-profile and plan-view image survey involved re-sampling of stations that had been sampled in previous surveys (e.g., EPA October 1994, SAIC 2002, and SAIC 2005), as well as sampling at additional stations located within and surrounding the HARS. Sampling was conducted at stations with remediation material of varying types and ages, as well as at stations where remediation material has not yet been placed since the HARS was designated in 1997. In addition to the sediment-profile survey, a towed acoustic sub-bottom profiling system was used to acquire sub-bottom reflector data over the 1993 Dioxin Mound and 1997 Category II Mound to help assess the integrity and thickness of the sand cap layer.

Similar to the results of many past sediment-profile imaging surveys in and around the HARS and former MDS, sediments ranged from silt-clays to gravels and included historic (i.e., relic) dredged material, predominantly fine-grained remediation material placed since 1997 in PRAs 1 through 4, and sand that represents the native sediment in areas outside the HARS boundaries. The remediation material observed in the images consisted of at least four distinct types of sediment: “conventional” organic-rich mud, red clay, clean fine sand from Ambrose Channel, and gravel/rock.

In response to the patchy mosaic of different habitat conditions, benthic communities were found to be in various stages of succession. As in the past, small opportunistic, Stage I polychaetes were abundant at many stations, reflecting their ability to colonize the sediment surface quickly and in high numbers following the physical seafloor disturbance associated with dredged material disposal. While Stage I opportunists are the long-term dominants on sandy bottoms around the HARS, the placement of fine-grained dredged sediments within both the HARS and the former MDS has resulted in soft-bottom conditions conducive to supporting infaunal succession beyond Stage I. The 2002, 2005, and 2006 sediment-profile/plan-view results all serve to confirm that such advanced succession has in fact been occurring, most notably in PRAs 1 through 4, where remediation activities have been on-going since 1997.

The majority of stations within the HARS, including most of those with remediation material, had either Stage II or III as the highest successional stage in both the 2005 and 2006 surveys. In particular, biological features indicating the presence of a diverse assemblage of surface- and subsurface-dwelling benthic organisms were observed in the sediment-profile and plan-view images over large portions of PRAs 1 through 4. Benthic habitat conditions, as indicated by Organism Sediment Index (OSI) values derived from analysis of the sediment-profile images, were found to be either undisturbed or only moderately disturbed at the majority of stations in PRAs 1 through 4. Overall, the 2006 OSI values suggested an intermediate to advanced degree of benthic community recovery from the disturbance effects of both historic and more-recent disposal activities.

The gridded cap thickness model created from the 2006 sub-bottom profile data indicated cap thickness values ranging between 4 to 7 feet over widespread areas of both the 1993 and 1997 Mounds, with maximum values over 10 feet observed in the overlap area between the Mounds. These results were consistent with the sub-bottom profiling results observed during the comprehensive monitoring surveys conducted in 2002 over these two capped Mounds. The ability to completely and accurately map the sand cap layer was impacted by the sometimes discontinuous nature of the various reflectors within the sub-bottom records. In general, these discontinuities were more prevalent in the cap overlap area and were likely associated with the increased disturbance caused by greater placement activity of both dredged material and capping sediments in these areas. Without any confirmatory sediment coring data, there was no way of positively stating the composition of the various sediment layers that might have been identified within a particular acoustic sub-bottom dataset. Within some of the cap overlap areas it was often possible to identify as many as four or five distinct reflectors within the top 5 m of the sediment column.

In addition to the monitoring operations addressed in this report, a comprehensive multibeam and backscatter survey was also conducted over the HARS in August 2006 to assess the overall physical conditions at the site and to map the progress of the on-going placement operations. The depth difference grid between the 2002 and 2006 surveys indicated little change in the bathymetry over the 1993 and 1997 Mound area since 2002. In addition, the 2006 multibeam backscatter imagery also showed that the sediment surface over the entire Mound region was quite consistent with no evidence of disturbed surface areas that might have been indicative of problems with the cap integrity. These results suggested that the Mounds have been stable since their creation with no indication of any significant areas of either erosion or deposition. The sub-bottom profiling results, the bathymetric depth difference results, and the backscatter imagery results observed during the 2006 operations were generally very consistent with the complimentary results observed during the more comprehensive monitoring conducted in 2002. When considered in conjunction with the comprehensive results observed in 2002, the consistency between the 2006 and 2002 datasets supports the conclusion that the cap material has remained in-place on the seafloor and has continued to be effective at isolating the underlying dioxin-contaminated sediment.

LIST OF ACRONYMS

ADISS	Automated Disposal Surveillance System
DAMOS	Disposal Area Monitoring System
DGPS	Differentially-corrected Global Positioning System
Eh	electro-chemical potential
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
GIS	Geographic Information System
GPS	Global Positioning System
HARS	Historic Area Remediation Site
m^2	square meters
MDS	Mud Dump Site
mm	millimeter
m/sec	meters per second
NAD 83	North American Datum of 1983
NYD	New York District
OSI	Organism-Sediment Index
PRA	priority remediation area
PV	Plan-view
QC	Quality Control
REMOTS	Remote Ecological Monitoring of the Seafloor
RPD	Redox Potential Discontinuity
R/V	Research Vessel
USACE	U.S. Army Corps of Engineers
SAIC	Science Applications International Corporation
SMMP	Site Management and Monitoring Plan
SPI	Sediment Profile Imaging
TVG	Time-varied Gain
UTC	Universal Time Coordinate

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1.0 INTRODUCTION

1.1 Background

Prior to September 1997, sediments dredged from New York/New Jersey Harbor Estuary were deposited at the Mud Dump Site (MDS), located in the New York Bight about six nautical miles east of Sandy Hook, New Jersey. In addition to routine unconfined placement of dredged material at the site over many years, two capping projects were conducted at the MDS in the 1990s. The 1993 Dioxin Capping Project placed an estimated 585,500 cubic yards of dioxin-contaminated dredged material from berthing facilities in Newark Bay at the MDS in summer 1993 and subsequently capped this material with approximately 1.7 million cubic yards of clean sand. The 1997 Category II Capping Project placed approximately 700,000 cubic yards of dioxin-contaminated dredged material from Newark Bay in the southern portion of the former MDS adjacent to the 1993 Dioxin Mound and subsequently capped this material with approximately 2.4 million cubic yards of clean sand from Ambrose Channel.

Based on an agreement among the Environmental Protection Agency (EPA), the Department of the Army, and the Department of Transportation, the MDS and some surrounding historical dredged material disposal areas were re-designated as the Historic Area Remediation Site (HARS) beginning in September 1997 (Figure 1.1-1). The HARS is divided into nine Priority Remediation Areas (PRAs) where remediation material is to be placed (Figure 1.1-2). A Buffer Zone surrounds the PRAs, and the No Discharge Zone is an area outside the PRAs where no further disposal is permitted (Figure 1.1-2).

Region 2 of the EPA and the New York District (NYD) of the U.S. Army Corps of Engineers (USACE) are jointly responsible for managing the HARS, primarily in an effort to reduce the elevated contamination and toxicity of surface sediments to acceptable levels. The two agencies have prepared a Site Management and Monitoring Plan (SMMP) for the HARS that identifies a number of actions, provisions, and practices to manage remediation activities and monitoring tasks. The main objective of the HARS SMMP is to ensure that placement of the remediation dredged material does not result in any significant adverse environmental impacts but does result in sufficient modification (i.e., remediation) of any unacceptable sediment chemistry and toxicity characteristics. To verify that such remediation is occurring, the SMMP includes a tiered environmental monitoring program designed to focus both on the entire HARS and on each of the nine PRAs.

Surveys involving sediment-profile imaging (SPI) and plan-view imaging are conducted periodically to evaluate the degree of benthic habitat recovery from the on-going remediation material placement activities. Most recently, sediment-profile/plan-view monitoring surveys were conducted at the HARS in 2002 and 2005 (SAIC 2003c; 2005). Due to the variety of substrates observed within the surveyed area and the varying lengths of time that the remediation material had been in place on the seafloor, a variety of infaunal successional stages were observed in the images from these surveys. However, benthic habitat conditions were considered to be either undisturbed or moderately disturbed over most of the surveyed area. The results of the 2005 survey, in particular, indicated a relatively advanced degree of benthic

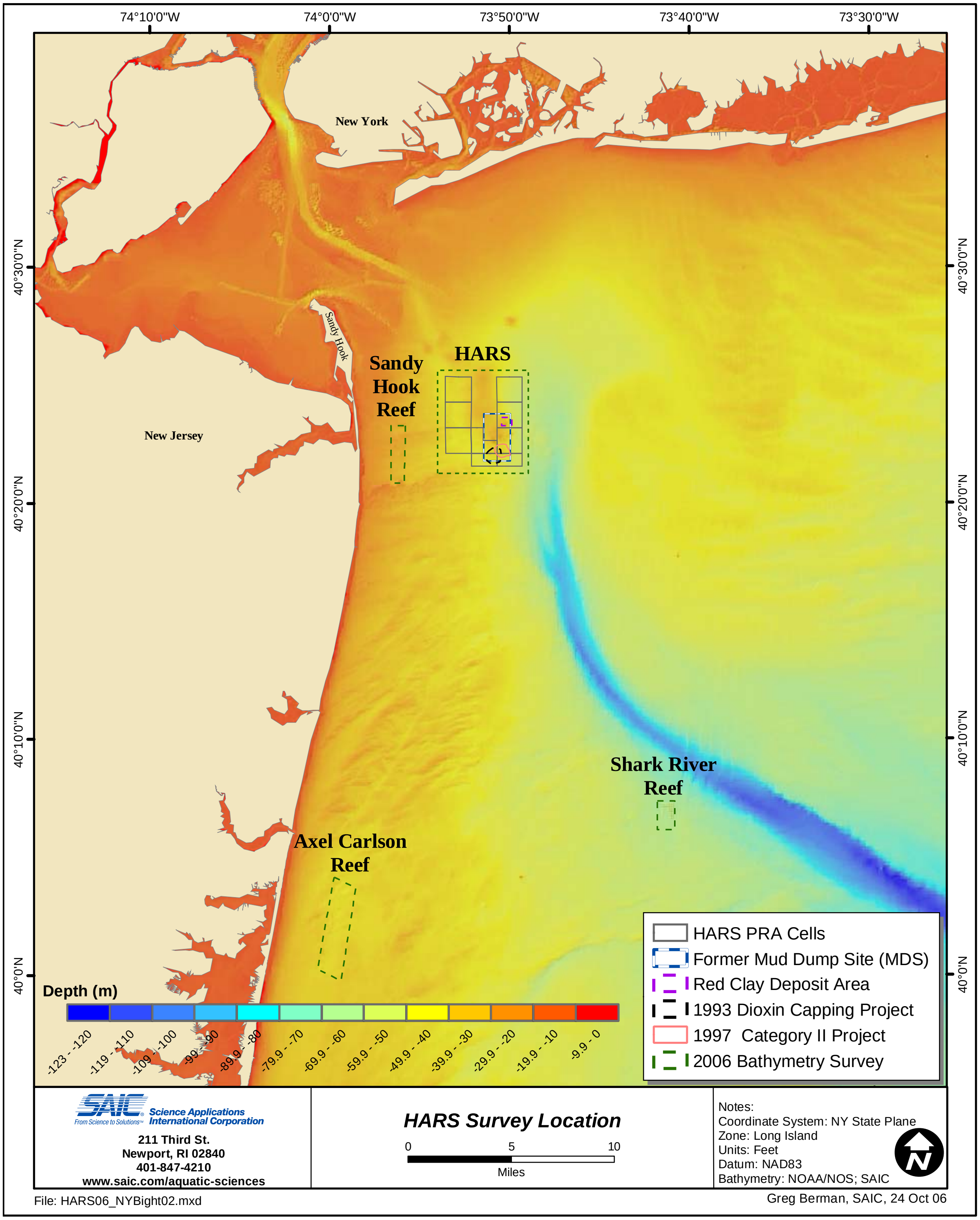


Figure 1.1-1. Map showing the locations of the former Mud Dump Site (MDS) and the Historic Area Remediation Site (HARS) in the New York Bight

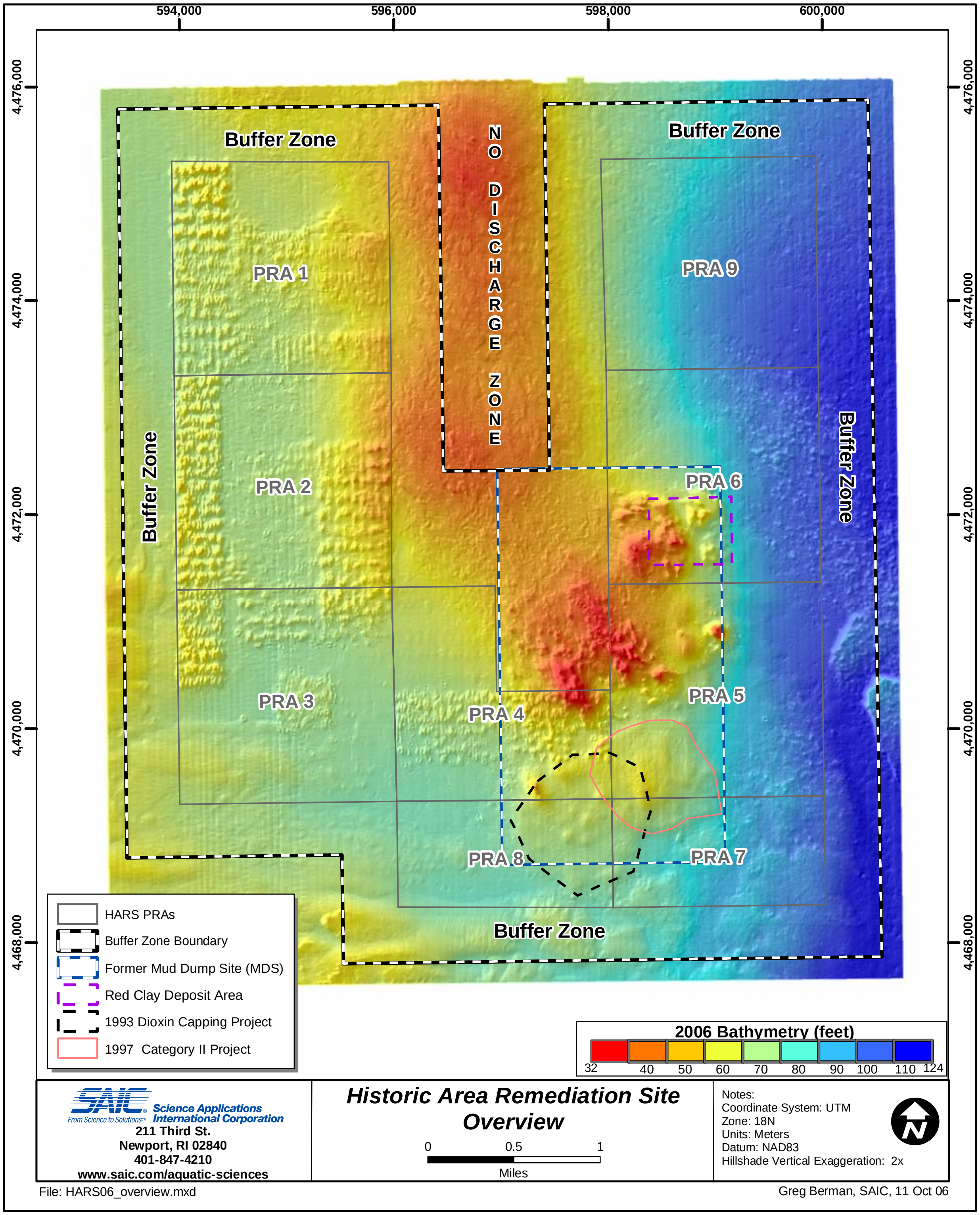


Figure 1.1-2. Map of the HARS PRAs, Buffer Zone and No Discharge Zone relative to 2006 multibeam bathymetry

community recovery from the disturbance effects of both historic and more-recent disposal activities.

The monitoring activities in 2002 also focused on assessing the integrity of both the 1993 Dioxin Capping Project Mound and the 1997 Category II Mound (SAIC 2003a; 2003b). The sub-bottom profiling results were consistent with the bathymetric depth differencing results, indicating an average sand cap thickness of 5 to 7 feet, with the greatest thickness (up to 9 feet) observed in the area of overlap between the 1993 and 1997 mounds. Sediment cores revealed an average sand cap thickness of 1.7 m (5.7 ft) over the 1997 Category II Mound and 1.5 m (4.9 ft) over the 1993 Dioxin Capping Project Mound. Cap thickness measurements from the cores were generally comparable to the cap thickness estimates obtained through sub-bottom profiling. Sediment chemistry results indicated a lack of any significant vertical migration of dioxin or furan from the underlying dredged material into the overlying cap material. These results supported the conclusion that the sand caps over both mounds had remained in-place on the seafloor and continued to be effective at isolating the underlying dioxin-contaminated sediment.

1.2 2006 Survey Objectives

During late August and early September of 2006, another survey involving both sediment-profile and plan-view imaging was conducted over remediated and unremediated areas within and outside the HARS. The primary objective of this survey was to assess any temporal changes in benthic habitat conditions that may have occurred since the last monitoring survey of 2005. In addition, acoustic sub-bottom profiling was conducted over the two capped dioxin mounds to continue monitoring the integrity and thickness of the cap material layer. In conjunction with the 2006 monitoring effort, multibeam bathymetry and backscatter imagery were also acquired to provide a high-resolution physical characterization of the HARS and to help plan future placement activities at the site. The results of the multibeam characterization are provided in a separate report (SAIC 2006).

The 2006 survey efforts addressed within this report involved the following techniques and objectives:

- Sediment-profile images and sediment plan-view photographs were collected at 61 stations to evaluate infaunal successional status and overall benthic habitat conditions.

- Acoustic sub-bottom profiling data were acquired over the 1993 and 1997 dioxin mounds to evaluate the thickness and integrity of the sand cap over these mounds, In addition, reconnaissance sub-bottom profile data were also acquired over several other areas of interest (e.g., recent and historic clay deposits) within the HARS.

2.0 METHODS

The Summer 2006 sediment-profile / plan-view imaging and sub-bottom profiling survey took place between 17 August and 9 September (Table 2.1-1). The *R/V Beavertail,* based out of Jamestown, RI, was used for all field operations. Sediment-profile and plan-view images were collected from 21 through 24 August, while surface sediments for subsequent chemical and biological analyses were collected by ERDC on 25 August and 7 through 9 September. Sub-bottom profiling survey operations were conducted on 17, 30, and 31 August and 6 September. Two extended periods of weather downtime were experienced due to strong northeasterly winds and the resulting large easterly seas.

2.1 Field Operations and Sampling Design

Sediment-profile and plan-view imaging operations were conducted at a total of 61 stations (Table 2.1-2 and Figure 2.1-1). Of these 61 stations, 20 were previously sampled by the EPA in October 1994 and again by SAIC in July 2002 and August 2005; the goal of sampling in the present study was to provide additional comparisons with these past surveys. These 20 stations are identified in Table 2.1-1 and are denoted by station numbers ranging between 4 and 36 to be consistent with the numbering scheme established during the 1994 EPA Region 2 study and maintained during the SAIC 2002 and 2005 monitoring studies (Battelle 1996; SAIC 2003c; SAIC 2005). Both sediment-profile and plan-view imaging were also conducted at an additional 13 stations occupied during the previous SAIC 2002 and 2005 surveys; these stations are identified with letter prefixes G through Q in Table 2.1-2 and Figure 2.1-1. Most of these stations were located in areas of Priority Remediation Areas (PRAs) 1, 2, 3, and 4 that had received remediation material at some point in time since the orginal designation of the HARS. In addition, sediment-profile and plan-view imaging was conducted at 7 supplemental stations within the HARS occupied previously during the Summer 2005 survey and 4 new stations located within PRAs 1 and 2; the objective of this sampling was to evaluate physical and biological sediment conditions and assess benthic recolonization status (Table 2.1-2 and Figure 2.1-1). These 11 stations were located over areas that have remediation material of differing ages based on the recorded placement data in the Automated Disposal Surveillance System (ADISS) database. Lastly, sediment-profile and plan-view images were collected at 17 additional stations within and surrounding the HARS that were selected based primarily on analyses of the 2005 multibeam dataset and observed differences in the acoustic backscatter return.

Concurrently with the 2006 survey, sediment-profile images were also collected at 39 stations located within the HARS, the Sewage Sludge Site, the Acid Waste Site, and at reference stations within the New York Bight in support of the sediment sampling survey conducted by the Engineering Research and Development Center (ERDC). Based on the observed sediment-profile results within each of these areas, a sub-set of these stations were selected for subsequent sediment and benthic tissue collection. Of these 39 stations, five were established within areas of the HARS that had received remediation material (annotated with “C” in Table 2.1-2) in PRAs 1, 2, 3, and 4 and six stations were located in areas that had not received remediation material (annotated with “UC” in Table 2.1-2) in PRAs 5, 6, and 9 and within the No Discharge Zone. Because these supplemental stations fall within the HARS, the sediment-profile and planview data are presented in this report along with the data from the 61 planned stations.

Table 2.1-1 Summary of field sampling operations aboard the *R/V Beavertail* during the Summer 2006 Survey at the HARS and other NY Bight sampling areas

Date	Daily Activity Type	Daily Operations Overview
8/14/2006	Mob	Mob and test gear in warehouse and prepare for loading on the *Beavertail*.
8/15/2006	Mob	Load required survey and sampling gear aboard the *Beavertail* alongside the dock in Jamestown, RI.
8/16/2006	Transit	*Beavertail* begin transit from Jamestown to Sandy Hook, NJ.
8/17/2006	Transit / Mob	*Beavertail* completes transit to Atlantic Highlands Marina; USCGS Sandy Hook is unavailable due to new ship arrivals
8/18/2006	Sub-bottom	Begin Sub-bottom Profiling in the HARS; problem with sub-bottom transceiver requires lease of back-up system
8/19/2006	Weather	*Beavertail* alongside Atlantic Highlands Marina due to large southerly seas
8/20/2006	Mob	*Beavertail* alongside Atlantic Highlands Marina and mobilizing for SPI operations
8/21/2006	SP / PV Imaging	Begin sediment-profile and plan-view imaging operations at the HARS; *Beavertail* begins docking at USCGS Sandy Hook
8/22/2006	SP / PV Imaging	Complete sediment-profile and plan-view imaging operations at the HARS
8/23/2006	SP / PV Imaging	Begin sediment-profile and plan-view imaging operations at the ERDC grab sample stations
8/24/2006	SP / PV Imaging	Complete sediment-profile and plan-view imaging operations at the ERDC grab sample stations
8/25/2006	Grab Sampling	Begin ERDC grab sampling operations in the HARS uncapped and reference stations
8/26/2006	Weather	*Beavertail* alongside at USCGS Sandy Hook due to large easterly seas
8/27/2006	Weather	*Beavertail* alongside at USCGS Sandy Hook due to large easterly seas
8/28/2006	Weather	*Beavertail* alongside at USCGS Sandy Hook due to large easterly seas
8/29/2006	Weather	*Beavertail* alongside at USCGS Sandy Hook due to large easterly seas; leased ChirpII arrives from Houston, TX
8/30/2006	Sub-bottom	Resume sub-bottom profiling operations with a leased Benthos ChirpII system; sea conditions / data were marginal
8/31/2006	Sub-bottom / Weather	Continue sub-bottom profiling operations; work suspended due to rough seas and poor data quality
9/1/2006 - 9/4/2006	Off	Due to an extended poor weather forecast due to the passage of Tropical Storm Ernesto we moved the *Beavertail* to the USACE facility at Caven Point and took all personnel off the project. No project costs were accrued during this period.
9/5/2006	Transit / Mob	*Beavertail* and SAIC crew return to Caven Point, transit back to USCGS Sandy Hook, and mobilize for sub-bottom operations
9/6/2006	Sub-bottom	Complete sub-bottom profiling operations at the HARS over the capped mounds and other areas of interest
9/7/2006	Grab Sampling	Continue ERDC grab sampling operations in the HARS over capped areas and southern reference stations
9/8/2006	Grab Sampling	Continue ERDC grab sampling operations at the northern reference stations and the Sewage Sludge Site
9/9/2006	Grab Sampling	Complete ERDC grab sampling operations at the eastern reference stations and the Acid Waste Site
9/10/2006	Transit	*Beavertail* begins transit from Caven Point back to Jamestown, RI
9/11/2006	Transit	*Beavertail* completes transit back to Jamestown, RI
9/12/2006	Demob	Offload sampling gear from the *Beavertail* alongside the dock in Jamestown, RI

Table 2.1-2. Coordinates and survey history of the stations sampled during the Sumer 2006 SPI survey at the HARS

Station	Easting	Northing	Latitude (NAD83)	Longitude (NAD83)	Survey History
4	1017151	93470.44	40.42316701	-73.88183299	Battelle 1994, SAIC 2002, 2005, 2006
7	1016643	91769.47	40.41850001	-73.88366701	Battelle 1994, SAIC 2002, 2005, 2006
11	1017621	89341.86	40.41183301	-73.88016702	Battelle 1994, SAIC 2002, 2005, 2006
13	1022497	87831.25	40.407667	-73.86266699	Battelle 1994, SAIC 2002, 2005, 2006
14	1029000	85170.38	40.400333	-73.839333	Battelle 1994, SAIC 2002, 2005, 2006
15	1032018	85054.78	40.39999999	-73.82849999	Battelle 1994, SAIC 2002, 2005, 2006
16	1023711	83582.65	40.396	-73.85833302	Battelle 1994, SAIC 2002, 2005, 2006
17	1027100	83224.05	40.39500001	-73.84616599	Battelle 1994, SAIC 2002, 2005, 2006
18	1030720	83777.15	40.39649999	-73.83316702	Battelle 1994, SAIC 2002, 2005, 2006
19	1017585	82177.07	40.392167	-73.88033302	Battelle 1994, SAIC 2002, 2005, 2006
20	1021856	81758.12	40.39100001	-73.86500001	Battelle 1994, SAIC 2002, 2005, 2006
24	1023904	78968.11	40.38333301	-73.85766701	Battelle 1994, SAIC 2002, 2005, 2006
25	1026550	79276.39	40.38416699	-73.84816701	Battelle 1994, SAIC 2002, 2005, 2006
26	1029707	79282.07	40.38416699	-73.83683299	Battelle 1994, SAIC 2002, 2005, 2006
27	1031935	79771.96	40.38549999	-73.828833	Battelle 1994, SAIC 2002, 2005, 2006
28	1015548	76952.2	40.37783301	-73.88766698	Battelle 1994, SAIC 2002, 2005, 2006
29	1019961	75986.98	40.37516701	-73.87183301	Battelle 1994, SAIC 2002, 2005, 2006
30	1029898	76489.18	40.3765	-73.83616702	Battelle 1994, SAIC 2002, 2005, 2006
34	1018946	71491.98	40.362833	-73.87549999	Battelle 1994, SAIC 2002, 2005, 2006
36	1028334	68410.4	40.35433299	-73.84183301	Battelle 1994, SAIC 2002, 2005, 2006
G1200	1016401	87171.41	40.40587999	-73.88456001	Battelle 1994, SAIC 2002, 2005, 2006
H2000	1019012	85863.44	40.40228	-73.87519001	Battelle 1994, SAIC 2002, 2005, 2006
I1200	1016404	84548.31	40.39868001	-73.88456	Battelle 1994, SAIC 2002, 2005, 2006
K0800	1015104	81919.87	40.39146999	-73.88924001	Battelle 1994, SAIC 2002, 2005, 2006
L1200	1016409	80610	40.38786999	-73.88456	Battelle 1994, SAIC 2002, 2005, 2006
L2400	1020323	80615.48	40.38787001	-73.87051001	Battelle 1994, SAIC 2002, 2005, 2006
M1200	1016411	79298.45	40.38426999	-73.88456	Battelle 1994, SAIC 2002, 2005, 2006
M2800	1021632	79305.89	40.38427	-73.86582002	Battelle 1994, SAIC 2002, 2005, 2006
N2000	1019023	77990.48	40.38067	-73.87519	Battelle 1994, SAIC 2002, 2005, 2006
P2800	1021638	75367.59	40.37346	-73.86581999	Battelle 1994, SAIC 2002, 2005, 2006
Q2400	1020333	74054.07	40.36985999	-73.87051	Battelle 1994, SAIC 2002, 2005, 2006
N3200	1022964	77966.54	40.38058801	-73.861046	Battelle 1994, SAIC 2002, 2005, 2006
P3200	1022982	75335.81	40.37336701	-73.86099601	Battelle 1994, SAIC 2002, 2005, 2006
A1	1012868	92007.75	40.419167	-73.89722199	SAIC 2006
A2	1012721	85732.87	40.40194399	-73.89777801	SAIC 2006
A3	1014055	69846.08	40.35833301	-73.89305601	SAIC 2006
A4	1012645	78102.45	40.381	-73.89808301	SAIC 2006
A5	1014592	74704.59	40.371667	-73.891111	SAIC 2006
A6	1034941	78098.14	40.38088901	-73.81805602	SAIC 2006
A7	1027417	87717.78	40.407333	-73.84499999	SAIC 2006
A8	1031182	89374.38	40.41186101	-73.83147199	SAIC 2006
A9	1026188	82645.74	40.393417	-73.84944399	SAIC 2006
A10	1023981	92994.6	40.421833	-73.85730599	SAIC 2006
A11	1033386	73884.86	40.36933299	-73.82366701	SAIC 2006
A12	1032947	91345.18	40.41726101	-73.82511701	SAIC 2006
A13	1026913	94017.83	40.42462799	-73.84676901	SAIC 2006
A14	1034150	93559.77	40.42333301	-73.82078298	SAIC 2006
A15	1031808	93443.97	40.423028	-73.829194	SAIC 2006
A16	1015010	88108.84	40.408458	-73.889547	SAIC 2006
A17	1014949	92000.08	40.419139	-73.88975	SAIC 2006
97004	1026514	72983.78	40.366895	-73.84833401	SAIC 2005, 2006
97006	1027814	73900.15	40.369404	-73.843663	SAIC 2005, 2006
97007	1030264	82598.8	40.39326799	-73.83481301	SAIC 2005, 2006
20031	1014475	85065.36	40.40010599	-73.89148199	SAIC 2005, 2006
20028	1020079	82849.5	40.39400301	-73.871374	SAIC 2005, 2006
20051	1020423	89084.27	40.41111501	-73.87010701	SAIC 2005, 2006
20041	1017626	77164.8	40.378409	-73.880208	SAIC 2005, 2006
20061	1019455	87911.3	40.40789929	-73.87358824	SAIC 2006
20062	1019764	90385.64	40.4146897	-73.87246469	SAIC 2006
20063	1014754	86364.85	40.40367192	-73.89047593	SAIC 2006
20064	1016981	83519.36	40.39585361	-73.88249397	SAIC 2006
HARS_C1_1	1016950	90690.92	40.41553845	-73.88257068	ERDC 2006
HARS_C2_1	1016879	85344.58	40.40086391	-73.8828514	ERDC 2006
HARS_C3_1	1016887	80047.72	40.38632488	-73.88284657	ERDC 2006
HARS_C4_1	1016832	74754.85	40.37179703	-73.88306996	ERDC 2006
HARS_C5_1	1023610	74236.54	40.37034694	-73.85875015	ERDC 2006
HARS_UC1_1	1024309	90688.88	40.41550272	-73.85614461	ERDC 2006
HARS_UC2_1	1024246	85111.85	40.40019501	-73.85640376	ERDC 2006
HARS_UC3_1	1030662	90441.66	40.41479324	-73.83333162	ERDC 2006
HARS_UC4_1	1030947	84982.57	40.39980747	-73.83234278	ERDC 2006
HARS_UC5_1	1030961	79544.43	40.38488063	-73.83233207	ERDC 2006
HARS_UC6_1	1030957	74176.28	40.37014598	-73.83238287	ERDC 2006

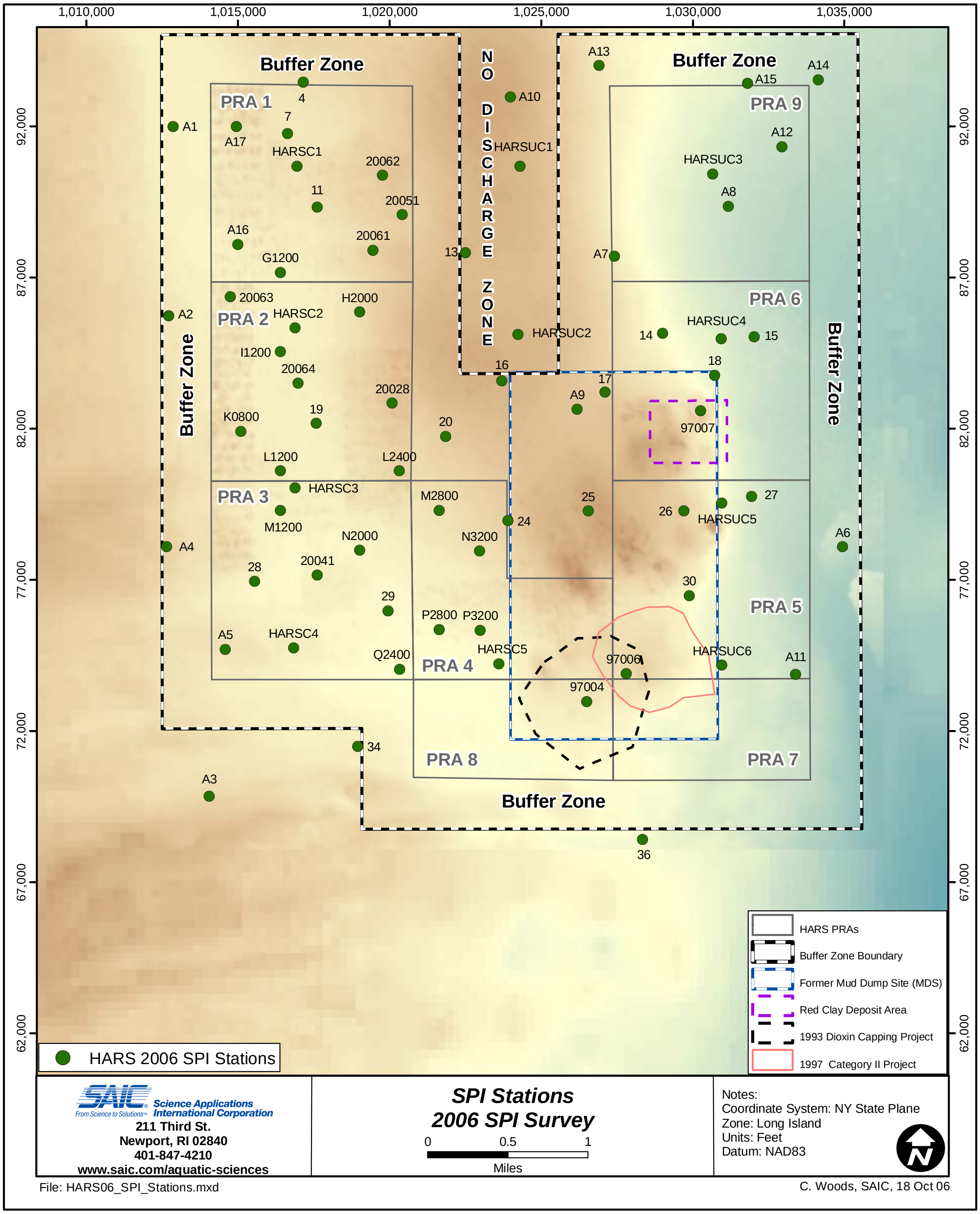


Figure 2.1-1. Locations of the stations in and around the HARS where sediment-profile/plan-view images were collected in the 2006 survey

2.2 Navigation and Positioning

Differentially corrected Global Positioning System (DGPS) data in conjunction with Coastal Oceanographic's HYPACKMax® navigation and survey control software were used to provide real-time vessel navigation to an accuracy of ±3 m for this survey. A Trimble DSMPro® GPS receiver was used to obtain raw satellite data and provide vessel position information in the horizontal control of North American Datum of 1983 (NAD 83). The DSMPro® GPS unit contains an integrated differential beacon receiver to improve overall accuracy of the satellite data to the necessary tolerances. The U.S. Coast Guard differential beacon broadcasting from Sandy Hook, NJ was utilized for real-time satellite corrections due to its proximity to the survey area.

The DGPS data were ported to HYPACKMax® data acquisition software for position logging and real-time helmsman display. The target stations were determined prior to the commencement of survey operations and stored in a project database. Throughout the survey, individual stations were selected and then displayed within HYPACKMax® to facilitate positioning of the survey vessel over the targeted sampling location. For each sampling event, the station ID, the geographic position, a Universal Time Coordinate (UTC) time stamp, and a text description were logged both electronically and manually. These data were used to conduct a daily review of sample quality and progress while still in the field, and also to enable rapid input into the project Geographic Information System (GIS) database. Both electronic and manual field logs were maintained throughout the field operations to provide an accurate record of sampling times, positions, and field observations.

2.3 Sediment-Profile and Sediment Plan-View Imaging

During the sediment-profile and plan-view survey operations, at least two replicate sediment-profile images and one plan-view image were collected at each of the 61 stations (Table 2.1-1; Figure 2.1-1). The survey was conducted using a camera frame configured with an Ocean Imaging Systems Model 3731-D digital sediment-profile camera system and a Photoseas 35-mm film-based, plan-view camera system (Figure 2.3-1).

2.3.1 Sediment-Profile Image Acquisition

A detailed description of sediment-profile imaging and the concepts underlying image interpretation are provided in Rhoads and Germano (1982 and 1986). The sediment-profile image camera is designed to obtain *in-situ* profile images of the top (20 cm) of seafloor sediment. Functioning like an inverted periscope, the camera consists of a wedge-shaped prism with a front face-plate and a back mirror mounted at a 45-degree angle to reflect the profile of the sediment-water interface facing the camera. The prism is filled with distilled water, the assembly contains an internal strobe used to illuminate the images, and a 6-megapixel digital camera (Nikon D-70) is mounted in a water-tight housing horizontally on top of the prism. The prism assembly is moved up and down into the sediments by producing tension or slack on the winch wire. Tension on the wire keeps the prism in the up position, out of the sediment.

The camera frame is lowered to the seafloor at a rate of approximately 1 m/sec (Figure 2.3-1). When the frame settles onto the seafloor, slack on the winch wire allows the prism to penetrate

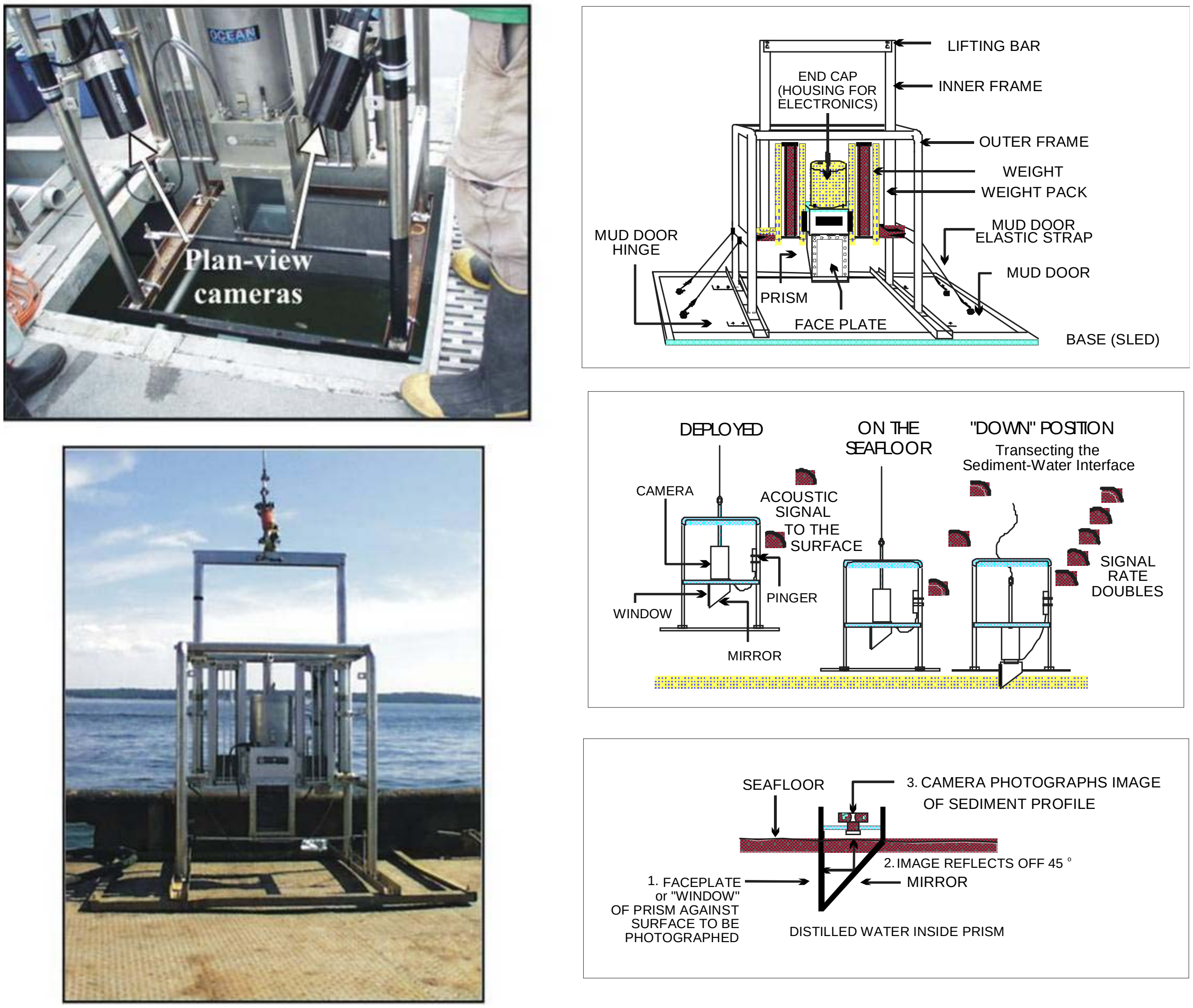


Figure 2.3-1. Schematic diagram of Benthos, Inc. Model 3731 REMOTS® (and Ocean Imaging Systems digital head) sediment-profile camera and sequence of operation on deployment. The image in the upper left shows the sediment-profile camera with plan-view camera attached.

the seafloor vertically. A passive hydraulic piston ensures that the prism enters the bottom slowly (approximately 6 cm/sec) and does not disturb the sediment-water interface. As the prism starts to penetrate the seafloor, a trigger activates a 13-second time delay on the shutter release to allow maximum penetration before an image is acquired. Because the sediment image acquired is directly against the face plate, turbidity of the ambient seawater does not affect image quality. When the camera is raised, a wiper blade cleans off the faceplate, the strobe is recharged, and the camera can be lowered for another replicate image. At least two replicate sediment-profile images were obtained at each station.

The digital sediment-profile camera system allows a rapid assessment of image quality once the camera frame has been brought aboard the sampling vessel. During the early stages of these sampling operations, the images were viewed more frequently to ensure that the camera and frame settings were suitable for the seafloor conditions. After the camera settings were confirmed and there were no problems obtaining two to three replicate images at each station, the camera was typically downloaded after acquiring around 60 images (or visiting approximately 20 stations). The digital images were stored directly on the cameras micro-drive, downloaded periodically onto a personal computer, and then backed-up daily on to a CD-ROM.

2.3.2 Sediment-Profile Image Analysis

The high-resolution digital sediment-profile images were easily imported directly into the image analysis system. SAIC's in-house computer-based image-processing system consists of a Visual Basic customized interface, with information stored in a Microsoft Access database, to consistently characterize the images and to catalogue all relevant quantitative and qualitative results. Analysis of each sediment-profile image yielded 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 (a measure of sediment aeration), infaunal successional stage, and Organism-Sediment Index (a summary parameter reflecting overall benthic habitat quality). Summaries of the standard sediment-profile measurement parameters presented in this report are presented in the subsections below.

Automatic database storage of all measured parameters allowed data from variables of interest to be compiled, sorted, displayed graphically, contoured, or compared statistically. Following the initial analysis of the sediment-profile images, the measurements were subjected to an independent QA/QC review by a Senior Scientist before the dataset was considered final. The final sediment-profile data were used in preparing the statistical analyses, summary tables, and maps that appear in this report. All of the analyzed sediment-profile and plan-view image data were retained in pre-formatted spreadsheets and incorporated into the project GIS and data management system.

2.3.2.1 Sediment Type Determination

The sediment grain-size major mode and range are estimated visually from the photographs by overlaying a grain-size comparator of the same scale. This comparator was prepared by photographing a series of Udden-Wentworth size classes (equal to or less than coarse silt up to granule and larger sizes) through the sediment-profile camera. Seven grain-size classes are on this comparator: finer than 4 phi, 4 to 3 phi, 3 to 2 phi, 2 to 1 phi, 1 to 0 phi, 0 to –1 phi, and coarser than -1 phi.

Table 2.3-1 is provided to allow conversion of phi units to other commonly used grain-size scales. The lower limit of optical resolution of the photographic system is about 62 microns (4 phi), allowing recognition of grain sizes equal to or greater than coarse silt. The accuracy of this method has been documented by comparing sediment-profile image estimates with grain-size statistics determined from laboratory sieve analyses.

The major modal grain size that is assigned to an image is the dominant grain size as estimated by area within the imaged sediment column. In those images that show layering of sand and mud, the dominant major mode that is assigned depends on how much of the image area is represented by sand versus mud. These textural assignments may or may not correspond to traditional sieve analyses depending on how closely the vertical sampling intervals are matched between the grab or core sample and the depth of the imaged sediment. Layering is noted as a comment accompanying the sediment-profile image data file.

2.3.2.2 Benthic Habitat Classification

Based on extensive past sediment-profile survey experience in coastal New England and the middle Atlantic Bight, five basic benthic habitat types have been found to exist in shallow-water estuarine and open-water nearshore environments: AM = Ampelisca mat, SH = shell bed, SA = hard sand bottom, HR = hard rock/gravel bottom, and UN = unconsolidated soft bottom (Table 2.3-2). Several sub-habitat types exist within these major categories (Table 2.3-2). Each of the sediment-profile images obtained in the present study was assigned one of the habitat categories listed in Table 2.3-2.

2.3.2.3 Mud Clasts

When fine-grained, cohesive sediments are disturbed, either by physical bottom scour or faunal activity (e.g., decapod foraging), intact clumps of sediment are often scattered about the seafloor. These mud clasts can be seen at the sediment-water interface in sediment-profile images. During image analysis, the number of clasts is counted, the diameter of a typical clast is measured, and their oxidation state is assessed. Depending on their place of origin and the depth of disturbance of the sediment column, mud clasts can be reduced or oxidized. Also, once at the sediment-water interface, these sediment clumps are subject to bottom-water oxygen levels and bottom currents. Based on laboratory microcosm observations of reduced sediments placed within an aerobic environment, oxidation of reduced surface layers by diffusion alone is quite rapid, occurring within 6–12 hours (Germano 1983). Consequently, the detection of reduced mud clasts in an obviously aerobic setting suggests a recent origin. The size and shape of mud clasts, e.g., angular versus rounded, are also considered. Mud clasts may be moved about and broken by bottom currents and/or animals (macro- or meiofauna; Germano 1983). Over time, large angular clasts become small and rounded. Overall, the abundance, distribution, oxidation state, and angularity of mud clasts are used to make inferences about the recent pattern of seafloor disturbance in an area.

Table 2.3-1. Sediment grain size scales

ASTM (Unified) Classification [1]	U.S. Std. Mesh [2]	Size in mm	PHI Size	Wentworth Classification [3]
Boulder		4096.	-12.0	
		1024.	-10.0	Boulder
	12 in (300 mm)	256.	-8.0	Large Cobble
		128.	-7.0	
Cobble		107.64	-6.75	
		90.51	-6.5	Small Cobble
	3 in. (75 mm)	76.11	-6.25	
		64.00	-6.0	
		53.82	-5.75	
		45.26	-5.5	Very Large Pebble
Coarse Gravel		38.05	-5.25	
		32.00	-5.0	
		26.91	-4.75	
		22.63	-4.5	Large Pebble
	3/4 in (19 mm)	19.03	-4.25	
		16.00	-4.0	
		13.45	-3.75	
		11.31	-3.5	Medium Pebble
Fine Gravel		9.51	-3.25	
	2.5	8.00	-3.0	
	3	6.73	-2.75	
	3.5	5.66	-2.5	Small Pebble
	4	4.76	-2.25	
	5	4.00	-2.0	
Coarse Sand	6	3.36	-1.75	
	7	2.83	-1.5	Granule
	8	2.38	-1.25	
	10	2.00	-1.0	
	12	1.68	-0.75	
	14	1.41	-0.5	Very Coarse Sand
	16	1.19	-0.25	
Medium Sand	18	1.00	0.0	
	20	0.84	0.25	
	25	0.71	0.5	Coarse Sand
	30	0.59	0.75	
	35	0.50	1.0	
	40	0.420	1.25	
	45	0.354	1.5	Medium Sand
	50	0.297	1.75	
	60	0.250	2.0	
	70	0.210	2.25	
Fine Sand	80	0.177	2.5	Fine Sand
	100	0.149	2.75	
	120	0.125	3.0	
	140	0.105	3.25	
	170	0.088	3.5	Very Fine Sand
	200	0.074	3.75	
	230	0.0625	4.0	
Fine-grained Soil:	270	0.0526	4.25	
	325	0.0442	4.5	Coarse Silt
Clay if PI > 4	400	0.0372	4.75	
Silt if PI < 4		0.0312	5.0	Medium Silt
		0.0156	6.0	Fine Silt
		0.0078	7.0	Very Fine Silt
		0.0039	8.0	Coarse Clay
		0.00195	9.0	Medium Clay
		0.00098	10.0	Fine Clay
		0.00049	11.0	
		0.00024	12.0	
		0.00012	13.0	
		0.000061	14.0	

1. ASTM Standard D 2487-92. This is the ASTM version of the Unified Soil Classification System. Both systems are similar (from ASTM (1993)).
2. Note that British Standard, French, and German DIN mesh sizes and classifications are different.
3. Wentworth sizes classes are based on the Phi scale ($-\log_2$ mm) cited in Krumbein and Sloss (1963).

Source: U.S. Army Corps of Engineers. (1995). Engineering and Design Coastal Geology, "Engineer Manual 1110-2-1810, Washington, D.C.

Table 2.3-2. Benthic habitat categories (Diaz, 1995)

Habitat AM: *Ampelisca* Mat Uniformly fine-grained (i.e., silty) sediments having well-formed amphipod (*Ampelisca* spp.) tube mats at the sediment-water interface.
Habitat SH: Shell Bed A layer of dead shells and shell fragments at the sediment surface overlying sediment ranging from hard sand to silts. Epifauna (e.g., bryozoans, tube-building polychaetes) commonly found attached to or living among the shells. Two distinct shell bed habitats: **SH.SI: Shell Bed over silty sediment -** shell layer overlying sediments ranging from fine sands to silts to silt-clay. **SH.SA: Shell Bed over sandy sediment -** shell layer overlying sediments ranging from fine to coarse sand.
Habitat SA: Hard Sand Bottom Homogeneous hard sandy sediments, do not appear to be bioturbated, bedforms common, successional stage mostly indeterminate because of low prism penetration. **SA.F: Fine sand -** uniform fine sand sediments (grain size: 4 to 3 phi). **SA.M: Medium sand -** uniform medium sand sediments (grain size: 3 to 2 phi). **SA.G: Medium sand with gravel -** predominately medium to coarse sand with a minor gravel fraction.
Habitat HR: Hard Rock/Gravel Bottom Hard bottom consisting of pebbles, cobbles and/or boulders, resulting in no or minimal penetration of the REMOTS camera prism. Some images showed pebbles overlying silty-sediments. The hard rock surfaces typically were covered with epifauna (e.g., bryozoans, sponges, tunicates).
Habitat UN: Unconsolidated Soft Bottom Fine-grained sediments ranging from very fine sand to silt-clay, with a complete range of successional stages (I, II and III). Biogenic features were common (e.g., amphipod and polychaete tubes at the sediment surface, small surface pits and mounds, large burrow openings, and feeding voids at depth). Several sub-categories: **UN.SS: Fine Sand/Silty -** very fine sand mixed with silt (grain size range from 4 to 2 phi), with little or no shell hash. **UN.SI: Silty -** homogeneous soft silty sediments (grain size range from >4 to 3 phi), with little or no shell hash. Generally deep prism penetration. **UN.SF: Very Soft Mud -** very soft muddy sediments (>4 phi) of high apparent water content, methane gas bubbles present in some images, deep prism penetration.

2.3.2.4 Sedimentary Methane

At extreme levels of organic-loading, pore-water sulfate is depleted, and methanogenesis occurs. The process of methanogenesis is detected by the appearance of methane bubbles in the sediment column. These gas-filled voids are readily discernable in sediment-profile images because of their irregular, generally circular aspect and glassy texture (due to the reflection of the strobe off the gas). If present, the number and total areal coverage of all methane pockets are measured.

2.3.2.5 Measurement of Dredged Material and Cap Layers

The recognition of dredged material from sediment-profile images is usually based on the presence of anomalous sedimentary materials within an area of ambient sediment. The ability to distinguish between ambient sediment and dredged or cap material demands that the survey extend well beyond the margins of a disposal site so that an accurate characterization of the ambient bottom is obtained. The distributional anomalies may be manifested in topographic roughness, differences in grain size, sorting, shell content, optical reflectance, fabric, or sediment compaction (i.e., camera prism penetration depth). Second-order anomalies may also provide information about the effects of dredged material on the benthos and benthic processes such as bioturbation (see following sections).

2.3.2.6 Boundary Roughness

Small-scale boundary roughness is measured from an image with the computer image analysis system. This vertical measurement is from the highest point at the sediment-water interface to the lowest point. This measurement of vertical relief is made within a horizontal distance of 15 cm (the total width of the optical window). Because the optical window is 20 cm high, the greatest possible roughness value is 20 cm. The source of the roughness is described if known. In most cases this is either biogenic (mounds and depressions formed by bioturbation or foraging activity) or relief formed by physical processes (ripples, scour depressions, rip-ups, mud clasts, etc.).

2.3.2.7 Optical Prism Penetration Depth

The optical prism of the sediment-profile camera penetrates the bottom under a static driving force imparted by its weight. The penetration depth into the bottom depends on the force exerted by the optical prism and the bearing strength of the sediment. If the weight of the camera prism is held constant, the change in penetration depth over a surveyed region will reflect horizontal variability in geotechnical properties of the seafloor. In this sense, the camera prism acts as a static-load penetrometer. The depth of penetration of the optical prism into the bottom can be a useful parameter, because dredged and capped materials often have different shear strengths and bearing capacities.

2.3.2.8 Infaunal Successional Stage

Determination of the infaunal successional stage applies only to soft-bottom habitats, where the sediment-profile camera is able to penetrate into the sediment. In hard bottom environments (i.e., rocky substrates), camera penetration is prevented and the standard suite of sediment-profile measurements cannot be made. In such instances, the infaunal successional stage is considered to be “indeterminate.” Hard bottom areas can support abundant and diverse epibenthic communities and therefore may represent habitat which is biologically productive or otherwise is of value as refuge or living space for organisms. However, the value of hard bottom habitats is not reflected in the sediment-profile successional stage designation.

The mapping of infaunal successional stages is based on the theory that organism-sediment interactions in marine soft-bottom habitats follow a predictable sequence after a major seafloor perturbation (e.g., passage of a storm, disturbance by bottom trawlers, dredged material deposition, hypoxia). The theory states that primary succession results in "the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance. These invertebrates interact with sediment in specific ways. Because functional types are the biological units of interest, our definition does not demand a sequential appearance of particular invertebrate species or genera" (Rhoads and Boyer 1982). This theory is formally developed in Rhoads and Germano (1982) and Rhoads and Boyer (1982).

Benthic disturbance can result from natural processes, such as seafloor erosion, changes in seafloor chemistry, and predator foraging, as well as from human activities like dredged material or sewage sludge disposal, thermal effluent from power plants, bottom trawling, pollution from industrial discharge, and excessive organic loading. Evaluation of successional stages involves deducing dynamics from structure, a technique pioneered by R. G. Johnson (1972) for marine soft-bottom habitats. The application of this approach to benthic monitoring requires *in-situ* measurements of salient structural features of organism-sediment relationships as imaged through sediment-profile technology.

Pioneering assemblages (Stage I assemblages) usually consist of dense aggregations of near-surface living, tube-dwelling polychaetes (Figure 2.3-2); alternately, opportunistic bivalves may colonize in dense aggregations after a disturbance (Rhoads and Germano 1982, Santos and Simon 1980a). These functional types are usually associated with a shallow redox boundary; and bioturbation depths are shallow, particularly in the earliest stages of colonization (Figure 2.3-2). In the absence of further disturbance, these early successional assemblages are eventually replaced by infaunal deposit feeders; the start of this "infaunalization" process is designated arbitrarily as Stage II. Typical Stage II species are shallow dwelling bivalves or, as is common in New England waters, tubicolous amphipods. In studies of hypoxia-induced benthic defaunation events in Tampa Bay, Florida, Ampeliscid amphipods appeared as the second temporal dominant in two of the four recolonization cycles (Santos and Simon 1980a, 1980b).

Stage III taxa, in turn, represent high-order successional stages typically found in low-disturbance regimes. These invertebrates are infaunal, and many feed at depth in a head-down orientation. The localized feeding activity results in distinctive excavations called feeding voids (Figure 2.3-2). Diagnostic features of these feeding structures include a generally semicircular shape with a flat bottom and arched roof, and a distinct granulometric change in the sediment particles overlying the floor of the structure. This granulometric change is caused by the accumulation of coarse particles that are rejected by the animals feeding selectively on fine-grained material. Other subsurface structures, such as burrows or methane gas bubbles, do not exhibit these characteristics and therefore are quite distinguishable from these distinctive feeding structures. The bioturbational activities of these deposit-feeders are responsible for aerating the

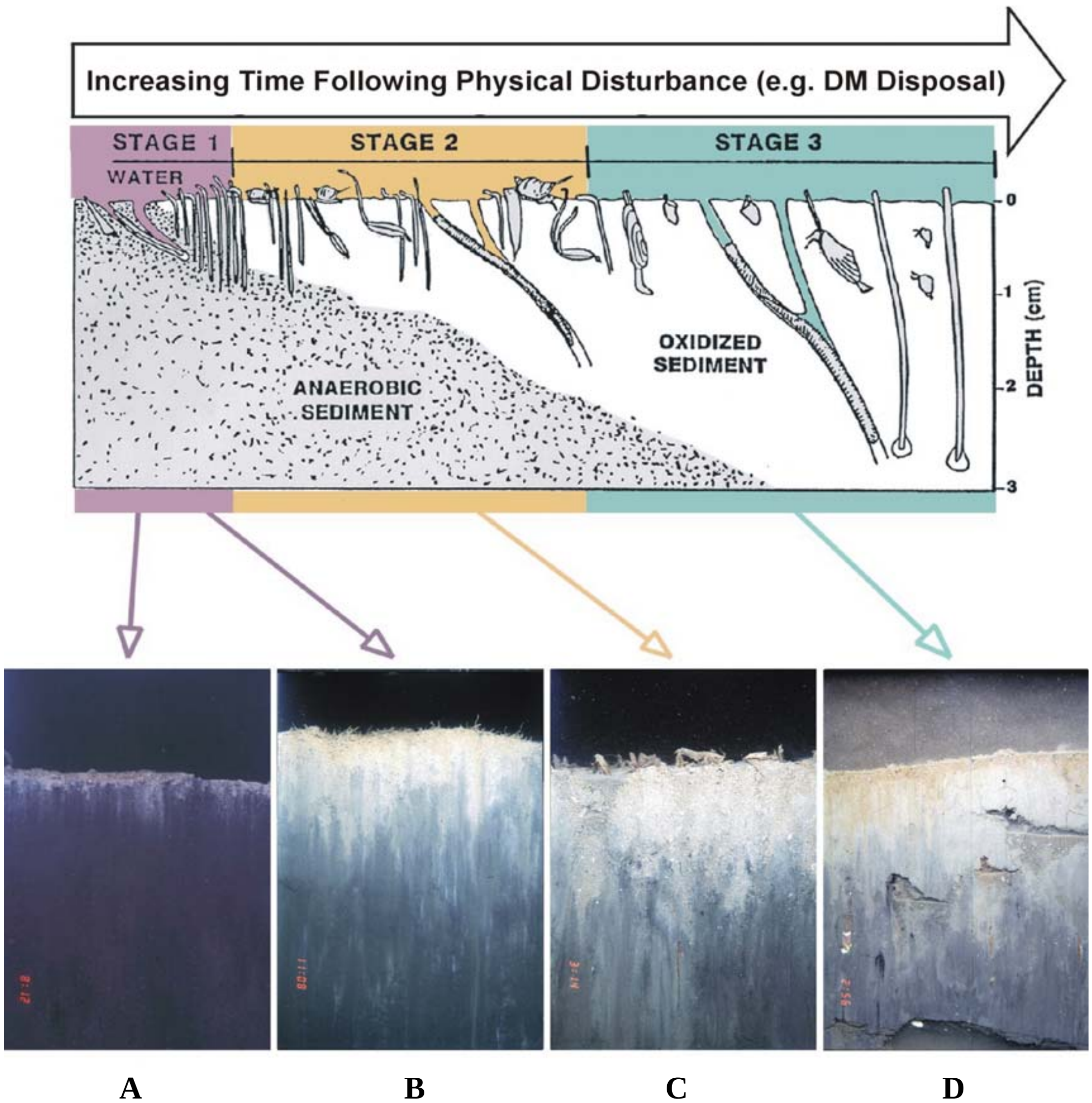


Figure 2.3-2. Schematic illustration of infaunal successional stages over time following a physical disturbance and a representative sediment-profile image for each stage (illustration modified from Rhoads snd Germano 1982). Image A shows highly reduced sediment with a very shallow redox layer (contrast between light-colored surface sediments and dark underlying sediments) and little evidence of infauna. Numerous small polychaete tubes are visible at the sediment surface in image B (Stage I), and the redox depth is deeper than in image A. A mixture of polychaete and amphipod tubes occurs at the sediment surface in image C (Stage II). Image D shows numerous burrow openings and feeding pockets (voids) at depth within the sediment; these are evidence of deposit-feeding, Stage III infauna. Note the apparent RPD is relatively deep in this image, as bioturbation by the Stage III organisms has resulted in increased sediment aeration, causing the redox horizon to be located several centimeters below the sediment-water interface.

sediment. In the retrograde transition of Stage III to Stage I, it is sometimes possible to recognize the presence of relict (i.e., collapsed and inactive) feeding voids.

The end-member stages (Stages I and III) are easily recognized in sediment-profile images by the presence of dense assemblages of near-surface polychaetes (Stage I) or the presence of subsurface feeding voids (Stage III; Figure 2.3-2). The presence of tubicolous amphipods at the sediment surface is indicative of Stage II. It is possible for Stage I polychaetes or Stage II tubicolous amphipods to be present at the sediment surface, while at the same time, Stage III organisms are present at depth within the sediment. In such instances, where two types of assemblages are visible in a sediment-profile image, the image is designated as having either a Stage I on Stage III (I–III) or Stage II on Stage III (II–III) successional stage. Additional information on sediment-profile image interpretation can be found in Rhoads and Germano (1982, 1986).

2.3.2.9 Apparent RPD Depth

Aerobic near-surface marine sediments typically have higher reflectance values relative to underlying anoxic sediments. Sand also has higher optical reflectance than mud. These differences in optical reflectance are readily apparent in sediment-profile images; the oxidized surface sediment contains particles coated with oxidized iron compounds (an olive color when associated with particles), while reduced and muddy sediments below this oxygenated layer are darker, generally gray to black, due to reduced iron compounds. The boundary between the lighter-colored oxidized surface sediment and underlying gray to black reduced sediment is called the apparent redox potential discontinuity (RPD).

The depth of the apparent RPD in the sediment column is an important time-integrator of dissolved oxygen conditions within sediment pore waters. In the absence of bioturbating organisms, this high reflectance layer (in muds) will typically reach a thickness of 2 mm (Rhoads 1974). This depth is related to the supply rate of molecular oxygen by diffusion into the bottom and the consumption of that oxygen by the sediment and associated microflora. In sediments that have very high sediment-oxygen demand, the sediment may lack a high reflectance layer even when the overlying water column is aerobic.

In the presence of bioturbating macrofauna, the thickness of the high reflectance layer may be several centimeters. The relationship between the thickness of this high reflectance layer and the presence or absence of free molecular oxygen in the associated pore waters must be made with caution. The boundary (or horizon) which separates the positive Eh region (oxidized) from the underlying negative Eh region (reduced) can only be determined accurately with microelectrodes. For this reason, we describe the optical reflectance boundary, as imaged, as the "apparent" RPD, and it is mapped as a mean value.

The depression of the apparent RPD within the sediment is relatively slow in organic-rich muds (on the order of 200 to 300 micrometers per day); therefore, this parameter has a long time-constant (Germano and Rhoads 1984). The rebound in the apparent RPD is also slow (Germano 1983). Measurable changes in the apparent RPD depth using the sediment-profile image optical technique can be detected over periods of one or two months. This parameter is used effectively to document changes (or gradients), which develop over a seasonal or yearly cycle related to water temperature effects on bioturbation rates, seasonal hypoxia, sediment oxygen demand, and infaunal recruitment. In sediment-profile surveys of ocean disposal sites sampled seasonally or on an annual basis throughout the New England region performed under the DAMOS (Disposal Area Monitoring System) Program for the USACE, New England Division, SAIC repeatedly has documented a drastic reduction in apparent RPD depths at disposal sites immediately after dredged material disposal, followed by a progressive post-disposal apparent RPD deepening (barring further physical disturbance). Consequently, time-series RPD measurements can be a critical diagnostic element in monitoring the degree of recolonization in an area by the ambient benthos.

The depth of the mean apparent RPD also can be affected by local erosion. The peaks of disposal mounds commonly are scoured by divergent flow over the mound. This can result in washing away of fines, development of shell or gravel lag deposits, and very thin apparent RPD depths. During storm periods, erosion may completely remove any evidence of the apparent RPD (Fredette et al. 1988).

Another important characteristic of the apparent RPD is the contrast in reflectance values at this boundary. This contrast is related to the interactions among the degree of organic-loading, bioturbational activity in the sediment, and the levels of bottom-water dissolved oxygen in an area. High inputs of labile organic material increase sediment oxygen demand and, subsequently, sulfate reduction rates (and the abundance of sulfide end-products). This results in more highly reduced (lower reflectance) sediments at depth and higher RPD contrasts. In a region of generally low RPD contrasts, images with high RPD contrasts indicate localized sites of relatively high past inputs of organic-rich material (e.g., organic or phytoplankton detritus, dredged material, sewage sludge, etc.).

2.3.2.10 Organism-Sediment Index (OSI)

The multi-parameter Organism-Sediment Index (OSI) has been constructed to characterize the degree of benthic habitat disturbance or degradation based on analysis of sediment-profile images. Benthic habitat disturbance is defined relative to two end-member standards. The lowest value is given to those bottoms which have low or no dissolved oxygen in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment (see Rhoads and Germano 1982, 1986, for sediment-profile criteria for these conditions). The OSI for such a condition is –10 (highly disturbed or degraded benthic habitat conditions). At the other end of the scale, an aerobic bottom with a deeply depressed RPD, evidence of a mature macrofaunal assemblage, and no apparent methane gas bubbles at depth will have an OSI value of +11 (unstressed or undisturbed benthic habitat conditions).

The OSI is a sum of the subset indices shown in Table 2.3-3. The OSI is calculated automatically by SAIC software after completion of all measurements from each sediment-profile image. The index has proven to be an excellent parameter for mapping disturbance gradients in an area and documenting ecosystem recovery after disturbance (Germano and Rhoads 1984, Revelas et al. 1987, Valente et al. 1992).

The OSI may be subject to seasonal changes because the mean apparent RPD depths vary as a result of temperature-controlled changes of bioturbation rates and sediment oxygen demand.

Table 2.3-3. Calculation of Sediment-Profile Organism Sediment Index

A. CHOOSE ONE VALUE:

Mean aRPD Depth	Index Value
0.00 cm	0
> 0 - 0.75 cm	1
0.75 - 1.50 cm	2
1.51 - 2.25 cm	3
2.26 - 3.00 cm	4
3.01 - 3.75 cm	5
> 3.75 cm	6

B. CHOOSE ONE VALUE:

Successional Stage	Index Value
Azoic	-4
Stage I	1
Stage I to II	2
Stage II	3
Stage II to III	4
Stage III	5
Stage I on III	5
Stage II on III	5

C. CHOOSE ONE OR BOTH IF APPROPRIATE:

Chemical Parameters	Index Value
Methane Present	-2
No/Low Dissolved Oxygen**	-4

REMOTS ORGANISM-SEDIMENT INDEX = Total of above subset indices (A+B+C)

RANGE: -10 - +11

Furthermore, the successional status of a station may change over the course of a season related to recruitment and mortality patterns or the disturbance history of the bottom. The sub-annual change in successional status is generally limited to Stage I (polychaete-dominated) and Stage II (amphipod-dominated) seres. Stage III seres tend to be maintained over periods of several years unless they are eliminated by increasing organic loading, extended periods of hypoxia, or burial by thick layers of dredged material. The recovery of Stage III seres following abatement of such events may take several years (Rhoads and Germano 1982). Stations that have low or moderate OSI values (< +6) are indicative of recently disturbed areas and tend to have greater temporal and spatial variation in benthic habitat quality than stations with higher OSI values (> +6).

2.3.3 Sediment Plan-View Image Acquisition and Analysis

Plan-view (i.e., "downward-looking" or horizontal sediment surface plane) photographs of approximately 0.3 m^2 of the seafloor surface were obtained in conjunction with the sediment-profile images at each station (Figure 2.3-1). The photographs were acquired with a PhotoSea 1000a 35-mm Underwater Camera System and a PhotoSea 1500s Strobe Light attached to the sediment-profile camera frame (Figure 2.3-1). The plan-view images were acquired immediately prior to the landing of the frame on the seafloor, providing an undisturbed record of the surface sediments before penetration of the sediment-profile camera prism. Once the camera frame was lifted above the sediments, the plan-view camera system automatically advanced the film and recharged the strobe in preparation for the next image. In this manner, a corresponding plan-view image was usually obtained for each sediment-profile image.

Towards the end of the second day of sampling operations, the plan-view camera system became entangled in the winch wire as the frame was being retrieved from the bottom and the underwater housing was damaged and flooded with seawater. The plan-view camera system was damaged beyond repair and almost a day's worth of plan-view data were lost. A back-up camera system was integrated onto the frame and used to obtain plan-view images at the remainder of the sampling stations over the final days of sampling. Due to time and budget constraints and the secondary importance of the plan-view data, there was no effort made to re-occupy those stations without plan-view images. At the end of each survey day, the exposed film was removed from the plan-view camera and processed at a local laboratory to enable an assessment of image quality while still in the field.

The plan-view photograph analysis supplemented the more detailed and comprehensive sediment-profile characterization of the seafloor. The 35-mm plan-view slides selected for analysis were manually analyzed based on established image review protocols. The plan-view analysis consisted of qualitative and quantitative descriptions of key sediment characteristics (e.g., sediment type, bedforms, and biological features) based on a manual review of the scanned 35-mm slides. The presence of shell debris and any evidence of epifaunal or infaunal organisms (e.g., tubes, burrow openings, etc.) also were recorded. Differences in the apparent brightness of the plan-view images at the same station were primarily due to small differences in the height of the camera above the seafloor at the time of each exposure. Secondary factors, such as water column turbidity, sediment composition, and possible differences in laboratory developing processes may also have contributed to observed differences in the image brightness.

2.4 Sub-bottom Profiling Data Acquisition and Analysis

The sub-bottom profiling operations included a series of east-west survey lines that were aligned over the 1993 and 1997 capped dioxin mounds, which were the main areas of interest. Sub-bottom profiling data were acquired with a Teledyne-Benthos (formerly Datasonics) ChirpII® dual-frequency, digital, sub-bottom profiling system, operating at swept frequency ranges of 2 to7 kHz and 8 to 20 kHz. The ChirpII® towfish was towed behind the survey vessel, while the ChirpII® topside data acquisition system recorded and displayed the acoustic data providing a real-time view of all of the sub-bottom data.

Sub-bottom profiling is a standard technique used for distinguishing and measuring various sediment layers that exist below the sediment/water interface. Sub-bottom systems are able to distinguish these sediment layers by measuring differences in acoustic impedance between the layers. Acoustic impedance is a function of both the density of a layer and speed of sound within that layer, and is affected by differences in grain size, roughness, and porosity. Sound energy transmitted to the seafloor is reflected off the boundaries between sediment layers of different acoustic impedance. A sub-bottom profiling system uses the energy reflected from these boundary layers to build the image. The depth of penetration and the degree of resolution of a sub-bottom system depends on the frequency and pulse width of the acoustic signal and the characteristics of the various layers encountered. The higher frequency ChirpII® signal provides greater resolution relative to the lower frequency signal, while the lower frequency signal provides greater sub-bottom penetration, particularly in areas where the initial seafloor reflector is quite hard. Because the higher frequency data provided little penetration through the surface sand cap layer, most of the subsequent analyses were focused only on the low frequency data.

During data acquisition, each sub-bottom survey line was saved into a separate file to facilitate post-processing. After data acquisition, the ChirpII® sub-bottom data were imported into both Chesapeake Technology's SonarWiz Map® and Triton-ELICS ISIS® software for reviewing, editing, and analysis. Within SonarWiz Map®, the frequency data were reviewed and time-varied gain (TVG) adjustments were made to enhance the detection of sub-bottom reflectors. In addition, any prominent sub-bottom reflectors that were detected were manually digitized to record both the location and the depth of the reflector. This process of digitizing sub-bottom reflectors using SonarWiz Map® created individual comma delimited files containing digitized points along the lane. Information in these files included the reflector name, reflector description, position (x and y) of each point, and depth (z) of each point relative to the towfish.

Upon completion of the sub-bottom reflector processing in SonarWiz Map®, the data were sorted into individual comma delimited files based on reflector type to facilitate Geographic Information System (GIS) processing. An estimate of the cap or sediment thickness was then obtained by measuring the difference (or depth) between the surface reflector and one of the detected sub-bottom reflectors. This process was completed using the ArcInfo® Grid module to generate a gridded data model for each surface based on the data set and a user-defined grid cell size. The surface model of cap thickness was then imported into ArcInfo ® for additional analysis and review, and to generate graphic products incorporating some of the other survey datasets.

During past surveys over both the 1993 and 1997 capped mounds, a speed of sound of 1711 m/s was used for computing cap thickness values from the acoustic sub-bottom profile data (SAIC 1998). When compared with an assumed speed of sound of 1500 m/s that is typically used during data acquisition, an increase to 1711 m/s leads to an apparent 14% increase in the computed cap thickness. When this 14% increase was applied to the 2002 sub-bottom results, greater differences were noted between the computed acoustic cap thickness values and the coring cap thickness results. Because it provided better overall agreement with the coring results and a more conservative estimate of cap thickness, an assumed speed of sound of 1500 m/s was used for generating the final acoustic cap thickness values in 2002 (SAIC 2003a; 2003b). For consistency with the 2002 survey, an assumed speed of sound 1500 m/s was used to process the 2006 survey data as well.

3.0 RESULTS

3.1 Sediment-Profile and Plan-View Imaging Survey

The sediment-profile and plan-view imaging results from the 2006 survey at stations located in and around the HARS are presented below. Stations located within the HARS that were associated with the ERDC sediment sampling survey are also presented in this section. A complete set of sediment-profile image analysis results are provided in Appendix A (Table A-1); these results are summarized in Table 3.1-1. Plan-view data from the 2006 survey are presented in Appendix B.

3.1.1 Dredged Material Distribution and Physical Sediment Characteristics

Similar to the previous sediment-profile surveys of July 2002 and August 2005, analysis of the sediment-profile images from the 2006 survey indicated that surface sediments within and surrounding the HARS were quite variable in composition. The different types of surface sediments observed in the images included fine-grained historic (i.e., relic) dredged material, dredged material of more recent origin (i.e., remediation material), fine sand that is considered the native sediment type on the ambient seafloor, and layering of sand over fine-grained relic or remediation dredged material (Figures 3.1-1, 3.1-2, and 3.1-3).

Placement of remediation material in PRAs 1, 2, 3, and 4 has been ongoing since designation of the HARS in September 1997. The surface sediment observed at the majority of sampling stations in PRAs 1, 2, 3, and 4 therefore consisted of different types of fine-grained remediation material, which ranged in texture from soft mud to sand (Figures 3.1-1 and 3.1-2). Rocks were detected at two stations (Stations A16 and 20063) located on the western side of PRAs 1 and 2; this coarse-grained remediation material likely is associated with the recent KVK channel deepening project.

At nine of the stations in PRAs 1 and 2, the observed remediation material consisted of clean, homogenous, light-colored fine sand that was dredged from Ambrose Channel as part of an on-going Navigation Improvement Project (Figure 3.1-4). At Station K0800 in PRA 2, Station M1200 in PRA 3, Stations P2800 and P3200 in PRA 4, and Station A2 outside PRA 2, the remediation material consisted of soft red clay (Figures 3.1-2 and 3.1-5). At the majority of stations in PRAs 1 through 4, the remediation material consisted of “conventional” soft, organic-rich, muddy dredged material (Figures 3.1-2 and 3.1-6).

Outside of the active PRAs 1 through 4, the majority of stations exhibited fine-grained relic dredged material from past disposal activities in and around the former Mud Dump Site (Figures 3.1-1 and 3.1-7). At Station 4 in PRA 1 and at Stations A9 and 17 located in the northwest quadrant of the former Mud Dump Site, a distinct stratigraphy was observed consisting of a surface layer of ambient fine sand overlying black, muddy dredged material at depth (Figures 3.1-1 and 3.1-8). Finally, fine sand was observed at Stations 97004 and 97006; this sand represents capping sand used in the 1993 Dioxin Mound and 1997 Category II Capping Projects (Figures 3.1-1 and 3.1-9).

Table 3.1-1. Summary of Sediment-Profile Imaging results for the Summer 2006 Survey over the HARS

Station	Grain Size Major Mode (# replicates)	Camera Penetration Mean (cm)	Dredged Material Thickness Mean (cm)	Number Of Reps With Dredged Material	Boundary Roughness Mean (cm)	Benthic Habitat (# replicates)	Highest Stage Present	Successional Stages Present (# replicates)	RPD Mean (cm)	OSI Mean
4	> 4 phi (2)	7.05	> 3.21	1	1.40	UN.SI (1), UN.SS (1)	ST III	ST II on III (1), ST III (1)	3.63	10.50
7	3 to 2 phi (1), 4 to 3 phi (1)	2.96	> 2.97	2	0.54	SA.F (2)	ST I	ST I (2)	2.96	5.50
11	> 4 phi (2)	15.74	> 15.75	2	1.23	UN.SI (2)	ST III	ST I on III (1), ST III (1)	1.42	7.50
13	3 to 2 phi (2)	4.34	0.00	0	1.18	SA.F (2)	ST I	ST I (2)	4.34	6.00
14	> 4 phi (2)	10.28	> 10.28	2	0.44	UN.SI (2)	ST I	ST I (2)	2.80	5.00
15	< -1 phi (1), 4 to 3 phi (1)	3.01	> 3.01	1	0.71	HR (1), UN.SS (1)	ST I	INDET (1), ST I (1)	1.85	4.00
16	3 to 2 phi (2)	2.97	0.00	0	2.37	SA.F (2)	ST I	ST I (2)	2.97	5.50
17	> 4 phi (1), 3 to 2 phi (1)	12.27	0.00	0	0.73	SA.F (1), UN.SI (1)	ST I on III	ST I (1), ST I on III (1)	4.12	8.00
18	> 4 phi (2)	7.73	> 7.73	2	0.75	UN.SI (2)	ST I on III	ST I on III (2)	1.90	8.00
19	3 to 2 phi (1), 4 to 3 phi (1)	5.81	> 5.81	2	0.46	SA.F (2)	ST II on III	ST II on III (2)	5.81	11.00
20	3 to 2 phi (2)	4.07	0.00	0	1.42	SA.F (2)	ST I	ST I (2)	4.07	6.50
24	1 to 0 phi (1), 3 to 2 phi (1)	5.04	> 2.31	1	1.60	SA.F (1), SA.G (1)	ST I	ST I (2)	5.46	7.00
25	< -1 phi (1), 0 to -1 phi (1)	0.79	> 0.79	2	1.09	HR (1), SA.G (1)	INDET	INDET (2)	INDET	INDET
26	< -1 phi (1), 3 to 2 phi (1)	4.04	> 2.07	1	0.63	SA.F (1), SA.G (1)	ST I	ST I (2)	3.94	7.00
27	> 4 phi (2)	11.10	> 11.1	2	0.35	UN.SI (2)	ST I on III	ST I on III (2)	1.29	7.00
28	> 4 phi (2)	8.21	> 8.21	2	0.82	UN.SI (2)	ST II on III	ST II on III (2)	1.90	8.00
29	> 4 phi (2)	10.40	> 10.40	2	0.60	UN.SI (2)	ST II on III	ST II on III (1), ST II to III (1)	1.88	7.50
30	4 to 3 phi (2)	6.09	> 6.09	2	2.02	UN.SS (2)	ST I on III	ST I (1), ST I on III (1)	0.81	5.00
34	3 to 2 phi (2)	4.52	0.00	0	0.46	SA.F (2)	ST I	ST I (2)	4.52	7.00
36	> 4 phi (2)	10.18	> 10.19	2	1.88	UN.SI (2)	ST II on III	ST I on III (1), ST II on III (1)	2.23	8.50
97004	3 to 2 phi (2)	4.38	0.00	0	0.89	SA.F (2)	ST II	ST 1 (1), ST II (1)	4.38	7.50
97006	3 to 2 phi (2)	2.80	0.00	0	0.98	SA.F (2)	ST II to III	ST II to III (2)	2.80	8.00
97007	> 4 phi (2)	8.02	> 8.02	2	0.89	UN.SI (2)	ST I	ST I (2)	2.93	5.50
20028	3 to 2 phi (2)	5.24	> 5.24	2	0.90	SA.F (2)	ST I	ST I (2)	5.24	6.50
20041	> 4 phi (2)	11.27	> 11.28	2	1.35	UN.SI (2)	ST I on III	ST I (1), ST I on III (1)	2.88	7.50
20051	3 to 2 phi (2)	3.18	> 3.18	2	0.73	SA.F (2)	ST I	ST I (2)	2.87	5.00
20061	3 to 2 phi (2)	5.27	> 5.27	2	1.47	SA.F (2)	ST I	ST I (2)	5.27	5.00
20062	3 to 2 phi (2)	3.42	> 3.43	2	1.18	SA.F (2)	ST I	ST I (2)	3.42	6.00
20063	< -1 phi (2)	1.33	> 1.33	2	2.65	HR (2)	INDET	INDET (2)	INDET	INDET
20064	3 to 2 phi (2)	5.88	> 5.88	2	0.21	SA.F (2)	ST II to III	ST II to III (2)	INDET	INDET
G1200	> 4 phi (2)	13.60	> 13.61	2	0.68	UN.SI (2)	ST I	ST I (2)	1.17	3.00
H2000	> 4 phi (1), 3 to 2 phi (1)	9.76	> 9.76	2	1.36	SA.F (1), UN.SI (1)	ST I	ST I (2)	2.69	5.00
I1200	> 4 phi (2)	10.91	> 10.92	2	0.62	UN.SI (2)	ST II on III	ST II on III (2)	1.88	8.00
K0800	> 4 phi (2)	11.75	> 11.75	2	0.37	UN.SF (1), UN.SI (1)	ST I on III	ST I on III (2)	3.09	10.00
L1200	3 to 2 phi (2)	4.39	> 4.39	2	1.01	SA.F (2)	ST II	ST I (1), ST II (1)	4.39	7.50
L2400	3 to 2 phi (2)	4.24	> 4.24	2	0.31	SA.F (2)	ST I	ST I (2)	4.24	7.00
M1200	> 4 phi (1)	1.07	1.07	1	2.00	UN.SI (1)	INDET	INDET (1)	1.07	INDET
M2800	> 4 phi (2)	8.32	> 8.32	2	0.61	UN.SI (2)	ST I on III	ST I on III (2)	2.87	9.00
N2000	> 4 phi (2)	9.95	> 9.95	2	0.89	UN.SI (2)	ST II on III	ST II on III (2)	1.98	8.00
N3200	> 4 phi (2)	14.36	> 14.37	2	0.80	UN.SI (2)	ST II on III	ST I on III (1), ST II on III (1)	2.28	8.50
P2800	> 4 phi (2)	10.48	> 10.48	2	1.18	UN.SI (2)	ST I on III	ST I (1), ST I on III (1)	1.74	5.50
P3200	> 4 phi (2)	9.72	> 9.72	2	2.13	UN.SI (2)	ST I on III	ST I (1), ST I on III (1)	3.49	8.00
Q2400	> 4 phi (2)	11.06	> 11.06	2	0.57	UN.SI (2)	ST II on III	ST II on III (2)	0.76	6.50
A1	> 4 phi (2)	8.47	> 8.47	2	0.70	UN.SI (2)	ST II on III	ST I on III (1), ST II on III (1)	2.45	9.00
A10	1 to 0 phi (1), N/A (1)	0.38	> 0.38	1	0.60	HR (1), SA.G (1)	ST I	INDET (1), ST I (1)	INDET	INDET
A11	< -1 phi (1)	0.00	0.00	0	0.00	HR (1)	INDET	INDET (1)	INDET	INDET
A12	> 4 phi (1), N/A (1)	4.77	> 4.62	1	0.87	HR (1), UN.SI (1)	ST I on III	INDET (1), ST I on III (1)	1.62	8.00
A13	1 to 0 phi (2)	7.88	> 7.88	2	2.32	SA.G (2)	ST I	ST I (2)	INDET	INDET
A14	> 4 phi (2)	10.10	> 10.1	2	0.93	UN.SI (2)	ST II to III	ST I to II (1), ST II to III (1)	1.65	6.00
A15	> 4 phi (2)	12.06	> 12.06	2	0.82	UN.SI (2)	ST II on III	ST I on III (1), ST II on III (1)	1.63	7.50
A16	N/A (1)	0.00	0.00	0	0.00	HR (1)	INDET	INDET (1)	INDET	INDET
A17	4 to 3 phi (2)	7.13	> 7.13	2	1.42	SA.F (1), UN.SS (1)	ST I on III	ST I on III (2)	2.40	9.00
A2	1 to 0 phi (2)	4.82	0.00	0	1.89	SA.M (2)	ST I	ST I (2)	4.82	6.50
A3	1 to 0 phi (2)	3.64	0.00	0	1.25	SA.G (2)	ST I	ST I (2)	3.64	6.50
A4	4 to 3 phi (2)	2.01	0.00	0	1.36	SA.F (2)	ST I	ST I (2)	2.01	4.00
A5	3 to 2 phi (2)	3.72	0.00	0	0.66	SA.F (2)	ST I on III	ST I (1), ST I on III (1)	3.72	8.50
A6	< -1 phi (1)	1.35	0.00	0	1.17	HR (1)	INDET	INDET (1)	INDET	INDET
A7	3 to 2 phi (2)	4.72	> 4.73	2	2.17	SA.F (1), UN.SS (1)	ST I	ST I (2)	2.89	5.50
A8	> 4 phi (2)	6.99	> 6.70	2	0.50	UN.SI (2)	ST I on III	ST I on III (2)	2.51	9.00
A9	3 to 2 phi (1), 4 to 3 phi (1)	12.03	0.00	0	1.50	UN.SS (2)	ST I on III	ST I on III (2)	5.27	11.00
HARSC1	3 to 2 phi (2)	9.36	> 9.37	2	1.49	SA.F (2)	ST I on III	ST I on III (2)	5.70	11.00
HARSC2	> 4 phi (2)	15.40	> 15.41	2	1.63	UN.SI (2)	ST I on III	ST I on III (2)	1.30	7.50
HARSC3	3 to 2 phi (2)	4.42	> 4.42	2	0.30	SA.F (2)	ST II on III	ST I on III (1), ST II on III (1)	4.42	10.50
HARSC4	3 to 2 phi (2)	3.47	0.00	0	0.75	SA.F (2)	ST I on III	ST I (1), ST I on III (1)	3.47	8.00
HARSC5	> 4 phi (2)	8.52	> 8.52	2	0.59	UN.SI (2)	ST II on III	ST I on III (1), ST II on III (1)	2.96	9.50
HARSUC1	2 to 1 phi (1), 3 to 2 phi (1)	3.24	0.00	0	1.79	SA.F (1), SA.M (1)	ST I	ST I (2)	3.24	5.50
HARSUC2	3 to 2 phi (2)	2.98	0.00	0	1.17	SA.F (2)	ST I	ST I (2)	2.98	5.50
HARSUC3	> 4 phi (2)	13.18	> 13.18	2	0.51	UN.SI (2)	ST II to III	ST I to II (1), ST II to III (1)	0.86	5.00
HARSUC4	> 4 phi (2)	8.89	> 8.89	2	1.28	UN.SI (2)	ST I on III	ST I (1), ST I on III (1)	1.04	5.00
HARSUC5	> 4 phi (2)	10.83	> 10.83	2	1.17	UN.SI (2)	ST I	ST I (2)	1.61	4.00
HARSUC6	> 4 phi (2)	8.40	> 8.40	2	0.95	UN.SI (1), UN.SS (1)	ST I to II	ST I (1), ST I to II (1)	2.38	5.00
AVG		7.0	5.69	1.4	1.1				2.9	7.1
MAX		15.7	>15.75	2.0	2.7				5.8	11.0
MIN		0.4	0.00	0.0	0.2				0.8	3.0

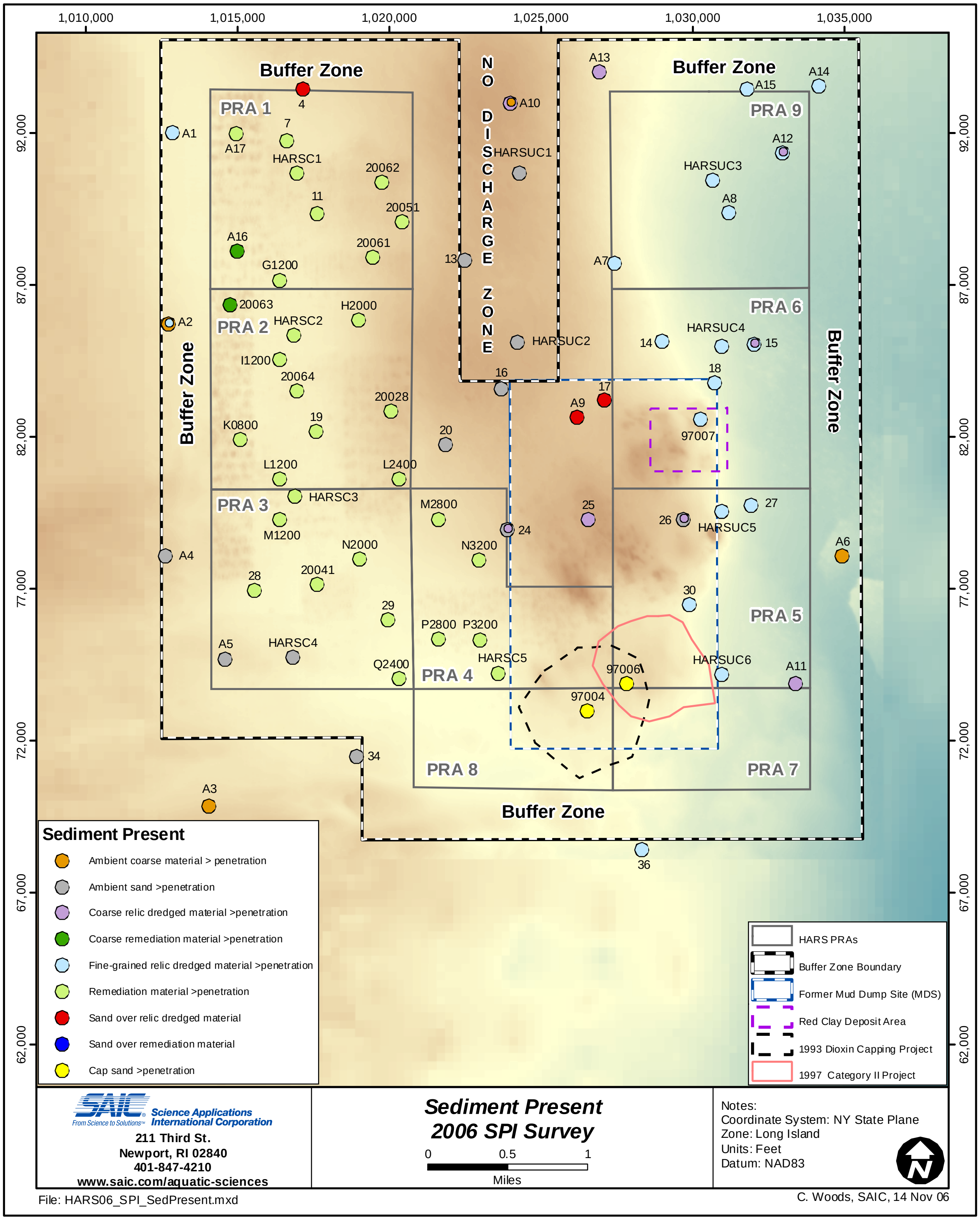


Figure 3.1-1. Sediment types observed at the 2006 sediment-profile stations

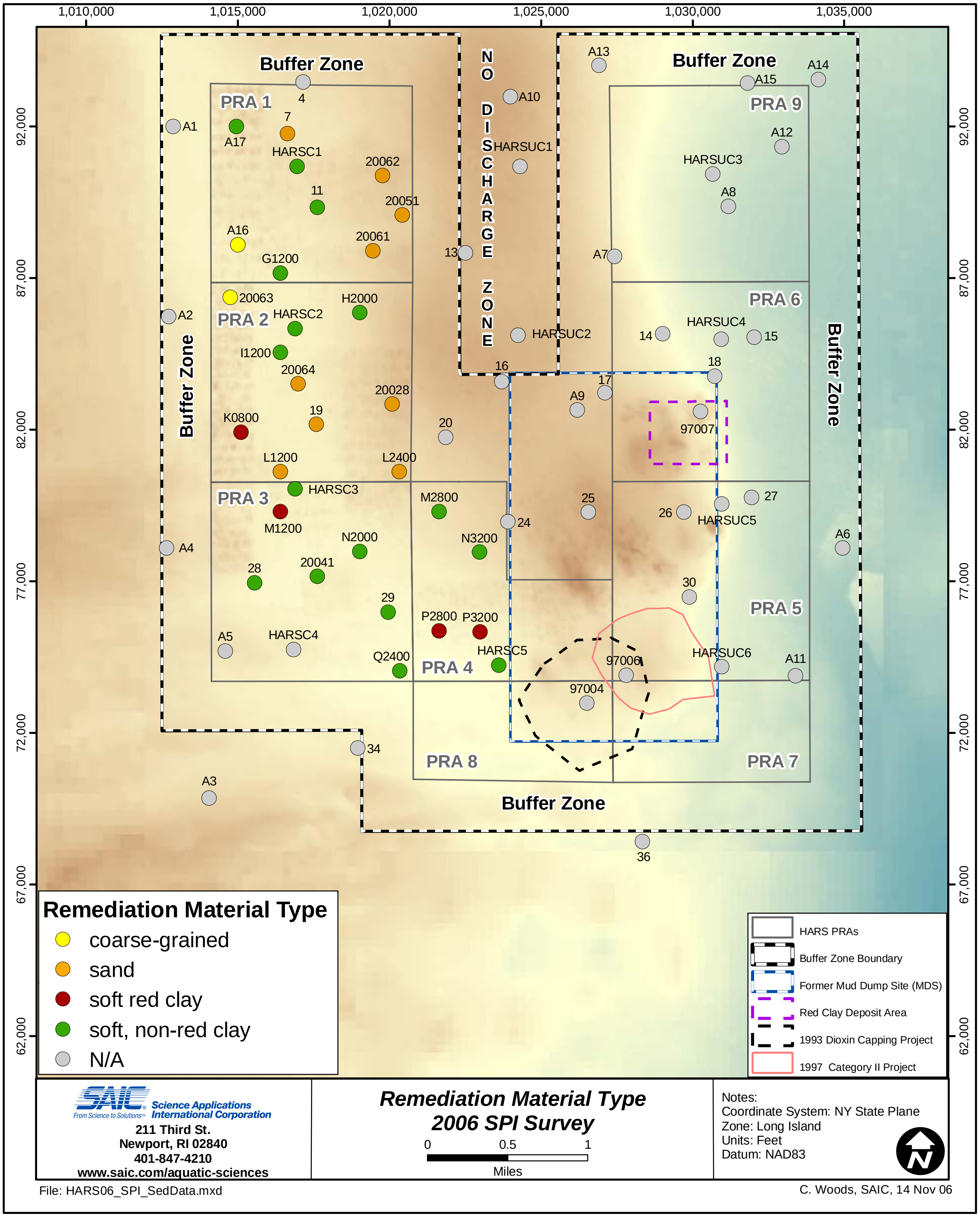


Figure 3.1-2. Types of remediation material observed at the 2006 sediment-profile stations

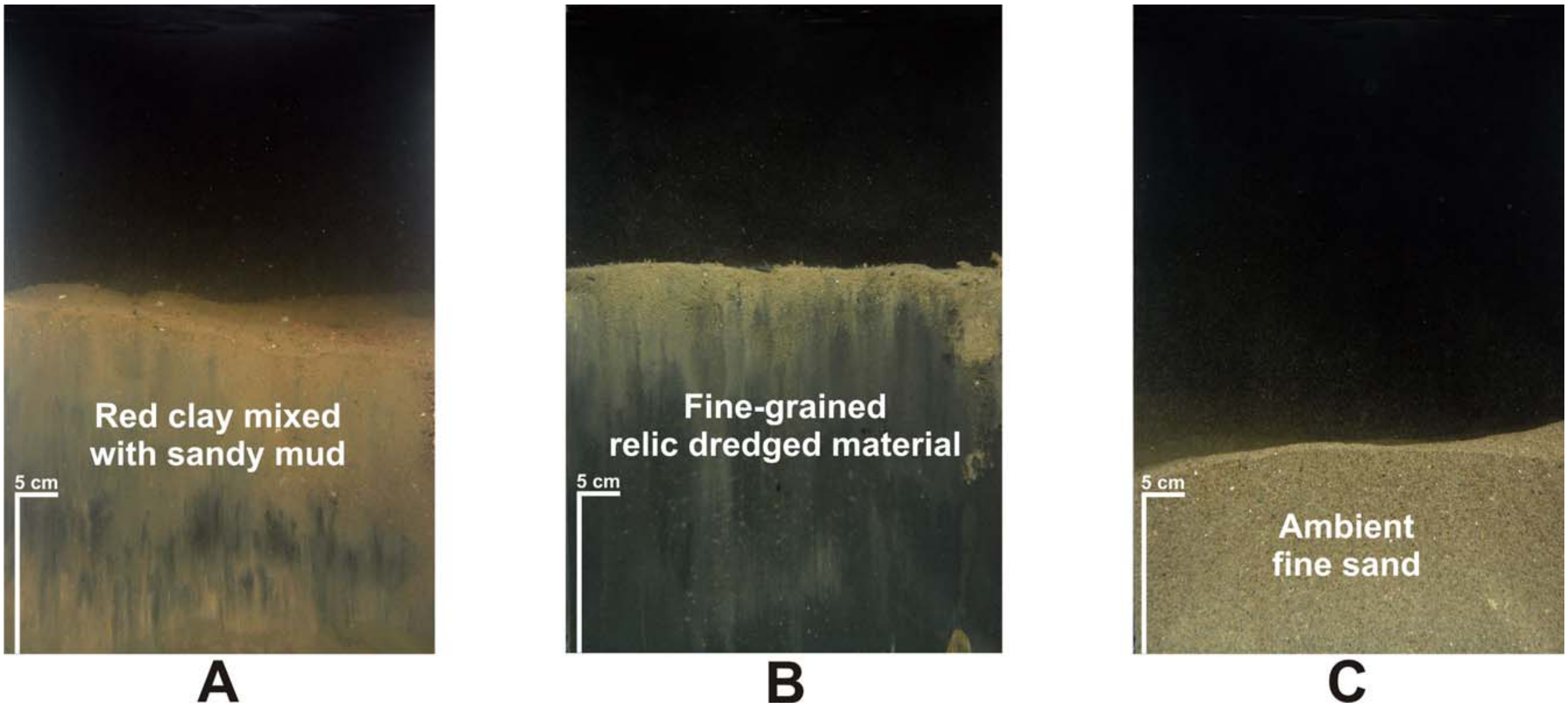


Figure 3.1-3. Sediment-profile images from Stations P2800 (A), 27 (B), and 24 (C) illustrating the various types of sediment observed over the surveyed area. Fine-grained remediation material composed of red clay and sandy mud (grain size major mode of >4 phi) is shown in image A. Image B displays fine-grained relic dredged material (grain size major mode of >4 phi), while Image C shows ambient fine sand (grain size major mode of 3 to 2 phi).

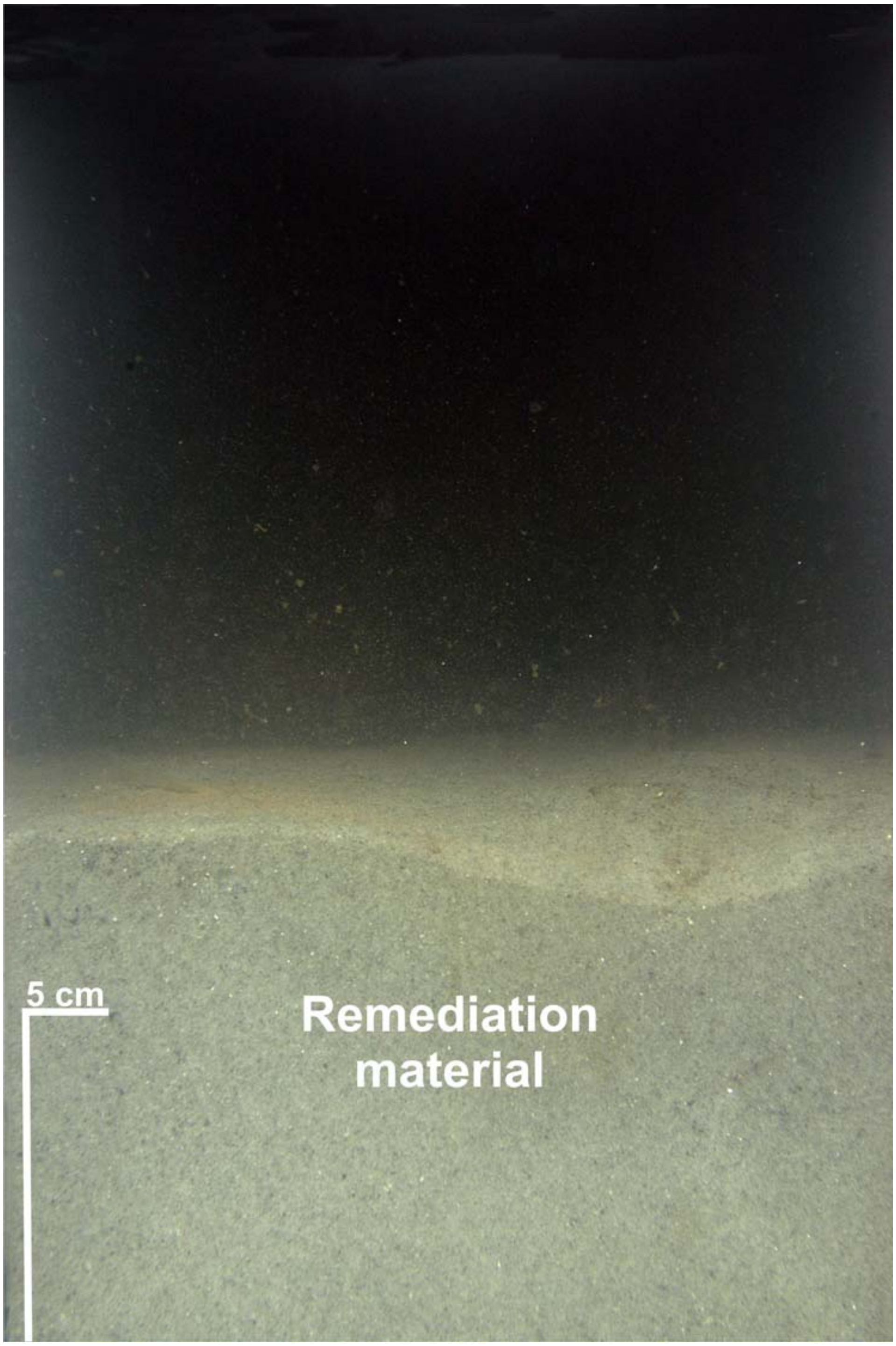


Figure 3.1-4. Sediment-profile image from Station 20028 illustrating remediation material consisting of clean, homogenous, fine sand from Ambrose Channel (grain size major mode of 3 to 2 phi)

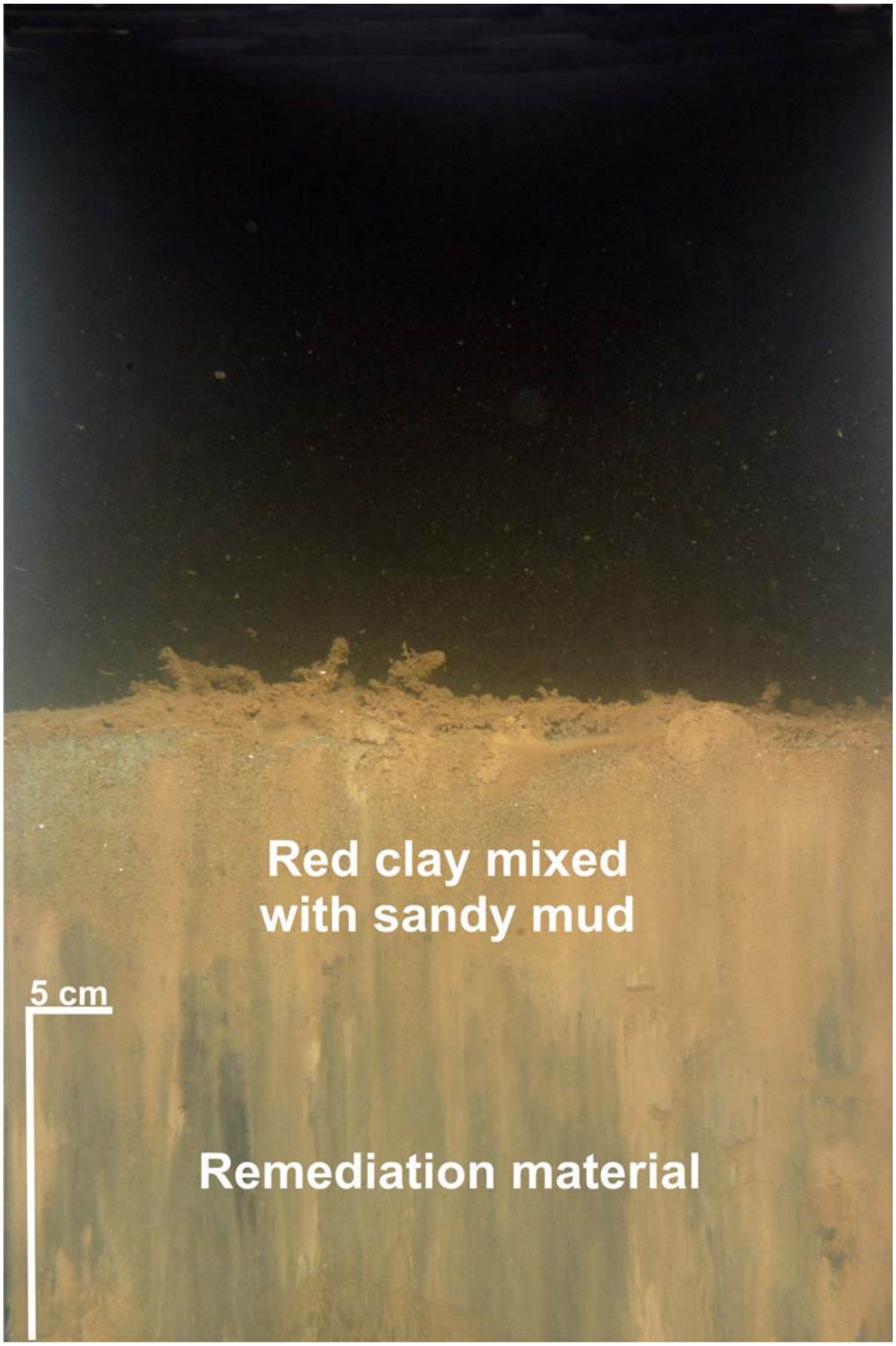


Figure 3.1-5. Sediment-profile image from Station K0800 illustrating fine grained remediation composed of soft red clay

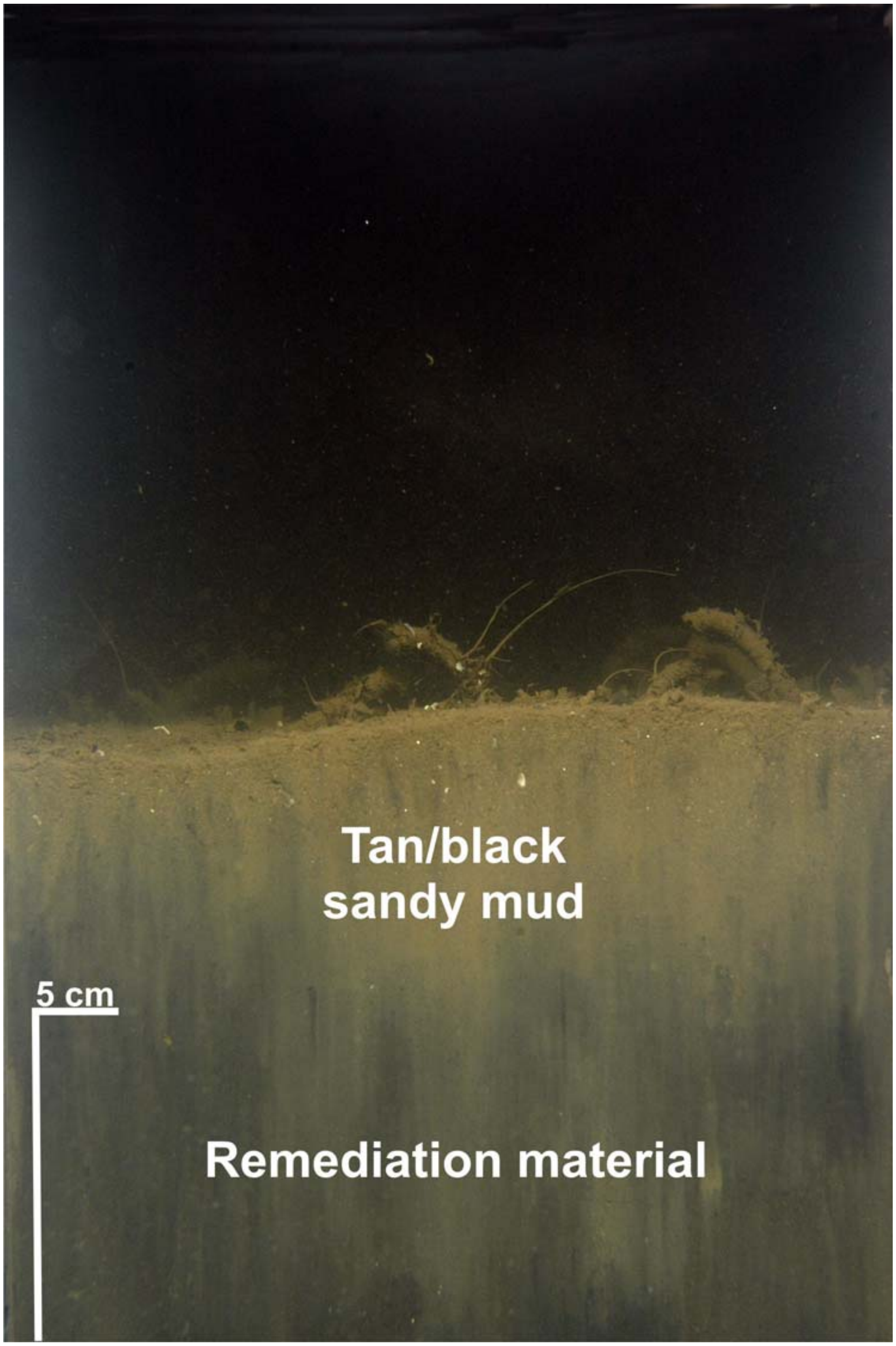


Figure 3.1-6. Sediment-profile image from Station 29 illustrating remediation material consisting of soft, organic-rich, sandy mud (grain size major mode of > 4 phi)

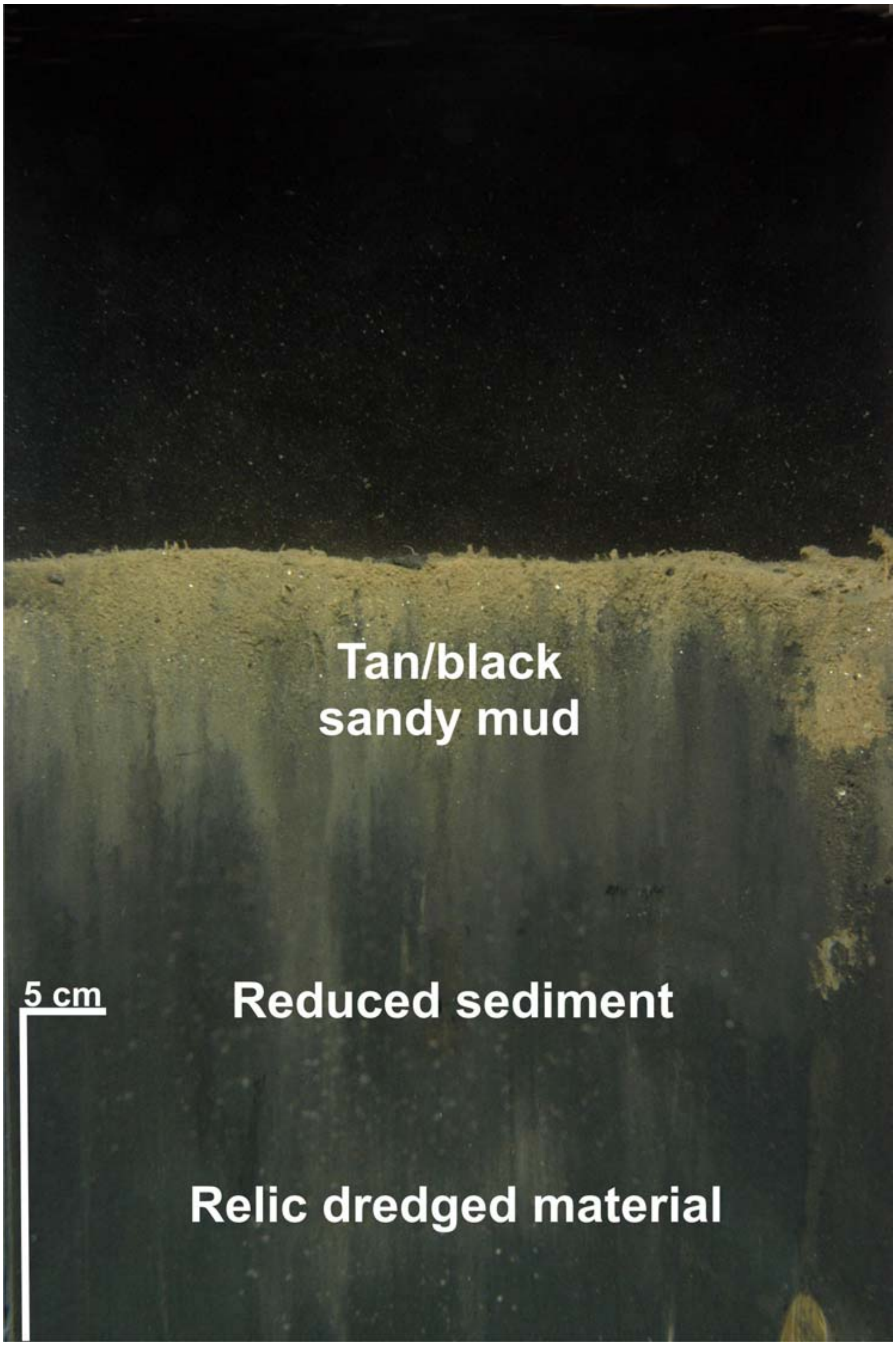


Figure 3.1-7. Sediment-profile image obtained from Station 27 displaying fine-grained relic dredged material (grain size major mode of > 4 phi). A layer of black, anoxic sediment is visible under an overlying oxidized layer.

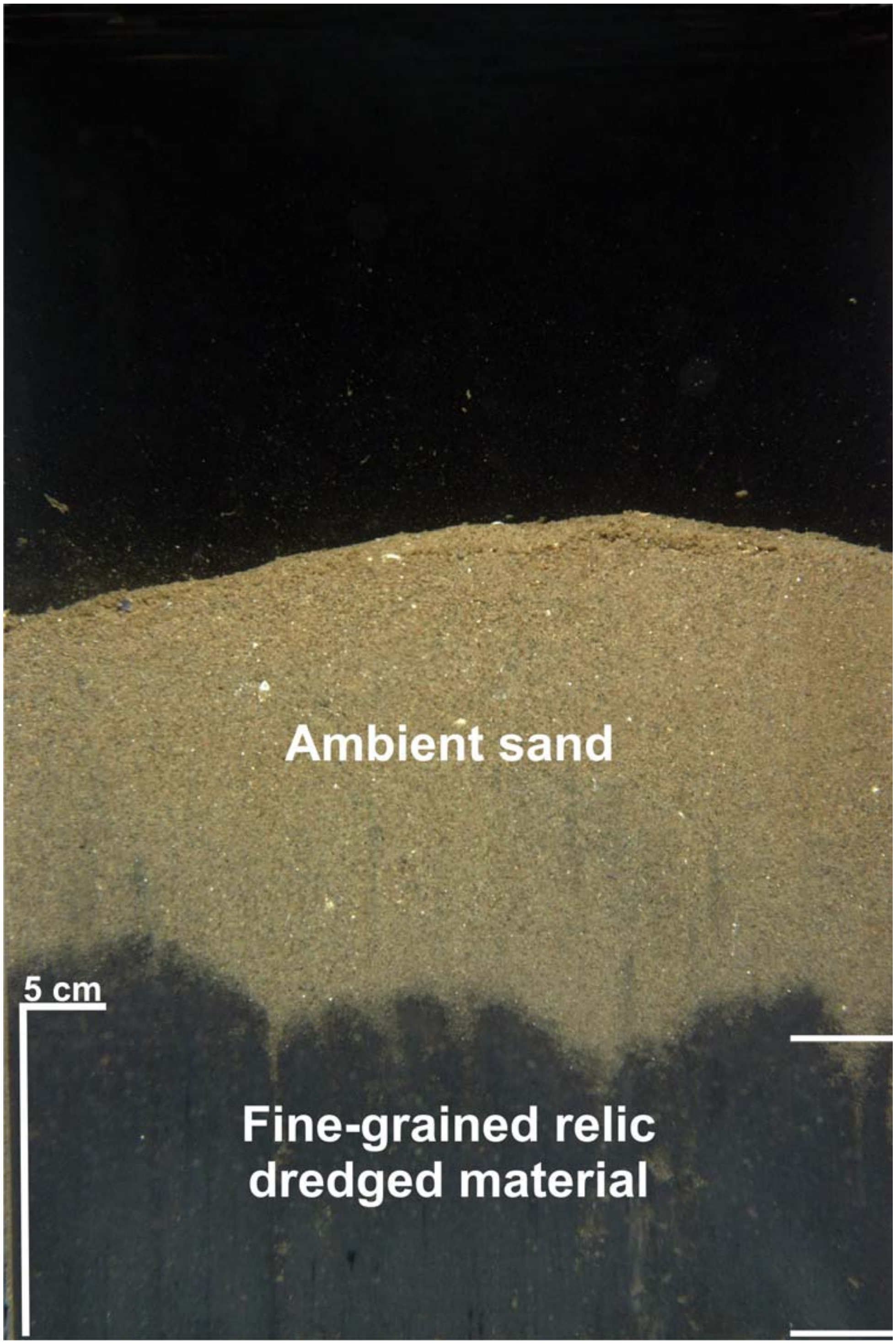


Figure 3.1-8. Sediment-profile image from Station A9 illustrating sand-over-mud layering. A surface layer of ambient fine sand overlies black, fine-grained dredged material at depth.

Figure 3.1-9. Sediment-profile image from Station 97004 showing capping material composed of fine sand from the 1993 Dioxin Capping Project

The thickness of the surface layer of relic dredged material or remediation material exceeded the sediment-profile camera's penetration depth (i.e., imaging depth) at most of stations (i.e., denoted by a greater than symbol in Table 3.1-1). Due to the ongoing disposal of remediation material within the HARS, multiple dredged material layers were often noted in the images (Figure 3.1-10). At some stations, the replicate sediment-profile images showed different sediment types to be present, suggesting a high degree of small-scale spatial variability in sediment composition (Figure 3.1-11). Numerous stations also exhibited subsurface layers of black, anoxic sediment beneath the overlying oxidized (i.e., RPD) layer, suggesting a high level of organic matter and concomitant elevated levels of reduced sulfides at depth (Figures 3.1-7 and 3.1-12).

Consistent with the variability in sediment types, a wide range of grain size major modes was observed among the sediment-profile stations, ranging from >4 phi (silt-clay) to < -1 phi (cobble; Figure 3.1-13). However, the majority of stations were characterized by either silt-clay (>4 phi) or fine sand (3 to 2 phi; Table 3.1-1; Figures 3.1-3 and 3.1-14). Significant variability in grain size and sediment composition was observed between the two replicate images at Stations 15 and 26 (Figure 3.1-11). As indicated, three stations displayed a unique stratigraphy of apparent ambient sand over an underlying layer of either relic dredged material or remediation material (see Figure 3.1-8).

The depth of penetration of the sediment-profile camera prism can be used to map gradients in the bearing strength (hardness) of the sediment. The penetration depth values have a potential range of 0 to 21 cm (i.e., no penetration to full penetration of the sediment-profile camera prism into the sediment). Freshly deposited, fine-grained sediments or older, highly bioturbated sediments tend to be soft and allow relatively deep penetration, while compact sands and coarse-grained sediments tend to be firm and resistant to camera prism penetration.

Mean camera penetration measurements at the 2006 sediment-profile stations ranged from 0.4 cm at Station A10 to 15.7 cm at Station 11 (overall average of 7.0 cm; Table 3.1-1). The wide range of values reflects the wide variety of sediment types observed across the surveyed area. In general, moderate to deep penetration was achieved at the stations with fine-grained relic dredged material or fine-grained remediation material within the HARS. Relatively shallow penetration occurred in the more compact sandy sediments at stations outside the HARS boundary, as well as at stations within the HARS displaying fine sand or coarse dredged material (Figure 3.1-15). Only three stations (Stations 11, HARSC2, and N3200) had camera penetration values over 14 cm; each of these stations was characterized by fine-grained remediation material (Figure 3.1-15). Apparent hard-bottom conditions (cobble, rock, or compact sand) resulted in a lack of penetration of the camera prism and prevented the analysis of key parameters (e.g., RPD, successional status, and OSI) in certain replicate images from Stations 25, 20063, 20064, A10, A11, A13, A16, and A6. No images were acquired at Station 20031 due to hard bottom conditions.

Excluding any stations where there was a lack of penetration of the camera prism into the sediment, small-scale boundary roughness values ranged from 0.2 cm at Station 20064 to 2.7 cm at Station 20063 (Table 3.1-1; Figure 3.1-16). The overall average of 1.1 cm reflects only a minor amount of small-scale surface relief across the 14-cm field-of-view in the images. Surface

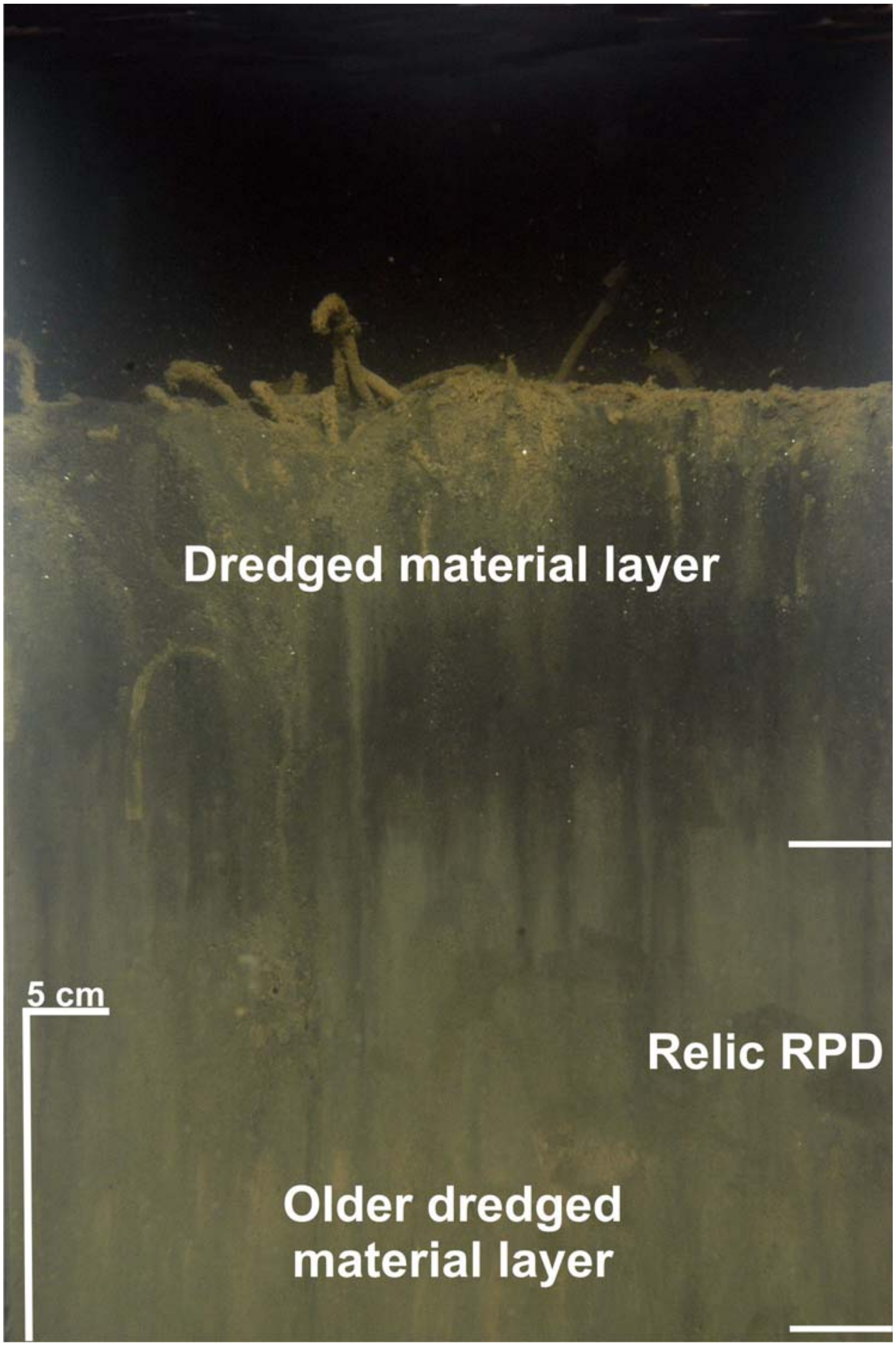


Figure 3.1-10. Sediment-profile image from Station 11 showing multiple dredged material layers. A relic RPD is also visible at depth.

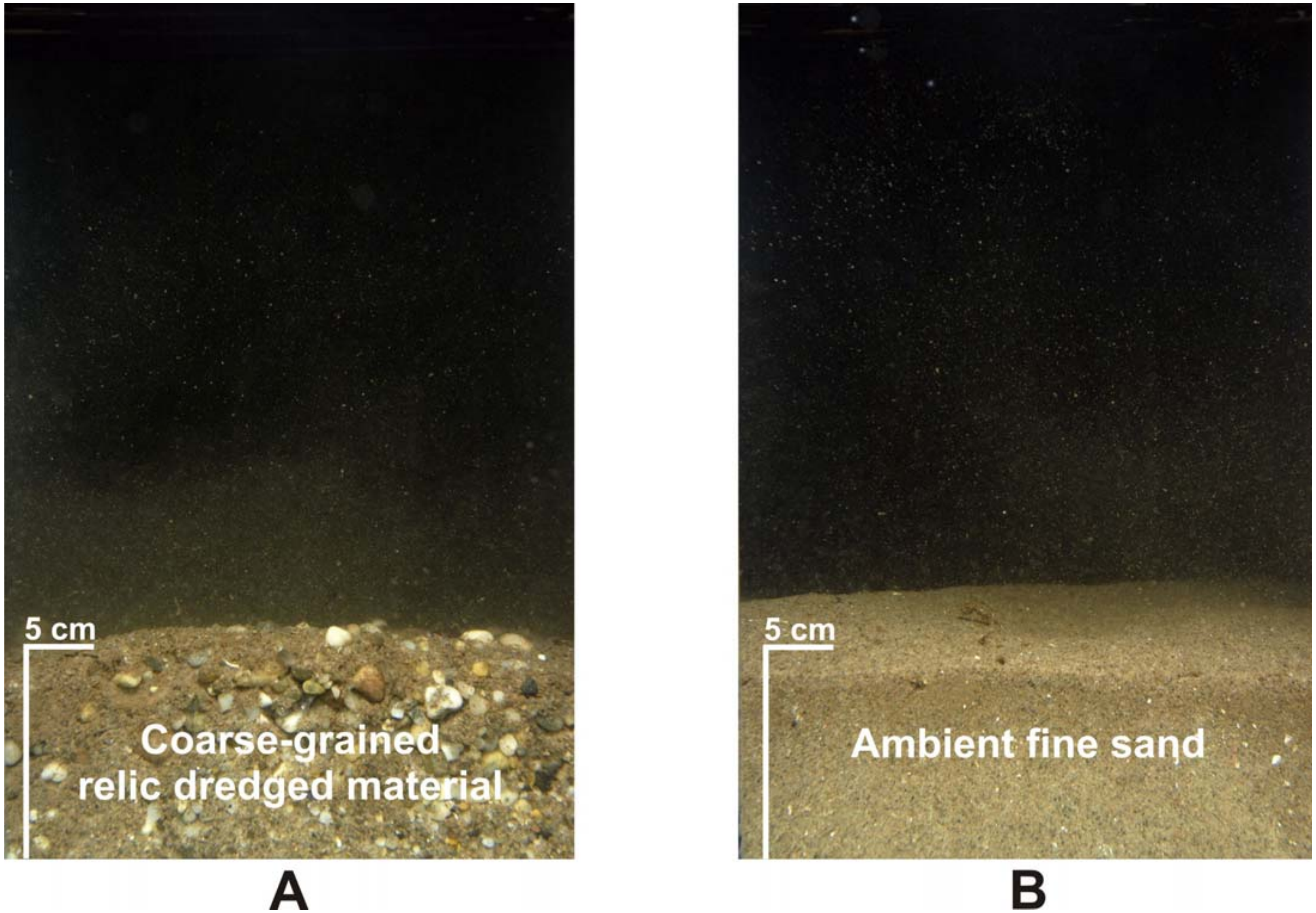


Figure 3.1-11. Replicate sediment-profile images from Station 26 showing small-scale variability in the appearance of the sediment. Image A shows coarse-grained relic dredged material (grain size major mode of <-1 phi), while the sediment in Image B is composed of ambient fine sand (grain size major mode of 3 to 2 phi).

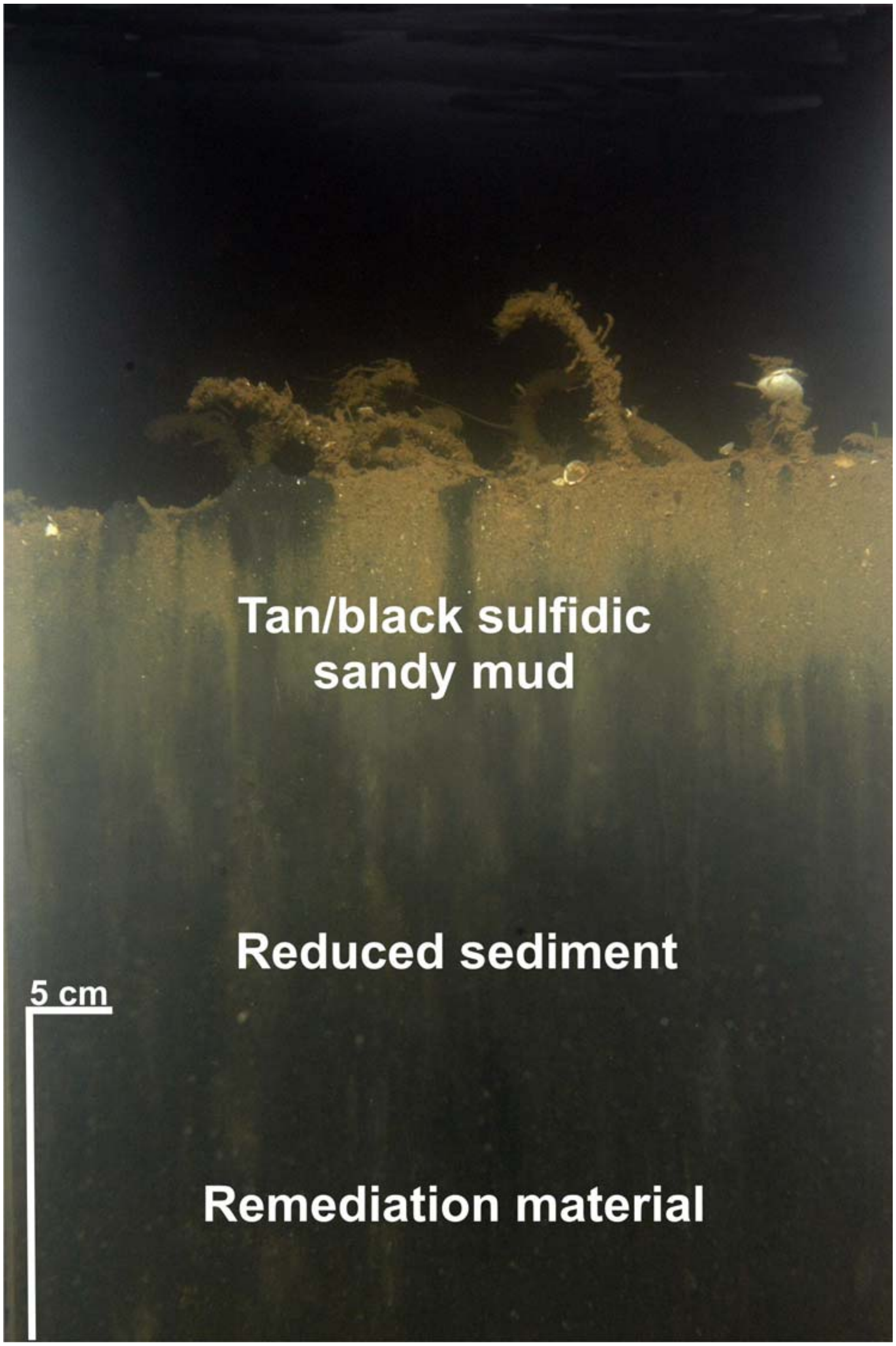


Figure 3.1-12. Sediment-profile image obtained from Station N3200 illustrating a subsurface layer of black, sulfidic (reduced) sediment underlying an oxygenated surface layer

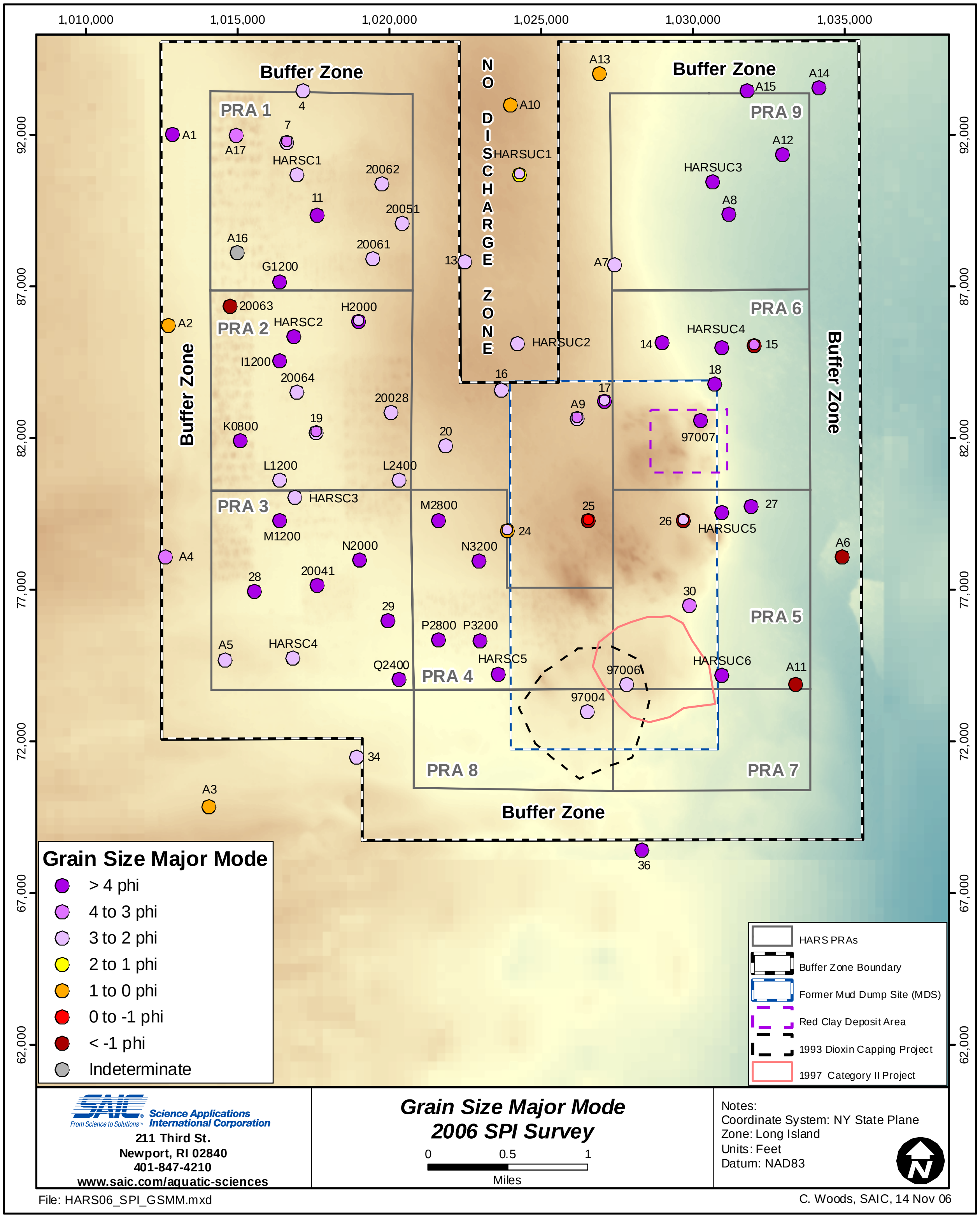


Figure 3.1-13. Grain size major mode (in phi units) of surface sediments observed at the 2006 sediment-profile stations

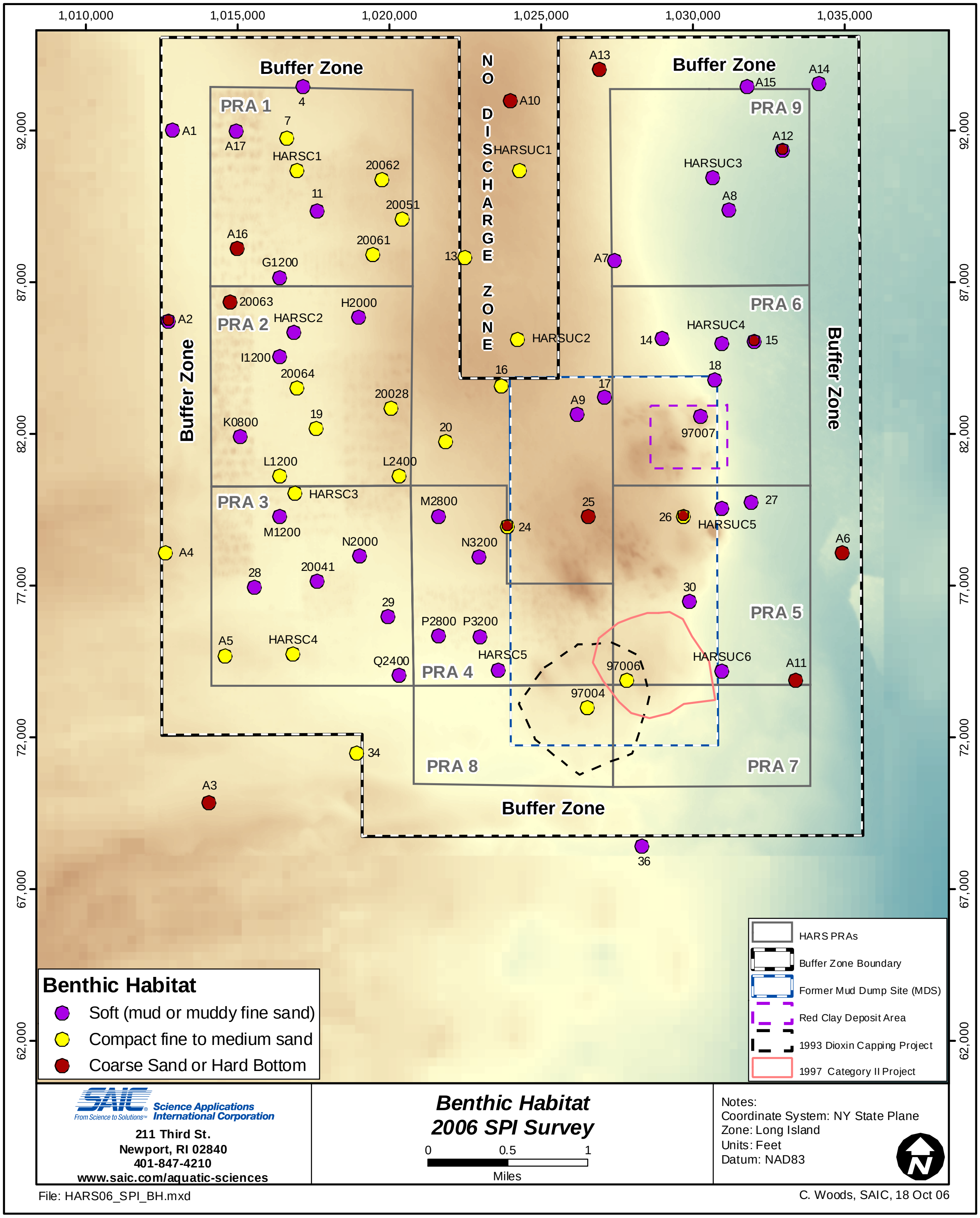


Figure 3.1-14. Benthic habitat types observed at the 2006 sediment-profile stations

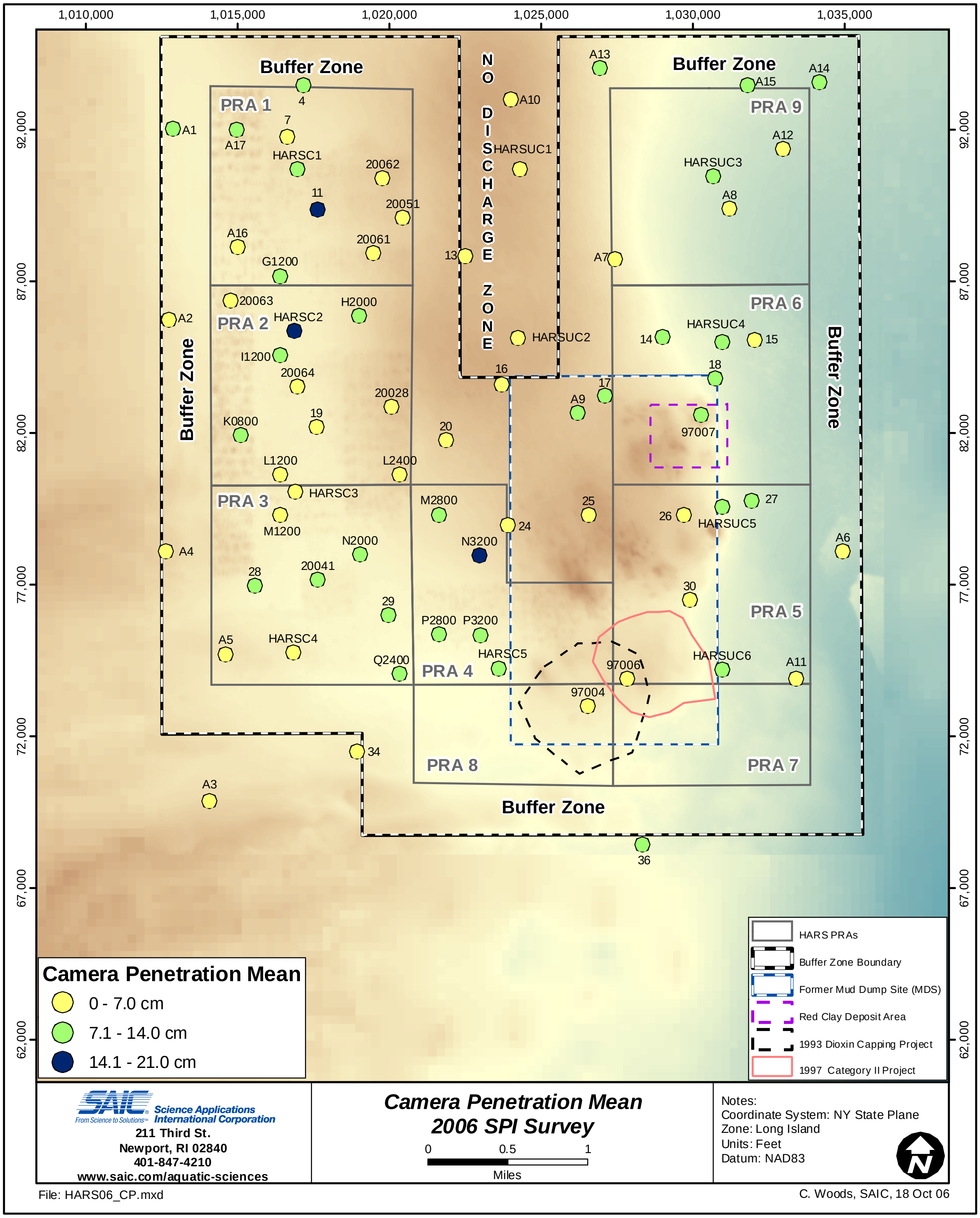


Figure 3.1-15. Mean prism penetrations depths (cm) at the 2006 sediment-profile stations

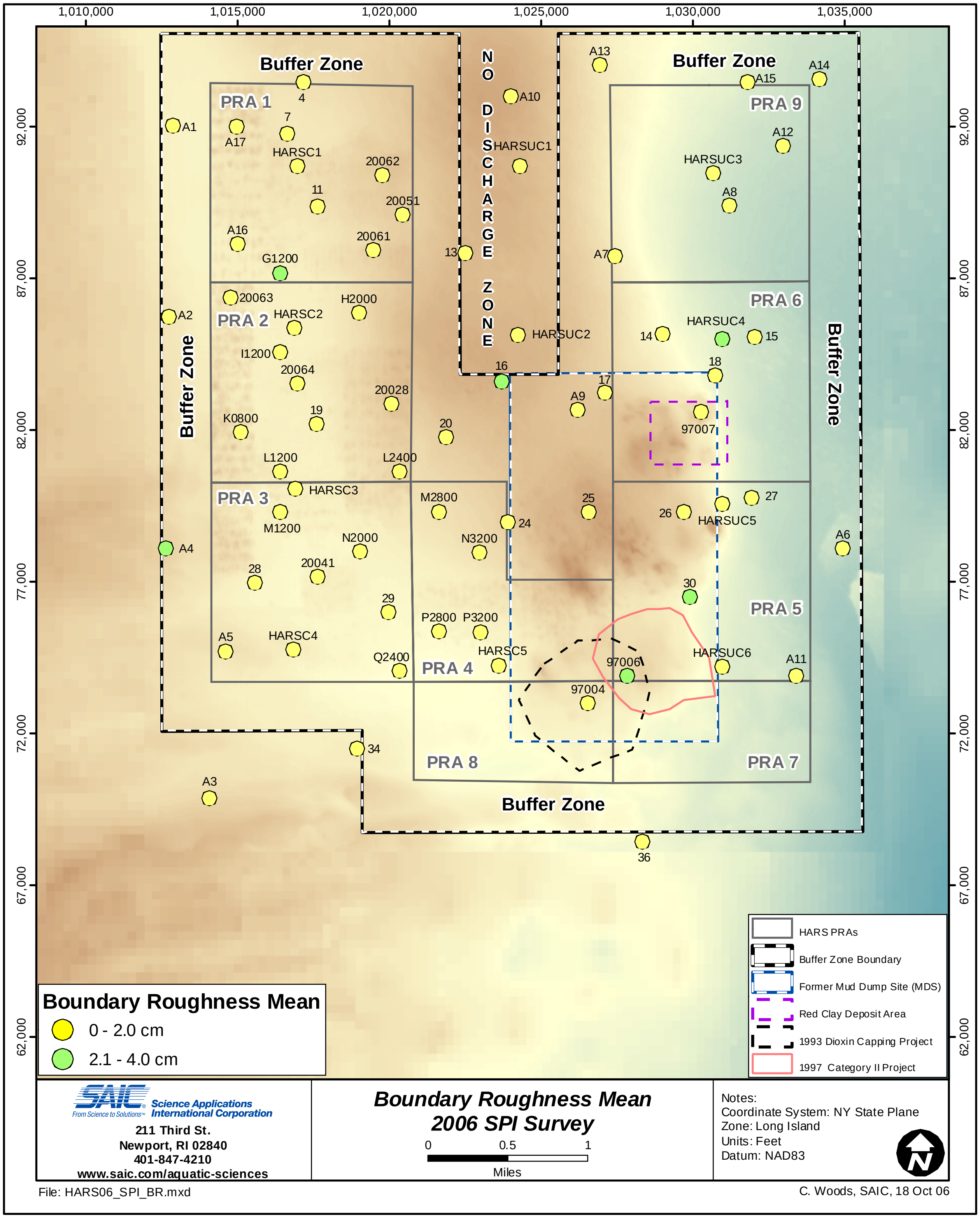


Figure 3.1-16. Average small-scale surface boundary roughness (cm) at the 2006 sediment-profile stations

roughness was attributed to physical factors in most (68%) of the replicate images, partly due to bedforms (e.g., sand ripples) at the sediment-water interface (Figure 3.1-17A). However, a number of stations also exhibited biogenic surface roughness due to the presence of polychaete tubes, amphipods stalks (i.e., "stick amphipods" of the Family Podoceridae), and shallow-dwelling bivalves (*Nucula* sp), as well as biological reworking by burrowing infauna at the sediment-water interface (Figure 3.1-17B). A depositional layer of brown flocculent material (organic detritus), often with small tubes or organisms, was observed at the sediment-water interface in a significant number of images across the survey area (Figure 3.1-18).

The sediment plan-view images supported the results of the sediment-profile analysis, revealing a variety of sediment types including silts, fine sand, and hard-bottom conditions over the surveyed area. No images were obtained at approximately one-third of the stations due to flooding of the underwater housing on the second day of operations. Fine-grained sediment dominated the plan-view images collected at the stations within PRAs 1 through 6 and PRA 9. Remediation material composed of fine Ambrose Channel sand or red clay was often visible in the plan-view images and agreed well with the corresponding sediment-profile image (Figure 3.1-19). Some recent remediation material composed of gravel and rock was visible in the plan-view images in PRAs 1 and 2 (Figure 3.1-20). Hard-bottom or firm-bottom conditions were detected in the sediment-profile and plan-view images at various stations (Stations 11, 14, 15, 97007, H2000, P2800, P3200, A3, A10, A12, and A13) within the HARS due to the presence of coarse sand and small rocks (Figures 3.1-21 and 3.1-22).

Small-scale spatial variability was detected at various stations with respect to grain size and benthic habitat. Variability within sediment-profile replicate images occurred at Stations 24, 26, 97007, and HARSUC1, while variability within plan-view replicate images was observed at Stations 11, P2800, A12, and P3200. Small-scale spatial variability in benthic habitat was also detected between sediment-profile images and the corresponding plan-view images at six stations (Stations 11, 15, A7, A12, H2000, P2800, and P3200). For example, the sediment-profile image from Station 11 revealed fine-grained sediment, while the plan-view image from the same station showed a hard bottom consisting of rock and cobble (Figure 3.1-23). The images were collected within just a few meters of each other, which is the distance between replicate drops of the camera while the vessel maintained a steady position at the ocean's surface at each station. The difference in benthic habitat conditions therefore reflects significant small-scale spatial variability on the seafloor at this station. Such variability is attributed to the placement of widely different types of remediation material in PRA 1 following the designation of the HARS in 1997. Variability among replicate plan-view images was also observed at Station A12, where one image revealed fine-grained sediment while a second image showed a hard bottom consisting of rock and cobble (Figure 3.1-24).

3.1.2 Benthic Recolonization Status and Benthic Habitat Conditions

Analysis of the plan-view images also provided insight into the nature and degree of benthic recolonization in areas of the HARS where dredged material has been placed. A number of biological features were detected in the sediment plan-view images including starfish, crabs, infaunal burrows, sand dollars, anemones, polychaete tubes, amphipod tubes, and shrimp (Figures 3.1-25 and 3.1-26). These organisms often appeared in the corresponding sediment-

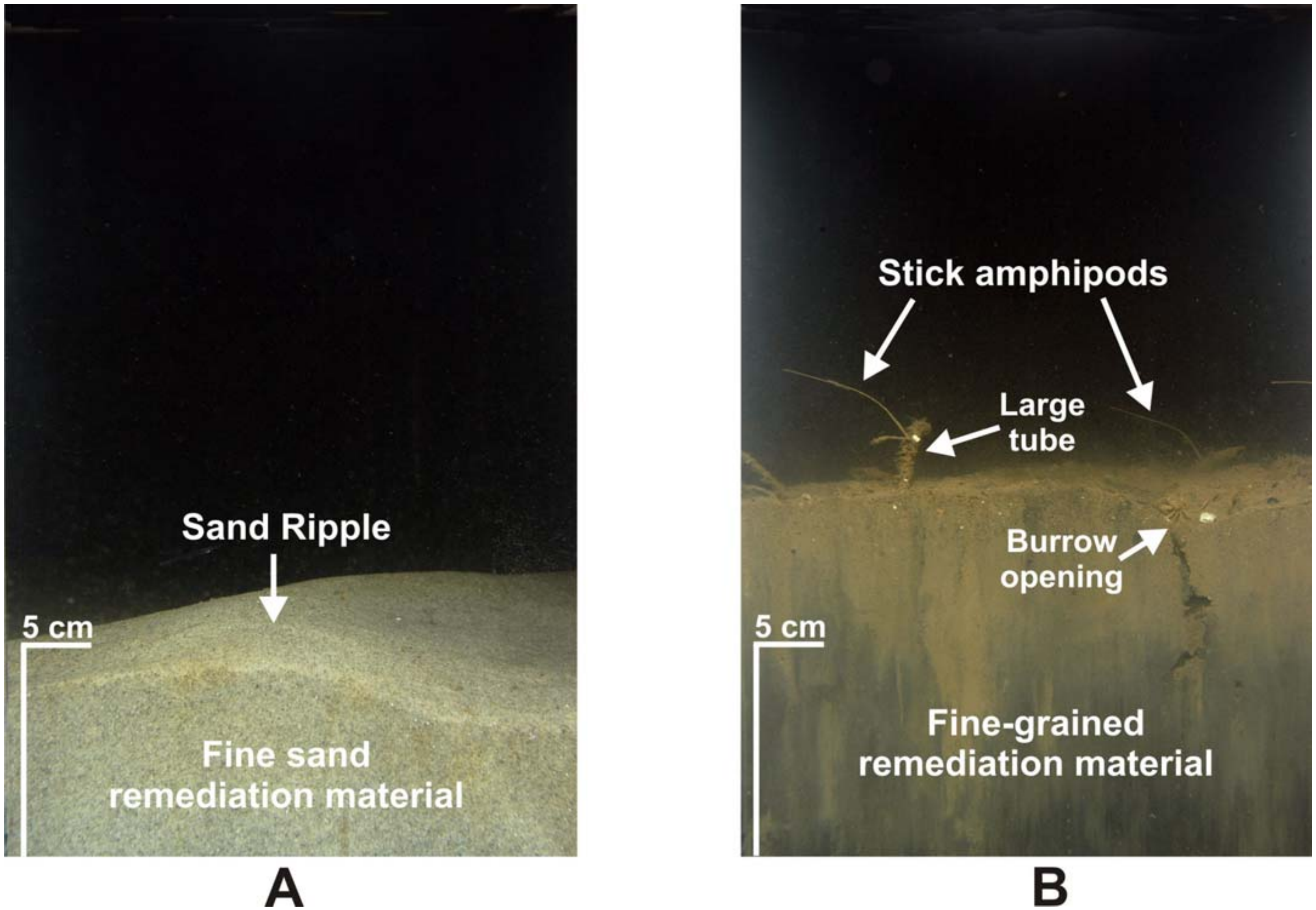


Figure 3.1-17. Sediment-profile images from Stations 20062 (A) and 28 (B) displaying physical and biogenic surface roughness. Image A shows physical surface roughness due to compact, rippled fine sand. Image B illustrates biogenic surface roughness due to the presence of polychaete tubes and amphipods stalks (i.e., "stick amphipods" of the Family Podoceridae), as well as biological reworking by burrowing infauna at the sediment-water interface.

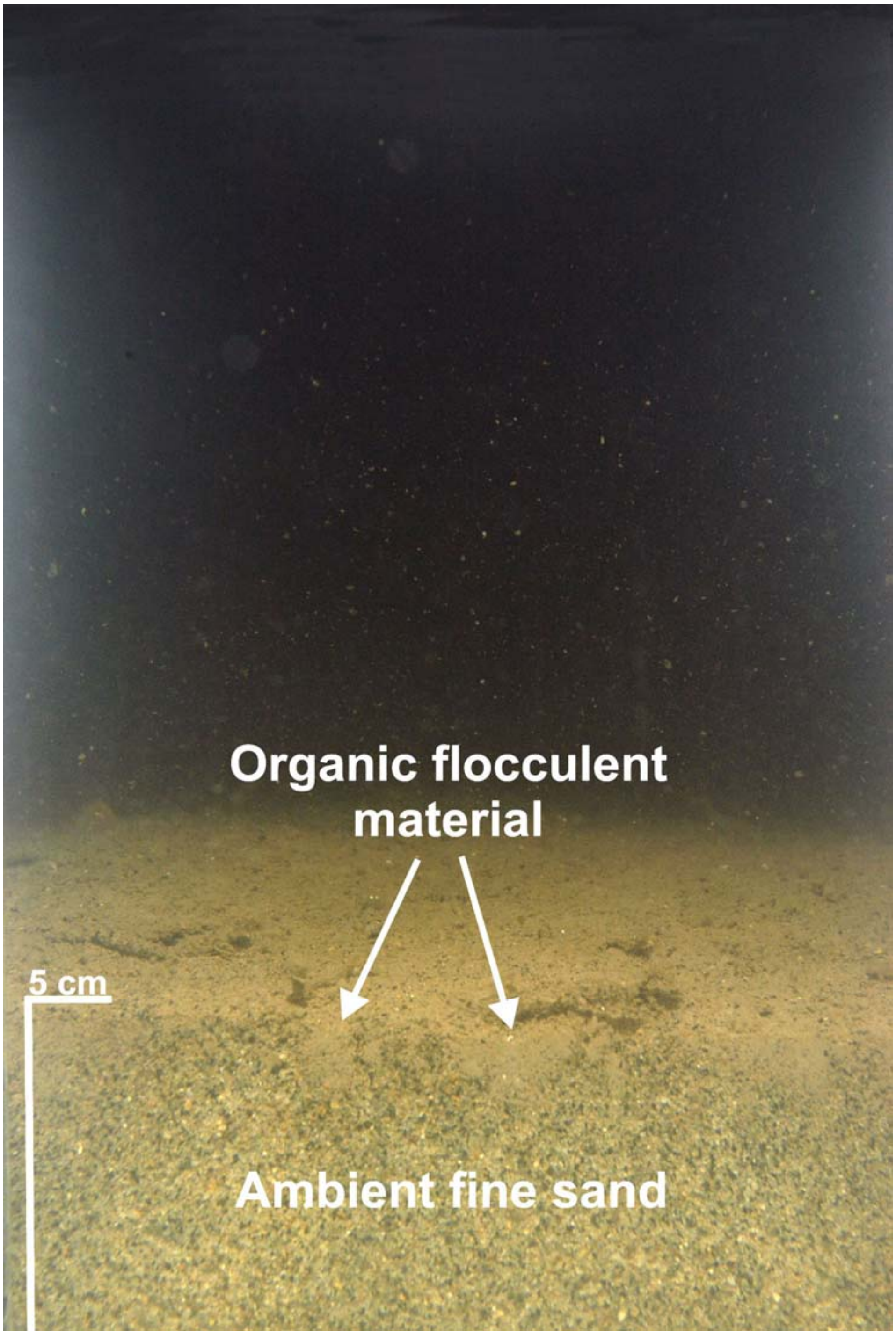
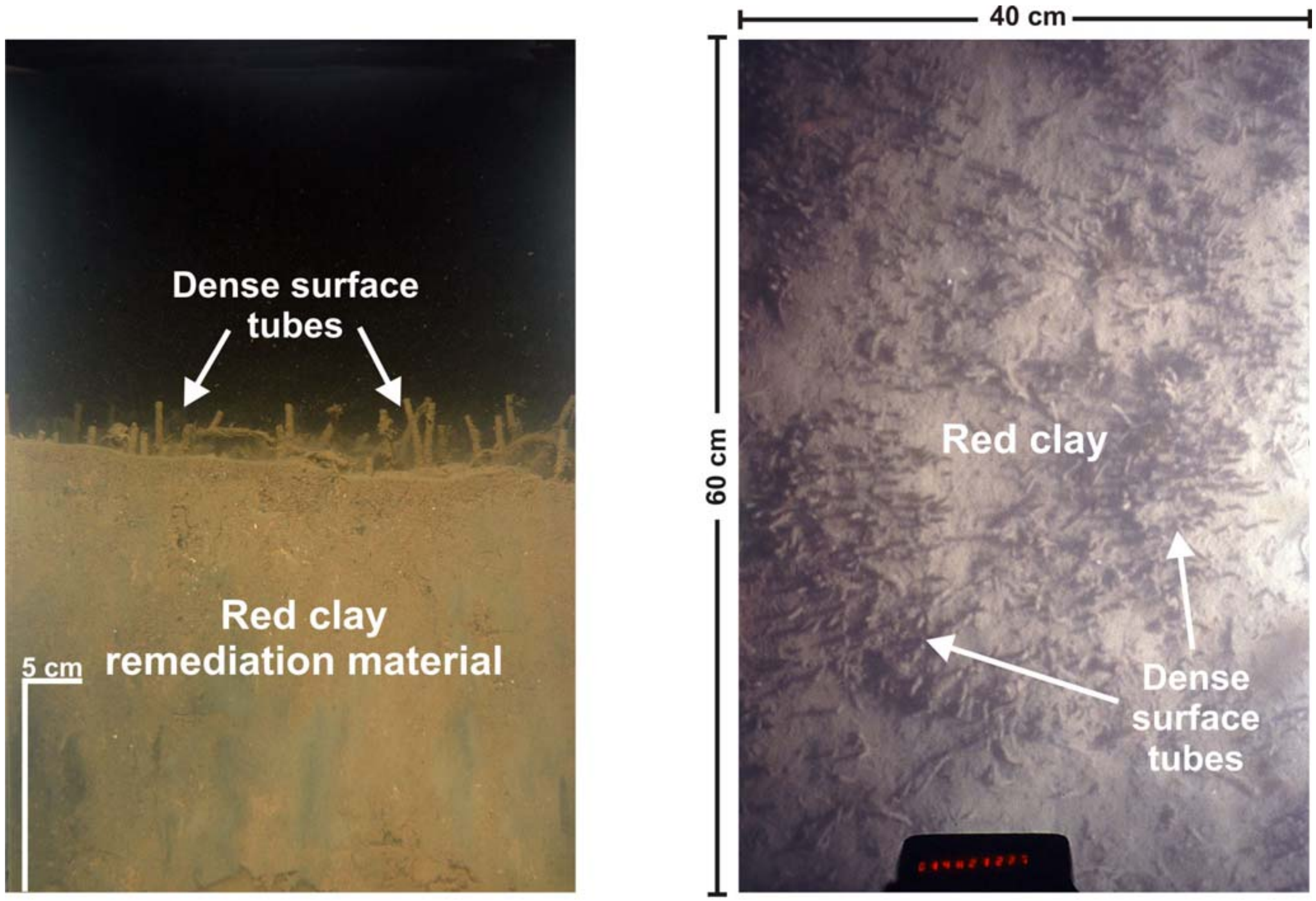


Figure 3.1-18. Sediment-profile image obtained from Station 34 illustrating a depositional layer of brown flocculent material (organic detritus) at the sediment surface



A B

Figure 3.1-19. Sediment-profile image (A) and corresponding plan-view image (B) from Station P3200 showing agreement in sediment composition, with remediation material composed of red clay visible in both images. The red clay remediation material is colonized by a dense assemblage of tubicolous polychaetes (tentatively identified as *Asabellides oculata*) at the sediment surface of both images.

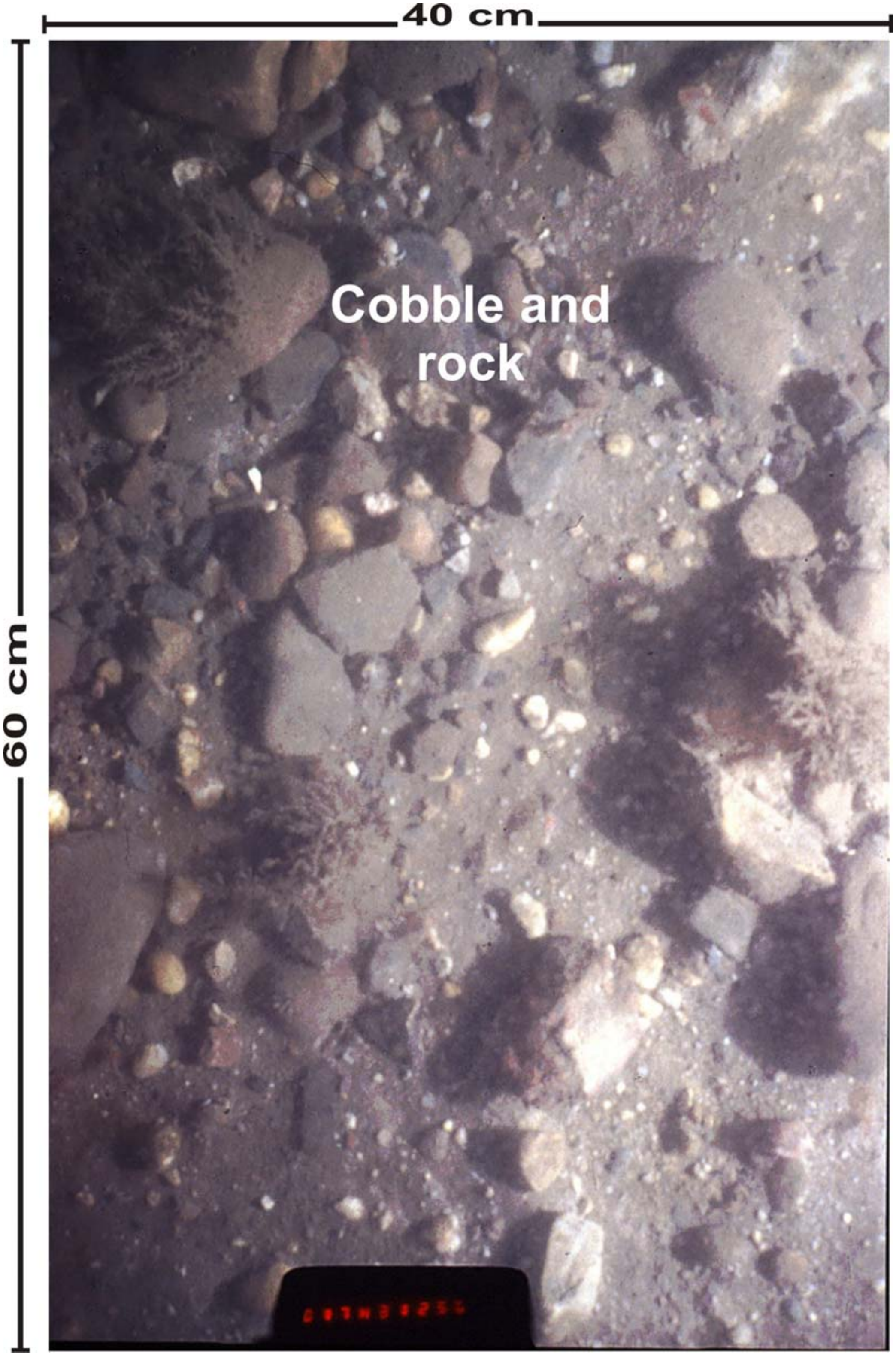


Figure 3.1-20. Plan-view image from Station 11 showing coarse grained remediation material composed of cobble and rock

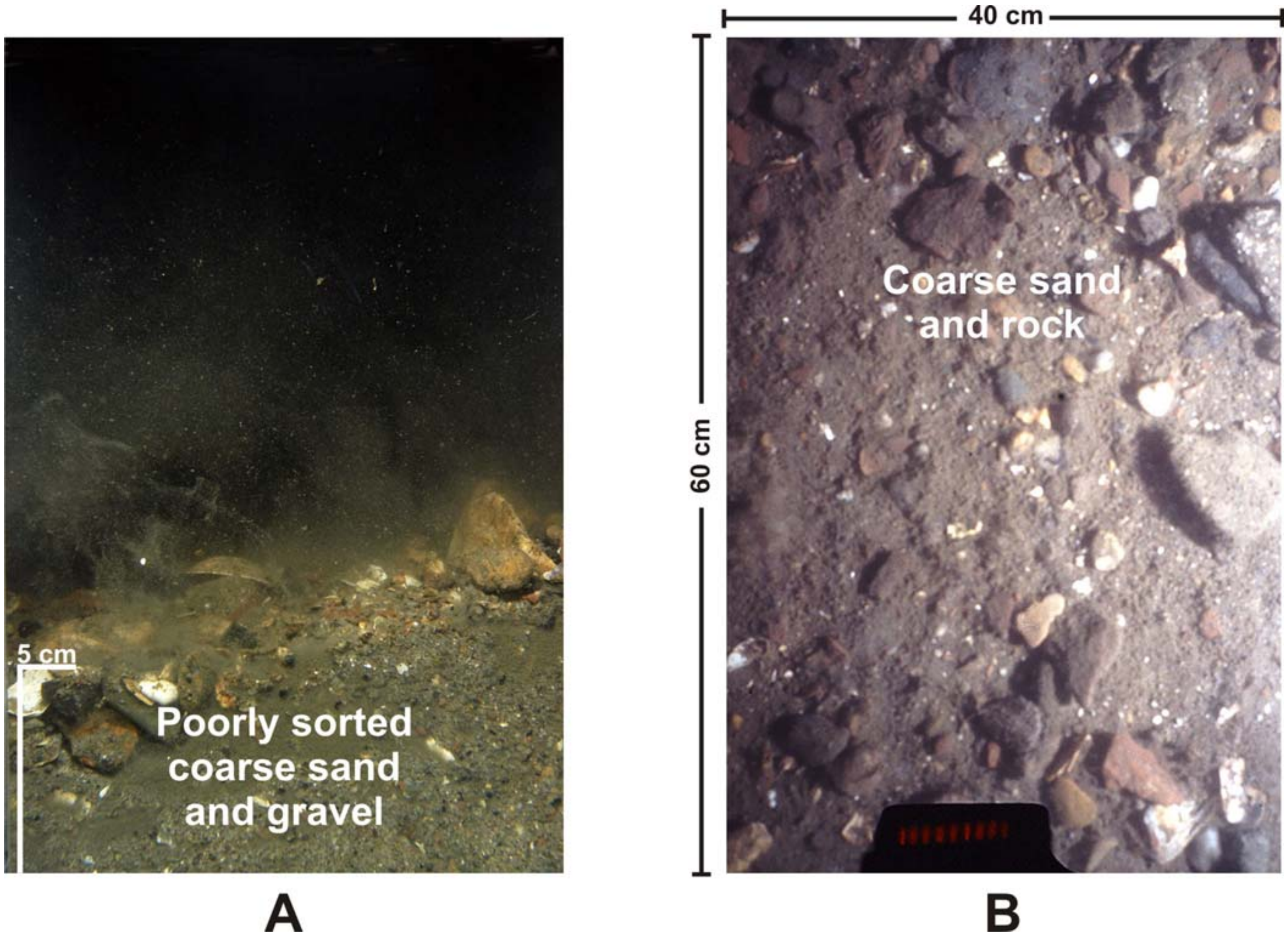


Figure 3.1-21. Sediment-profile image (A) and corresponding plan-view image (B) from Station A13 showing agreement in sediment composition. The sediment-profile image shows poorly sorted, coarse-grained relic dredged material. A hard bottom composed of coarse sand and rock is also visible in the plan-view image.

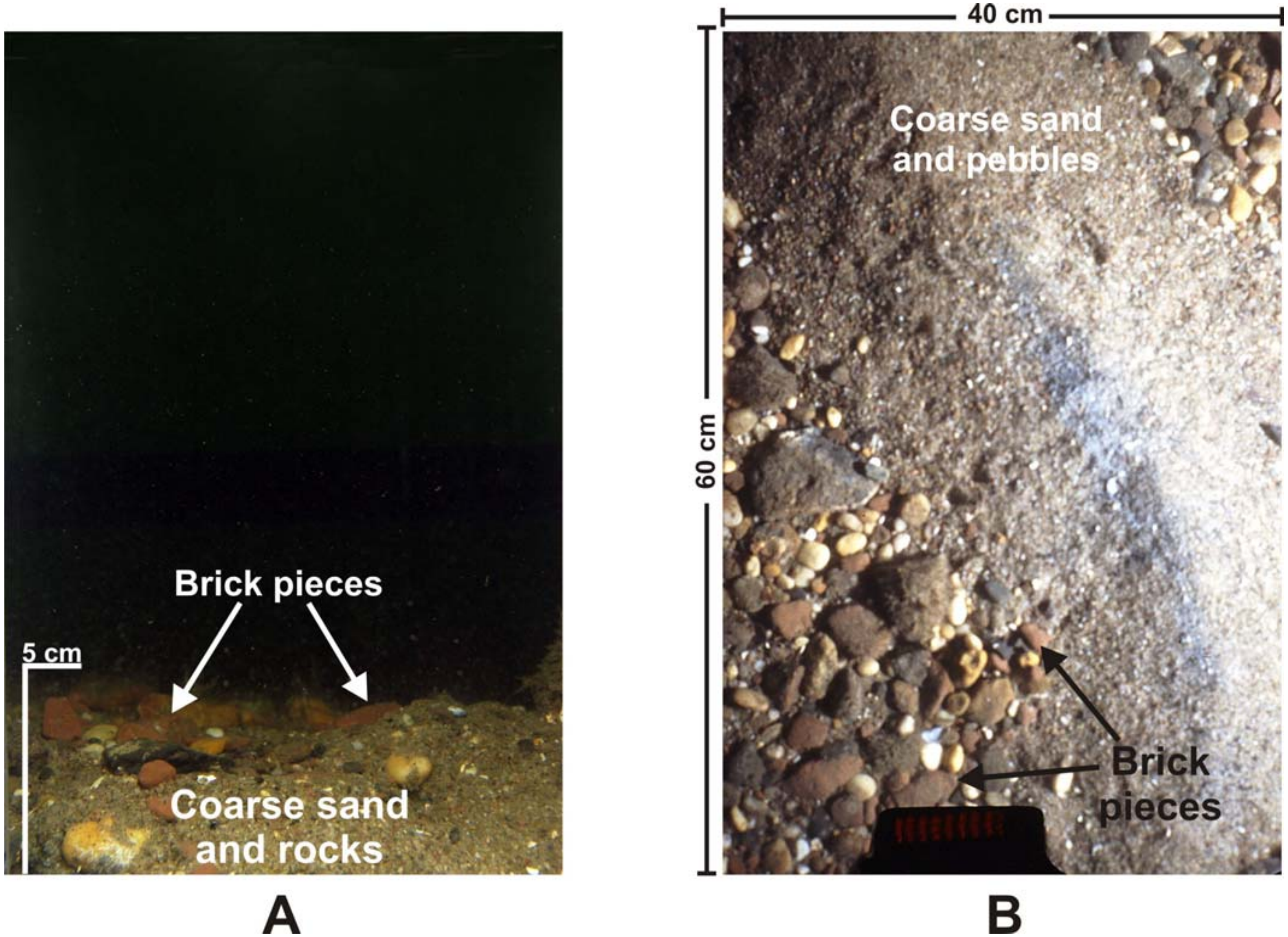


Figure 3.1-22. Sediment-profile image (A) and corresponding plan-view image (B) from Station A10 displaying hard bottom conditions consisting of coarse sand and pebbles at this station. Brick fragments are also visible at the sediment surface of both images.

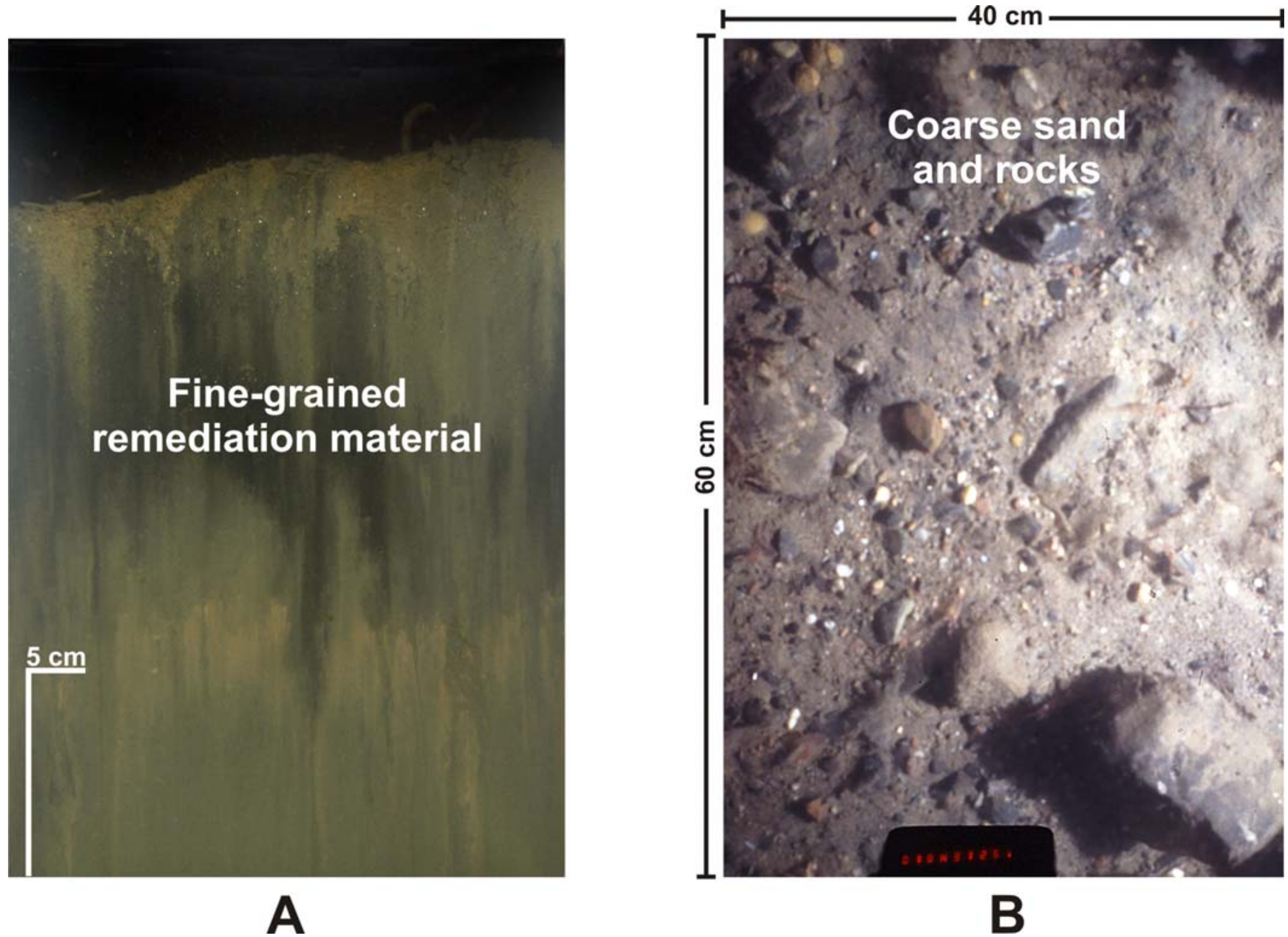


Figure 3.1-23. Sediment-profile image (A) and plan-view image (B) from Station 11 illustrating within-station variability in sediment types. A soft, silt bottom is evident in Image A (replicate 1), while a hard rock and cobble bottom is present in Image B (replicate 2). Replicate images were collected at the same station within a few meters of each other.

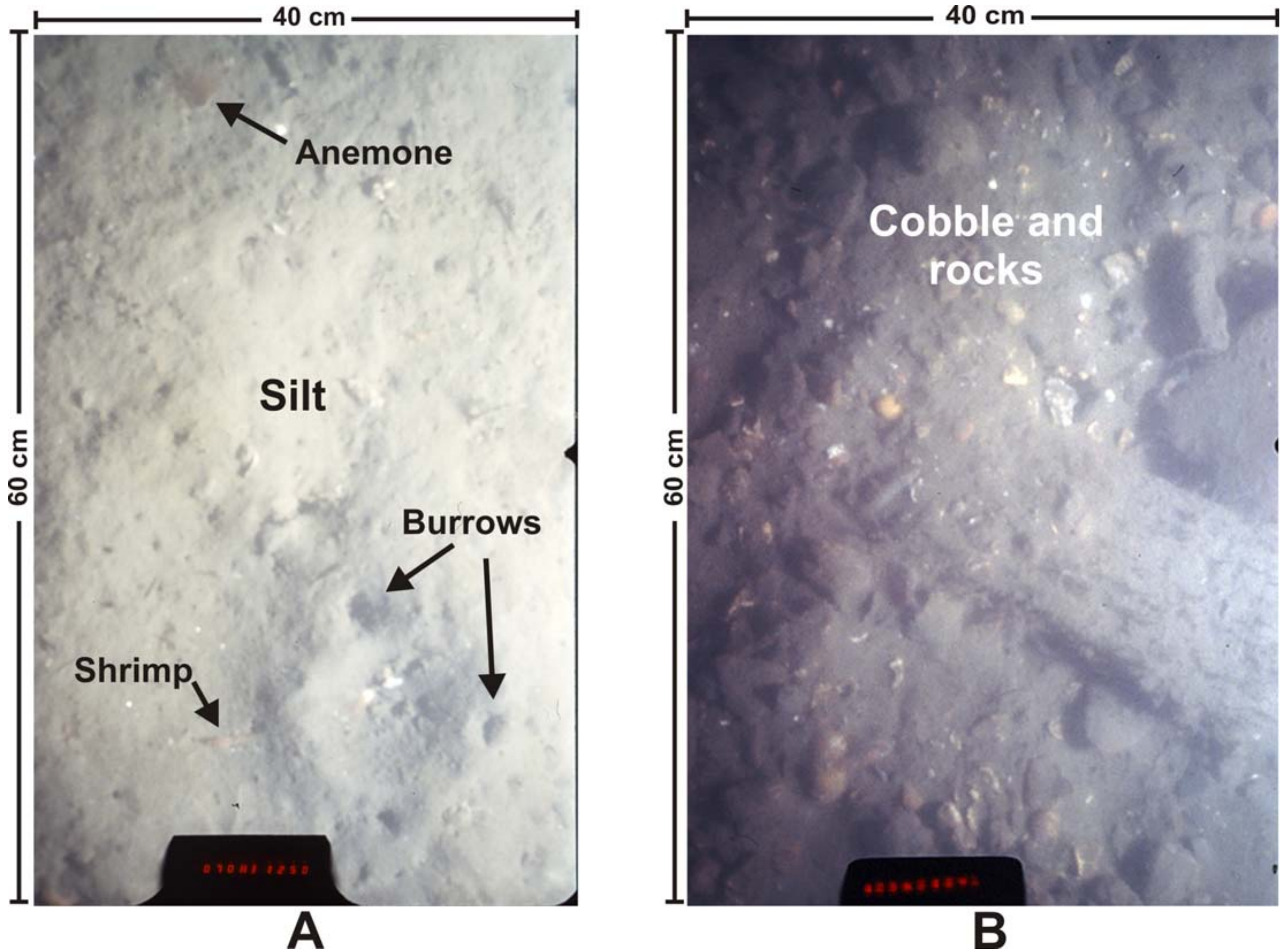


Figure 3.1-24. Plan-view images from Station A12 displaying variability among replicate images. Image A shows fine-grained sediment (silt), while Image B is characterized by a hard bottom (cobble and rock). Apparent difference in sediment coloring is a function of image brightness (due to small differences in the height of the camera above the seafloor at the time of each exposure).

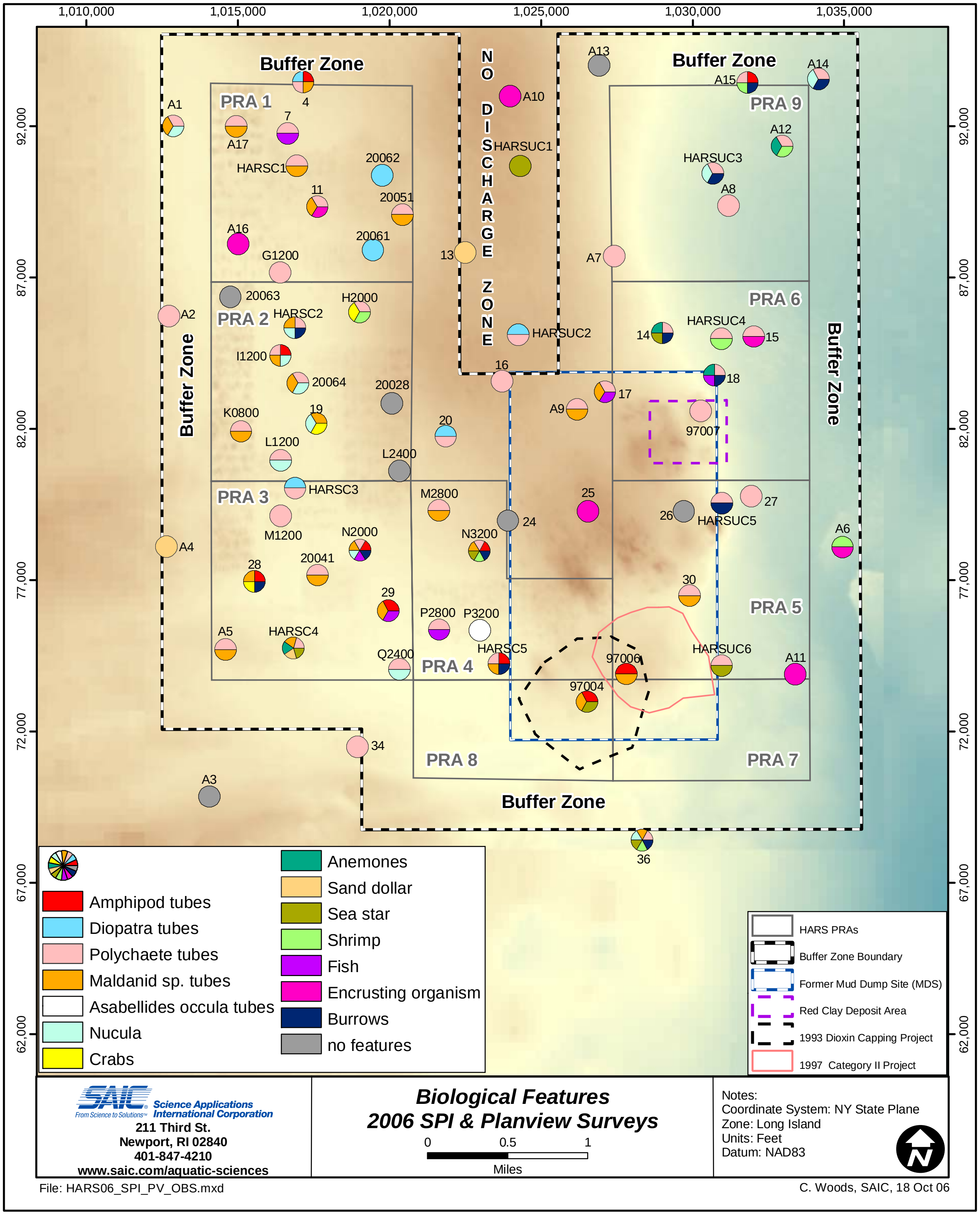


Figure 3.1-25. Map of biological features observed at the sediment surface of sediment-profile and plan-view images

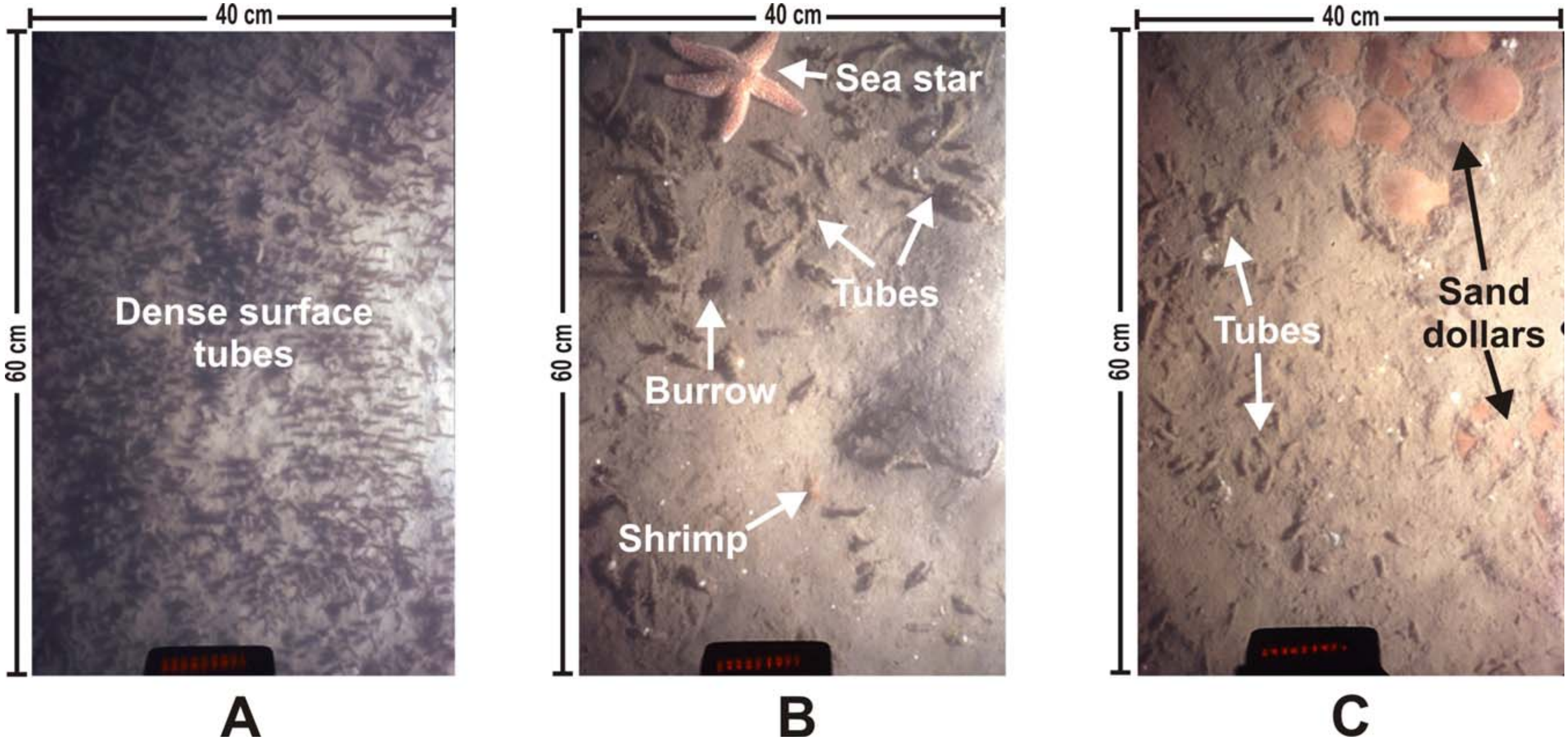


Figure 3.1-26. Plan-view images from Stations P2800 (A), N3200 (B), and HARSC4 (C) showing a variety of biological features at the sediment surface. Image A shows a dense mat of surface tubes, while Image B shows large surface tubes, a seastar, shrimp, and an infaunal burrow. Sand dollars and surface tubes are visible at the sediment surface of Image C.

profile images (Figures 3.1-19 and 3.1-27). Dense tube mats (possibly the polychaete *Asabellides oculata*) were observed at the surface of red clay remediation material at Station P3200 (Figure 3.1-19). In addition, large surface tubes (possibly constructed by bamboo worms of the Family Maldanidae) were observed at the surface of remediation material at 26 stations, located primarily in PRAs 1 through 4 (Figure 3.1-27). Fish were also observed at the sediment surface at six stations (Stations A7, 17, 18, 29, N2000, and P2800). A large burrow opening, possibly due to the burrowing activities of a juvenile lobster, was present in one of the planview images from Station HARSC5 (Figure 3.1-28). A thin layer of brown organic flocculent material was also found to be covering the sediment surface in both the sediment-profile and plan-view images at many sandy stations within the surveyed area (Figure 3.1-27).

In terms of the sediment-profile images, three parameters were used to assess benthic recolonization status and overall benthic habitat conditions within the surveyed area: apparent RPD depth, infaunal successional status, and Organism Sediment Index (OSI). A wide variety of successional stages were observed at the stations over the surveyed area, including Stage I surface-dwelling organisms, Stage II infaunal amphipods and shallow-dwelling bivalves, and larger-bodied, subsurface-dwelling Stage III infauna (Table 3.1-1 and Figure 3.1-29). Stage I pioneering, tubicolous polychaetes occurred alone at 34% of the stations. Stage I only was observed most consistently at the sandy stations within and outside the HARS boundary (Figures 3.1-29 and 3.1-30).

Stage II taxa, in combination with higher successional stages (Stage III), were prevalent throughout the surveyed area, occurring at 26% of the stations. Stage II organisms tend to live at or just below the sediment-water interface; examples include the stick amphipods (Family Podoceridae) and the shallow-dwelling bivalve (*Nucula* sp.; Figures 3.1-31). A total of 3 replicate images displayed a “Stage I going to II” successional status (Stage I community living on the sediment surface, with evidence of activity below the sediment surface indicating progress toward an intermediate successional status).

Higher successional stages (Stages I on III, II on III, or III by itself), indicative of advanced benthic recolonization, were observed most consistently at the stations with fine-grained relic dredged material or remediation material within the HARS boundary (Figures 3.1-29). However, a number of sandy stations located primarily within PRAs 1, 2, and 3 displayed an advanced successional status as a result of large Stage III tubes (tentatively identified as sub-surface deposit-feeding bamboo worms of the polychaete family Maldanidae) at the sediment surface (e.g., Figure 3.1-27, 3.1-30A and C, 3.1-31A and 3.1-32). “Stage II going to III” was assigned to a total of 6 replicate images and represents an intermediate successional status with some evidence of progression to a Stage III equilibrium community (e.g., burrowing infauna). Evidence of Stage III head-down, deposit-feeding infauna (active feeding voids in the subsurface sediments) was detected at 45% of the stations. When present, Stage III organisms were often accompanied by either Stage I or Stage II organisms at the sediment-water interface (Figure 3.1-30, images A and C). Six stations were given an “indeterminate” successional designation due to hard bottom conditions in both replicate images.

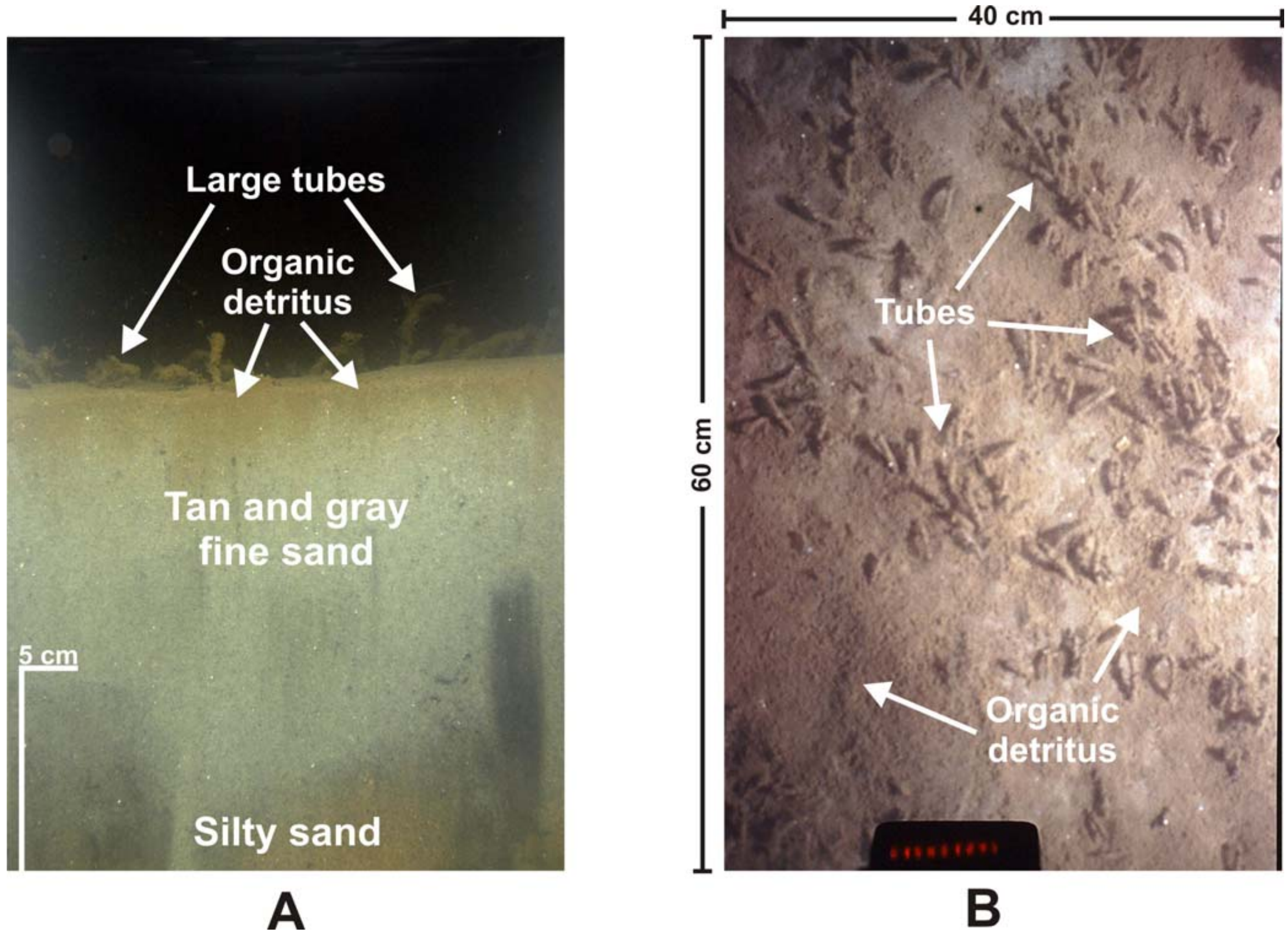


Figure 3.1-27. Sediment-profile image (A) and corresponding plan-view image (B) from Station HARSC1 showing a dense assemblage of large tubicolous polychaetes (possibly bamboo worms of the polychaete Family Maldanidae) at the sediment surface. Both images show a layer of brown flocculent organic detritus at the surface of the fine sand.

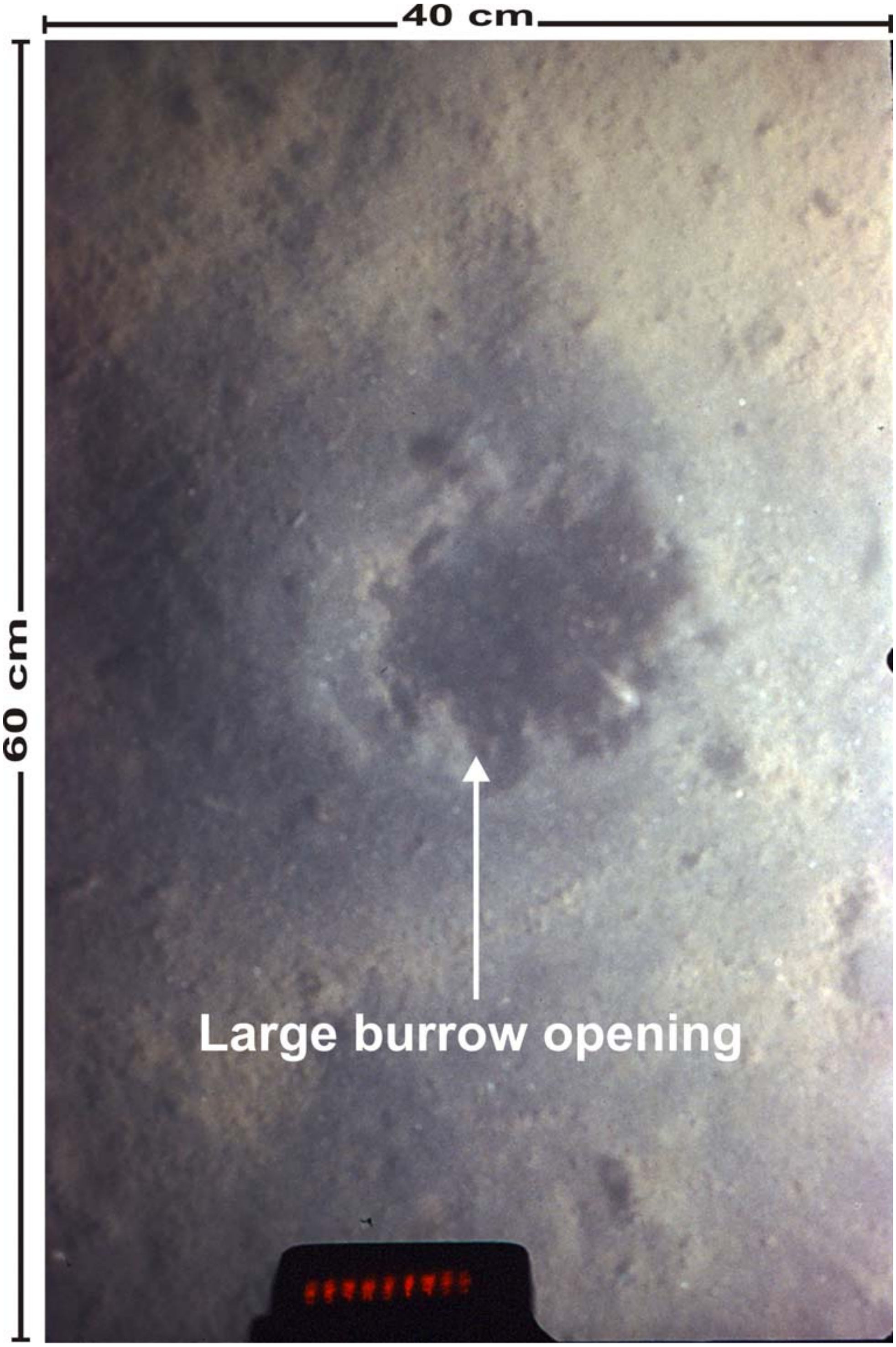


Figure 3.1-28. Plan-view image from Station HARSC5 showing a large burrow opening at the sediment surface possibly due to the burrowing activities of a juvenile lobster

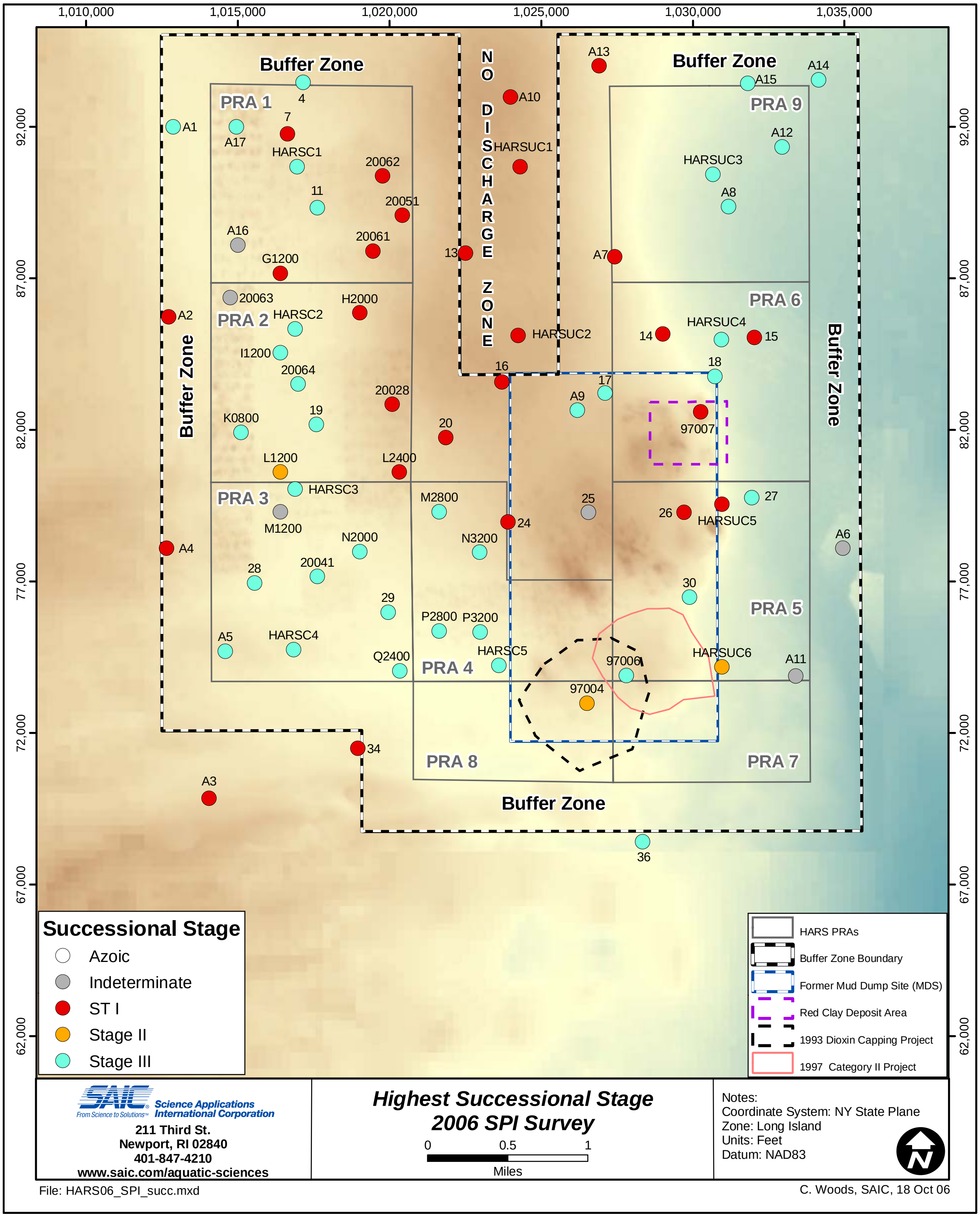
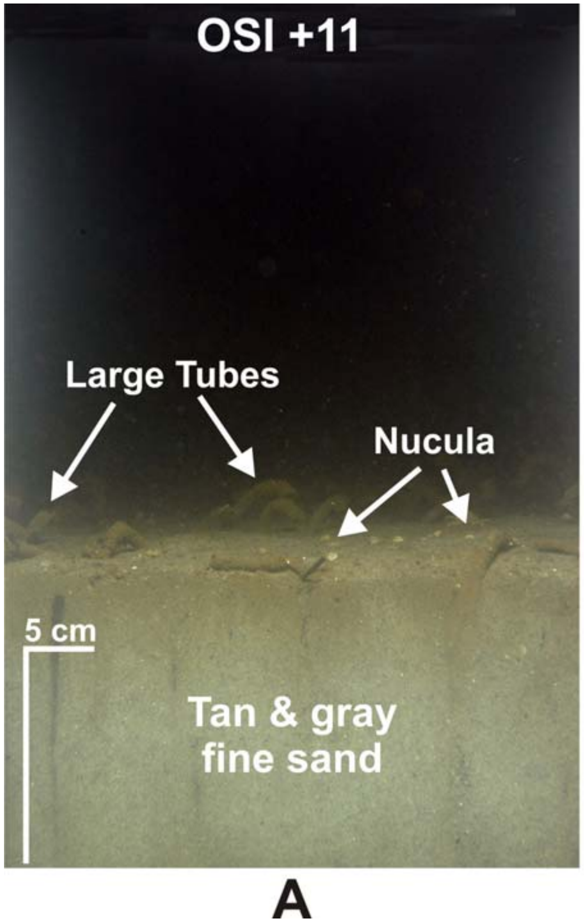


Figure 3.1-29. Highest successional stage observed at each of the 2006 SEDIMENT-PROFILE stations. The blue "Stage III" symbol denotes either Stage I on III, Stage II on III, or Stage III present at this station.



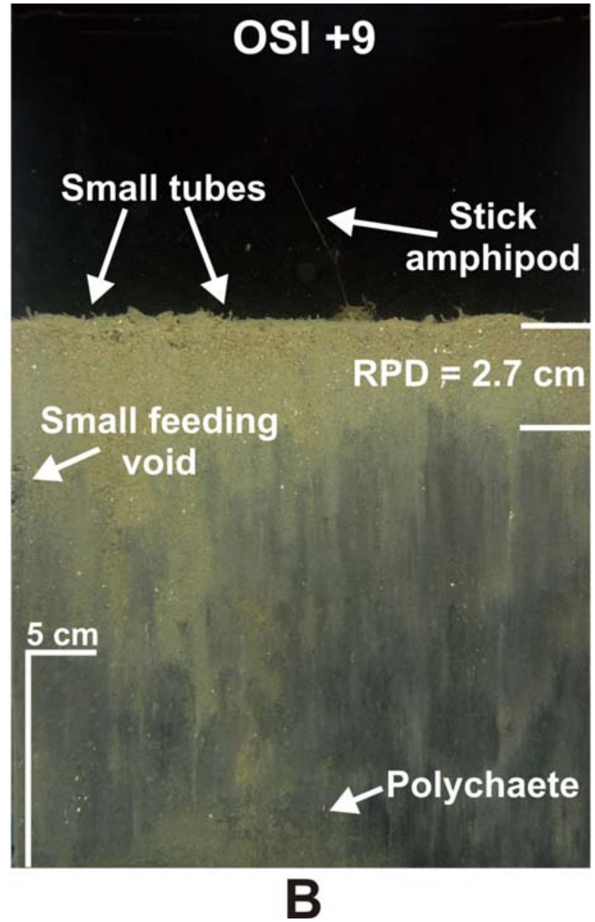


Figure 3.1-30. Sediment-profile images from Stations 19 (A) and A15 (B) illustrating an advanced recolonization of the surface sediment. A Stage II on III successional status was assigned to both images as a result of Stage II taxa (shallow-dwelling bivalves, *Nucula* sp., or stick amphipods) at the sediment-water interface along with Stage III tubes at the surface (A) or over Stage III feeding voids at depth (B). Image A also illustrates an RPD depth measurement greater than camera prism penetration (i.e., RPD>pen). The presence of these advanced successional stages and moderate RPD depths results in an OSI of +11 for Image A and +9 for Image B (undisturbed benthic habitat quality).

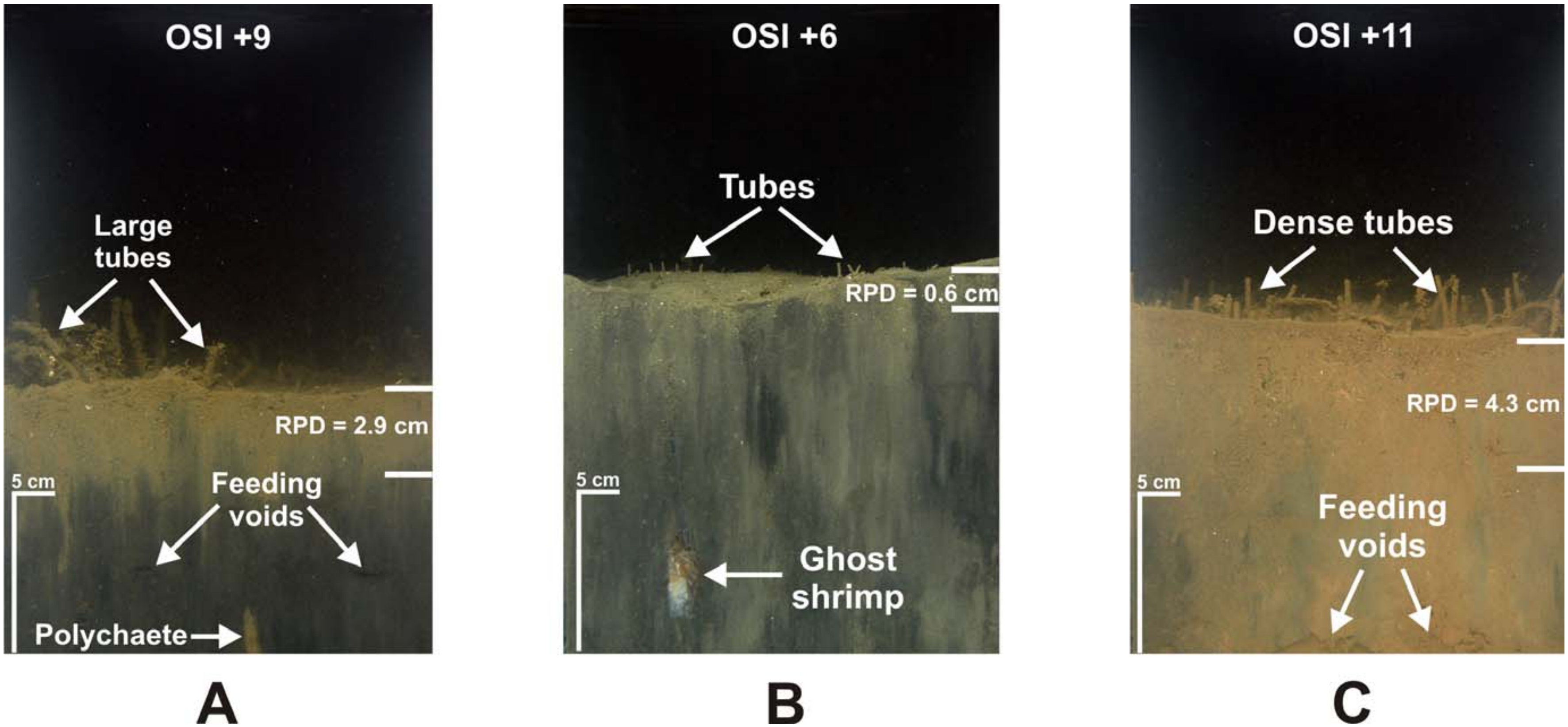


Figure 3.1-31. Sediment-profile images from Stations M2800 (A) and A15 (B) and P3200 (C) illustrating advanced recolonization of the dredged material. Each image was given a Stage I on III successional status as a result of tubicolous polychaetes at the sediment surface together with Stage III organisms and feeding voids at depth. Advanced successional stages along with deep RPD depths resulted in OSI values indicative of undisturbed benthic habitat quality for Images A and C, while a shallow RPD and an advanced successional status in Image B resulted in an OSI of +6 indicative of moderately disturbed benthic habitat quality.

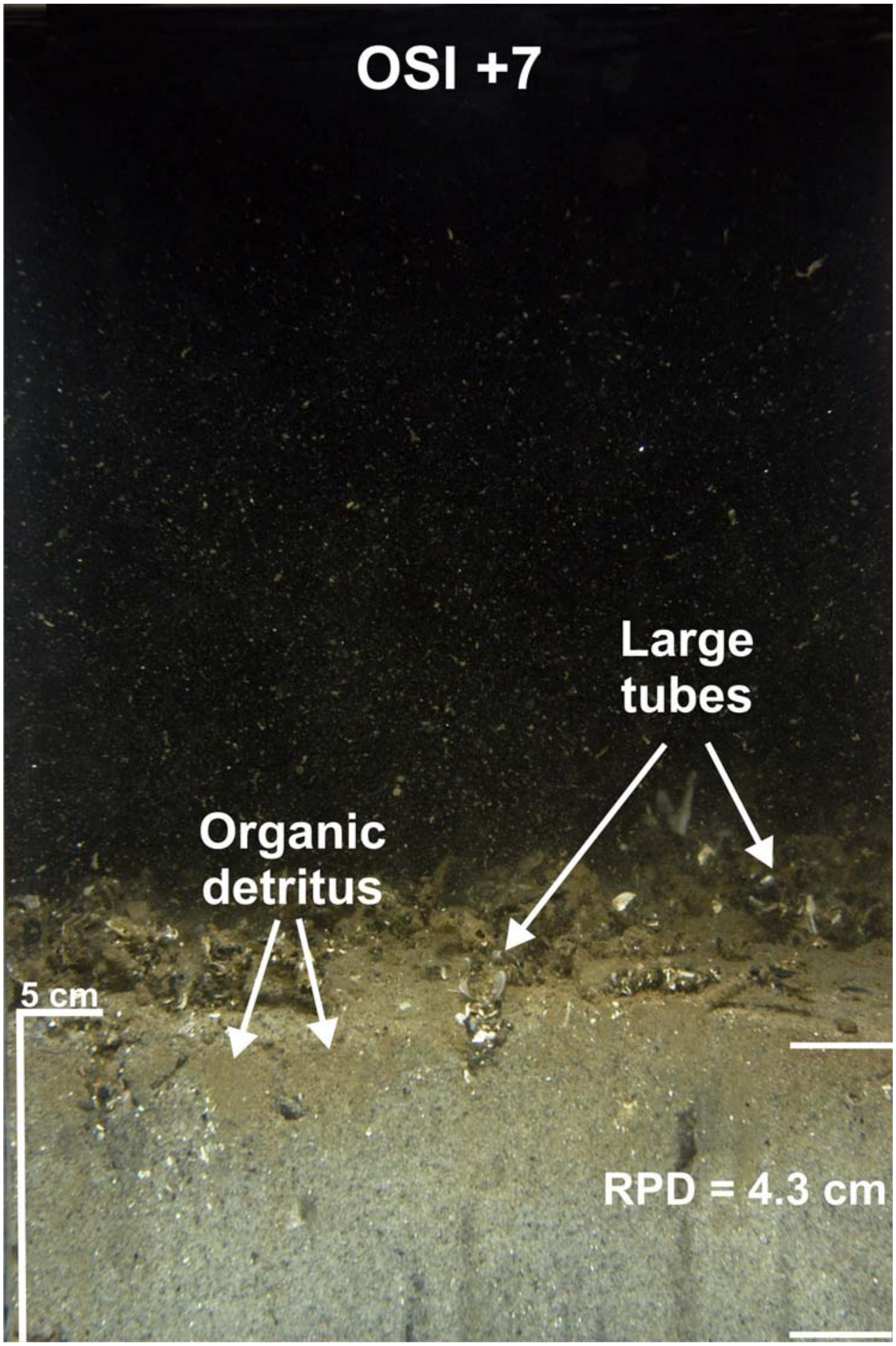


Figure 3.1-32. Sediment-profile image from Station 20061 illustrating colonization of the remediation material with dense, relatively thick tubes occurring at the sediment surface (OSI +7)

The RPD provides a measure of the apparent depth within the sediment column where geochemical conditions are predominantly oxidizing. Below the RPD, these conditions are predominantly reducing. The average RPD values were quite variable across the surveyed area, ranging from 0.8 cm at Stations 30 and Q2400, characterized by fine-grained dredged material (sandy mud), to 5.8 cm at Station 19 characterized by uniform fine Ambrose Channel sand (Table 3.1-1; Figure 3.1-33). The overall mean apparent RPD depth at the 2006 sediment-profile stations was 2.9 cm (Table 3.1-1). Overall, the measured RPD depths were indicative of a moderate to high degree of surface sediment aeration and biogenic mixing. At the sandy stations located primarily outside the remediation areas of the HARS (ambient stations) and sandy stations within PRAs 1 and 2, this oxidation was attributed to physical mixing of the uppermost sediment layer related to periodic bedload movement of the sand. The deepest mean apparent RPD depths occurred at the stations with high reflectance sand and were often a function of the camera prism penetration depth (i.e., RPD greater than penetration; Figure 3.1-31A). At stations characterized by fine-grained recent and relic dredged material, the creation and maintenance of oxidizing conditions within the sediment column, and corresponding increases in the RPD depth, were attributed primarily to the bioturbation activities of infaunal organisms. Due to hard bottom conditions, the RPD was not measurable at eight stations.

Although no evidence of redox rebound intervals was noted in the surficial sediments, a relic RPD (an indicator of sediment layering) was detected at two stations (Stations 11 and N2000) that had multiple dredged material layers (Figure 3.1-10). Relic RPDs usually occur when a relatively thin layer of dredged material is placed over an older deposit or ambient sediments, and represent the depth of oxygenation in the underlying material prior to being covered by the fresh deposit. A new RPD will be formed at the sediment surface as oxygen is incorporated into the surficial sediments via the bioturbational activity of the benthic infauna. None of the replicate images obtained within the HARS survey area exhibited any evidence of apparent low dissolved oxygen conditions or methane gas entrained within the sediment. Although methane gas bubbles had been detected at Station 11 in both the 2002 and 2005 sediment-profile surveys (suggesting the presence of high organic content remediation material), no methane was detected at this station in the 2006 survey.

Mean OSI values over the HARS survey area ranged from +3.0 to +11, with an overall mean value of +7.1 (Table 3.1-1; Figure 3.1-34). The overall value is considered indicative of undisturbed or non-degraded benthic habitat conditions. Station G1200, located in PRA 1, was the only station to display an mean OSI value falling between 0 and +3. Values in this range suggest disturbed or degraded benthic habitat conditions. At Station G1200, the relatively low OSI value was attributed to physical disturbance from placement of remediation material in the recent past (i.e., in 2006). The intermediate to high OSI values calculated at the other stations within the HARS boundary indicate a fairly advanced degree of recovery from disturbance associated with either post-HARS placement of remediation material or disposal of dredged material in the more-distant past (i.e., prior to designation of the HARS in 1997; Figure 3.1-30).

Because the OSI was developed for characterizing disturbance primarily in soft-bottom, muddy environments, the values calculated for the sandy stations, where penetration of the sediment-profile camera was often low, provide a somewhat less robust indicator of habitat conditions. These stations were labeled as having either moderately degraded or non-degraded conditions.

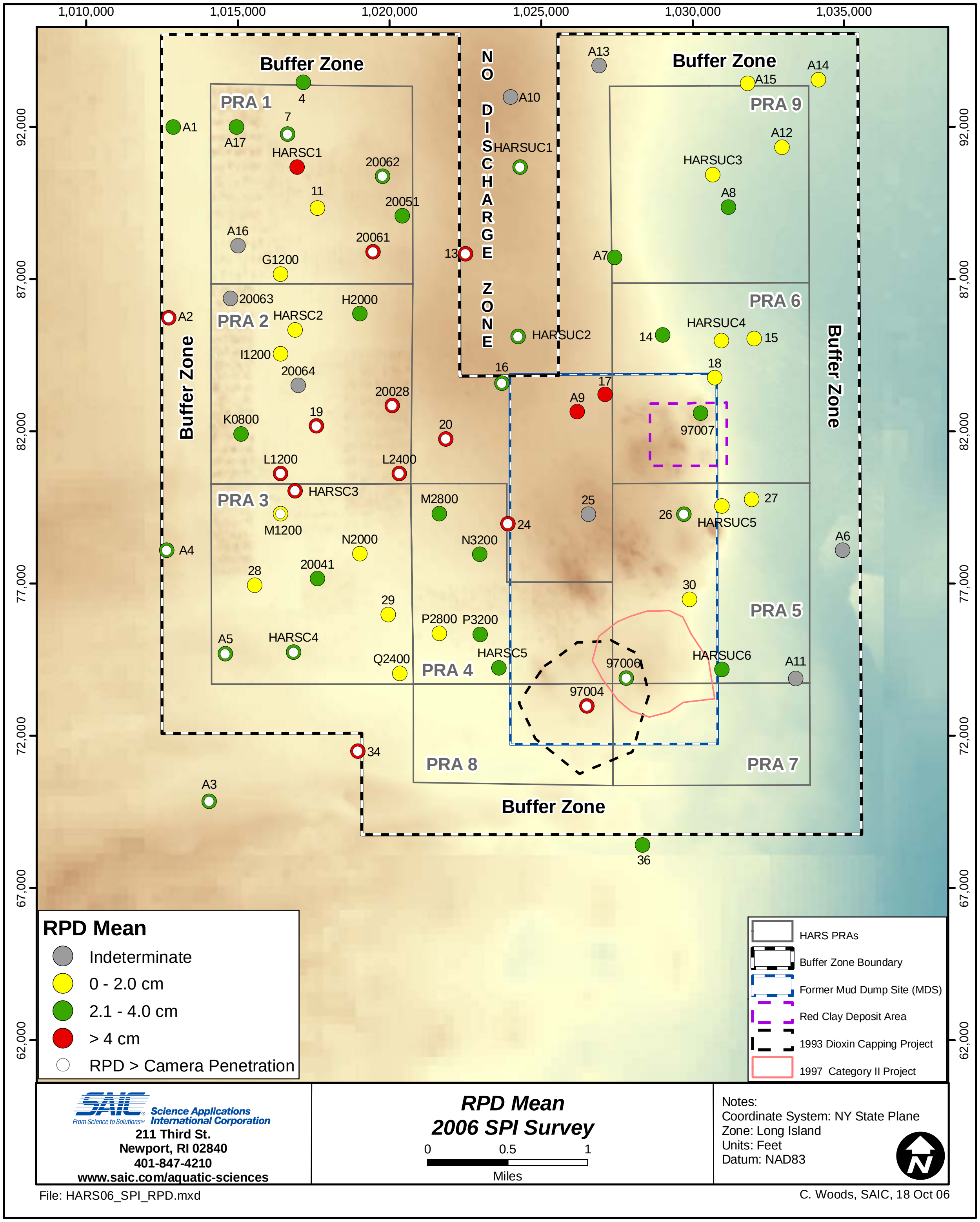


Figure 3.1-33. Mean apparent RPD depths at the 2006 sediment-profile stations

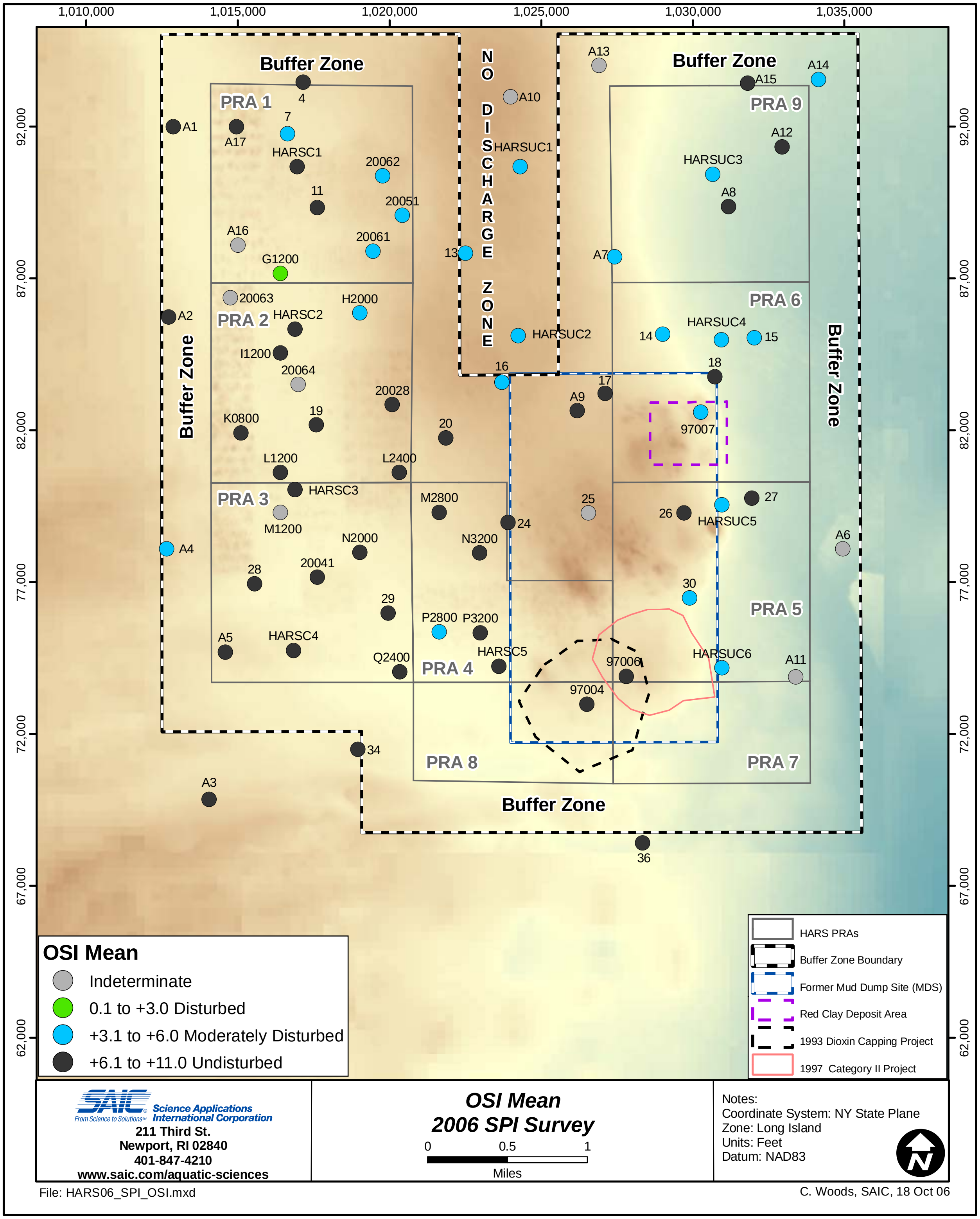


Figure 3.1-34. Mean OSI values at the 2006 sediment-profile stations

In general, the benthic habitat at these stations consisted of clean sand (either ambient sand or remediation material from Ambrose Channel) that appeared to be supporting healthy benthic communities. OSI calculations were not possible at nine stations due to either an indeterminate RPD depth and/or successional status.

3.1.3 Comparison with Previous Surveys

Of the 61 stations sampled in the 2006 sediment-profile survey, 33 were sampled in the previous surveys of 2002 and 2005. An additional 6 stations were sampled in both 2005 and 2006, but not in 2002. A multi-year comparison of results for three key sediment-profile parameters (grain size major mode, successional stage, and OSI) is provided in Table 3.1-2.

At the majority of stations, there were either no significant changes in sediment grain size, or else the observed changes were relatively minor (i.e., a difference of only a single phi class). Differences of more than one grain size phi class indicate more significant changes in physical habitat conditions. At stations 7, 19, and 24, the sediment type changed from silt-clay (>4 phi) in 2002 to fine sand (3 to 2 phi) or coarse sand (1 to 0 phi) in 2005/2006 (Table 3.1-2). Station 20051 likewise changed from silt-clay in 2005 to fine sand in 2006 (Table 3.1-2). All of these stations are located in PRAs 1 through 4, where remediation material has been placed at various times and locations throughout the period of 2002 to 2006. At stations 7, 19 and 20051, the change from muddy remediation material in 2002/2005 to fine sand in 2006 is due to the placement of Ambrose Channel sand in PRAs 1 and 2 over the past few years. At station 24 in PRA 4, the year-to-year differences are attributed to small scale spatial variability at this location.

There was another group of stations, all clustered in the southern half of PRA 2 or the northern half of PRA 3, where the grain major mode changed from rocks (<-1 phi) or coarse sand (1 to 0 phi) in 2002/2005 to either silt-clay (>4 phi) or fine sand (3 to 2 phi) in 2006. This group includes stations K0800, L1200, L2400, M1200 and 20028 (Table 3.1-2). At these stations, rocks and coarser-grained remediation material associated with the KVK deepening project have become buried by fine-grained remediation material. At the time of the 2006 survey, the new remediation material consisted of red clay at stations K0800 and M1200, and Ambrose Channel sand at stations L1200, L2400, and 20028 (Figure 3.1-2).

In the 2002, 2005, and 2006 surveys, benthic communities across the HARS were found to be comprised of diverse infauna and epifauna representing different successional stages. Of the 33 stations common to all three surveys, the majority of stations in 2002 showed Stage I as the highest successional stage, while the majority in 2005 and 2006 where characterized by the presence of Stage III (alone or in combination with Stages I or II; Table 3.1-2 and Figure 3.1-35). The years 2005 and 2006 were very similar in terms of the number of stations showing each of the different successional stages (Figure 3.1-35). Stations which had Stage I only in 2002 versus Stage III (alone or in combination with Stages I or II) in 2005/2006 were located both in remediated and unremediated areas of the HARS. Overall, the results suggest that the general region of the HARS has become colonized to a greater extent by populations of larger-bodied, Stage III organisms in recent years.

Table 3.1-2. A multi-year comparison of results for three key SPI parameters (grain size major mode, successional stage, and OSI)

	Grain Size Major Mode			Highest Successional Stage			Mean OSI		
Station	**2002**	**2005**	**2006**	**2002**	**2005**	**2006**	**2002**	**2005**	**2006**
4	3 to 2 phi (2)	4 to 3 phi (2)	3 to 2 phi	ST II	ST I to II	ST III	5.0	6.0	10.5
7	> 4 phi (2)	> 4 phi (2)	3 to 2 phi (1), 4 to 3 phi (1)	ST II	ST III	ST I	6.5	8.5	5.5
11	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST I	ST I on III	ST III	4.0	6.5	7.5
13	3 to 2 phi (2)	3 to 2 phi (2)	3 to 2 phi (2)	ST I	ST I	ST I	7.0	4.5	6.0
14	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST II on III	ST I on III	ST I	8.0	4.5	5.0
15	> 4 phi (1), 1 to 0 phi (1)	> 4 phi (2)	< -1 phi (1), 4 to 3 phi (1)	ST I	ST I on III	ST I	6.0	4.0	4.0
16	3 to 2 phi (2)	1 to 0 phi (1), 2 to 1 phi (1)	3 to 2 phi (2)	ST I	ST I	ST I	6.0	3.5	5.5
17	> 4 phi (2)	> 4 phi (2)	> 4 phi (1), 3 to 2 phi (1)	ST II	ST I	ST I on III	5.0	5.0	8.0
18	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST II	ST I to II	ST I on III	6.0	6.0	8.0
19	> 4 phi (2)	> 4 phi (2)	3 to 2 phi (1), 4 to 3 phi (1)	ST I on III	ST II to III	ST II on III	11.0	7.0	11.0
20	3 to 2 phi (2)	3 to 2 phi (2)	3 to 2 phi (2)	ST I	ST I	ST I	6.5	4.5	6.5
24	> 4 phi (2)	3 to 2 phi (2)	1 to 0 phi (1), 3 to 2 phi (1)	ST I	ST I	ST I	2.0	5.0	7.0
25	1 to 0 phi (2)	0 to -1 phi (1), 1 to 0 phi (1)	< -1 phi (1), 0 to -1 phi (1)	ST I	ST I	INDET	7.0	4.0	INDET
26	3 to 2 phi (2)	2 to 1 phi (2)	< -1 phi (1), 3 to 2 phi (1)	ST I	ST I	ST I	5.0	4.0	7.0
27	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST II on III	ST I on III	ST I on III	6.5	8.0	7.0
28	4 to 3 phi (1)	> 4 phi (2)	> 4 phi (2)	ST I	ST I on III	ST II on III	3.0	5.5	8.0
29	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST I on III	ST I on III	ST II on III	7.0	6.5	7.5
30	> 4 phi (1), 3 to 2 phi (1)	> 4 phi (2)	4 to 3 phi (2)	ST I on III	ST II on III	ST I on III	7.5	7.0	5.0
34	2 to 1 phi (2)	3 to 2 phi (2)	3 to 2 phi (2)	ST I	ST I	ST I	7.0	5.0	7.0
36	> 4 phi (1), 4 to 3 phi (1)	> 4 phi (1), 4 to 3 phi (1)	> 4 phi (2)	ST I on III	ST II	ST II on III	6.5	5.0	8.5
G1200	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST I	ST I on III	ST I	4.5	6.0	3.0
H2000	> 4 phi (2)	> 4 phi (2)	> 4 phi (1), 3 to 2 phi (1)	ST I on III	ST I on III	ST I	10.0	5.0	5.0
I1200	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	INDET	ST I on III	ST II on III	INDET	5.5	8.0
K0800	1 to 0 phi (1), 4 to 3 phi (1)	> 4 phi (2)	> 4 phi (2)	INDET	ST III	ST I on III	INDET	INDET	10.0
L1200	< -1 phi (2)	> 4 phi (2)	3 to 2 phi (2)	INDET	ST I	ST II	INDET	3.0	7.5
L2400	< -1 phi (1), 1 to 0 phi (1)	< -1 phi (1)	3 to 2 phi (2)	ST I	INDET	ST I	7.0	INDET	7.0
M1200	1 to 0 phi (1), 4 to 3 phi (1)	> 4 phi (1), N/A (1)	> 4 phi (1)	ST I	ST I	INDET	4.0	4.0	INDET
M2800	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	INDET	ST II on III	ST I on III	INDET	8.0	9.0
N2000	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST III	ST I on III	ST II on III	2.0	8.0	8.0
N3200	> 4 phi (2)	> 4 phi (1), 4 to 3 phi (1)	> 4 phi (2)	ST I	ST I on III	ST II on III	6.5	8.5	8.5
P2800	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST I on III	ST I on III	ST I on III	6.0	5.5	5.5
P3200	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST I	ST I	ST I on III	5.5	4.5	8.0
Q2400	> 4 phi (2)	> 4 phi (2)	> 4 phi (2)	ST I on III	ST II	ST II on III	6.0	6.0	6.5
97004	N/A	3 to 2 phi (2)	3 to 2 phi (2)	N/A	ST I	ST II	N/A	4.50	7.50
97006	N/A	3 to 2 phi (2)	3 to 2 phi (2)	N/A	ST I	ST II to III	N/A	4.00	8.00
97007	N/A	> 4 phi (2)	> 4 phi (2)	N/A	ST I	ST I	N/A	4.00	5.50
20028	N/A	< -1 phi (1), > 4 phi (1)	3 to 2 phi (2)	N/A	ST I	ST I	N/A	4.00	6.5
20041	N/A	> 4 phi (2)	> 4 phi (2)	N/A	ST I on III	ST I on III	N/A	8.50	7.5
20051	N/A	> 4 phi (2)	3 to 2 phi (2)	N/A	ST I on III	ST I	N/A	4.00	5.0

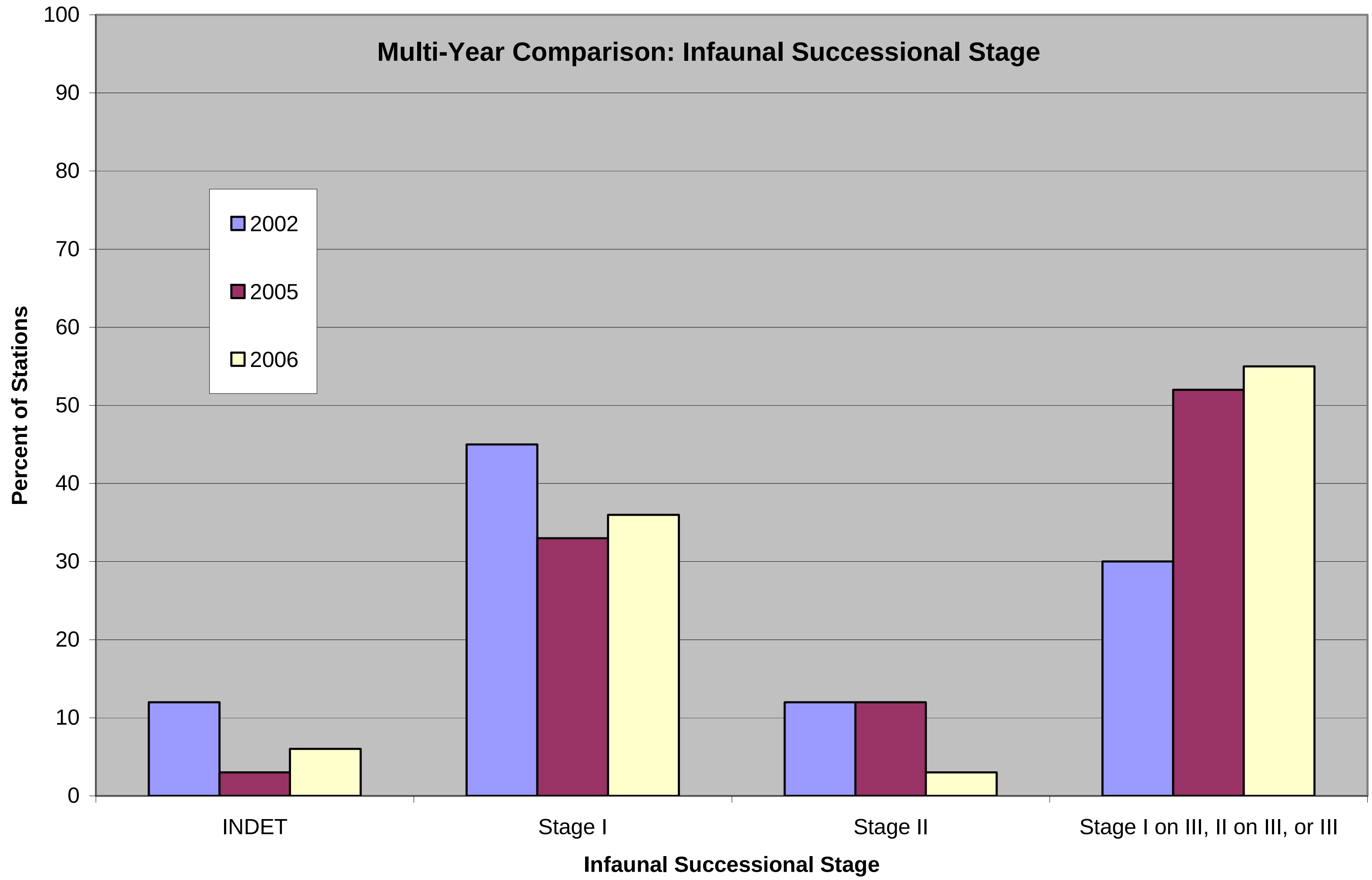


Figure 3.1-35. Infaunal successional stages observed in the 2002, 2005, and 2006 sediment-profile surveys

Reflecting the infaunal successional dynamics, the OSI values indicate that habitat conditions at the majority of stations have been classified as either moderately disturbed or undisturbed in all three years (Table 3.1-2; Figure 3.1-36). The number of stations with undisturbed habitat conditions increased between 2005 and 2006 (Figure 3.1-36), reflecting the fact that 2006 also had the highest proportion of stations with a more advanced, Stage III successional designation (Figure 3.1-35).

3.2 Sub-Bottom Profiling Survey

The primary focus of the 2006 sub-bottom profile effort was to assess the integrity and approximate thickness of the sand cap layer over the 1993 and 1997 capped mounds. In addition, some limited reconnaissance sub-bottom data were also acquired over other areas of the HARS. Due to scheduling issues created by weather-related delays and required coordination with the ERDC grab sampling effort, the sub-bottom data acquisition operations were conducted over multiple single day efforts over the course of the field operations (Table 2.1-1). Due to sea conditions encountered during some portions of sub-bottom data acquisition, particularly on 30 August, heave-induced motion of the towfish resulted in some degradation of data quality. Though the surging towfish motion caused by large seas did create “noise” in the data record, the seafloor surface and sub-bottom reflectors could still be clearly identified (Figure 3.2-1). Despite the noisiness of the record, the seafloor surface and sometimes numerous sub-bottom reflectors can be distinguished within the top 3 to 4 m of the sediment column. During these larger sea condition periods, the surging motion of the towfish also caused an unnatural waviness on both the seafloor surface and the underlying sub-bottom reflectors. During the process of manually digitizing the various sub-bottom reflectors, the heave-related artifacts were removed by subjectively smoothing over these features.

The ability to completely and accurately map the sand cap layer was also impacted by the sometimes discontinuous nature of these reflectors in the sub-bottom records. Though the sand cap/dredged material interface could be reliably detected throughout most of the records, there were several areas where the interface could not be clearly distinguished, resulting in sporadic along-track data gaps in the digitized sub-bottom reflector files. These data gaps were primarily associated with areas where the sand cap reflector did not provide a distinct horizon or where the seafloor surface acoustic return masked the underlying sand cap layer (Figure 3.2-1 and 3.2-2). In general, these discontinuities were more prevalent in the cap overlap area and were likely associated with the increased disturbance caused by greater placement activity of both dredged material and capping sediments in these areas. In those areas on the periphery of the Mounds, the apparent cap reflector tended to be more distinct throughout and easier to track continuously (Figure 3.2-3). Any discontinuities in the acoustic layer being tracked were interpolated over as part of the manual digitizing process. In many cases this interpolation was straightforward, but in some areas, particularly where multiple layers were evident, the interpolation became a more subjective process (Figure 3.2-2). Although the resulting gridded cap thickness models essentially smoothed over any of the data gap areas, there was less confidence in the grid results over these areas.

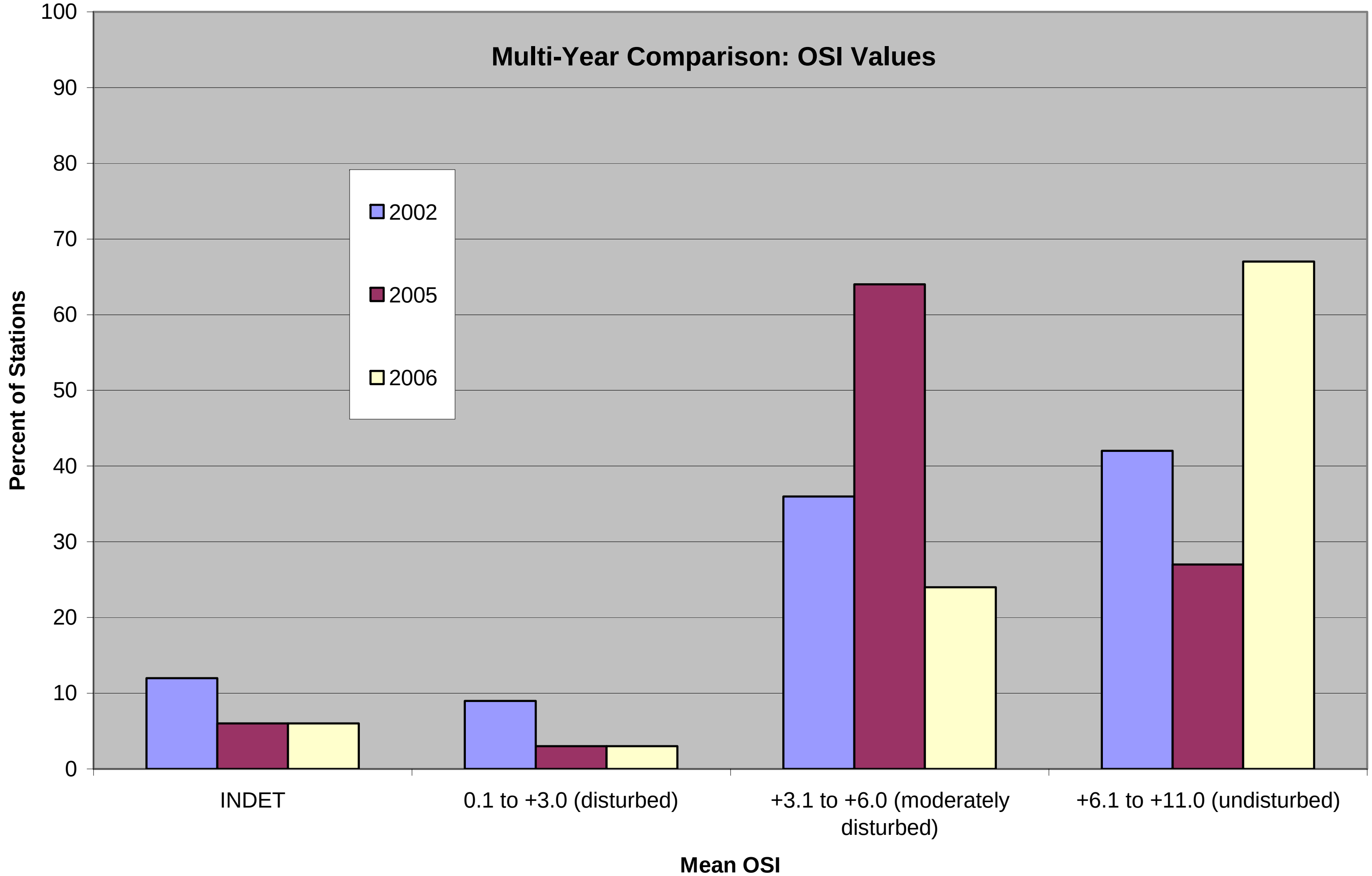


Figure 3.1-36. Mean OSI values observed in the 2002, 2005, and 2006 sediment-profile surveys

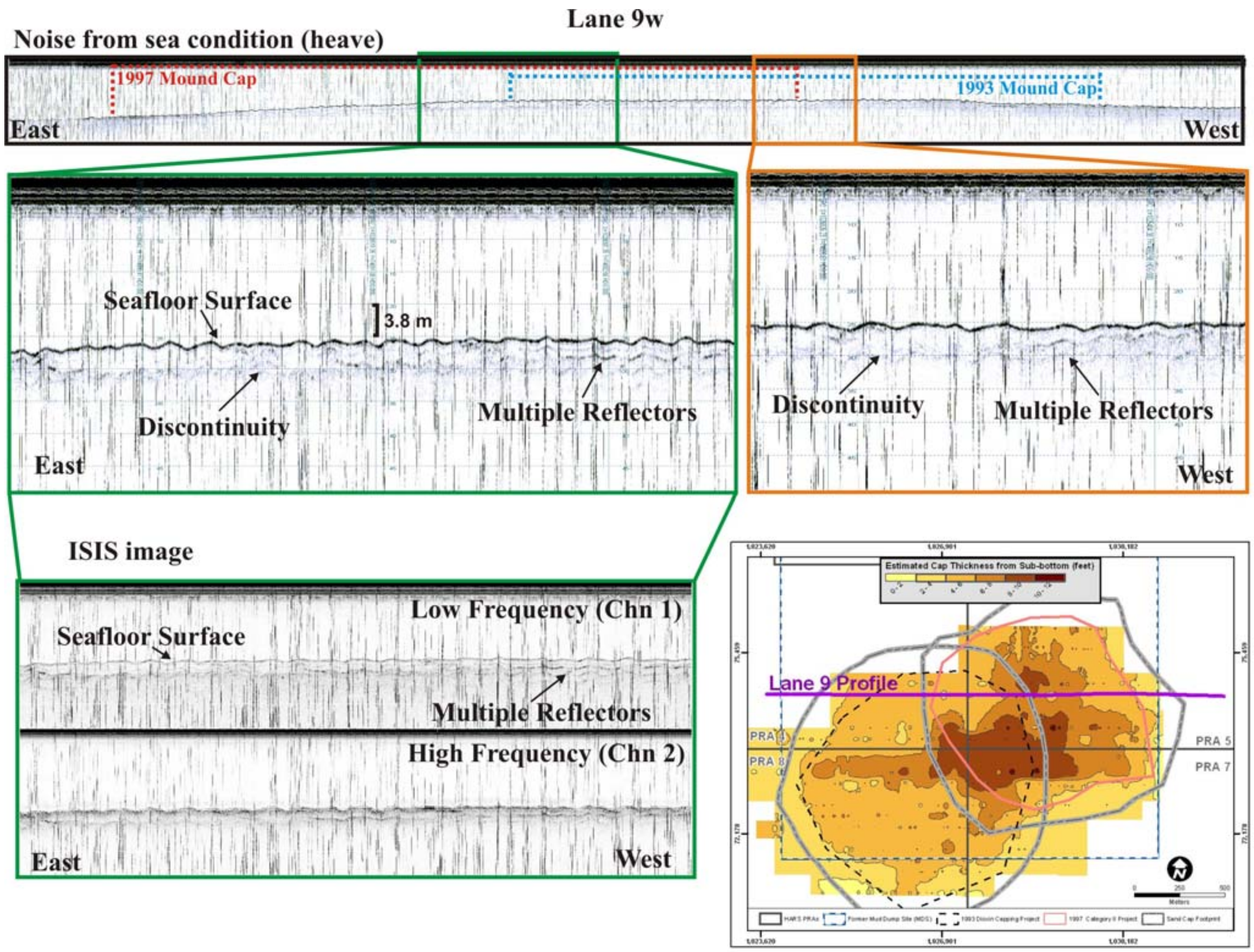


Figure 3.2-1. Sub-bottom profile record from Lane 9w over the1993 and 1997 capped mounds illustrating the effect of heavy sea conditions on the data quality. Despite the "noisy" data, multiple reflectors could still be detected and the data were useable for their intended purpose. The inset map shows the location of this lane over the mound area.

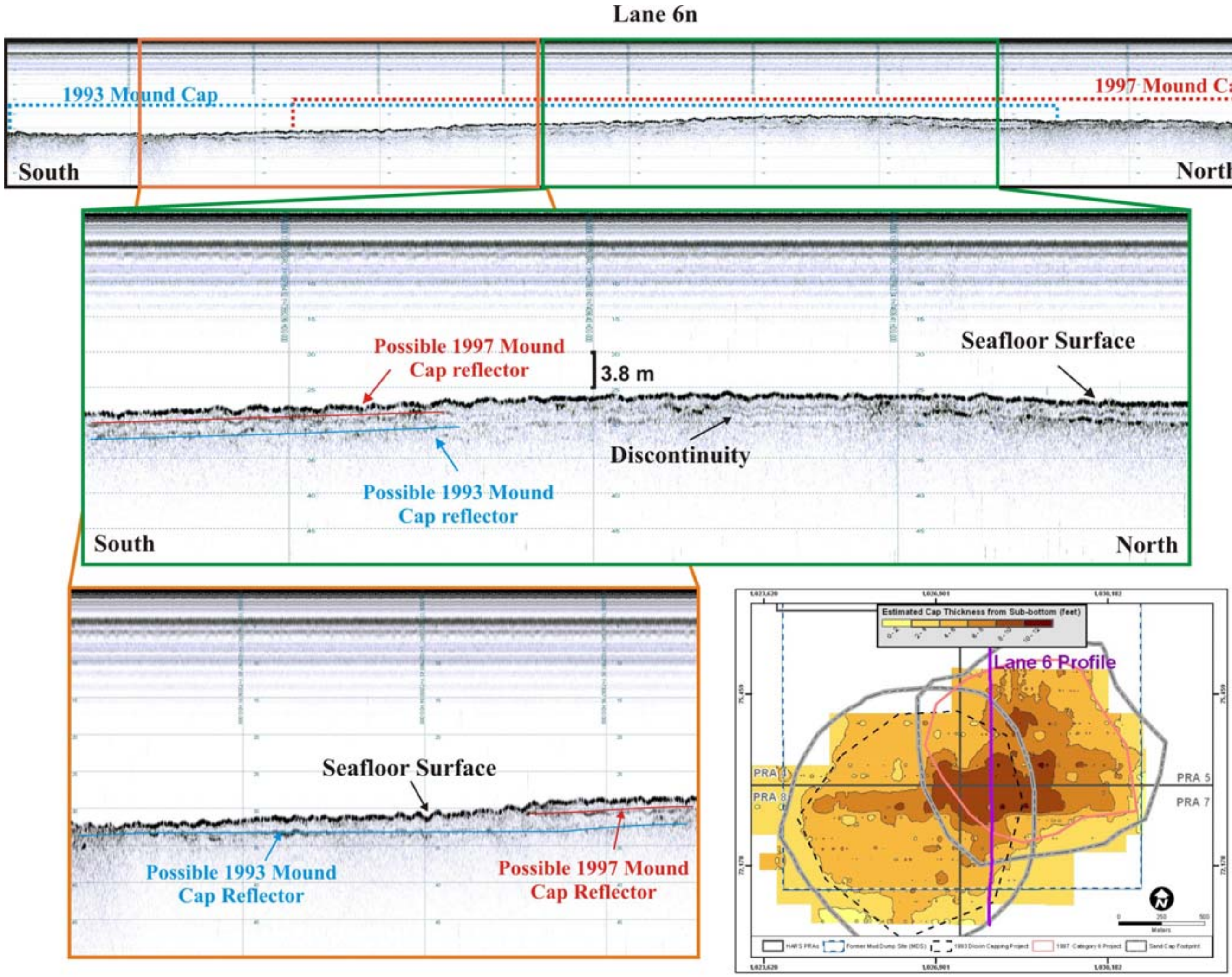


Figure 3.2-2. Sub-bottom profile record from Lane 6n over the1993 and 1997 mound area illustrating the nature of the apparent cap reflectors in this area. Although well-defined cap reflectors were evident in the records, there were sporadic discontinuities in these reflectors, particularly in the cap overlap area. The inset map shows the location of this lane over the mound area.

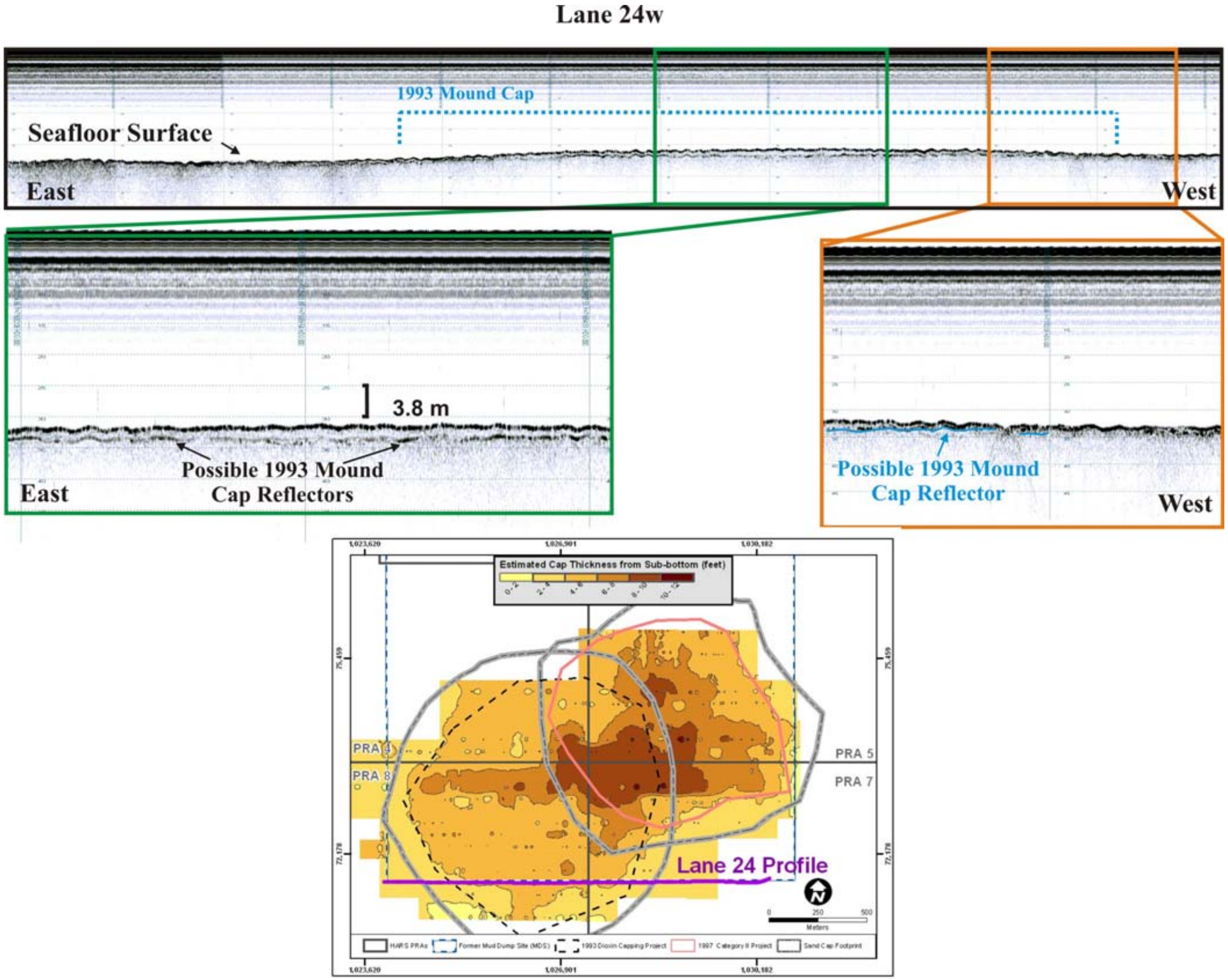


Figure 3.2-3. Sub-bottom profile record from Lane 24w over the southern portion of the 1993 mound area illustrating the relatively continuous cap reflector that could be detected in this area of relatively limited surface disturbance. The inset map shows the location of this lane over the mound area.

Finally, without any confirmatory sediment coring data, there was no way of positively stating the composition of the various sediment layers that might have been identified within a particular acoustic sub-bottom dataset. In addition to the initial water-column/seafloor interface, there may have been multiple sand cap/recent dredged material interfaces, as well as an older relic dredged material/ambient sediment interface. Within some of the cap overlap areas, it was often possible to identify as many as four or five distinct reflectors within the top 5 m of the sediment column (Figure 3.2-1 and 3.2-2). Though a reasonable assumption of the probable sediment layering could be made based upon the known placement history at the site, there was no way of conclusively making this connection based solely on the acoustic data. Though the acoustic sub-bottom data did provide a good broad-scale view of the cap thickness and integrity, there was a degree of subjectivity in the interpretation and application of these data.

An apparently hard, sand feature rising about 12 to 16 feet above the surrounding bottom was detected in several of the lanes that ran through the northwestern portion of the 1993 Mound. Though there were no sub-surface reflectors detected directly beneath this feature, the apparent start of the 1993 Mound was evident just to the east of this feature (Figure 3.2-4). The layer beneath this feature and the adjacent cap material reflector was presumed to be the relic dredged material deposit. Another distinct reflector periodically observed below the dredged material layer was identified as the probable dredged material/ambient sediment interface or basement sand reflector. When visible, this reflector was generally seen about 20 to 25 ft below the seafloor surface. Because the basement reflector was only detected intermittently along some of the lanes, a gridded model of apparent relic dredged material thickness could not be generated.

Based on the digitized sub-bottom reflector data, a gridded cap thickness model was generated to provide an indication of approximate cap coverage over the Mound region (Figure 3.2-5). A view of the individual digitized data points that were used in creating this grid has been included on the figure to help illustrate the extent of the data coverage and the degree of interpolation required. Based on this gridded cap thickness model, most of the area within the mound footprints appeared to be covered by around 4 to 7 feet of cap material (Figure 3.2-5). The 1997 Mound exhibited somewhat greater cap thicknesses relative to the 1993 Mound. The greatest cap thicknesses of more than 10 feet were detected in the area where the northeast portion of the 1993 Mound overlapped with the southwest portion of the 1997 Mound. In this area, the layering of cap material from the two projects was clearly indicated by the multiple distinct sub-bottom reflectors detected in the survey lanes passing over the area of overlap (Figure 3.2-2). As discussed above, the process of digitizing the cap reflector was more subjective in this cap overlap area because often more than two reflectors (multiple cap and dredged material layers) were visible in this area and sometimes these reflectors were not continuous through this area.

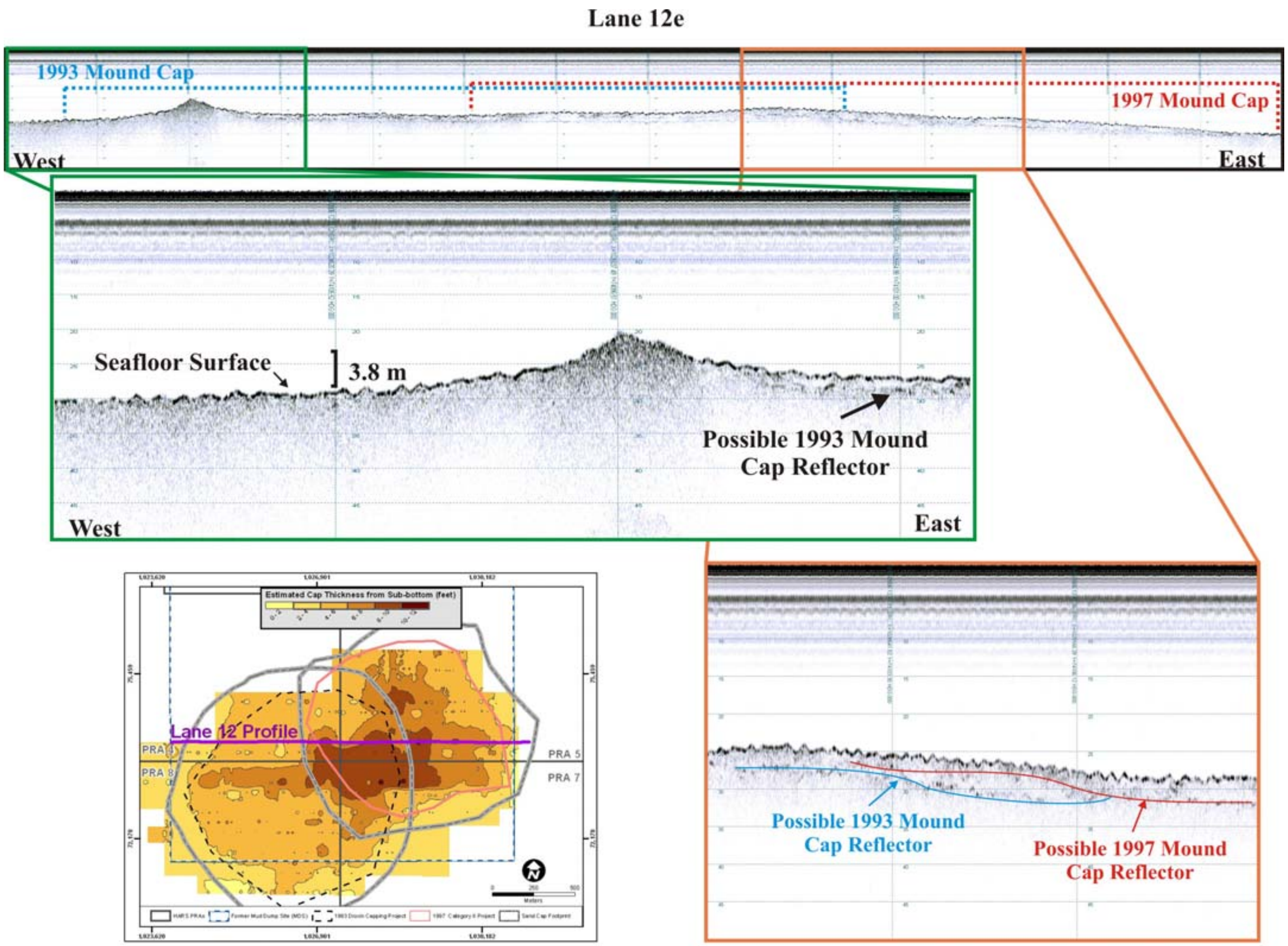


Figure 3.2-4. Sub-bottom profile record from Lane 12e over the1993 and 1997 mound area illustrating an historic bathymetric high point feature near the western edge of the 1993 cap layer. Within the cap overlap area near the center of this record, apparent sand cap thicknesses of approximately 7 to over 10 feet were detected. The inset map shows the location of this lane over the mound area.

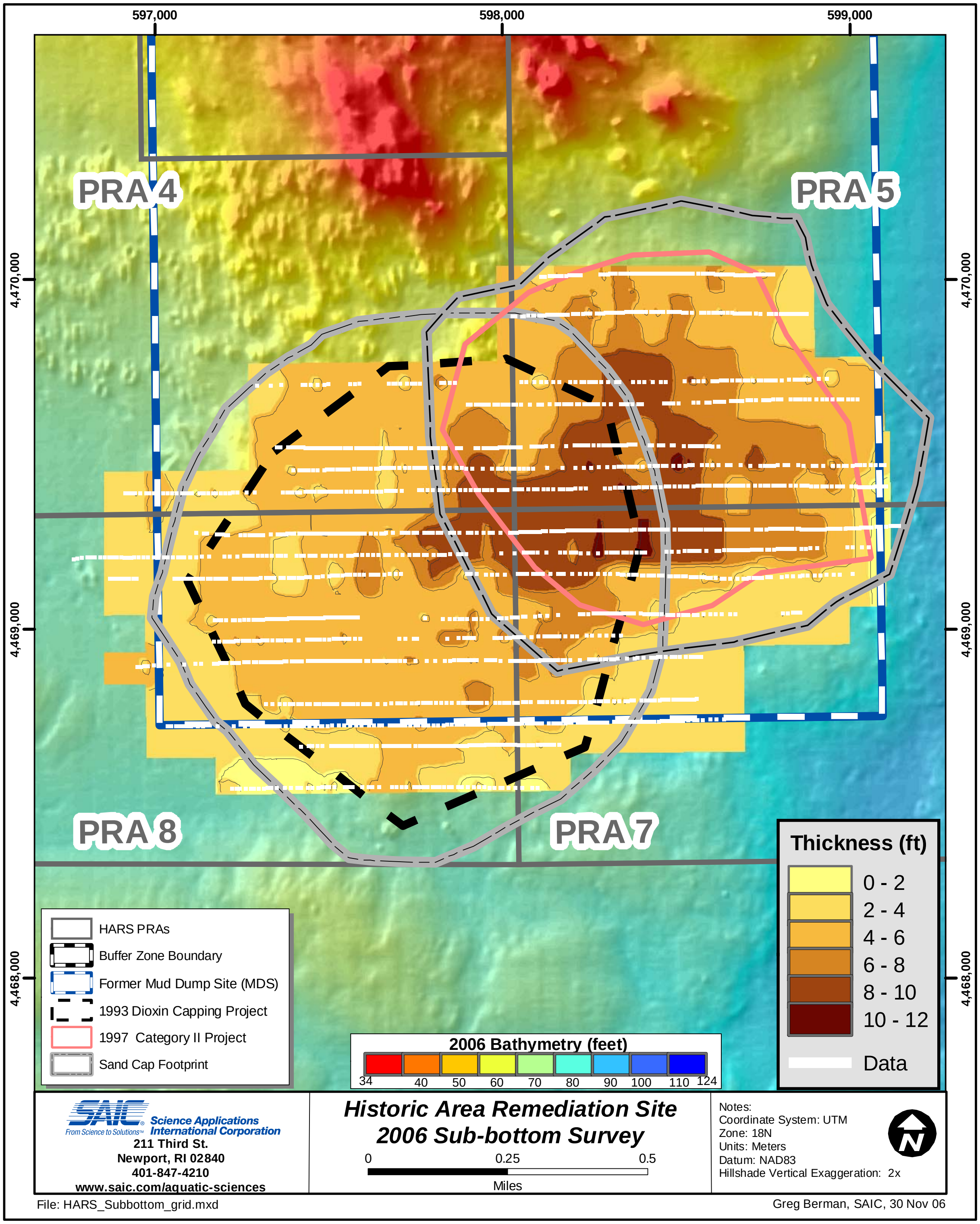


Figure 3.2-5. Gridded surface model of apparent cap thickness created from low frequency sub-bottom profile data acquired along east-west survey lanes over the 1993 and 1997 capped mounds. The individual digitized data points that were used to generate the gridded model are indicated by the white dots.

4.0 DISCUSSION

In the most recent previous surveys of July 2002 and August 2005, sediment toxicity and sediment-profile/plan-view data were collected simultaneously at stations located within and around the HARS. The sampling occurred both in areas that have received and in those that have not yet received any remediation material since the HARS was designated in 1997. The surveys have demonstrated an overall absence of any significant sediment toxicity (measured using the standard 10-day acute test using the amphipod *Ampelisca abdita*) in areas of both historic and recent dredged material/remediation material placement.

The sediment-profile and plan-view images likewise have demonstrated that areas affected by dredged material placement have been colonized successfully by communities of benthic infaunal organisms, with the degree of colonization dependent both on the timing of past disposal and on the type of material. Based on analysis of the sediment-profile images, benthic habitat conditions at most of the stations sampled in these recent previous sediment-profile surveys have been considered either undisturbed or only moderately disturbed, indicating relatively rapid recovery from past dredged material disposal impacts.

Given this background, the objectives of the 2006 sediment-profile/plan-view survey at the HARS were twofold: 1) to continue evaluating infaunal successional status and overall benthic habitat conditions at stations in and around the HARS; and 2) to assess any temporal changes in benthic habitat conditions that may have occurred since the previous surveys of 2002 and 2005. The goals of the sub-bottom profiling survey were to evaluate any changes to the thickness or stability of the 1993 and 1997 Mounds relative to the results observed during the more comprehensive monitoring survey conducted in 2002.

4.1 Physical Benthic Habitat Conditions

Similar to both the 2002 and 2005 surveys, there were two basic types of sediment observed in the 2006 sediment-profile and plan-view images: 1) dredged material that had been in place on the seafloor for various lengths of time, and 2) native or “ambient” sediment, consisting of either compact, rippled fine sand or gravel. Fine sands and gravels are common across wide areas of the inner New York Bight, and the presence of ripples indicates that some of these areas are subject to periodic, elevated bottom currents capable of inducing bedload transport of the sand. Ambient, rippled fine sand or gravel were found primarily at stations outside the HARS boundary, particularly within the no-discharge zone between PRAs 1 and 9 and at several of the stations in the southwest quadrant of PRA 3 and the adjoining buffer zone. Such native sediment has been observed consistently in these same areas in past surveys.

In the previous sediment-profile survey of 2005, the sediment-profile images revealed a 5- to 8-cm thick surface layer of native fine sand overlying muddy, black dredged material at four stations (Stations 6, 17, 97003 and 20023). Of these four, only Station 17 was re-sampled in the 2006 survey, and both it and nearby Station A9 again showed the same sand-over-black-mud layering (e.g., Figure 3.1-8). In general, such layering has been observed routinely in a number of past sediment-profile surveys conducted in and around the HARS and the former MDS. It results when ambient fine sand is transported by bottom currents into seafloor areas where organic-rich, fine-grained dredged material was placed in the past, in effect representing a natural capping process. The sand cap acts to isolate the dredged material and prevent it from becoming oxidized through contact with overlying, aerated bottom water. Instead of developing a light-colored surface oxidized layer (i.e., an RPD), the capped dredged material retains a dark grey or black coloration through time, indicative of a high inventory of sulfides and a strongly reducing state.

The sand-over-dredged-material stratigraphy observed at Station 17 in both 2005 and 2006 also had been detected in the sediment-profile survey of 2002. In contrast, stations 13, 22 and 46 exhibited this stratigraphy in 2002, but not in 2005. Station 13 also did not exhibit this stratigraphy in the 2006 survey, while the other two stations were not sampled in 2006. If the underlying dredged material originally occurred in small patches before being covered by the sand, it could easily be missed in the spaces between individual camera drops, both within a given survey and among surveys conducted at different times. It is also possible that the thickness of the overlying sand layer varies through time, as the sand shifts and migrates on the seafloor. The underlying dredged material layer therefore would only be captured in a profile image in places where, or at times when, the sand layer was relatively thin, given that the penetration of the sediment-profile camera in sandy sediments tends to be limited to a maximum depth of about 10 cm.

A surface deposit of fines and organic detritus occurred at many stations. This material appeared as a very thin layer (or "veneer") of flocculent material on the sediment surface that was most clearly visible in the profile images when contrasted against a backdrop of light-colored sand (e.g., Figures 3.1-18, 3.1-27, and 3.1-32). Both large and small mud tubes constructed by surface-dwelling worms were frequently observed as part of the surface deposits of flocculent organic matter (Figure 3.1-27).

Such surface deposits have been observed regularly in past sediment-profile surveys at the HARS, primarily in images collected during the summer or early fall, following the annual peak of biological production in the overlying water column. For example, many of the images from the previous survey of August 2005 also showed this same type of deposit of flocculent material on the sediment surface. Both higher biological production in the water column and more quiescent conditions during the early- to mid-summer months act to favor the settlement and net accumulation of fines and organic detritus at the sediment surface. It is also likely that some of the fines were associated with the on-going placement of dredged material in PRAs 1 through 4. As loads of this material fall through the water column, it is reasonable to assume that plumes containing the finest sediment fractions are transported laterally, with the fines eventually being deposited as a thin film on the sediment surface in areas surrounding the disposal locations.

When bottom currents become elevated during higher-energy storm events, such as hurricanes and nor'easters, the thin surface deposits of fines, flocculent organic detritus and associated fragile mud tubes are readily swept away. In this way, population levels of some of the benthic taxa visible in the sediment-profile and plan-view images are closely tied to the annual cycles of erosion and deposition of the fines and organic matter. The flocculant organic matter and associated mud tubes observed at the sediment surface in the summer 2006 survey, therefore, may not be permanent or even persistent features in and around the HARS. The 2006 results help to characterize typical benthic habitat conditions during the summer season, but these conditions might be different during and immediately following the higher-energy winter months.

Dredged material was found at almost all of the sediment-profile stations located within the HARS. At each station, the dredged material was placed into one of the following three basic categories: 1) older or "relic" dredged material that has been in place on the seafloor since before the HARS was designated in September 1997, 2) remediation material that has been placed in a carefully controlled manner in PRAs 1 through 4 following the designation of the HARS, and 3) sand used to cap dioxin-contaminated dredged material in the south end of the former MDS as part of major capping projects undertaken in 1993 and 1997.

Most of the relic dredged material was fine-grained, and, as in previous surveys, it was found primarily in PRAs 5, 6 and 9. As before, this is not surprising, because there was significant historic disposal in these PRAs, and none of them has yet received any remediation material. In contrast, the dredged material observed at the majority of stations in PRAs 1 through 4 was remediation material, and its distribution on the seafloor closely matched the release points at the sea surface that were recorded by the Automated Disposal Surveillance System (ADISS) installed on the disposal scows (Figure 4.1-1).

The remediation material observed in the images consisted of at least four distinct types of sediment, as follows: 1) "conventional" organic-rich mud, 2) red clay, 3) clean fine sand from Ambrose Channel, and 4) gravel/rock (Figure 3.1-2). The gravel/rock was not widespread; this sediment type occurred only at stations A16 and 20063 located near the western border of PRAs 1 and 2. The rocks were placed in this location over several years in the early 2000's as part of the Kill Van Kull (KVK) channel-deepening project. The KVK rocks originally covered a much wider area of PRA 2 and the northern part of PRA 3. As noted in the 2005 sediment-profile survey, quantities of fine-grained remediation material placed over the rocks apparently have been sufficient to bury them completely across most of the area of PRAs 2 and 3. The 2006 results confirm that any rocks observed in the past at stations in PRAs 1 through 4 continue to remain buried by more recently-placed, finer-grained remediation material.

Remediation material consisting of red clay was observed at four stations: stations K0800 and M1200 in the western halves of PRAs 2 and 3, and stations P2800 and P3200 in the southern half of PRA 4. Red clay also was observed at these same four stations in the 2005 sediment-profile survey, suggesting that no new remediation material has been placed at these locations in the year between the two surveys. This is consistent with the distribution of ADISS disposal points, which have been concentrated mainly in PRAs 1 and 2 in 2005 and 2006 (Figure 4.1-2).

Conventional dredged material consisting of relatively soft, organic-rich mud was the type of remediation material observed at many of the stations in PRAs 1 through 4. This is the same type of material that had been observed at these same stations in the 2005 survey, such that the material observed in 2006 was either newly placed (i.e., placed during the last year) or represents slightly older (i.e., pre-2005) remediation material.

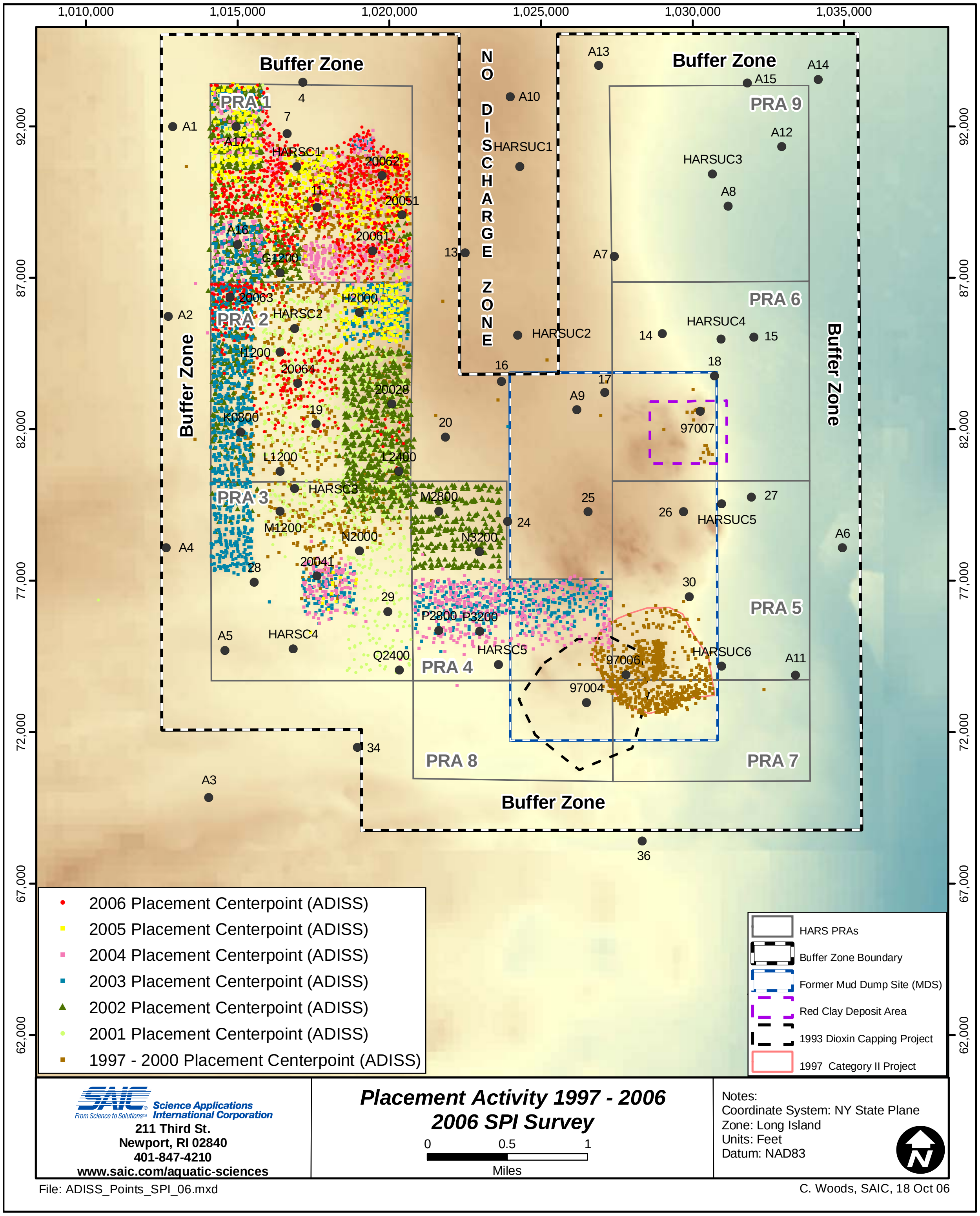


Figure 4.1-1. Locations of the 2006 sediment-profile/plan-view stations within and immediately outside the HARS in relation to dredged material placement events over the period March 1998 to August 2006

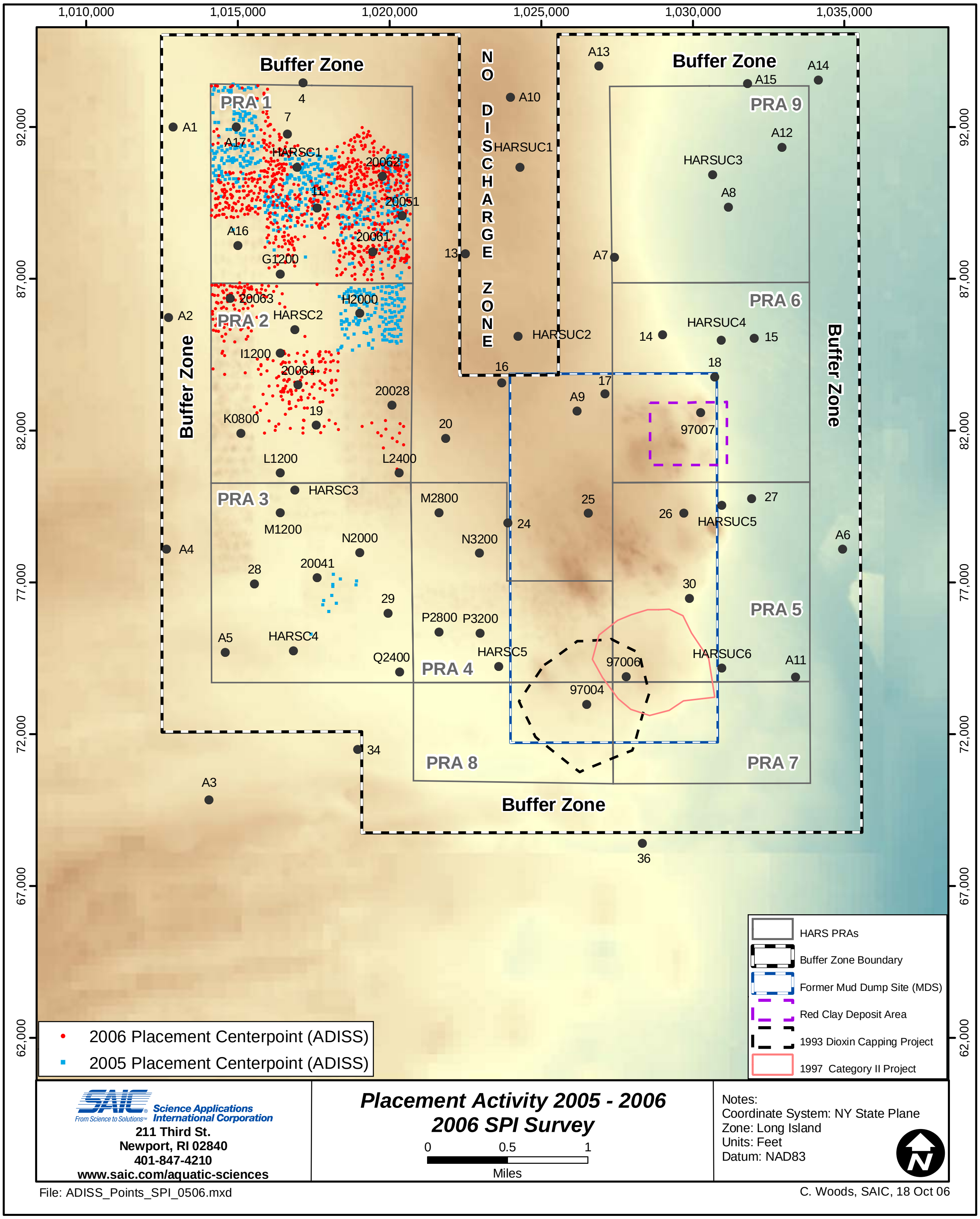


Figure 4.1-2. Locations of the 2006 sediment-profile /plan-view stations within and immediately outside the HARS in relation to dredged material placement events over the period January 2005 to August 2006

There were several stations where soft, muddy remediation material was observed in the 2005 survey and a distinctly different substrate type occurred in the 2006 images. The new substrate consisted of clean, very fine, homogenous, light-colored sand assumed to be from Ambrose Channel. This change in substrate types was observed at Stations 7 and 20051 in PRA 1 and Stations 19 and L1200 in PRA 2. At stations 20028 and L2400 along the eastern side of PRA 2, coarse dredged material observed in 2005 likewise was replaced with clean, fine, Ambrose Channel sand in 2006. The distribution of this sand generally corresponds with the ADISS disposal points from 2005 and 2006, which were concentrated in PRAs 1 and 2, in the general vicinity of the stations where the change in substrate type was observed (Figure 4.1-2). The Ambrose Channel sand also was observed at several stations in PRAs 1 and 2 that had not been sampled previously in 2005, including stations 20061, 20062, and 20064. Overall, there was excellent agreement between the mapped distribution of remediation material on the seafloor (Figures 3.1-1 and 3.1-2) and the ADISS placement points marking the locations where this material has been released from scows at the sea surface over the past 9 years (Figures 4.1-1 and 4.1-2).

Clean fine sand was observed at Stations 97004 located over the 1993 Dioxin Capping Project Mound, as well as at Station 97006 located over the 1997 Category II Project Mound. This sand represents the sediment that was originally dredged from Ambrose Channel (during the early to mid-1990s, prior to designation of the HARS) and used for capping of the underlying fine-grained sediment containing low levels of dioxin. The continued presence of sand at these sediment-profile stations provides continuing evidence that the integrity of the two caps has not been compromised, at least at these two, spatially limited sediment-profile sampling locations.

Overall, the physical habitat conditions observed in 2006 were similar to those of the previous 2002 and 2005 surveys. In all three surveys, the stations outside the HARS were characterized mainly by rippled fine sand representing native sediment, while stations within the HARS had either relic dredged material (in unremediated areas) or various types of remediation material in PRAs 1 through 4. Some locations in PRAs 1 and 2 that had exhibited fine-grained remediation material in 2005 were found to be covered with clean Ambrose Channel sand in 2006, as a result of the on-going remediation activities in these two PRAs.

4.2 Biological Conditions and Benthic Recolonization Status

The 2006 survey echoed the results of numerous past investigations in showing that the seafloor in and around the HARS was a patchy mosaic of different habitat conditions, in terms of both substrate type and disturbance history. In response to this mosaic, benthic communities were found to be in various stages of succession. As in the past, small opportunistic, Stage I polychaetes were abundant at many stations, reflecting their ability to colonize the sediment surface quickly and in high numbers following the physical seafloor disturbance associated with dredged material disposal. Because they are well-adapted to the physical disturbance associated with periodic sand movement, Stage I organisms also continued to be abundant in the native sandy sediments that characterize areas surrounding HARS. These populations provide a ready source of larva to establish new colonies in fresh dredged material deposits.

The general scarcity of organic-rich, fine-grained sediments in the sandy seafloor areas surrounding the HARS inhibits the process of succession that otherwise might be expected to lead to the establishment of more advanced, Stage II and III "soft-bottom" benthic communities. In addition to being dominated by smaller-bodied Stage I polychaetes, there are often high numbers of the sand dollar *Echinarachnius parma* observed on sandy bottoms around the HARS (e.g., Figure 3.1-26, right image). Several species of small, Stage I polychaetes and amphipods, together with *E. parma*, appear to comprise a basic natural benthic assemblage in the New York Bight (Chang et al. 1992).

While Stage I opportunists are the long-term dominants on sandy bottoms around the HARS, the placement of fine-grained dredged sediments within both the HARS and the former MDS has resulted in soft-bottom conditions conducive to supporting infaunal succession beyond Stage I. The 2002, 2005 and 2006 sediment-profile/plan-view results all serve to confirm that such advanced succession has in fact been occurring, most notably in PRAs 1 through 4 where remediation activities have been on-going since 1997. The majority of stations within the HARS, including most of those with remediation material, had either Stage II or III as the highest successional stage in both the 2005 and 2006 surveys (Figure 3.1-35).

Stage II taxa tend to live at or just below the sediment-water interface; examples of such shallow-dwelling taxa in the 2006 sediment-profile images include stick-dwelling amphipods (Family Podoceridae; e.g., Figure 3.1-17B) and the shallow-dwelling nut clam *Nucula* sp. (e.g., Figure 3.1-30A). These organisms have been observed in sediment-profile/plan-view surveys conducted over the past several years in and around the HARS. Tube-dwelling Ampeliscid amphipods (*Ampelisca* sp.) also had been observed in the images at a few stations in the 2005 survey but were not observed in any of the 2006 images. The absence of these organisms in 2006 may simply be a reflection of the significant seasonal fluctuations in abundance that characterize their natural populations (Franz and Harris 1988; Franz and Tanacredi 1992). In general, both *Nucula* sp. and the Ampeliscid amphipods have been observed to colonize deposits of fine-grained sediment, including dredged material, in very high numbers. Both have been commonly reported in historical benthic studies of the inner New York Bight (Caracciolo and Steimle 1983; Chang et al. 1992).

The Stage II Podocerid amphipods have not been as commonly reported in historical studies; they appear to have become increasingly abundant across the surveyed area over the past several years. These organisms are clearly identifiable in sediment-profile images by the distinctive whip-like stalks or "masts" that they construct out of mud and organic debris to raise themselves a few centimeters above the seafloor and thereby facilitate suspension-feeding (e.g., Figure 3.1-17B). There is a likelihood that the organism observed in the present and past sediment-profile surveys is the species *Dulichia porrecta*; this is the only Podocerid amphipod that was identified in the benthic grab samples taken at the HARS in the summer of 2002.

In the 2005 sediment-profile survey, dense tube mats of a surface-dwelling polychaete tentatively identified as *Asabellides oculata* occurred at a few stations having red clay remediation material. Tube mats of this species were again seen at the surface of red clay at Station P3200 in the 2006 survey (e.g., Figure 3.1-19). In general, this tube-builder is known to form occasional tube mats in sandy sediments on the mid-Atlantic inner continental shelf

(Diaz et al. 2004), including the nearshore zone off New Jersey (U.S. Army Corps of Engineers 2001). Trapping of fine-grained sediment within *A. oculata* tube mats resulted in creation of low mounds and thus was reported to have influenced topography on the inner shelf of New Jersey in May of 2002 (Clapp et al. 2002).

In contrast to both the 2002 and 2005 surveys, there were a significant number of stations in the 2006 survey where relatively large, thick tubes occurred at the sediment surface in moderate to high densities (e.g., Figures 3.1-26 and 3.1-27). These tubes generally were several centimeters long, relatively thick and appeared to be made of brown mud and mucous (e.g., Figures 3.1-10 and 3.1-12). They occurred both at stations having conventional muddy dredged material (e.g., Figures 3.1-10 and 3.1-12) and fine sand (e.g., Figure 3.1-27 and 3.1-32) and were considered to be evidence of Stage III polychaetes, possibly sub-surface deposit-feeding bamboo worms of the Family Maldanidae. These larger tubes were most prevalent at the stations with remediation material in PRAs 1 through 4. Of the 34 stations within these four PRAs, the thick tubes occurred at more than half (19, or 56%). They also occurred at stations A9 and 30 in the former MDS and at Station 97006 located over the 1997 Category II Capping Project mound.

Presumably, there was a successful recruitment event for these larger polychaetes in the months prior to the 2006 sediment-profile/plan-view survey. Compared with the results of the previous 2002 and 2005 surveys, their high relative abundance and widespread distribution in 2006 are unusual. These results may simply reflect normal seasonal and inter-annual variation in benthic populations within the HARS and the wider surrounding NY Bight region, such that the high numbers of this particular species observed in 2006 represents a transient, one-time phenomenon. Future sediment-profile monitoring will help determine the persistence of this relatively new type of polychaete tube at the sediment surface within the HARS and surrounding areas. It is interesting that the tubes occurred on fine sand substrate as well as mud (e.g., Figures 3.1-30A and 3.1-32). It is hypothesized that the fines and organic detritus that were also commonly observed on top of the sand served as both a building material for the tubes and a food source for the polychaetes.

Both the 2005 and 2006 survey results continue to be significant in terms of addressing any on-going questions or concerns about the ability of benthic organisms to colonize areas of red clay. Originally, red clay dredged from Newark Bay in 1997 was placed in the northeast quadrant of the former MDS, and intensive sediment-profile/plan-view and benthic grab surveys were conducted both one year and five years following its placement. Although the benthic recolonization process was found to be slower than normal, with only low numbers of Stage I organisms visible in the 1998 images, by 2002 it was found that the red clay deposits had become colonized by diverse and abundant communities of both infauna and epifauna (SAIC 1998; 2003; Valente 2006). The present survey echoes the results of the 2002 and 2005 surveys: biological features indicating the presence of a diverse assemblage of surface- and subsurface-dwelling benthos were observed in the sediment-profile and plan-view images over portions of PRAs 1 through 4 where red clay remediation material (among other types of material) has been placed on an on-going basis since HARS designation in 1997 (e.g., Figure 3.3-19).

Average RPD depths were moderately well-developed over the HARS and surrounding area in both the 2005 and 2006 surveys. None of the sediment-profile images exhibited any evidence of apparent low dissolved oxygen conditions at the sediment-water interface or methane gas entrained within the sediment. Although Station 11 showed methane gas bubbles in both the 2002 and 2005 surveys, no methane was detected at this station during the 2006 survey. It is possible that remediation material containing methane that previously occurred at this location has now been buried by new, thicker layers of remediation material, effectively burying the methane production zone.

Benthic habitat conditions, as indicated by OSI values, were either undisturbed or moderately disturbed at the majority of stations in PRAs 1 through 4. This result is similar to that of the 2005 survey. In both years, the OSI values reflect various stages of benthic recovery from the physical disturbance associated with placement of remediation material at various times and locations within these PRAs over the past several years. There did not appear to be any consistent patterns in the relationship between OSI values versus either length of time since placement or type of remediation material. Overall, both the 2005 and 2006 OSI values indicate an intermediate to advanced degree of recovery from the disturbance effects of both historic and more-recent disposal activities, as evidenced by the diverse and abundant infaunal and epifaunal communities observed in the sediment-profile and plan-view images at the HARS stations. One particularly notable result of the 2006 survey was the widespread presence of relatively large, thick polychaete tubes covering the surface of recent remediation material at many of the stations in PRAs 1 through 4.

4.3 Stability of the 1993 and 1997 Capped Mounds

The summer 2002 multi-disciplinary survey of 1993 Dioxin Capping Project Mound and the 1997 Category II Mound included single-beam bathymetry, side-scan sonar imaging, sub-bottom profiling, sediment profile imaging, and sediment coring with associated laboratory geotechnical/chemical analyses. The primary conclusion from the comprehensive 2002 survey was that the sand caps had remained stable since their creation (SAIC 2003a; 2003b). The depth difference analysis conducted with the 2002 bathymetric surveys concluded there was no appreciable change in the distribution or thickness of the sand cap over either of the mounds since their creation. The sub-bottom profiling data acquired over both mounds indicated an approximate sand cap thickness of 4 to 7 feet, with the greatest thicknesses of up to 10 feet observed in the area of the overlap between the 1993 and 1997 mounds.

The sediment cores collected in 2002 over the 1993 and 1997 Mounds generally agreed with the sub-bottom profiling results. The cores exhibited an average cap thickness of 4.9 feet over the 1993 mound and 5.7 feet over the 1997 mound. The minimum observed cap thickness in a core was 1.6 feet and the maximum cap thickness was 9.2 feet. The laboratory chemistry results showed no significant vertical migration of dioxin or furan from the underlying dredged material into the overlying cap material. Sediment-profile results indicated that the surface of the sand cap continued to be inhabited by a benthic community comprised of small, surface-dwelling opportunists (Stages I and II), similar to the community at the nearby South Reference Area. Both the sediment-profile and benthic grab sampling results indicated that the surfaces of the 1993 and 1997 Mounds represented a relatively healthy and productive habitat for benthic organisms at the time of the summer 2002 survey.

The 2002 surface model was generated from sub-bottom profile lanes that were run in a north-south direction, while the 2006 surface model was based upon lanes run primarily in an east-west direction. In addition, because the 2002 dataset was less dense, the resulting grid was created at a coarser resolution than the 2006 grid. Despite these minor differences, the gridded cap thickness model created from the 2006 sub-bottom profile data generally agreed well with the similar cap thickness model generated in 2002 (Figure 4.3-1). Both gridded models indicated cap thickness values ranging between 4 to 7 feet over widespread areas of both Mounds, with maximum values over 10 feet observed in the cap overlap area. As discussed in Section 3.2, in those areas with multiple and/or or intermittent reflectors the process of manually selecting and digitizing the sand cap layer can be quite subjective. A certain degree of difference could be expected in the digitizing results from two different individuals even if interpreting the same sub-bottom profile dataset. Any differences observed between the 2002 and 2006 cap thickness models are likely the result of subjective differences in data interpretation during the digitizing process.

Although the gridded cap thickness models created in 2002 and 2006 indicated complete cap coverage throughout, there were several areas in the records where a distinct cap reflector could not be detected. As discussed in Section 3.2, these data gaps were primarily associated with areas where the sand cap reflector did not provide a distinct horizon or where the seafloor surface acoustic return masked the underlying sand cap layer. In general, these discontinuities were more prevalent in the cap overlap area and were likely associated with the increased disturbance caused by greater placement activity of both dredged material and capping sediments in these areas. Any discontinuities in the sub-bottom layer being tracked were interpolated over as part of the manual digitizing process. Though it is unlikely that these intermittent gaps in the sub-bottom records are indicative of any issues with the integrity or thickness of the cap layer, it would be worthwhile to target some of these areas during any subsequent coring operations over the Mounds. In addition to some of these intermittent sub-bottom reflector areas, the 2002 sediment-profile results also indicated a couple of additional areas (Stations A-22 and A-18) where sediment cores would be warranted to further investigate pockets of black sediment that were observed beneath a surface layer of clean cap sand (SAIC 2003a).

In addition to the monitoring operations addressed in this report, a comprehensive multibeam and backscatter survey was also conducted over the HARS in August 2006 to assess the overall physical conditions at the site and to map the progress of the on-going placement operations (SAIC 2006). To assess the overall stability of the Mound area since the 2002 survey, a bathymetric depth difference grid was computed between the 2002 single-beam survey and the 2006 multibeam survey (Figure 4.3-2). With the exception of the northwest portion of the Mound overlap area where recent placement operations in PRA 4 have resulted in some accumulation of material, this depth difference grid indicated little change in the bathymetry over the Mound area since 2002. Similarly, the 2002 depth difference results had also indicated little change in the Mound bathymetry since shortly after the creation of the Mounds. These results suggest that the Mounds have been stable since their creation with no indication of any significant areas of either erosion or deposition. In addition, the 2006 multibeam backscatter imagery also showed that the sediment surface over the entire Mound region was quite consistent with no disturbed areas that might have been indicative of problems with the cap integrity.

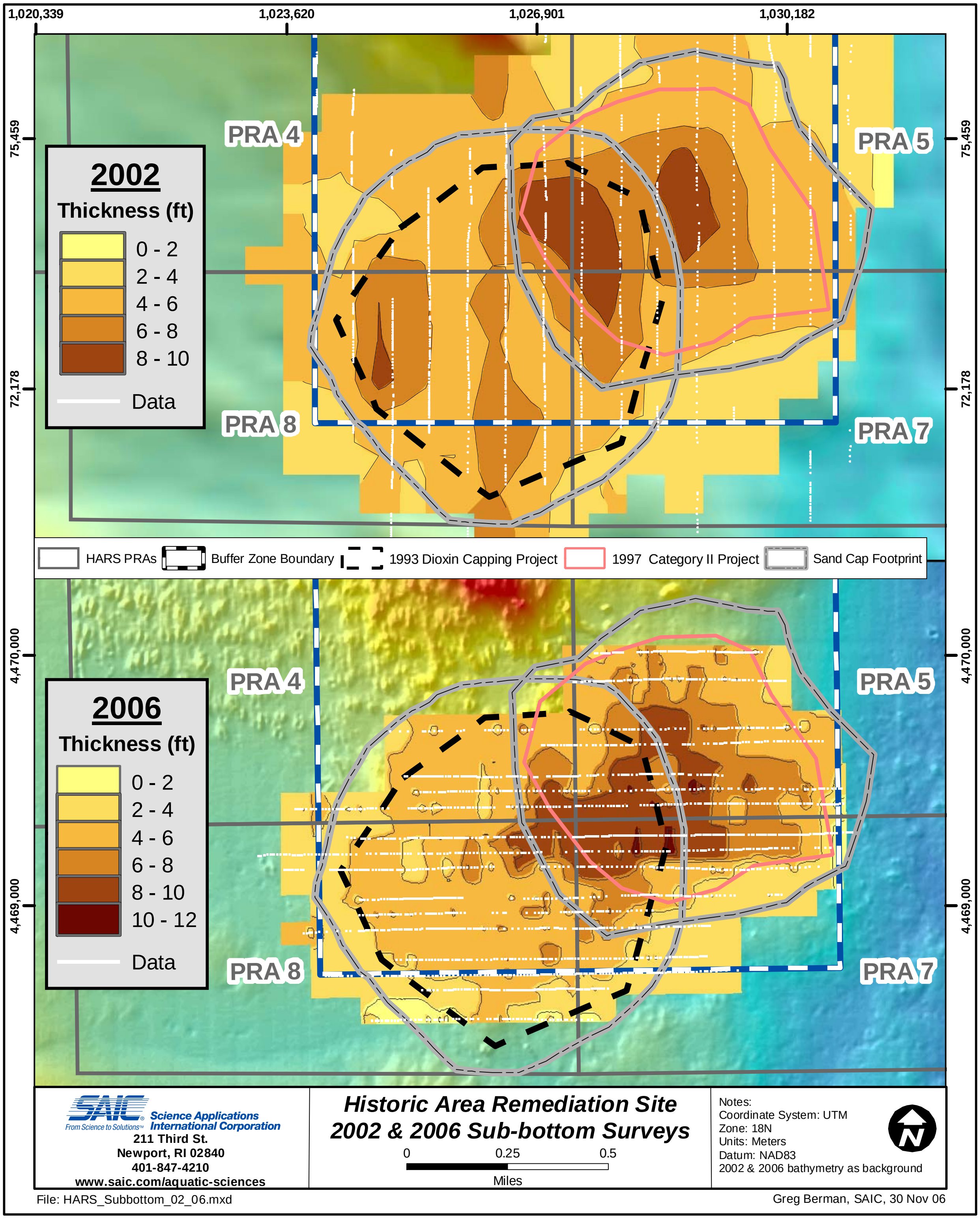


Figure 4.3-1. Comparison of the gridded surface models of apparent cap thickness created from the 2002 and 2006 sub-bottom profiling surveys over the capped mounds. The 2002 model was gridded at a much coarser resolution than the 2006 model.

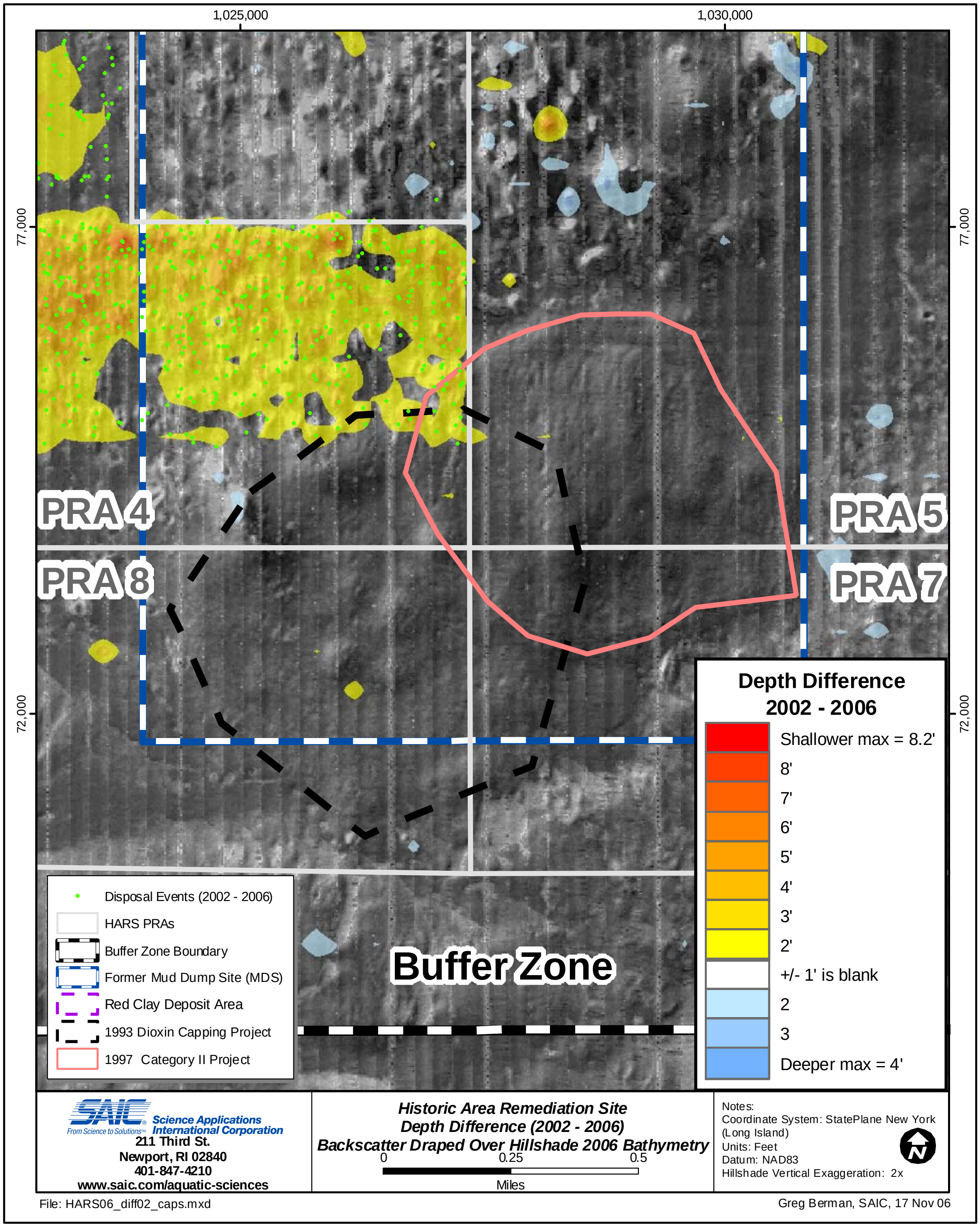


Figure 4.3-2. Disposal point data from the HARS from 2002 through 2006 depicted over the depth difference computed between the 2002 single-beam survey and the 2006 multibeam survey in the capped mound region; the 2006 multibeam hillshade bathymetry and backscatter is included as the backdrop.

Though there were a few selected areas that may warrant detailed coring investigation to assess more definitively the cap thickness during future comprehensive monitoring operations, there were no direct indications of any potential issues with the cap thickness or stability over any of the Mound areas based on the 2006 monitoring results. The sub-bottom profiling results, the bathymetric depth difference results, and the backscatter imagery results observed during the 2006 operations were generally very consistent with the complimentary results observed during the more comprehensive monitoring conducted in 2002. When considered in conjunction with the comprehensive results observed in 2002, the consistency between the similar 2006 and 2002 datasets supports the conclusion that the cap material has remained in-place on the seafloor and presumably has continued to be effective at isolating the underlying dioxin-contaminated sediment.

5.0 SUMMARY

- Similar to the results of many past sediment-profile surveys in and around the HARS and former MDS, there were two basic types of sediment observed in the sediment-profile and plan-view images from 2006: 1) dredged material that had been in place on the seafloor for various lengths of time, and 2) native or "ambient" sediment, consisting of either compact, rippled fine sand or gravel. These sediments, which range in texture from silt-clays to gravels, include historic (i.e., relic) dredged material, predominantly fine-grained remediation material placed since 1997 in PRAs 1 through 4, and sand that represents the native sediment in areas outside the HARS boundaries.

- The remediation material observed in the images consisted of at least four distinct types of sediment, as follows: 1) "conventional" organic-rich mud, 2) red clay, 3) clean fine sand from Ambrose Channel, and 4) gravel/rock. Several stations in PRAs 1 and 2 where soft, muddy remediation material was observed in the 2005 survey displayed a new substrate consisting of clean, very fine, homogenous, light-colored sand assumed to be from Ambrose Channel.

- As in past surveys, the surface sediments at several stations displayed a unique stratigraphy consisting of a thin (5-to 8-cm thick) surface layer of native fine sand overlying fine-grained, black dredged material. This stratigraphy is presumed to result when ambient fine sand is transported by bottom currents into seafloor areas where organic-rich, fine-grained dredged material was placed in the past, in effect representing a natural capping process.

- Similar to the 2005 survey, a thin surface deposit of fines and flocculent organic detritus was present at many stations. Such surface deposits have been observed regularly in past sediment-profile surveys at the HARS, primarily in images collected during the summer or early fall, following the annual peak of biological production in the overlying water column. During the winter months, these thin surface deposits are typically swept away by higher-energy wave and bottom currents.

- Clean fine sand was observed at one station over the 1993 Dioxin Capping Project Mound and the 1997 Category II Project Mound. This sand represents the sediment that was originally dredged from Ambrose Channel (during the early to mid-1990s, prior to designation of the HARS) and used for capping of the underlying fine-grained sediment containing low levels of dioxin. The continued presence of sand at these sediment-profile stations provides continuing evidence that the integrity of the two caps has not been compromised, at least at these two, spatially limited sediment-profile sampling locations.

- The 2006 survey echoed the results of numerous past investigations in showing that the seafloor in and around the HARS was a patchy mosaic of different habitat conditions, in terms of both substrate type and disturbance history. In response to this mosaic, benthic communities were found to be in various stages of succession. As in the past, small opportunistic, Stage I polychaetes were abundant at many stations, reflecting their ability to colonize the sediment surface quickly and in high numbers following the physical seafloor disturbance associated with dredged material disposal.

- While Stage I opportunists are the long-term dominants on sandy bottoms around the HARS, the placement of fine-grained dredged sediments within both the HARS and the former MDS has resulted in soft-bottom conditions conducive to supporting infaunal succession beyond Stage I. The 2002, 2005 and 2006 sediment-profile/plan-view results all serve to confirm that such advanced succession has in fact been occurring, most notably in PRAs 1 through 4 where remediation activities have been on-going since 1997. The majority of stations within the HARS, including most of those with remediation material, had either Stage II or III as the highest successional stage in both the 2005 and 2006 surveys.

- The majority of stations within the HARS, including most of those with remediation material, had an advanced successional status consisting of Stage I on III, Stage II on III, or Stage III. Stage II taxa included stick-dwelling amphipods (Family Podoceridae) and the shallow-dwelling nut clam *Nucula* sp. Evidence of Stage III taxa in the sediment-profile images included subsurface burrows, feeding voids and, in a few cases, the organisms themselves visible at depth within the sediment column.

- In contrast to both the 2002 and 2005 surveys, there were a significant number of stations in the 2006 survey where relatively large, thick tubes occurred at the sediment surface in moderate to high densities. They occurred both at stations having conventional muddy dredged material and fine sand and were considered to be evidence of Stage III polychaetes. These larger tubes were most prevalent at the stations with remediation material in PRAs 1 through 4 and are thought to be the result of a successful recruitment event for these larger polychaetes in the months prior to the 2006 sediment-profile/plan-view survey.

- Both the 2005 and 2006 survey continue to be significant in terms of addressing any on-going questions or concerns about the ability of benthic organisms to colonize areas of red clay. The present survey echoes the results of the 2002 and 2005 surveys: biological features indicating the presence of a diverse assemblage of surface- and subsurface-dwelling benthos were observed in the sediment-profile and plan-view images over portions of PRAs 1 through 4 where red clay remediation material (among other types of material) has been placed on an on-going basis since HARS designation in 1997.

- In the 2002, 2005 and 2006 surveys, benthic communities across the HARS were found to be comprised of diverse infauna and epifauna representing different successional stages. Of the 33 stations common to all three surveys, the majority of stations in 2002 showed Stage I as the highest successional stage, while the majority in 2005 and 2006 where characterized by the presence of Stage III (alone or in combination with Stages I or II). Reflecting the infaunal successional dynamics, the OSI values indicate that habitat conditions at the majority of stations have been classified as either moderately disturbed or undisturbed in all three years. The number of stations with undisturbed habitat conditions increased between 2005 and 2006, reflecting the fact that 2006 also had the highest proportion of stations with a more advanced, Stage III successional designation.

- Benthic habitat conditions, as indicated by OSI values, were either undisturbed or moderately disturbed at the majority of stations in PRAs 1 through 4. This result is similar to that of the 2005 survey. Overall, both the 2005 and 2006 OSI values indicate an intermediate to advanced degree of recovery from the disturbance effects of both historic and more-recent disposal activities, as evidenced by the diverse and abundant infaunal and epifaunal communities observed in the sediment-profile and plan-view images at the HARS stations.

- The gridded cap thickness model created from the 2006 sub-bottom profile data indicated cap thickness values ranging between 4 to 7 feet over widespread areas of both the 1993 and 1997 Mounds, with maximum values over 10 feet observed in the cap overlap area. These results were consistent with the sub-bottom profiling results observed during the comprehensive monitoring surveys conducted in 2002 over the capped Mounds.

- The ability to completely and accurately map the sand cap layer was also impacted by the sometimes discontinuous nature of these reflectors in the sub-bottom records. In general, these discontinuities were more prevalent in the cap overlap area and were likely associated with the increased disturbance caused by greater placement activity of both dredged material and capping sediments in these areas. Any discontinuities in the acoustic layer being tracked were interpolated over as part of the manual digitizing process. Most differences observed between the 2002 and 2006 cap thickness models are likely the result of subjective differences in data interpretation and interpolation during the manual digitizing process.

- Without any confirmatory sediment coring data, there was no way of positively stating the composition of the various sediment layers that might have been identified within a particular acoustic sub-bottom dataset. Within some of the cap overlap areas, it was often possible to identify as many as four or five distinct reflectors within the top 5 m of the sediment column. Though a reasonable assumption of the probable sediment layering could be made based upon the known placement history at the site, there was no way of conclusively making this connection based solely on the acoustic data.

- Though it is unlikely that the intermittent gaps in the sub-bottom records are indicative of any issues with the integrity or thickness of the cap layer, it would be worthwhile to target some of these areas during any subsequent coring operations over the Mounds. In addition to some of these intermittent sub-bottom reflector areas, the 2002 sediment-profile results also indicated a couple of additional areas (Stations A-22 and A-18) where sediment cores would be warranted to further investigate pockets of black sediment that was observed beneath a surface layer of clean cap sand.

- In addition to the monitoring operations addressed in this report, a comprehensive multibeam and backscatter survey were also conducted over the HARS in August 2006 to assess the overall physical conditions at the site and to map the progress of the on-going placement operations. With the exception of the northwest portion of the Mound overlap area where recent placement operations in PRA 4 have resulted in some accumulation of material, the depth difference grid between the 2002 and 2006 surveys indicated little change in the bathymetry over the Mound area since 2002. Similarly, the 2002 depth difference results had also indicated little change in the Mound bathymetry since shortly after the creation of the Mounds. These results suggest that the Mounds have been stable since their creation with no indication of any significant areas of either erosion or deposition.

- The 2006 multibeam backscatter imagery also showed that the sediment surface over the entire Mound region was quite consistent with no disturbed areas that might have been indicative of problems with the cap integrity.

- The sub-bottom profiling results, the bathymetric depth difference results, and the backscatter imagery results observed during the 2006 operations were generally very consistent with the complimentary results observed during the more comprehensive monitoring conducted in 2002. When considered in conjunction with the comprehensive results observed in 2002, the consistency between the similar 2006 and 2002 datasets supports the conclusion that the cap material has remained in-place on the seafloor and has continued to be effective at isolating the underlying dioxin-contaminated sediment.

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APPENDIX A

Appendix A-1. Sediment-profile Imaging data for the 2006 summer survey at the HARS

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi)			Benthic Habitat	Mud Clasts Present	Camera Penetration (cm)				Dredged Material Thickness (cm)			Redox Rebound Thickness (cm)			Apparent RPD Thickness (cm)		
					Min	Max	Maj Mode			Min	Max	Range	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
4	B	8/22/2006	18:54:08	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	5.63	7.19	1.56	6.41	> 5.63	> 7.19	> 6.41	0	0	0	0.81	4.12	3.05
4	E	8/23/2006	12:18:27	ST III	> 4 phi	-1 phi	> 4 phi	UN.SS	FALSE	7.07	8.31	1.24	7.69	0	0	0	0	0	0	3.20	5.15	4.22
7	A	8/22/2006	19:02:20	ST I	4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.61	4.11	0.5	3.86	> 3.61	> 4.11	> 3.86	0	0	0	>3.61	>4.11	>3.86
7	D	8/23/2006	12:25:04	ST I	> 4 phi	2 phi	4 to 3 phi	SA.F	FALSE	1.78	2.37	0.59	2.07	> 1.78	> 2.37	> 2.07	0	0	0	>1.78	>2.37	>2.07
11	A	8/22/2006	19:12:50	ST III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	13.95	14.69	0.74	14.32	> 13.95	> 14.69	> 14.32	0	0	0	0.04	3.02	1.62
11	C	8/22/2006	19:14:30	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	16.31	18.02	1.71	17.17	> 16.31	> 18.02	> 17.17	0	0	0	0.04	2.24	1.23
13	A	8/21/2006	18:01:34	ST I	> 4 phi	1 phi	3 to 2 phi	SA.F	FALSE	5.32	6.07	0.75	5.7	0	0	0	0	0	0	>5.32	>6.07	>5.7
13	C	8/21/2006	18:03:37	ST I	4 phi	1 phi	3 to 2 phi	SA.F	FALSE	2.18	3.8	1.62	2.99	0	0	0	0	0	0	>2.18	>3.8	>2.99
14	A	8/21/2006	13:37:27	ST I	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	8.78	9.14	0.36	8.96	> 8.78	> 9.14	> 8.96	0	0	0	0.81	3.83	2.61
14	D	8/23/2006	17:13:55	ST I	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	11.34	11.87	0.53	11.6	> 11.34	> 11.87	> 11.6	0	0	0	0.88	3.83	3.00
15	B	8/21/2006	14:00:22	ST I	> 4 phi	2 phi	4 to 3 phi	UN.SS	FALSE	5.3	6.72	1.42	6.01	> 5.3	> 6.72	> 6.01	0	0	0	0.04	4.64	1.85
15	C	8/21/2006	14:01:05	INDET	< -1 phi	< -1 phi	< -1 phi	HR	FALSE	.	.	.	.	0	0	0	0	0	0	-99.00	-99.00	-99.00
16	A	8/21/2006	17:25:43	ST I	4 phi	1 phi	3 to 2 phi	SA.F	FALSE	2.18	3.42	1.24	2.8	0	0	0	0	0	0	>2.18	>3.42	>2.8
16	B	8/21/2006	17:26:48	ST I	4 phi	1 phi	3 to 2 phi	SA.F	FALSE	1.4	4.89	3.49	3.14	0	0	0	0	0	0	>1.4	>4.89	>3.14
17	A	8/21/2006	17:43:25	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	12.7	13.37	0.67	13.03	0	0	0	0	0	0	0.26	3.86	2.27
17	C	8/21/2006	17:45:40	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	11.13	11.91	0.78	11.52	0	0	0	0	0	0	1.10	6.88	5.97
18	A	8/21/2006	14:09:31	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	6.67	7.64	0.97	7.15	> 6.67	> 7.64	> 7.15	0	0	0	0.48	3.64	1.91
18	B	8/21/2006	14:10:53	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	8.05	8.57	0.52	8.31	> 8.05	> 8.57	> 8.31	0	0	0	0.85	3.02	1.90
19	D	8/23/2006	13:19:22	ST II on III	> 4 phi	2 phi	4 to 3 phi	SA.F	FALSE	6.39	6.72	0.33	6.55	> 6.39	> 6.72	> 6.55	0	0	0	>6.39	>6.72	>6.55
19	F	8/23/2006	13:21:02	ST II on III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	4.77	5.36	0.59	5.07	> 4.77	> 5.36	> 5.07	0	0	0	>4.77	>5.36	>5.07
20	B	8/21/2006	17:17:15	ST I	4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.46	5.77	2.31	4.61	0	0	0	0	0	0	>3.46	>5.77	>4.61
20	C	8/21/2006	17:18:14	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.26	3.8	0.54	3.53	0	0	0	0	0	0	>3.26	>3.8	>3.53
24	A	8/21/2006	17:03:05	ST I	4 phi	1 phi	3 to 2 phi	SA.F	FALSE	4.89	6.03	1.14	5.46	0	0	0	0	0	0	>4.89	>6.03	>5.46
24	B	8/21/2006	17:04:01	ST I	> 4 phi	< -1 phi	1 to 0 phi	SA.G	FALSE	3.59	5.65	2.06	4.62	> 3.59	> 5.65	> 4.62	0	0	0	IND	IND	IND
25	B	8/21/2006	16:53:52	INDET	3 phi	< -1 phi	0 to -1 phi	SA.G	FALSE	0.26	1.33	1.07	0.8	> 0.26	> 1.33	> 0.8	0	0	0	IND	IND	IND
25	C	8/21/2006	16:54:45	INDET	> 4 phi	< -1 phi	< -1 phi	HR	FALSE	0.22	1.33	1.11	0.78	> 0.22	> 1.33	> 0.78	0	0	0	IND	IND	IND
26	B	8/21/2006	16:43:00	ST I	4 phi	< -1 phi	< -1 phi	SA.G	FALSE	3.63	4.65	1.02	4.14	> 3.63	> 4.65	> 4.14	0	0	0	IND	IND	IND
26	C	8/21/2006	16:44:01	ST I	4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.82	4.06	0.24	3.94	0	0	0	0	0	0	>3.82	>4.06	>3.94
27	A	8/21/2006	14:40:34	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.14	10.57	0.43	10.35	> 10.14	> 10.57	> 10.35	0	0	0	0.22	2.24	1.29
27	B	8/21/2006	14:41:43	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	11.72	11.99	0.27	11.85	> 11.72	> 11.99	> 11.85	0	0	0	0.15	2.28	1.30
28	A	8/22/2006	13:27:53	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	7.67	8.62	0.95	8.15	> 7.67	> 8.62	> 8.15	0	0	0	0.33	4.86	2.93
28	B	8/22/2006	13:28:56	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	7.93	8.62	0.69	8.27	> 7.93	> 8.62	> 8.16	0	0	0	0.33	1.77	0.87
29	A	8/22/2006	12:44:42	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	8.69	9.57	0.88	9.13	> 8.69	> 9.57	> 8.17	0	0	0	1.03	3.90	2.60
29	D	8/22/2006	12:52:59	ST II to III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	11.51	11.82	0.31	11.66	> 11.51	> 11.82	> 8.18	0	0	0	0.26	2.10	1.15
30	B	8/21/2006	15:29:19	ST I on III	> 4 phi	2 phi	4 to 3 phi	UN.SS	FALSE	4.37	7.01	2.64	5.69	> 4.37	> 7.01	> 8.19	0	0	0	0.04	1.69	0.76
30	C	8/21/2006	15:31:58	ST I	> 4 phi	2 phi	4 to 3 phi	UN.SS	TRUE	5.79	7.19	1.4	6.49	> 5.79	> 7.19	> 8.20	0	0	0	0.40	1.43	0.85
34	A	8/22/2006	12:11:10	ST I	> 4 phi	1 phi	3 to 2 phi	SA.F	FALSE	4.16	4.56	0.4	4.36	0	0	> 8.21	0	0	0	>4.16	>4.56	>4.36
34	C	8/22/2006	12:13:34	ST I	> 4 phi	1 phi	3 to 2 phi	SA.F	FALSE	4.41	4.94	0.53	4.68	0	0	> 8.22	0	0	0	>4.41	>4.94	>4.68
36	D	8/23/2006	15:42:11	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	7.48	10.25	2.77	8.86	> 7.48	> 10.25	> 8.23	0	0	0	0.48	3.53	2.44
36	F	8/23/2006	15:43:45	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	11.01	12.01	1	11.51	> 11.01	> 12.01	> 8.24	0	0	0	0.29	4.16	2.02
97004	A	8/21/2006	16:14:08	ST II	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.8	3.84	1.04	3.32	0	0	> 8.25	0	0	0	>2.8	>3.84	>3.32
97004	C	8/21/2006	16:18:09	ST I	4 phi	2 phi	3 to 2 phi	SA.F	FALSE	5.08	5.82	0.74	5.45	0	0	> 8.26	0	0	0	>5.08	>5.82	>5.45
97006	A	8/21/2006	16:23:55	ST II to III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.4	3.54	1.14	2.97	0	0	> 8.27	0	0	0	>2.4	>3.54	>2.97
97006	B	8/21/2006	16:27:34	ST II to III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.21	3.02	0.81	2.62	0	0	> 8.28	0	0	0	>2.21	>3.02	>2.62
97007	D	8/23/2006	16:26:33	ST I	> 4 phi	3 phi	> 4 phi	UN.SI	FALSE	8.38	9.35	0.97	8.86	> 8.38	> 9.35	> 8.29	0	0	0	0.85	5.22	3.57
97007	F	8/23/2006	16:28:24	ST I	> 4 phi	3 phi	> 4 phi	UN.SI	FALSE	6.77	7.59	0.82	7.18	> 6.77	> 7.59	> 8.30	0	0	0	0.15	5.26	2.29

Appendix A-1 (cont)

Station	Replicate	Methane			OSI	Surface	Low	Comments	Sediment	Sediment
		Count	Depth	Diam		Roughness	DO		Present	Thickness (cm)
4	B	0	0	0	10	Biogenic	NO	DM>pen=remed material, brn/blk sandy m, shell frags, dense thick ST III tubes (bamboo worms), stick amps (Podoceridae), org detritus, sm void	remediation material	6.41
4	E	0	0	0	11	Physical	NO	Ambient sand/DM (=remed material), brn fine sand/blk sulfidic sandy m, v red sed @z, shell frags, lg ST III tubes (Diopatra?), poly @z	Ambient/remediation material	3.90/3.74
7	A	0	0	0	7	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), RPD>pen	remediation material	3.86
7	D	0	0	0	4	Physical	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), brn floc @ surf, shell frags, RPD>pen	remediation material	2.07
11	A	0	0	0	8	Biogenic	NO	DM>pen=remed, tan/blk sandy m, red sed band @z, relic RPD, multiple DM lyrs, dense lg ST III tubes (Maldanids), expelled sed from Maldanids	remediation material	14.32
11	C	0	0	0	7	Physical	NO	DM>pen=remed material, tan/blk sandy m, v red sed @z, relic RPD, DM layering, surf rework, v sm void, ST III Maldanid tubes & ST I tubes	remediation material	17.17
13	A	0	0	0	7	Physical	NO	Ambient tan fine sand, RPD>pen, sand dollars, shell frags, wiper clasts, depositional floc	Ambient	5.7
13	C	0	0	0	5	Physical	NO	Ambient tan fine sand, RPD>pen, sand ripple, sand dollars, shell frags, Diopatra tube	Ambient	2.99
14	A	0	0	0	5	Physical	NO	Relic DM>pen, tan/bk sulfidic sandy m, dark image, red sed @z, shell frags, sm tubes	Relic Dredged Material Layer	8.96
14	D	0	0	0	5	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, shell frags, red clast, tubes, org @z	Relic Dredged Material Layer	11.60
15	B	0	0	0	4	Physical	NO	Relic DM>pen, tan silty sand/blk sandy m, shell frags, tubes, brick pieces @ surf and @z	Relic Dredged Material Layer	6.01
15	C	0	0	0	99	Indeterminate	NO	Underpen, hard bottom, bushy bryozoan or hydroid	Indeterminate	0
16	A	0	0	0	5	Physical	NO	Ambient tan fine sand, underpen, RPD>pen, sand ripple, shell frags	Ambient	2.8
16	B	0	0	0	6	Physical	NO	Ambient tan fine sand, RPD>pen, sand ripple	Ambient	3.14
17	A	0	0	0	9	Physical	NO	Ambient sand/relic DM, tan fine sand/blk sulfidic sandy m, sed layering, v red sed @z, shell frags, poly @z, tubes, pebble?, lg ST III surf tube	Ambient/Relic Dredged Material Layer	1.92/11.5
17	C	0	0	0	7	Physical	NO	Ambient sand/relic DM, tan fine sand/blk sulfidic silt & clay, v red sed @z, sed layering, wiper clasts, shell bits, sm surf tubes	Ambient/Relic Dredged Material Layer	5.57/6.05
18	A	0	0	0	8	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, red clasts, sm tubes, thin burrow, burrowing anemone, surf rework, fecal mound/lyr	Relic Dredged Material Layer	7.15
18	B	0	0	0	8	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, red clasts, tubes, shell bits, ST III poly @z	Relic Dredged Material Layer	8.31
19	D	0	0	0	11	Physical	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), RPD>pen, dense ST III tubes (Maldanids), Nucula, crab @ surf	remediation material	6.55
19	F	0	0	0	11	Physical	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), RPD>pen, lg ST III tubes, Nucula, brn floc @ surf	remediation material	5.07
20	B	0	0	0	7	Physical	NO	Ambient tan fine sand, RPD>pen, sand ripple, Diopatra tube	Ambient	4.61
20	C	0	0	0	6	Physical	NO	Ambient tan fine sand, RPD>pen, shell frags, sand ripple, v sm tubes, brown org floc @ surf	Ambient	3.53
24	A	0	0	0	7	Physical	NO	Ambient tan fine sand, RPD>pen, sand ripple	Ambient	5.46
24	B	0	0	0	99	Physical	NO	Coarse grained relic DM, tan coarse sand & pebbles w/mud, poorly sorted, shell & brick frags	Relic Dredged Material Layer	4.62
25	B	0	0	0	99	Physical	NO	Relic DM>pen, coarse sand & pebbles, underpen, shell & brick frags	Relic Dredged Material Layer	0.80
25	C	0	0	0	99	Physical	NO	Relic DM>pen, sand & rock, underpen, shell frags, encrusted rocks-bryozoans, brick frags	Relic Dredged Material Layer	0.78
26	B	0	0	0	99	Physical	NO	Coarse grained relic DM>pen, brn sand & pebbles, shell frags	Relic Dredged Material Layer	4.14
26	C	0	0	0	7	Physical	NO	Ambient tan fine sand, shell bits, RPD>pen, sm-scale variability at this station	Ambient	3.94
27	A	0	0	0	7	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, tubes, burrows-openings, sm polys @z, ST III org @z	Relic Dredged Material Layer	10.35
27	B	0	0	0	7	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, red clasts, tubes, ST III org @z, surf rework	Relic Dredged Material Layer	11.85
28	A	0	0	0	9	Biogenic	NO	DM>pen=remed material, tan/blk sulfdic sandy m, red sed @z, shell frgs, lg ST III tubes (Maldanids?), stick amps (Podoceridae), crab @ surf, burrow-opening, voids	remediation material	8.15
28	B	0	0	0	7	Biogenic	NO	DM>pen=remed material, reddish tan/blk sulfidic sandy m, red sed @z, lg ST III tubes (Maldanids), stick amps (Podoceridae)	remediation material	8.27
29	A	0	0	0	9	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, shell frags, stick amps (Podoceridae), lg ST III tubes (Maldanid)	remediation material	9.13
29	D	0	0	0	6	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, polys @z, dense tubes, Ampelisca?	remediation material	11.82
30	B	0	0	0	7	Physical	NO	Relic DM>pen, tan silty sand/blk sandy m, red sed @z, wiper clast-obscured RPD, shell frags, tubes, bamboo worm-far, sm brick pieces-far	Relic Dredged Material Layer	5.69
30	C	0	0	0	3	Physical	NO	Relic DM>pen, tan silty sand & blk sandy m, red sed @z, shell frags, sm surf tubes, red clasts	Relic Dredged Material Layer	6.49
34	A	0	0	0	7	Physical	NO	Ambient brn fine sand, RPD>pen, brn org floc @ surf, recumbent tubes	Ambient	4.36
34	C	0	0	0	7	Physical	NO	Ambient brn fine sand, RPD>pen, brn org floc @ surf, tubes-far	Ambient	4.68
36	D	0	0	0	9	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, red sed @z, nucula, tubes, lg ST III tube (Maldanid)	Relic Dredged Material Layer	8.86
36	F	0	0	0	8	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, red sed @z, burrow opening, tubes	Relic Dredged Material Layer	11.51
97004	A	0	0	0	8	Physical	NO	Cap material (1993)>pen, tan fine sand, RPD>pen, brn org floc @surf, tubes, stick amps	Cap Material Thickness	3.32
97004	C	0	0	0	7	Physical	NO	Cap material (1993) >pen, tan fine sand, RPD>pen, lg tubes	Cap Material Thickness	5.45
97006	A	0	0	0	8	Physical	NO	Cap material (Category II) >pen, tan fine sand, RPD>pen, sand ripple, lg ST III tubes, stick amps	Cap Material Thickness	2.97
97006	B	0	0	0	8	Physical	NO	Cap material (Category II) >pen, tan fine sand, RPD>pen, brn org floc @ surf, ST III tubes, shell bits	Cap Material Thickness	2.62
97007	D	0	0	0	6	Physical	NO	Relic DM>penl, red clay mixed w/sandy m, RPD measurable, red sed @z	Relic Dredged Material Layer	8.86
97007	F	0	0	0	5	Physical	NO	Relic DM>pen, red clay, rocks @ surf, shell frags, fecal lyr, RPD deeper?, poly @z	Relic Dredged Material Layer	7.18

Appendix A-1 (cont)

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi)			Benthic Habitat	Mud Clasts Present	Camera Penetration (cm)				Dredged Material Thickness (cm)			Redox Rebound Thickness (cm)			Apparent RPD Thickness (cm)		
					Min	Max	Maj Mode			Min	Max	Range	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
20028	A	8/22/2006	15:34:52	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	6.44	7.48	1.04	6.96	> 6.44	> 7.48	> 8.31	0	0	0	>6.44	>7.48	>6.96
20028	B	8/22/2006	15:35:52	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.13	3.89	0.76	3.51	> 3.13	> 3.89	> 8.32	0	0	0	>3.13	>3.89	>3.51
20041	D	8/23/2006	13:49:50	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.76	12.37	1.61	11.57	> 10.76	> 12.37	> 8.33	0	0	0	0.85	4.38	2.69
20041	E	8/23/2006	13:50:33	ST I	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.44	11.53	1.09	10.98	> 10.44	> 11.53	> 8.34	0	0	0	0.66	4.23	3.06
20051	A	8/21/2006	18:21:09	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.45	3.51	1.06	2.98	> 2.45	> 3.51	> 8.35	0	0	0	0.33	3.24	2.24
20051	B	8/21/2006	18:22:04	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.18	3.59	0.41	3.38	> 3.18	> 3.59	> 8.36	0	0	0	1.07	3.83	3.49
20061	A	8/21/2006	18:11:43	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	4.08	4.84	0.76	4.46	> 4.08	> 4.84	> 8.37	0	0	0	0.33	5.26	4.27
20061	B	8/21/2006	18:12:38	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	4.98	7.15	2.17	6.07	> 4.98	> 7.15	> 8.38	0	0	0	0.07	1.84	1.15
20062	A	8/21/2006	18:29:43	ST I	4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.75	3.97	1.22	3.36	> 2.75	> 3.97	> 8.39	0	0	0	>2.75	>3.97	>3.36
20062	B	8/21/2006	18:30:40	ST I	4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.92	4.06	1.14	3.49	> 2.92	> 4.06	> 8.40	0	0	0	>2.92	>4.06	>3.49
20063	A	8/22/2006	17:27:26	INDET	< -1 phi	< -1 phi	< -1 phi	HR	FALSE	0	4.46	4.46	2.23	> 0	> 4.46	> 8.41	0	0	0	IND	IND	IND
20063	C	8/22/2006	17:29:03	INDET	< -1 phi	< -1 phi	< -1 phi	HR	FALSE	0	0.85	0.85	0.43	> 0	> 0.85	> 8.42	0	0	0	IND	IND	IND
20064	A	8/22/2006	16:00:50	ST II to III	4 phi	1 phi	3 to 2 phi	SA.F	FALSE	6.25	6.48	0.23	6.36	> 6.25	> 6.48	> 6.36	0	0	0	IND	IND	IND
20064	B	8/22/2006	16:01:42	ST II to III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	5.3	5.49	0.19	5.39	> 5.3	> 5.49	> 5.39	0	0	0	IND	IND	IND
G1200	B	8/22/2006	17:57:37	ST I	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	13.29	13.51	0.22	13.4	> 13.29	> 13.51	> 13.4	0	0	0	0.18	1.84	1.27
G1200	E	8/22/2006	18:05:16	ST I	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	13.24	14.38	1.14	13.81	> 13.24	> 14.38	> 13.81	0	0	0	0.07	1.91	1.07
H2000	D	8/23/2006	12:58:48	ST I	> 4 phi	< -1 phi	> 4 phi	UN.SI	FALSE	8.78	10.73	1.95	9.75	> 8.78	> 10.73	> 9.75	0	0	0	0.04	3.42	2.04
H2000	E	8/23/2006	12:59:38	ST I	> 4 phi	1 phi	3 to 2 phi	SA.F	TRUE	9.38	10.14	0.76	9.76	> 9.38	> 10.14	> 9.76	0	0	0	1.18	6.51	3.34
I1200	A	8/22/2006	16:31:29	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	9.78	10.23	0.45	10	> 9.78	> 10.23	> 10	0	0	0	0.29	2.72	1.68
I1200	B	8/22/2006	16:32:26	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	11.44	12.23	0.79	11.83	> 11.44	> 12.23	> 11.83	0	0	0	0.18	2.65	2.08
K0800	B	8/22/2006	15:50:37	ST I on III	> 4 phi	3 phi	> 4 phi	UN.SI	FALSE	8.9	9.3	0.4	9.1	> 8.9	> 9.3	> 9.1	0	0	0	0.55	4.78	3.90
K0800	E	8/23/2006	13:29:31	ST I on III	> 4 phi	3 phi	> 4 phi	UN.SF	FALSE	14.24	14.57	0.33	14.4	> 14.24	> 14.57	> 14.4	0	0	0	0.26	5.22	2.28
L1200	A	8/22/2006	15:09:15	ST II	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.46	3.92	0.46	3.69	> 3.46	> 3.92	> 3.69	0	0	0	>3.46	>3.92	>3.69
L1200	C	8/22/2006	15:11:05	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	4.3	5.87	1.57	5.09	> 4.3	> 5.87	> 5.09	0	0	0	>4.3	>5.87	>5.09
L2400	A	8/22/2006	15:24:56	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	4.11	4.39	0.28	4.25	> 4.11	> 4.39	> 4.25	0	0	0	>4.11	>4.39	>4.25
L2400	B	8/22/2006	15:25:51	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	4.06	4.41	0.35	4.23	> 4.06	> 4.41	> 4.23	0	0	0	>4.06	>4.41	>4.23
M1200	D	8/22/2006	14:31:33	INDET	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	0.07	2.07	2	1.07	> 0.07	> 2.07	> 1.07	0	0	0	>0.07	>2.07	>1.07
M2800	A	8/22/2006	14:11:46	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	7.74	8.52	0.78	8.13	> 7.74	> 8.52	> 8.13	0	0	0	0.29	4.38	2.87
M2800	B	8/22/2006	14:12:32	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	8.29	8.73	0.44	8.51	> 8.29	> 8.73	> 8.51	0	0	0	IND	IND	IND
N2000	A	8/22/2006	13:48:21	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.09	10.35	0.26	10.22	> 10.09	> 10.35	> 10.22	0	0	0	0.37	3.38	2.74
N2000	B	8/22/2006	13:49:19	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	8.92	10.44	1.52	9.68	> 8.92	> 10.44	> 9.68	0	0	0	0.18	4.30	1.22
N3200	D	8/23/2006	15:03:13	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	15.33	15.83	0.5	15.58	> 15.33	> 15.83	> 15.58	0	0	0	0.22	3.83	2.07
N3200	F	8/23/2006	15:05:09	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	12.61	13.7	1.09	13.15	> 12.61	> 13.7	> 13.15	0	0	0	1.18	3.68	2.49
P2800	B	8/22/2006	12:36:17	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.77	11.51	0.74	11.14	> 10.77	> 11.51	> 11.14	0	0	0	0.18	2.69	1.38
P2800	C	8/22/2006	12:37:14	ST I	> 4 phi	1 phi	> 4 phi	UN.SI	TRUE	9	10.63	1.63	9.82	> 9	> 10.63	> 9.82	0	0	0	0.88	3.24	2.10
P3200	C	8/22/2006	12:27:28	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	9.35	10.71	1.36	10.03	> 9.35	> 10.71	> 10.03	0	0	0	0.85	5.63	4.27
P3200	F	8/23/2006	14:42:31	ST I	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	7.95	10.85	2.9	9.4	> 7.95	> 10.85	> 9.4	0	0	0	0.26	4.08	2.71
Q2400	B	8/22/2006	13:03:06	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.73	11.63	0.9	11.18	> 10.73	> 11.63	> 11.18	0	0	0	0.22	1.73	0.69
Q2400	C	8/22/2006	13:04:03	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.82	11.06	0.24	10.94	> 10.82	> 11.06	> 10.94	0	0	0	0.22	1.99	0.84
A1	A	8/22/2006	18:27:34	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	8.12	9	0.88	8.56	> 8.12	> 9	> 8.56	0	0	0	0.37	4.30	3.27
A1	B	8/22/2006	18:28:33	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	8.12	8.64	0.52	8.38	> 8.12	> 8.64	> 8.38	0	0	0	0.18	3.31	1.64
A10	A	8/21/2006	18:42:35	INDET	N/A	N/A	N/A	HR	FALSE	0	0	0	0	0	0	0	0	0	0	IND	IND	IND
A10	B	8/21/2006	18:43:32	ST I	3 phi	< -1 phi	1 to 0 phi	SA.G	FALSE	0.17	1.36	1.19	0.76	> 0.17	> 1.36	> 0.76	0	0	0	IND	IND	IND
A11	B	8/21/2006	15:14:51	INDET	< -1 phi	< -1 phi	< -1 phi	HR	FALSE	0	0	0	0	0	0	0	0	0	0	IND	IND	IND

Appendix A-1 (cont)

Station	Replicate	Methane Count	Methane Depth	Methane Diam	OSI	Surface Roughness	Low DO	Comments	Sediment Present	Sediment Thickness (cm)
20028	A	0	0	0	7	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), RPD>pen, sand ripple, brn floc @ surf	remediation material	6.96
20028	B	0	0	0	6	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), RPD>pen, sand ripples	remediation material	3.51
20041	D	0	0	0	9	Biogenic	NO	DM>pen=remed material, reddish brn/blk sandy m, dense lg ST III tubes (Maldanids), shell frags	remediation material	11.57
20041	E	0	0	0	6	Physical	NO	DM>pen=remed material, reddish brn silty sand/blk sandy m, v red sed @z, sm tubes, sand over mud layering	remediation material	4.19
20051	A	0	0	0	4	Physical	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), brn floc @ surf, red sed @z, lg tubes (Diopatra?), advanced colonization of new DM	remediation material	2.98
20051	B	0	0	0	6	Physical	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), shell frags, mussel, tubes (Diopatra)	remediation material	3.38
20061	A	0	0	0	7	Biogenic	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), lg dense tubes (Diopatra), shells, brn org floc @ surf, dense colonization of DM sand	remediation material	4.46
20061	B	0	0	0	3	Physical	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), sand ripple, brn org floc @ surf, blk streaks @ z	remediation material	6.07
20062	A	0	0	0	6	Physical	NO	Recent DM>pen=remediation material (Ambrose fine sand), RPD>pen, sand ripple	remediation material	3.36
20062	B	0	0	0	6	Physical	NO	Recent DM>pen=remediation material (Ambrose sand), dense tubes (Diopatra)	remediation material	3.49
20063	A	0	0	0	99	Indeterminate	NO	Hard bottom, remediation material, underpen, rocks	remediation material	2.23
20063	C	0	0	0	99	Indeterminate	NO	Hard bottom, remediation material, underpen, rocks	remediation material	0.43
20064	A	0	0	0	99	Physical	NO	Recent DM>pen=remediation material, tan & gry fine sand (Ambrose), wiper clasts (red clay), dense Nucula, lg ST III tubes (Maldanids)	remediation material	6.36
20064	B	0	0	0	99	Biogenic	NO	Recent DM>pen=remediation material, tan & gry fine sand (Ambrose), dense lg surf tubes (Maldanids), Nucula, red sed @z	remediation material	5.39
G1200	B	0	0	0	3	Physical	NO	DM>pen=remed material, brn silty sand/sandy m, flock lyr, tube, shallow RPD	remediation material	13.40
G1200	E	0	0	0	3	Physical	NO	DM>pen=remed material, brn/blk sandy m, red sed @z, red clasts, wiper clasts, tubes	remediation material	13.81
H2000	D	0	0	0	4	Physical	NO	DM>pen=remed material, tan sand/blk sulfidic sandy m, rocks @ surf, flock lyr, wiper clasts	remediation material	9.75
H2000	E	0	0	0	6	Physical	NO	DM>pen=remed material, tan silty sand/blk sandy m, red sed @z, red clast, shell bits	remediation material	9.76
I1200	A	0	0	0	8	Biogenic	NO	DM>pen=remed material, reddish brn silty sand/blk sandy m, surf sand=Ambrose, lg tubes, Nucula, stick amps (Podoceridae), sm burrows	remediation material	10.00
I1200	B	0	0	0	8	Biogenic	NO	DM>pen=remed material, tan silty sand/blk sandy m, red sed @z, surf sand=Ambrose material, lg ST III tubes, wiper clasts, stick amps (Podoceridae), sm poly @z	remediation material	11.83
K0800	B	0	0	0	11	Biogenic	NO	DM>pen=remediation material, red clay and blk sandy m, surf sand lyr, tubes, sm filled voids, fecal/flock lyr, clay clump @ surf, thin lyr Ambrose sand over red clay	remediation material	9.10
K0800	E	0	0	0	9	Physical	NO	DM>pen=remediation material, red clay & blk sandy m, red sed @z, lg ST III tubes, surf rework, fecal lyr	remediation material	14.40
L1200	A	0	0	0	8	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), RPD>pen, Nucula, tube-far, brn floc @ surf	remediation material	3.69
L1200	C	0	0	0	7	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), RPD>pen, sand ripple, brn floc @ surf, sm tubes	remediation material	5.09
L2400	A	0	0	0	7	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), RPD>pen, shell bits, brn floc @ surf	remediation material	4.25
L2400	B	0	0	0	7	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), RPD>pen, shell bits, brn floc @ surf, rock-far?	remediation material	4.23
M1200	D	0	0	0	99	Physical	NO	DM>pen=remediation material, sandy red clay, underpen, rocks-far?, RPD>pen, sm tubes	remediation material	1.07
M2800	A	0	0	0	9	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, dense lg surf tubes (sp?), shell bits, voids, lg poly @z	remediation material	8.13
M2800	B	0	0	0	99	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, wiper clasts-obscured RPD, dense lg surf tubes (Maldanids), shell bits	remediation material	8.51
N2000	A	0	0	0	9	Physical	NO	DM>pen=remed material, tan/blk sulfdic sandy m, Nucula, stick amp (Podoceridae), tubes, void, multipled lyrs=relic RPD	remediation material	10.22
N2000	B	0	0	0	7	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, lg ST III tubes, stick amp, burrow opening, shell bits, smeared RPD	remediation material	9.68
N3200	D	0	0	0	8	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, shell frags, lg tubes, sm void, polys @z	remediation material	15.58
N3200	F	0	0	0	9	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, shells, wiper clasts, lg ST III tubes (Maldanids), stick amp	remediation material	13.15
P2800	B	0	0	0	7	Physical	NO	DM>pen=remed material, red clay mixed w/blk sandy m, red sed @z, shell frags, ST III polys @z, sm tubes	remediation material	11.14
P2800	C	0	0	0	4	Physical	NO	DM>pen=remed material, red clay mixed w/sandy m, red sed @z (multiple lyrs=banding), shell frags, sm brick pieces @ surf, tubes, sed lyr	remediation material	9.82
P3200	C	0	0	0	11	Biogenic	NO	DM>pen=remed material, red clay mixed w/sandy m, red sed @z, dense tubes (A.occulata), fecal lyr, voids, surf rework, polys @z	remediation material	10.03
P3200	F	0	0	0	5	Physical	NO	DM>pen=remed material, red clay mixed w/sandy m, sed layering, shell frags, red sed @z, tubes	remediation material	9.40
Q2400	B	0	0	0	6	Physical	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, tubes, nucula, void	remediation material	11.18
Q2400	C	0	0	0	7	Physical	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, dense Nucula @ surf, tubes, shallow voids	remediation material	10.94
A1	A	0	0	0	10	Biogenic	NO	Relic DM>pen, tan/blk sandy m, red sed @z, tubes, dense Nucula, sm shallow void, shell frags, fecal/flock lyr, lg tubes	Relic Dredged Material Layer	8.56
A1	B	0	0	0	8	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, Nucula, fecal lyr, lg ST III tubes	Relic Dredged Material Layer	8.38
A10	A	0	0	0	99	Indeterminate	NO	Ambient hard bottom, underpen, bryozoans, sponges	Indeterminate	0
A10	B	0	0	0	99	Physical	NO	Relic DM>pen, sand & rocks, underpen, shell frags, brick pieces	Relic Dredged Material Layer	0.76
A11	B	0	0	0	99	Indeterminate	NO	Underpen, hard bottom, bryozoans or hydroids	Indeterminate	0

Appendix A-1 (cont)

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Maj Mode	Benthic Habitat	Mud Clasts Present	Camera Penetration (cm) Min	Camera Penetration (cm) Max	Camera Penetration (cm) Range	Camera Penetration (cm) Mean	Dredged Material Thickness (cm) Min	Dredged Material Thickness (cm) Max	Dredged Material Thickness (cm) Mean	Redox Rebound Thickness (cm) Min	Redox Rebound Thickness (cm) Max	Redox Rebound Thickness (cm) Mean	Apparent RPD Thickness (cm) Min	Apparent RPD Thickness (cm) Max	Apparent RPD Thickness (cm) Mean
A12	A	8/21/2006	12:50:23	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	8.67	9.81	1.14	9.24	> 8.67	> 9.81	> 9.24	0	0	0	0.18	3.20	1.62
A12	C	8/21/2006	12:57:30	INDET	N/A	N/A	N/A	HR	FALSE	.	0.6	0.6	0.3	0	0	0	0	0	0	IND	IND	IND
A13	D	8/21/2006	19:11:36	ST I	> 4 phi	< -1 phi	1 to 0 phi	SA.G	FALSE	4.22	6.77	2.55	5.49	> 4.22	> 6.77	> 5.49	0	0	0	IND	IND	IND
A13	G	8/23/2006	18:25:35	ST I	> 4 phi	< -1 phi	1 to 0 phi	SA.G	FALSE	9.21	11.3	2.09	10.26	> 9.21	> 11.3	> 10.26	0	0	0	IND	IND	IND
A14	A	8/21/2006	19:51:03	ST I to II	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	9.21	9.35	0.14	9.28	> 9.21	> 9.35	> 9.28	0	0	0	0.18	1.47	0.85
A14	B	8/21/2006	19:51:59	ST II to III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.06	11.77	1.71	10.92	> 10.06	> 11.77	> 10.92	0	0	0	0.81	4.41	2.46
A15	A	8/21/2006	19:41:45	ST II on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	12.61	12.8	0.19	12.7	> 12.61	> 12.8	> 12.7	0	0	0	0.48	3.68	2.67
A15	B	8/21/2006	19:42:48	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.68	12.13	1.45	11.41	> 10.68	> 12.13	> 11.41	0	0	0	0.15	1.18	0.58
A16	A	8/22/2006	18:13:45	INDET	N/A	N/A	N/A	HR	FALSE	0	0	0	0	0	0	0	0	0	0	IND	IND	IND
A17	A	8/22/2006	18:39:47	ST I on III	> 4 phi	2 phi	4 to 3 phi	SA.F	FALSE	3.56	5.13	1.57	4.35	> 3.56	> 5.13	> 4.35	0	0	0	0.74	2.69	1.66
A17	E	8/23/2006	12:34:26	ST I on III	> 4 phi	2 phi	4 to 3 phi	UN.SS	FALSE	9.26	10.54	1.28	9.9	> 9.26	> 10.54	> 9.9	0	0	0	0.81	4.71	3.15
A2	B	8/22/2006	17:15:55	ST I	> 4 phi	< -1 phi	1 to 0 phi	SA.M	FALSE	2.54	4.18	1.64	3.36	0	0	0	0	0	0	>2.54	>4.18	>3.36
A2	C	8/22/2006	17:16:47	ST I	3 phi	0 phi	1 to 0 phi	SA.M	FALSE	5.22	7.36	2.14	6.29	0	0	0	0	0	0	>5.22	>7.36	>6.29
A3	A	8/22/2006	11:56:25	ST I	3 phi	0 phi	1 to 0 phi	SA.G	FALSE	2.28	3.84	1.56	3.06	0	0	0	0	0	0	>2.28	>3.84	>3.06
A3	B	8/22/2006	11:57:23	ST I	3 phi	0 phi	1 to 0 phi	SA.G	FALSE	3.75	4.68	0.93	4.22	0	0	0	0	0	0	>3.75	>4.68	>4.22
A4	A	8/22/2006	14:45:50	ST I	> 4 phi	2 phi	4 to 3 phi	SA.F	FALSE	1.64	2.18	0.54	1.91	0	0	0	0	0	0	>1.64	>2.18	>1.91
A4	B	8/22/2006	14:46:45	ST I	> 4 phi	2 phi	4 to 3 phi	SA.F	FALSE	1.04	3.21	2.17	2.12	0	0	0	0	0	0	>1.04	>3.21	>2.12
A5	D	8/23/2006	14:02:08	ST I on III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.59	4.18	0.59	3.88	0	0	0	0	0	0	>3.59	>4.18	>3.88
A5	E	8/23/2006	14:03:02	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.18	3.92	0.74	3.55	0	0	0	0	0	0	>3.18	>3.92	>3.55
A6	B	8/21/2006	14:58:03	INDET	< -1 phi	< -1 phi	< -1 phi	HR	FALSE	0.76	1.93	1.17	1.35	0	0	0	0	0	0	IND	IND	IND
A7	E	8/23/2006	17:47:36	ST I	> 4 phi	1 phi	3 to 2 phi	SA.F	FALSE	2.4	5.27	2.87	3.84	> 2.4	> 5.27	> 3.84	0	0	0	0.40	5.41	3.46
A7	F	8/23/2006	17:48:27	ST I	> 4 phi	1 phi	3 to 2 phi	UN.SS	FALSE	4.87	6.34	1.47	5.61	> 4.87	> 6.34	> 5.61	0	0	0	0.15	3.38	2.33
A8	A	8/21/2006	13:07:09	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	9.62	9.87	0.25	9.74	> 9.62	> 9.87	> 9.74	0	0	0	0.63	2.35	1.68
A8	E	8/23/2006	18:50:49	ST I on III	> 4 phi	< -1 phi	> 4 phi	UN.SI	FALSE	3.87	4.63	0.76	4.25	> 3.87	> 4.63	> 4.25	0	0	0	0.99	4.52	3.35
A9	A	8/21/2006	17:35:10	ST I on III	> 4 phi	2 phi	3 to 2 phi	UN.SS	FALSE	10.82	12.37	1.55	11.59	0	0	0	0	0	0	1.84	7.98	6.68
A9	B	8/21/2006	17:36:27	ST I on III	> 4 phi	2 phi	4 to 3 phi	UN.SS	FALSE	11.75	13.19	1.44	12.47	0	0	0	0	0	0	0.59	4.75	3.87
HARSC1	1A	8/23/2006	12:41:08	ST I on III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	11.42	12.29	0.87	11.85	> 11.42	> 12.29	> 11.85	0	0	0	0.44	5.19	4.52
HARSC1	1B	8/23/2006	12:41:59	ST I on III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	5.82	7.93	2.11	6.88	> 5.82	> 7.93	> 6.88	0	0	0	>5.82	>7.93	>6.88
HARSC2	1A	8/23/2006	13:09:38	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	16.45	17.18	0.73	16.82	> 16.45	> 17.18	> 16.82	0	0	0	0.37	2.91	1.65
HARSC2	1B	8/23/2006	13:10:45	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	12.72	15.26	2.54	13.99	> 12.72	> 15.26	> 13.99	0	0	0	0.04	1.80	0.96
HARSC3	1A	8/23/2006	13:37:50	ST I on III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	5.13	5.44	0.31	5.28	> 5.13	> 5.44	> 5.28	0	0	0	>5.13	>5.44	>5.28
HARSC3	1B	8/23/2006	13:39:08	ST II on III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	3.42	3.7	0.28	3.56	> 3.42	> 3.7	> 3.56	0	0	0	>3.42	>3.7	>3.56
HARSC4	1A	8/23/2006	14:20:29	ST I	4 phi	1 phi	3 to 2 phi	SA.F	FALSE	4.18	4.39	0.21	4.28	0	0	0	0	0	0	>4.18	>4.39	>4.28
HARSC4	1C	8/23/2006	14:22:39	ST I on III	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.02	3.3	1.28	2.66	0	0	0	0	0	0	>2.02	>3.3	>2.66
HARSC5	1A	8/23/2006	14:48:37	ST II on III	> 4 phi	3 phi	> 4 phi	UN.SI	FALSE	6.64	7.24	0.6	6.94	> 6.64	> 7.24	> 6.94	0	0	0	1.99	5.52	4.16
HARSC5	1C	8/23/2006	14:50:24	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	TRUE	9.81	10.39	0.58	10.1	> 9.81	> 10.39	> 10.1	0	0	0	0.40	2.91	1.77
HARSUC1	1A	8/23/2006	18:05:49	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	1.57	4.13	2.56	2.85	0	0	0	0	0	0	>1.57	>4.13	>2.85
HARSUC1	1B	8/23/2006	18:06:45	ST I	> 4 phi	1 phi	2 to 1 phi	SA.M	FALSE	3.13	4.16	1.03	3.64	0	0	0	0	0	0	>3.13	>4.16	>3.64
HARSUC2	1B	8/23/2006	17:01:42	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.04	3.54	1.5	2.79	0	0	0	0	0	0	>2.04	>3.54	>2.79
HARSUC2	1C	8/23/2006	17:02:38	ST I	> 4 phi	2 phi	3 to 2 phi	SA.F	FALSE	2.75	3.59	0.84	3.17	0	0	0	0	0	0	>2.75	>3.59	>3.17
HARSUC3	1A	8/23/2006	18:59:10	ST II to III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	12.91	13.6	0.69	13.26	> 12.91	> 13.6	> 13.26	0	0	0	0.07	1.95	0.85
HARSUC3	1B	8/23/2006	19:00:02	ST I to II	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	12.94	13.27	0.33	13.1	> 12.94	> 13.27	> 13.1	0	0	0	0.11	1.84	0.87
HARSUC4	1A	8/23/2006	17:34:04	ST I	> 4 phi	3 phi	> 4 phi	UN.SI	TRUE	6.64	7.91	1.27	7.27	> 6.64	> 7.91	> 7.27	0	0	0	0.04	1.95	0.90
HARSUC4	1C	8/23/2006	17:35:49	ST I on III	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	9.85	11.15	1.3	10.5	> 9.85	> 11.15	> 10.5	0	0	0	0.44	2.32	1.18
HARSUC5	1A	8/23/2006	16:14:30	ST I	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	10.14	11.2	1.06	10.67	> 10.14	> 11.2	> 10.67	0	0	0	0.18	3.68	2.44
HARSUC5	1B	8/23/2006	16:15:48	ST I	> 4 phi	3 phi	> 4 phi	UN.SI	TRUE	10.35	11.63	1.28	10.99	> 10.35	> 11.63	> 10.99	0	0	0	0.40	1.03	0.77
HARSUC6	1A	8/23/2006	15:58:25	ST I	> 4 phi	2 phi	> 4 phi	UN.SS	FALSE	6.77	8.31	1.54	7.54	> 6.77	> 8.31	> 7.54	0	0	0	0.22	3.42	2.09
HARSUC6	1C	8/23/2006	16:00:26	ST I to II	> 4 phi	2 phi	> 4 phi	UN.SI	FALSE	9.07	9.44	0.37	9.25	> 9.07	> 9.44	> 9.25	0	0	0	0.18	3.94	2.67

Appendix A-1 (cont)

Station	Replicate	Methane Count	Methane Depth	Methane Diam	OSI	Surface Roughness	Low DO	Comments	Sediment Present	Sediment Thickness (cm)
A12	A	0	0	0	8	Biogenic	NO	Relic DM>pen, tan silty sand/blk sandy m, red sed @z, voids, polys @z, tubes, brick piece @ surf, shell bits, fecal lyr	Relic Dredged Material Layer	9.24
A12	C	0	0	0	99	Indeterminate	NO	Underpen, hard bottom, encrusted rocks, coarse grained relic DM?	Indeterminate	0
A13	D	0	0	0	99	Physical	NO	Relic DM>pen, poorly sorted coarse sand, gravel, shell frags, and brick pieces	Relic Dredged Material Layer	5.49
A13	G	0	0	0	99	Physical	NO	Relic DM>pen, coarse sand, poorly sorted, shell frags	Relic Dredged Material Layer	10.26
A14	A	0	0	0	4	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, red sed @z, dense tubes, shell bits	Relic Dredged Material Layer	9.28
A14	B	0	0	0	8	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, sm & lg tubes, gry clay @z, stick amp-far, Nucula, burrow?	Relic Dredged Material Layer	10.92
A15	A	0	0	0	9	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, tubes, stick amp (Podoceridae), shell bits, poly @z, sm void	Relic Dredged Material Layer	12.70
A15	B	0	0	0	6	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, red sed @z, tubes, burrowing ghost shrimp @z, shell bits, fecal lyrs	Relic Dredged Material Layer	11.41
A16	A	0	0	0	99	Indeterminate	NO	Underpen, hard bottom, bryozoans, rock, DM=KVK rock?	Indeterminate	0
A17	A	0	0	0	8	Biogenic	NO	DM>pen=remed material, reddish brn muddy fine sand & blk m, Ambrose sand?, red sed @z, tubes, dense thick ST III surf tubes	remediation material	4.35
A17	E	0	0	0	10	Biogenic	NO	DM>pen=remed material, reddish brn muddy sand mixed w/gry sand & blk m, Ambrose sand?, red sed @z, sed layering, brn floc @ surf, tubes, biogenic mound?	remediation material	9.90
A2	B	0	0	0	6	Physical	NO	Thin lyr red clay remediation material/ambient coarse sand, underpen, RPD>pen, sm ST I tubes @ surf	remediation material/Ambient	1.5/2.68
A2	C	0	0	0	7	Physical	NO	Ambient medium & coarse sand, RPD>pen	Ambient	6.29
A3	A	0	0	0	6	Physical	NO	Ambient coarse sand & pebbles, RPD>pen	Ambient	3.06
A3	B	0	0	0	7	Physical	NO	Ambient brn coarse sand & pebbles, RPD>pen	Ambient	4.22
A4	A	0	0	0	4	Physical	NO	Ambient tan fine sand, underpen, RPD>pen, sand dollars	Ambient	1.91
A4	B	0	0	0	4	Physical	NO	Ambient tan fine sand, underpen, RPD>pen, sand dollars, shell frags	Ambient	2.12
A5	D	0	0	0	11	Physical	NO	Ambient brn fine sand, dense lg ST III tubes, RPD>pen, brn floc @ surf	Ambient	3.88
A5	E	0	0	0	6	Physical	NO	Ambient brn fine sand, RPD>pen, sm ST I tubes, brn floc @ surf	Ambient	3.55
A6	B	0	0	0	99	Physical	NO	Ambient hard bottom, underpen, bryozoans, shrimp @ surf	Ambient	1.35
A7	E	0	0	0	6	Physical	NO	Relic DM>pen, brn fine sand, shell bits, sm pebbles, red sed @z, sm ST I tubes	Relic Dredged Material Layer	3.84
A7	F	0	0	0	5	Physical	NO	Relic DM>pen, brn sand mixed w/sandy m, poorly sorted, shell frags, tubes, suspended poly, brn floc @ surf	Relic Dredged Material Layer	5.61
A8	A	0	0	0	8	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, dark image, shell frags, tubes, polys @z, sm void	Relic Dredged Material Layer	9.74
A8	E	0	0	0	10	Physical	NO	Relic DM>pen, rocks/tan & blk sandy m, shell frags, voids, sponge @ surf?, tubes, brick frags?	Relic Dredged Material Layer	4.25
A9	A	0	0	0	11	Physical	NO	Ambient sand/relic DM, tan fine sand/blk sulfidic sandy m, v red sed @z, sed layering, shell bits, sm tubes, lg worms @ z	Ambient/Relic Dredged Material Layer	6.60/4.90
A9	B	0	0	0	11	Indeterminate	NO	Ambient sand/relic DM, tan fine sand/blk sulfidic sandy m, v red sed @z, sed layering, wiper clasts-obscured image, lg ST III tubes (bamboo worms), void @z?	Ambient/Relic Dredged Material Layer	6.20/5.60
HARSC1	1A	0	0	0	11	Biogenic	NO	DM>pen=remed material, tan & gry fine sand (Ambrose)/blk silty sand, dense lg surf tubes, brn org floc @ surf, red sed @z, sm voids?	remediation material	11.85
HARSC1	1B	0	0	0	11	Biogenic	NO	DM>pen=remed material, tan & gry silty sand (Ambrose sand), brn org floc @ surf, RPD>pen, wiper clasts, dense lg ST III tubes, shell bits	remediation material	6.88
HARSC2	1A	0	0	0	8	Physical	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, red clasts, lg ST III tubes, shell bits, Nucula?, DM layering	remediation material	16.82
HARSC2	1B	0	0	0	7	Biogenic	NO	DM>pen=remed material, tan/blk sulfidic sandy m, v red sed @z, sm tubes, burrow, voids, surf rework, fecal lyrs	remediation material	13.99
HARSC3	1A	0	0	0	11	Physical	NO	DM>pen=remed material, gry fine sand (Ambrose), red clay wiper clasts, RPD>pen, shell frags, lg ST III tubes, Nucula?	remediation material	5.28
HARSC3	1B	0	0	0	10	Physical	NO	DM>pen=remed material, tan & gry fine sand (Ambrose), shell frags, Nucula, ST III tubes, RPD>pen	remediation material	3.56
HARSC4	1A	0	0	0	7	Physical	NO	Ambient brn fine sand, RPD>pen	Ambient	4.28
HARSC4	1C	0	0	0	9	Physical	NO	Ambient brn fine sand, RPD>pen, sand dollars, brn org floc @ surf, lg ST III tubes	Ambient	2.66
HARSC5	1A	0	0	0	11	Physical	NO	DM>pen=remed material, reddish-tan/blk sandy m, red sed @z, sm burrow-opening, tubes, shell bits, stick amp-far	remediation material	6.94
HARSC5	1C	0	0	0	8	Physical	NO	DM>pen=remed material, reddish-tan/blk sandy m, red sed @z, wiper clasts, red clasts, lg ST III tubes	remediation material	2.98
HARSUC1	1A	0	0	0	5	Physical	NO	Ambient brn fine sand, RPD>pen, sand ripple, underpen	Ambient	2.85
HARSUC1	1B	0	0	0	6	Physical	NO	Ambient brn medium sand, RPD>pen, underpen, slight ripple	Ambient	3.64
HARSUC2	1B	0	0	0	5	Physical	NO	Ambient brn fine sand, RPD>pen, sand ripple, sm tubes (Diopatra), shell frags, underpen	Ambient	2.79
HARSUC2	1C	0	0	0	6	Physical	NO	Ambient tan fine sand, RPD>pen, underpen, shell frags	Ambient	3.17
HARSUC3	1A	0	0	0	6	Biogenic	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, Nucula, fecal lyr, surf rework, sm burrows, void?, lg recumbent tube	Relic Dredged Material Layer	13.26
HARSUC3	1B	0	0	0	4	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, shell bits, fecal lyr, Nucula?	Relic Dredged Material Layer	13.10
HARSUC4	1A	0	0	0	3	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, m clumps @ surf, red clast	Relic Dredged Material Layer	7.27
HARSUC4	1C	0	0	0	7	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, sm tubes, void	Relic Dredged Material Layer	10.50
HARSUC5	1A	0	0	0	5	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, shell bits, tubes	Relic Dredged Material Layer	10.67
HARSUC5	1B	0	0	0	3	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, shallow RPD, sm tubes, org @ surf, ox burrow	Relic Dredged Material Layer	10.99
HARSUC6	1A	0	0	0	4	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, fecal lyr, shell bits, dark image	Relic Dredged Material Layer	7.54
HARSUC6	1C	0	0	0	6	Physical	NO	Relic DM>pen, tan/blk sulfidic sandy m, v red sed @z, assorted tubes	Relic Dredged Material Layer	9.25

APPENDIX B

Appendix B-1. Plan-view Imaging data for the 2006 summer survey at the HARS

Station	Replicate	Date	UTC Time	Northing	Easting	Obscured	General Bottom Description	Hard Bottom/Reef	Sand (Fine/Med/Coarse)	Silt/Clay
20061	A	8/21/2006	18:11:43	1019432.02	87819.84		NO IMAGE	~	~	~
20062	A	8/21/2006	18:29:43	1019708.18	90385.67		NO IMAGE	~	~	~
20063	A	8/22/2006	17:27:26	1014755.16	86310.11		NO IMAGE	~	~	~
20064	A	8/22/2006	16:00:50	1016949.02	83462.14		NO IMAGE	~	~	~
A1	A	8/22/2006	18:27:34	1012871.35	91948.73		NO IMAGE	~	~	~
A2	A	8/22/2006	17:14:58	1012726.86	85730.82		NO IMAGE	~	~	~
A3	A	8/22/2006	11:56:25	1014001.85	69867.99	N	hard, sand with pebbles,some silt surface	Y	Medium	N
A4	A	8/22/2006	14:45:50	1012595.55	78081.14		NO IMAGE	~	~	~
A5	F	8/23/2006	14:03:55	1014708.10	74542.49	N	soft, sandy silt ,worm tubes	N	Fine	Y
A6	A	8/21/06	14:52:52	1035000.31	78083.44		NO IMAGE	~	~	~
A7	A	8/21/06	13:22:37	1027411.52	87765.86	N	soft, silt, tubes, fish trail	N	N	Y
A7	B	8/21/06	13:24:10	1027456.69	87685.18	N	soft, silt, fish, tubes	N	N	Y
A8	A	8/21/06	13:07:09	1031215.13	89320.04	N	soft, silt, crab, 1 shrimp	N	N	Y
A9	A	8/21/06	17:35:10	1026176.29	82689.92		NO IMAGE	~	~	~
A10	D	8/23/2006	18:15:51	1024026.75	92946.22	N	Hard, pebble and cobble over sand, some shell fragments	Y	Coarse	N
A11	A	8/21/06	15:10:09	1033467.66	73852.97		NO IMAGE	~	~	~
A12	A1	8/21/06	12:50:23	1032947.32	91345.18	N	soft, silt, shrimp, anemone	N	N	Y
A12	D	8/23/2006	18:38:59	1033004.45	91371.03	N	gravel and cobble over silt	Y	N	Y
A13	A	8/21/06	19:02:04	1026912.24	94043.45		NO IMAGE	~	~	~
A13	E	8/21/06	19:12:33	1026921.60	93996.72	N	silt layer on pebble and gravel over sand	Y	Medium	N
A14	A	8/21/06	19:51:03	1034184.70	93606.71		NO IMAGE	~	~	~
A15	A	8/21/06	19:41:45	1031814.21	93425.28		NO IMAGE	~	~	~
A16	A	8/22/2006	18:13:45	1014998.42	88130.20		NO IMAGE	~	~	~
A17	D	8/23/2006	12:33:19	1014983.87	91944.02	N	soft silt, shells , large worm tube	N	Fine	Y
97004	D	8/23/2006	15:17:49	1026574.70	73005.14	N	sand, many large worm tubes, org. floc	N	Fine	Y
97006	E	8/23/2006	15:27:36	1027828.07	73876.25	N	sand,small worm tubes, org. floc	N	Medium	N
97007	E	8/23/2006	16:27:32	1030315.28	82625.13	N	silt layer on cobble over sand,large worm tubes, red clay	Y	Fine	Y
20031	A	8/22/2006	17:02:39	1014517.66	85051.69		NO IMAGE	~	~	~
20028	A	8/22/2006	15:34:52	1020056.18	82851.41		NO IMAGE	~	~	~
20051	A	8/21/06	18:21:09	1020389.16	89046.57		NO IMAGE	~	~	~
20041	C	8/22/2006	13:40:49	1017599.26	77126.87	N	silty sand,large worm tubes	N	Medium	Y
4	E	8/23/2006	12:18:27	1017156.97	93462.43	N	silt layer over sand,large worm tubes, org. floc	N	Medium	Y
7	E	8/23/2006	12:25:50	1016631.60	91760.95	N	sand,small worm tubes, org. floc	N	Fine	N
11	D	8/23/2006	12:48:47	1017587.19	89362.58	N	silt layer over sand, tubes, org. floc	N	Medium	Y
11	E	8/23/2006	12:49:46	1017594.16	89354.09	N	hard, rocks gravel over sand	Y	Medium	N
13	A	8/21/06	18:01:34	1022495.45	87844.49		NO IMAGE	~	~	~
14	C	8/21/06	13:42:48	1029062.74	85134.79	N	silt layer over sand,seastar	Y	Medium	Y
15	D	8/23/2006	17:24:43	1032086.73	85070.10	N	encrusted rocks and shell over sand	Y	Medium	N
16	E	8/23/2006	16:51:39	1023784.01	83514.15	N	med. sand, ripples	N	Medium	N
17	D	8/23/2006	16:38:51	1027102.01	83222.23	N	silty sand,shell, large tube, org. floc	N	Fine	Y
18	A	8/21/06	14:09:31	1030725.33	83788.09	N	silty sand,small worm tubes, seastar	N	Fine	Y
19	D	8/23/2006	13:19:22	1017605.36	82180.62	N	fine sand w org. floc, large tubes	N	Fine	Y
20	A	8/21/06	17:16:08	1021926.44	81798.30		NO IMAGE	~	~	~
24	A	8/21/06	17:03:05	1023867.94	79001.57		NO IMAGE	~	~	~
25	A	8/21/06	16:52:51	1026572.16	79290.88		NO IMAGE	~	~	~
26	A	8/21/06	16:42:04	1029762.98	79300.27		NO IMAGE	~	~	~
27	A	8/21/06	14:40:34	1031914.13	79810.78		NO IMAGE	~	~	~
28	A	8/22/2006	13:27:53	1015538.16	76965.06	N	soft, silt over sand red clay?, large tubes	N	Fine	Y
29	C	8/22/2006	12:46:50	1019928.28	76020.81	N	soft, silt over sand, large tubes	N	Fine	Y
30	A	8/21/06	15:28:08	1029935.82	76512.32		NO IMAGE	~	~	~
34	B	8/22/2006	12:12:32	1018951.62	71486.04	N	soft, silt over sand, org floc, large tubes	N	Medium	Y
36	E	8/23/2006	15:42:58	1028415.30	68376.06	N	soft, silt over sand, org floc, large tubes	N	Fine	Y

Appendix B-1 (cont)

Station	Replicate	Epifauna	Infauna	Burrows (#)	Bedforms	Shell Material	DM	CAP	Comments
20061	A	~	~	~	~	~	~	~	
20062	A	~	~	~	~	~	~	~	
20063	A	~	~	~	~	~	~	~	
20064	A	~	~	~	~	~	~	~	
A1	A	~	~	~	~	~	~	~	
A2	A	~	~	~	~	~	~	~	
A3	A	N	Y	0	N	N	N	N	some silt, pebble on surface, some worm tubes at left
A4	A	~	~	~	~	~	~	~	
A5	F	N	Y	0	N	Y	N	N	soft, silt, worm tubes
A6	A	~	~	~	~	~	~	~	
A7	A	N	Y	0	N	Y	IND	IND	soft , worm tubes, shell fragments ,sediment trail from fish
A7	B	Y	Y	0	N	Y	IND	IND	soft, tubes, fish foreground, film cut during processing
A8	A	Y	N	2	N	Y	Y	N	soft, silt, crab in burrow, shrimp, 1 burrow midframe
A9	A	~	~	~	~	~	~	~	
A10	D	N	N	0	Y	Y	N	N	Hard, pebble and cobble over sand, some shell fragments
A11	A	~	~	~	~	~	~	~	
A12	A1	Y	N	0	N	Y	IND	IND	soft, silt, shrimp, anemone
A12	D	N	N	0	N	Y	Y	Y	Hard surface over soft substrate, pebble and cobble over silt, mussel, clam shell frags
A13	A	~	~	~	~	~	~	~	
A13	E	N	N	0	N	Y	N	N	thin silt layer on pebble, gravel over sand, shell frags, mussel shell
A14	A	~	~	~	~	~	~	~	
A15	A	~	~	~	~	~	~	~	
A16	A	~	~	~	~	~	~	~	
A17	D	N	Y	0	N	Y	Y	N	soft silt, shells, large tube(worm?)
97004	D	N	Y	0	N	Y	N	Y	sand cap, large worm tubes,dense mat (sp. Maldanid?) shell, seastar, org.floc
97006	E	N	Y	0	Y	Y	N	Y	sand cap, small worm tubes, shell,org floc
97007	E	N	Y	0	N	Y	Y	Y	silt layer on cobble over sand, red clay,large worm tubes, shell frags
20031	A	~	~	~	~	~	~	~	
20028	A	~	~	~	~	~	~	~	
20051	A	~	~	~	~	~	~	~	
20041	C	N	Y	0	N	Y	Y	N	silt layer over sand,rocks, large worm tubes
4	E	N	Y	0	N	Y	Y	N	silt layer over sand,large worm tubes (bamboo), shell frags, org. floc
7	E	Y	Y	0	N	Y	Y	N	sand,org. floc, small worm tubes, sediment trail from fish
11	D	N	Y	0	N	Y	Y	N	silt over sand, dense tube mat, vegetative matter center frame ?
11	E	Y	N	0	N	Y	Y	N	hard, rocks gravel over sand, bryozoan?
13	A	~	~	~	~	~	~	~	
14	C	Y	Y	3	N	Y	Y	N	silt layer over sand,seastar, anemone, burrow
15	D	Y	N	0	N	Y	IND	IND	rocks and shell over sand, mussel shell, encrusted rock
16	E	N	Y	0	Y	Y	N	N	med. Sand, ripples, large worm tube, shell frags
17	D	N	Y	0	N	Y	IND	N	silty sand,shells, large worm tube, fish or sand lance?
18	A	Y	Y	1	N	Y	Y	N	silty sand,small worm tubes, seastar w shrimp or sm fish, burrow
19	D	N	Y	0	N	Y	Y	N	fine sand w org. floc, many large worm tubes (maldanids)
20	A	~	~	~	~	~	~	~	
24	A	~	~	~	~	~	~	~	
25	A	~	~	~	~	~	~	~	
26	A	~	~	~	~	~	~	~	
27	A	~	~	~	~	~	~	~	
28	A	N	Y	0	N	Y	Y	N	soft, silt over sand red clay?, large worm tubes, shell frags
29	C	Y	Y	0	N	Y	Y	N	soft, silt over sand, large worm tubes, flatfish (sand dab?)
30	A	~	~	~	~	~	~	~	
34	B	N	Y	0	N	Y	N	N	soft, silt over sand, org. floc, large worm tubes, surf clam shell
36	E	Y	Y	0	N	Y	IND	N	soft, silt over sand, large worm tubes, seastar, shrimp

Appendix B-1 (cont)

Station	Replicate	Date	UTC Time	Northing	Easting	Obscured	General Bottom Description	Hard Bottom/Reef	Sand (Fine/Med/Coarse)	Silt/Clay
G1200	A	8/22/2006	17:56:43	1016376.80	87198.71		NO IMAGE	~	~	~
H2000	E	8/23/2006	12:59:38	1018958.68	85788.07	N	gravel, shell bed over sand	Y	Medium	N
I1200	A	8/22/2006	16:31:29	1016409.50	84573.82		NO IMAGE	~	~	~
K0800	D	8/23/2006	13:28:29	1015103.37	81845.80	N	soft, silt over sand, dense large tube mat	N	Fine	Y
L1200	A	8/22/2006	15:09:15	1016430.55	80579.67		NO IMAGE	~	~	~
L2400	A	8/22/2006	15:24:56	1020291.08	80660.36		NO IMAGE	~	~	~
M1200	A	8/22/2006	14:23:45	1016419.33	79224.38		NO IMAGE	~	~	~
M2800	C	8/22/2006	14:13:30	1021580.22	79282.13	N	soft, silt over sand, dense large tube mat	N	Fine	Y
N2000	B	8/22/2006	13:49:19	1019002.76	77976.48	N	soft silt	N	N	Y
N2000	C	8/22/2006	13:50:12	1018988.32	78005.00	N	soft silt, tubes	N	N	Y
P2800	A	8/22/2006	12:35:19	1021617.31	75374.85	N	gravel, rocks on soft silt, red clay	Y	N	Y
P2800	E	8/23/2006	14:34:17	1021685.61	75354.31	N	soft silt, dense large worm tubes	N	N	Y
Q2400	A	8/22/2006	13:02:07	1020316.59	74078.34	N	soft silt, org floc, large worm tube	N	N	Y
N3200	C	8/22/2006	14:01:58	1022917.73	77948.37	N	soft sandy silt, large worm tubes	N	Fine	Y
P3200	B	8/22/2006	12:26:28	1022940.38	75376.30	N	soft silt, red clay, large worm tubes	N	N	Y
P3200	D	8/23/2006	14:40:47	1022981.77	75341.15	N	hard, rocks gravel over silt,red clay	Y	Fine	Y
HARS_C1_1	A	8/23/2006	12:41:08	1016922.10	90737.60	N	silty sand, large tube worm mat	N	Fine	Y
HARS_C2_1	B	8/23/2006	13:10:45	1016865.31	85309.14	N	sandy silt, large tube worms	N	Fine	Y
HARS_C4_1	C	8/23/2006	14:22:39	1016914.36	74674.07	N	silty sand, sand dollars, sea star, tubes	N	Fine	Y
HARS_UC1_1	A	8/23/2006	18:05:49	1024329.27	90718.89	N	medium sand, sea stars	N	Medium	N
HARS_UC2_1	B	8/23/2006	17:01:42	1024272.20	85049.35	N	rippled fine sand, large tube worms	N	Fine	N
HARS_UC3_1	C	8/23/2006	19:00:56	1030656.13	90393.72	N	sandy silt, small tube worms	N	Fine	Y
HARS_UC4_1	A	8/23/2006	17:34:04	1030933.42	84945.21	N	fine sandy silt w/ clay clumps, shrimp	N	Fine	Y
HARS_UC5_1	C	8/23/2006	16:16:27	1030961.92	79515.66	N	sandy silt, organic floc	N	Fine	Y
HARS_UC6_1	A	8/23/2006	15:58:25	1030968.46	74158.33	N	sandy silt, sea star, orgainc floc	N	Fine	Y

Appendix B-1 (cont)

Station	Replicate	Epifauna	Infauna	Burrows (#)	Bedforms	Shell Material	DM	CAP	Comments
G1200	A	~	~	~	~	~	~	~	
H2000	E	Y	Y	0	N	Y	Y	N	gravel, shells on sand, large worm tubes, mussel shells, crab,shrimp
I1200	A	~	~	~	~	~	~	~	
K0800	D	N	Y	0	N	N	Y	N	soft, silt over sand, many large worm tubes
L1200	A	~	~	~	~	~	~	~	
L2400	A	~	~	~	~	~	~	~	
M1200	A	~	~	~	~	~	~	~	
M2800	C	N	Y	0	N	Y	Y	N	soft, silt over sand, many large worm tubes, shell frags
N2000	B	Y	N	0	N	N	Y	N	soft silt (over sand?) skate
N2000	C	N	Y	0	N	N	Y	N	soft silt, large worm tubes
P2800	A	Y	Y	0	N	Y	Y	N	gravel over silt, red clay, fish tail and shadow at right, large worm tubes
P2800	E	N	Y	0	N	N	Y	N	soft silt, dense tube mat, possible fish?
Q2400	A	N	Y	0	N	Y	Y	N	silty sand , org. floc, tubes
N3200	C	Y	Y	0	N	Y	Y	N	soft sandy silt, large worm tubes seastar, shrimp and burrow
P3200	B	N	Y	0	N	N	Y	N	soft silt, red clay, large worm tubes
P3200	D	N	N	0	N	Y	Y	N	hard, rocks gravel over silt, red clay, large worm tubes, mussel shell
HARS_C1_1	A	N	Y	0	N	N	Y	N	Dredge material, dense tube mat (sp. Maldanid), organic floc
HARS_C2_1	B	N	Y	4	N	N	N	N	Dredge material, large tube worm mat (sp. Maldanid), organic floc
HARS_C4_1	C	Y	Y	0	N	Y	N	N	11 sand dollars, sea stars, anemone, small tubes, organic floc
HARS_UC1_1	A	Y	N	0	N	Y	N	N	2 sea stars, shell frag, organism tracks
HARS_UC2_1	B	N	Y	0	Y	Y	N	N	large tube worms, rippled sand
HARS_UC3_1	C	N	Y	3	N	N	Y	N	Dredge material, small tube worms, organic floc
HARS_UC4_1	A	Y	N	2	N	Y	Y	N	shrimp, large clay or mud clumps, shell frag, orgainc floc
HARS_UC5_1	C	N	Y	0	N	N	Y	N	Dredge material, small tube worms, organic floc
HARS_UC6_1	A	Y	Y	3	N	N	Y	N	Dredge material, sea star, small tube worms, orgainc floc