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July 2002

Disposal Area Monitoring System DAMOS

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13. ABSTRACT

This report presents the results of a DAMOS monitoring survey conducted in July 2002 at the historic Machias Bay Disposal Site (MADS) near Eastport, Maine. The objective of this survey was to document the distribution of historic dredged material on the seafloor and evaluate biological conditions within the disposal site. The July 2002 field operations consisted of precision bathymetry, side-scan sonar, and sediment-profile imaging. The results of this survey will assist with assessing the suitability of MADS as a disposal site for the placement of material from future maintenance dredging projects in the region.

The July 2002 bathymetry and side-scan sonar data indicated the presence of a historic sediment deposit near the center of MADS. Side-scan sonar and REMOTS® sediment-profile data indicated that the surface of the historic disposal mound was composed of slightly coarser, denser surface sediments than the surrounding ambient sediment of Machias Bay, and appears to be a stable feature on the seafloor. Surface sediments over the majority of the disposal site were composed of fine-grained (reddish-tan over gray) sandy silt that was comparable to the reference area sediments, confirming the depositional nature of the area. A significant presence of mud clumps and clasts at the sediment-water interface at both the disposal site and reference area stations suggest this area is subject to widespread physical disturbance, likely due to lobster fishing activity.

The benthic community within the disposal site was similar to that observed at the reference areas, with both Stage I surface-dwelling and advanced Stage III deeper-dwelling infauna present within the surface sediments. Stage III activity was observed in 76% of the stations sampled within MADS, which is comparable to 80% for the stations sampled within the reference areas. Shallow to moderate redox potential discontinuity (RPD) depths suggested bioturbational activity was low within the surface sediments, resulting in Organism Sediment Index (OSI) values below +6. However, the benthic habitat conditions detected during the July 2002 survey do not appear to be a product of a recent physical disturbance, but rather are likely a function of the significant sand content within both the ambient and deposited material, as well as cold bottom waters.

The data collected as part of the July 2002 survey suggests there is no evidence of long-term impacts from past dredged material disposal within MADS, and it is anticipated that future placement of organically enriched sediment may, in fact, stimulate the productivity of the seafloor. Future monitoring of MADS should be conducted in late summer/early fall when bottom waters are at their warmest in order to document benthic habitat recovery.

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EXECUTIVE SUMMARY

The Disposal Area Monitoring System (DAMOS), managed by the New England District (NAE) of the U.S. Army Corps of Engineers, conducts detailed monitoring studies to detect and minimize any physical, chemical, and biological impacts associated with dredging and dredged material disposal activities in New England. This report presents the results of a DAMOS monitoring survey conducted by Science Applications International Corporation (SAIC) in July 2002 at the historic Machias Bay Disposal Site (MADS) near Eastport, Maine. The objective of this survey was to document the distribution of historic dredged material on the seafloor and evaluate biological conditions within the disposal site.

Maintenance and improvement dredging of Bucks Harbor, Machiasport and the six-foot channel in the Machias River, was performed between 1971 and 1974, where a total estimated volume of 55,300 m^3 of dredged material was deposited at MADS, a 1230 × 1230 m area of seafloor situated in the central portion of Machias Bay. The July 2002 field operations mark the first monitoring survey conducted at MADS under the DAMOS program. The results of this survey will assist with assessing the suitability of MADS as a disposal site for the placement of material from future maintenance dredging projects in the region. As part of the July 2002 field effort, a precision bathymetric and side-scan sonar survey was performed to assess the distribution of historic disposed sediment. In addition, a Remote Ecological Monitoring of the Seafloor (REMOTS®) sediment-profile imaging survey was conducted to further delineate the spatial distribution of historic dredged material on the seafloor and assess the benthic recolonization status over the disposal site relative to two nearby reference areas.

The July 2002 bathymetry and side-scan sonar data indicated the presence of a historic sediment deposit on the seafloor at MADS. This roughly circular deposit located in the center of MADS had a maximum height of approximately 2 m and an estimated diameter of about 300 m on the seafloor. Side-scan sonar and REMOTS® sediment-profile data indicated that the surface of the historic disposal mound was composed of slightly coarser, denser surface sediments than the surrounding ambient sediment of Machias Bay, and appears to be a stable feature on the seafloor.

Surface sediments at most of the disposal site stations were composed of fine-grained (reddish-tan over gray) sediment that was comparable to the reference area sediments at 24 of the 25 REMOTS® sampling stations, and confirmed the depositional nature of the area. One station near the apex of the disposal mound exhibited a coarser deposit of historic dredged material of indeterminate depth. The surface sediments at that station indicate an armored mound surface of pebbles and shells. In addition, a significant

presence of mud clumps and clasts at the sediment surface of both the disposal site and reference area stations suggest this area is subject to some degree of physical disturbance, possibly due to lobster fishing activity.

The average depth of the apparent Redox-Potential Discontinuity (RPD) over MADS (1.7 cm) and at the nearby reference areas (1.9 cm) was considered indicative of moderately oxygenated surface sediments at the time of the July 2002 survey. The benthic community within the disposal site was similar to that observed at the reference areas, with both Stage I surface-dwelling and advanced Stage III deeper-dwelling infauna present within the surface sediments. Stage III activity (advanced, well-developed benthic community) was observed in 76% of the stations sampled within MADS, which is comparable to 80% for the stations sampled within the reference areas.

Benthic habitat conditions within MADS appear to be quite similar to the reference area stations, with overall Organism-Sediment Index (OSI) values of +5.3 and +5.9, respectively. These intermediate OSI values, generally indicative of moderately disturbed benthic habitat quality, were the result of somewhat shallow RPD depths and a mixture of both Stage I and small Stage III organisms (evidenced by small, indistinct feeding voids). The habitat conditions detected during the July 2002 survey do not appear to be a product of a recent physical disturbance, but rather are likely a function of the significant sand content within both the ambient and deposited material, as well as cold bottom waters. Sandy sediments do not provide an abundance of organic matter to support an active deposit-feeding benthic infaunal community. In addition, cold bottom water temperatures at this site tend to slow the metabolism and foraging activity of resident infauna. As a result, benthic conditions in this area may not be conducive to supporting large populations of Stage III organisms, limiting the amount of bioturbation that occurs within the surface sediments.

There is no evidence of long-term impacts from past dredged material disposal within MADS, and it is anticipated that future placement of organically enriched sediment may, in fact, stimulate the productivity of the seafloor. Future monitoring of MADS should be conducted in late summer/early fall when bottom waters are at their warmest in order to document benthic habitat recovery.

1.0 INTRODUCTION

In 1977, the New England District (NAE) of the U.S. Army Corps of Engineers established the Disposal Area Monitoring System (DAMOS) to monitor the environmental impacts associated with the subaqueous disposal of sediments dredged from harbors, inlets, and bays in the New England region. The DAMOS Program conducts detailed monitoring studies to detect and minimize any physical, chemical, and biological impacts of dredging and dredged material disposal activities. DAMOS monitoring helps to ensure that any effects of sediment deposition on the marine environment are confined to designated seafloor areas and are of limited duration. A flexible, tiered monitoring protocol (Germano et al. 1994) is applied in the long-term management of dredged material disposal at ten regional open-water sites along the coast of New England (Figure 1-1). Three regional dredged material disposal sites exist off the coast of Maine (e.g. Cape Arundel Disposal Site [CADS], Portland Disposal Site [PDS], and Rockland Disposal Site [RDS]). RDS, located in West Penobscot Bay, is currently the only active site generally available to the dredging projects Downeast (Morris 1996).

The historic Machias Bay Disposal Site (MADS) is situated in the central portion of Machias Bay in Downeast Maine (Figures 1-2 and 1-3). This site has not been used in approximately 30 years, but is being considered for disposal of sediments from maintenance dredging projects in the region. This report presents the results of the first monitoring survey conducted under the DAMOS program at MADS to document the distribution of historic dredged material on the seafloor and assess the benthic recolonization status within the confines of the disposal site.

1.1 Background

The coast of Maine has 5,600 kilometers (3,480 miles) of tidally influenced shoreline, with many small, shallow harbors. These harbors are usually quite close to open water, but protected from heavy seas by large bedrock islands or submerged reefs. At the headwaters of many embayments, there are relatively short, shallow rivers that provide drainage to the coastal mountain range. The rivers along the Eastern coast of Maine are gentle flowing and relatively undeveloped (Maine Rivers 2002). Freshwater influences from the northern coastal mountains include the Machias and East Machias Rivers, which empty into the upper Machias Bay area. Runoff from the various upland sources carries freshwater and sediment downstream until it meets the effects of incoming tides from the Gulf of Maine.

Machias Bay, part of Washington County, is located along the Atlantic Seacoast between Ellsworth and St. Andrews, Maine. The Washington County coastline has

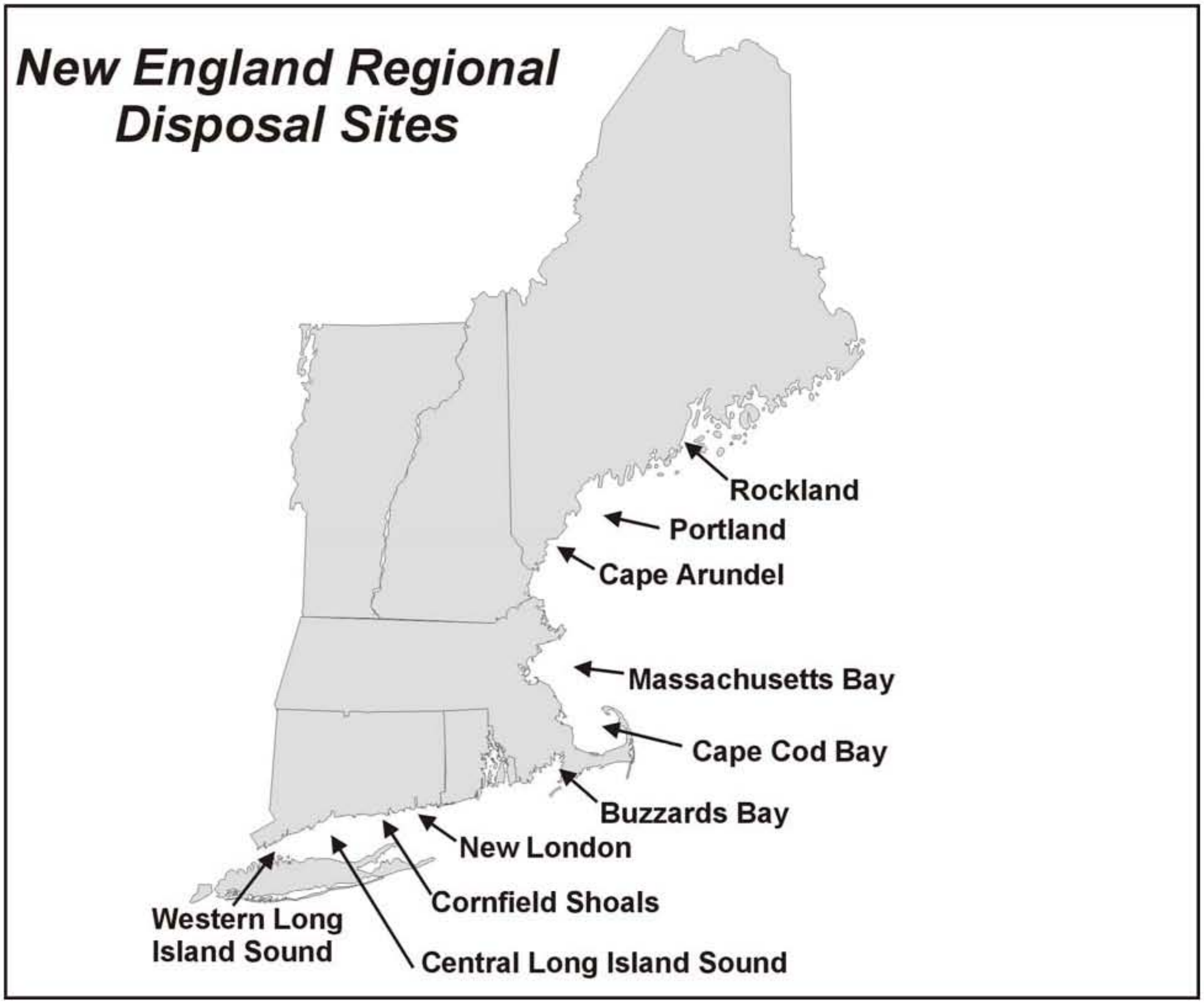


Figure 1-1. Regional dredged material disposal sites along the coast of New England that are regularly monitored as part of the DAMOS program

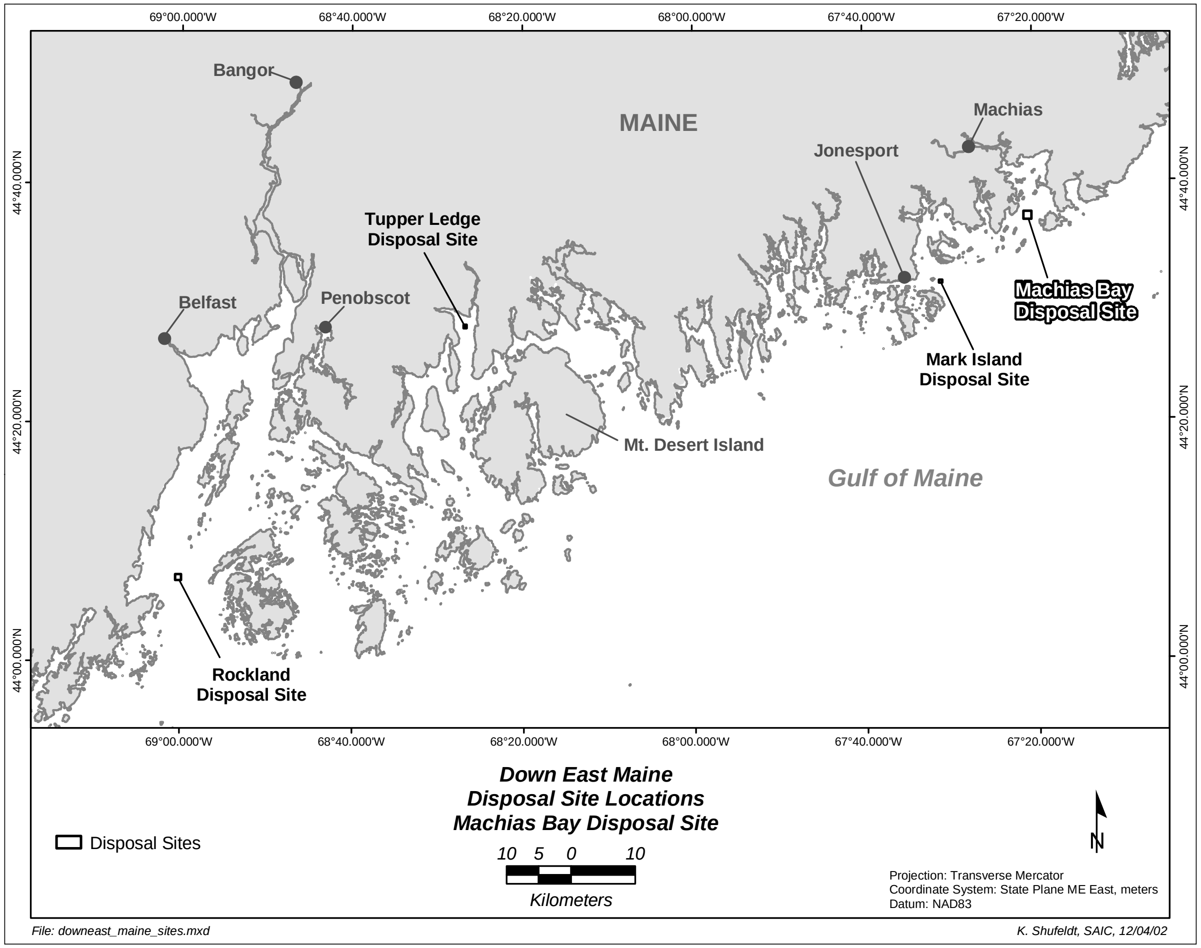


Figure 1-2. Location of the Machias Bay Disposal Site relative to the coast of eastern Maine

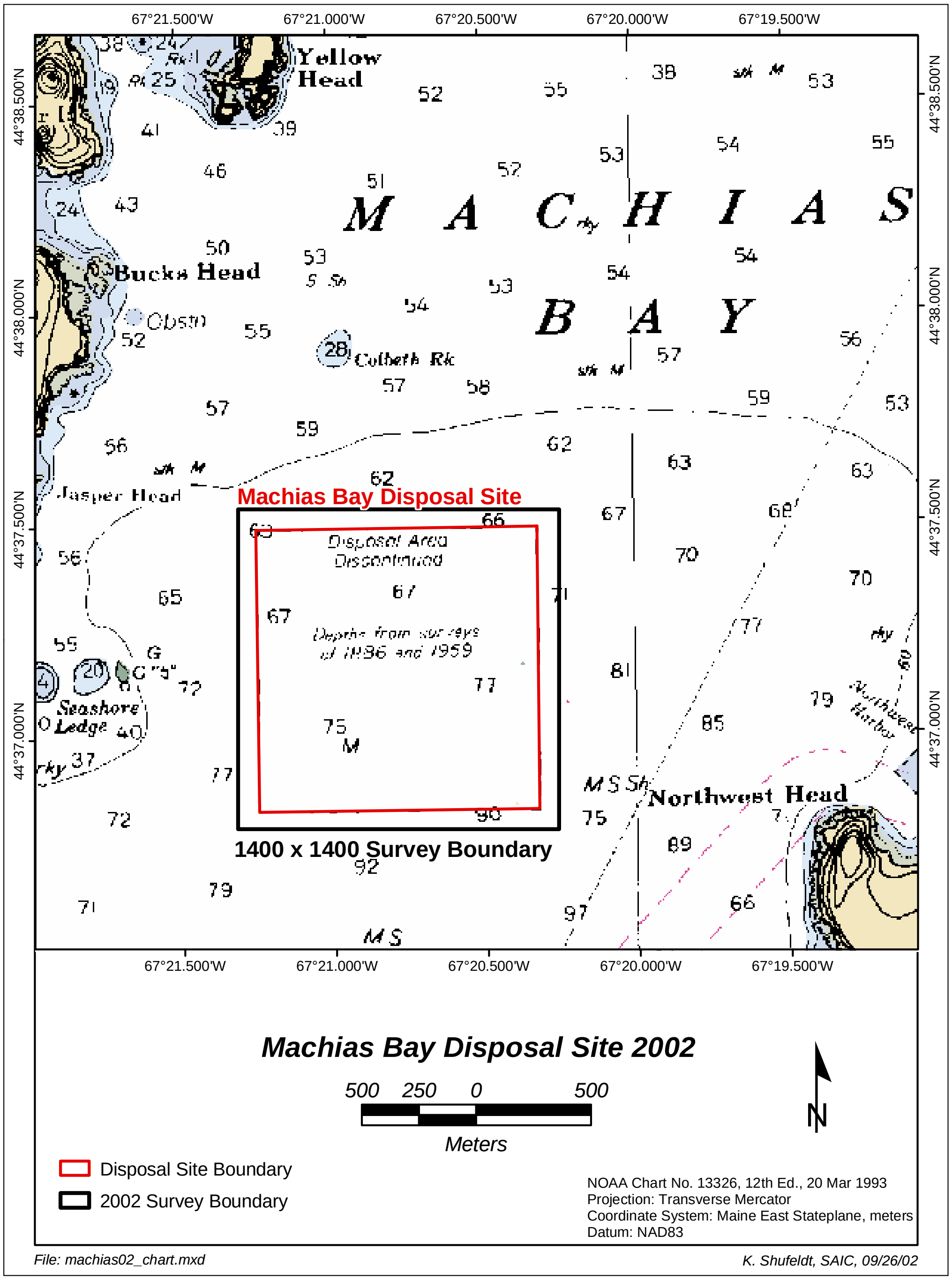


Figure 1-3. Detail of NOAA Chart No. 13326 showing the location of the Machias Bay Disposal Site in Machias Bay

numerous islands, bays and harbors that are the result of a regional depression during the glacial period when the sea encroached on the land, and extended far inland into the existing river valleys. The greatest rise and fall of tides on the shores of the continental United States occur along the Washington County coast, where 5.5 m tidal variations are common (Mainerec.com 2002). The Machias Bay area includes several neighboring towns and communities, the largest port being Machiasport in Eastern Maine. In the early 1800s, the Machias area served as a leader in the lumber, fishing, and shipbuilding industries. Today, Machias Bay is host to a relatively active boating community consisting of commercial fishing vessels, tourist excursion boats, and pleasure craft.

1.2 Machias Bay Disposal Site

The Machias Bay Disposal Site (MADS) is a 1230 × 1230 m area of seafloor situated in the central portion of Machias Bay, Maine. This site, centered at 44°37.156´ N, 67°20.787´ W (NAD 83), is located approximately 1.8 km east of Howard Point near the entrance of the Gulf of Maine (Figure 1-2). Bucks Harbor lies to the west of Machias Bay, while the Machias and East Machias Rivers flow into Machias Bay from the northwest.

Dredging activity in the Machias Bay region dates back to the late 1800s when the Machias River was dredged to six feet. Two relatively recent Army Corps of Engineers projects have since used MADS in the 1970s: the Machias River in Machias, and Bucks Harbor in Machiasport. Maintenance of the six-foot channel was performed again between June and September 1971 with an estimated 5,900 m^3 of material removed and deposited at the Machias Bay Disposal Site. In June and July 1974, a total estimated volume of 49,400 m^3 of sediment was dredged from Bucks Harbor and deposited at MADS. The improvement dredging project at Bucks Harbor marked the last use of the site for dredged material disposal. As a result, the seafloor within the disposal site has remained relatively undisturbed for approximately 30 years.

1.3 Survey Objectives and Predictions

The July 2002 survey marks the first monitoring effort under the DAMOS program to determine the suitability of this historic disposal site for future maintenance dredging projects in the region. The results of this initial baseline study aim to confirm the depositional nature of this area and its suitability as a seafloor containment site for dredged material.

The specific objectives of the July 2002 survey effort were to:

1) Document the distribution of historic dredged material on the seafloor within MADS

2) Assess benthic community status within the confines of MADS relative to existing seafloor conditions at two nearby reference areas

The July 2002 field effort tested the following predictions:

1) The disposal site will show little to no physical topography from historic disposal from past Machias River and Bucks Harbor dredging projects (total volume of 55,300 m^3) due to unfocused disposal.

2) Limited evidence of prior dredged material placement activity will be identified.

3) The historic disposal site should be in a fully developed successional status supporting a mature and stable assemblage of Stage II and Stage III communities, as predicted by the DAMOS tiered monitoring protocols.

To address the first objective, precision bathymetric and side-scan sonar surveys were conducted over MADS. In addition, a REMOTS® sediment-profile imaging survey was performed to delineate the distribution of historic dredged material and assess the benthic recolonization status over the disposal site relative to the nearby reference areas.

2.0 METHODS

The following section will provide an overview of the methods employed during the July 2002 environmental monitoring survey at MADS. Field operations were conducted aboard the *M/V Beavertail* from 1 to 3 July 2002 and consisted of REMOTS® sediment-profile imaging, single-beam bathymetry and side-scan sonar. MADS was surveyed for the purpose of assessing the suitability of this historic site for potential use by future maintenance projects in the region.

2.1 Navigation

During the field operations, differentially-corrected Global Positioning System (DGPS) data in conjunction with Coastal Oceanographic's HYPACK® navigation and survey software were used to provide real-time positioning of the survey vessel to an accuracy of ±5 m. 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 GPS receiver has an integrated differential beacon receiver to improve the overall accuracy of the satellite data to the necessary tolerances. The U.S. Coast Guard differential beacon broadcasting from Penobscot, Maine (290 kHz) was utilized for real-time satellite corrections due to its geographic position relative to MADS.

The DGPS data were ported to Coastal Oceanographic's HYPACK® data acquisition software for position logging and helm display. REMOTS® sampling stations and bathymetric survey lanes were determined before the commencement of the field operations and stored in a project database. During the field operations, individual stations were selected and displayed by the navigation system in order to position the survey vessel over the correct geographic coordinates. The position of the vessel during the acquisition of each REMOTS® image was logged with a time stamp in Universal Time Coordinated (UTC) and a text identifier to facilitate Quality Control (QC) and rapid input into a Geographic Information System (GIS) database.

2.2 Bathymetric Data Acquisition and Analysis

2.2.1 Bathymetric Data Acquisition

Bathymetric data were collected over a 1400 × 1400 m area encompassing MADS to examine bottom topography and assess the distribution of sediment placed within the disposal site boundary in the 1970s (Figure 2-1). The bathymetric survey was centered at coordinates 44°37.156´ N, 67°20.787´ W (NAD 83) and consisted of a total of 29 survey lanes, oriented north-south and spaced at 50 m intervals.

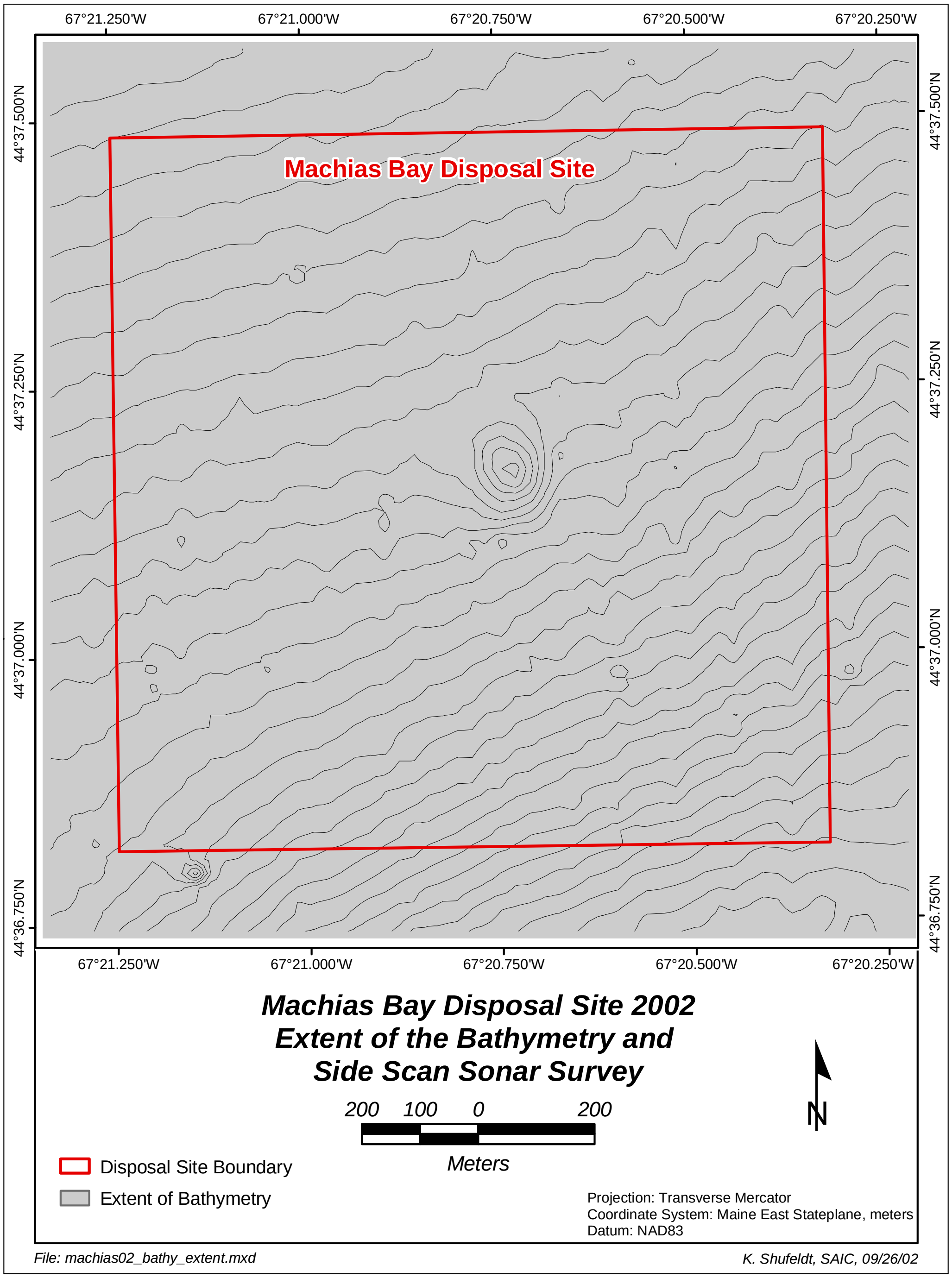


Figure 2-1. Map showing the 1400 × 1400 m survey area occupied as part of the July 2002 field operations relative to the boundary of MADS

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

2.2.2 Bathymetric Data Processing

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

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

Observed tide data were obtained from the NOAA tide station in Eastport, ME (Station number 8410140) through the National Water Level Observation Network. The NOAA six-minute tide data were downloaded in the MLLW datum and corrected for tidal offsets. A tide gauge mooring was deployed at the start of the survey, at coordinates 47°09.248´ N, 71°02.191´ W (NAD83), in close proximity to the survey boundary to document water levels over the survey area and aid in applying correctors to the NOAA data. Based on the comparison between the NOAA tide data and the local tide gauge, a height corrector was calculated for the Machias Bay data. The best fit between the NOAA observed data and the moored tide gauge data indicated a nine-minute time offset and a height correction of 0.7 (Figure 2-2).

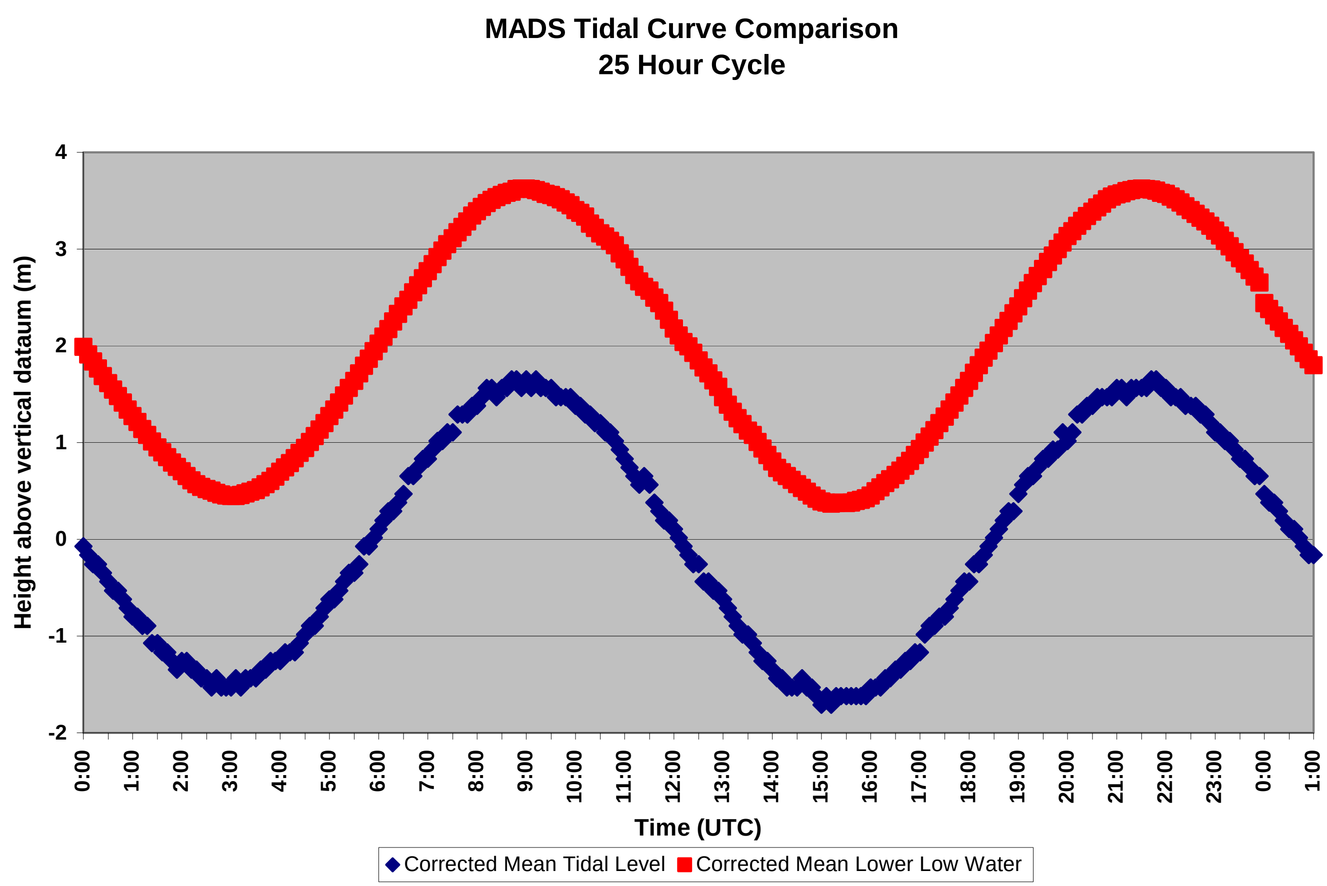


Figure 2-2. Tidal datum, phase, and height comparisons of the water levels recorded on site versus the adjusted NOAA observed tidal data for Machias Bay

2.2.3 Bathymetric Data Analysis

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

After the bathymetric data were fully edited and reduced to MLLW, cross-check comparisons on overlapping data were performed in order to verify the proper application of the correctors and to evaluate the consistency of the data set. Once the data were verified, they were then processed through the HYPACK® Sort routine in order to thin the survey data and reduce the overall size of the dataset. Because of the rapid rate at which a survey echosounder can generate data (approximately ten depths per second), the along-track data density for a single-beam survey tends to be very high (multiple soundings per meter). In most cases, these data sets contain many redundant data points that can be eliminated without any effect on the overall quality of the data. The Sort routine examines the full dataset along each survey line and then extracts only the representative soundings based on a user-specified distance interval or search radius. The output from the Sort routine is a merged ASCII-xyz file that may contain anywhere from 2 to 10% of the original data set. These greatly reduced, but still representative, data sets are far more efficient to use in the subsequent modeling and analysis routines. The 2002 MADS bathymetric survey data were gridded through the ESRI® ArcMap software module to generate a depth model for the entire survey area, using a grid cell size 25 × 25 m.

2.3 Side-Scan Sonar Data Acquisition and Analysis

Side-scan sonar is a swath data type that provides an acoustic representation of the seafloor, yielding information on sediment type, bottom targets, and generalized seafloor characteristics by detecting the back-scattered signals emitted from a towed transducer housed in a towfish. Side-scan data provide information on size of an object, height above the seafloor, and its horizontal distance from the towfish. Dense objects (e.g., rocks and firm sediment) reflect strong signals and appear as dark areas on the side-scan records. Conversely, areas characterized by soft features (e.g., muddy sediments), which absorb sonar energy, appear as lighter areas in the side-scan records.

2.3.1 Side-Scan Sonar Data Acquisition

The area covered in the side-scan sonar survey was centered at MADS and measured 1400 × 1400 m (Figure 2-1). The side-scan sonar survey consisted of 15 survey lanes oriented north/south and spaced at 100 m intervals to provide a full mosaic of the bottom features and assess the distribution of historic disposed sediment in and around the historic site. The position of the towfish was calculated in real-time by HYPACK® navigation package, based on cable scope (layback) and speed of the survey vessel. This information was embedded within the digital side-scan sonar data to allow for the geo-referencing of each acoustic return.

Side-scan sonar imagery data was acquired with an EdgeTech DF1000 side-scan sonar towfish, interfaced with a PC-based Triton-Elics ISIS® sonar acquisition system. The DF1000 operates at frequencies of 100 and 500 kHz and the range-scale was set to 100 m throughout the survey. The DF1000 side-scan fish was towed behind the survey vessel with a double-armored coaxial tow cable. The ISIS® system recorded acoustic data from the towfish and position information from the navigation system, and displayed real-time imagery on a PC monitor. With the lanes spaced at 100 m intervals and side-scan range scale set to 100 m, over 200% bottom coverage was obtained during the side-scan operations.

2.3.2 Side-Scan Sonar Data Processing

Individual survey lines were played back in ISIS® and converted to a format for use in the Delph Map mosaicing program. Upon playback of the side-scan records, adjustments were made to the time-varying-gain (TVG) of the return signal and the portions of the record corresponding to water column were removed. As each line was completed in ISIS® it was imported into Delph Map to check for processing accuracy during the file conversion from one program to the other. Upon processing completion of all of the side-scan survey lines, a mosaic was generated in Delph Map to check if any coverage gaps were present between survey lines. After the mosaic was completed it was saved and exported out of Delph Map as a geo-referenced Tiff file. This Tiff image was then imported into a GIS environment as a geo-referenced data source and capable of being compared overlain with various existing and future data sets from the corresponding area.

2.4 REMOTS® Sediment-Profile Imaging

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

The REMOTS® hardware consists of a Benthos Model 3731 sediment-profile camera designed to obtain undisturbed, vertical cross-section photographs (in situ profiles) of the upper 15 to 20 cm of the seafloor (Figure 2-3). Computer-aided analysis of each REMOTS® image yields a suite of standard measured parameters, including sediment grain size major mode, camera prism penetration depth (an indirect measure of sediment bearing capacity/density), small-scale surface boundary roughness, depth of the apparent redox potential discontinuity (RPD, a measure of sediment aeration), infaunal successional stage, and Organism-Sediment Index (OSI, a summary parameter reflecting overall benthic habitat conditions).

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

The REMOTS® survey performed over MADS as part of the July 2002 field effort consisted of a 25-station rectangular sampling grid centered at coordinates 44°37.156´ N, 67°20.787´ W (NAD 83) within the 1230 × 1230 m historic disposal site boundary (Table 2-1; Figure 2-4). The sampling grid consisted of five rows of stations evenly spaced from the center of the historic disposal site boundary (two rows to the north of the center, two rows to the south of the center and a row of five at the center). All 25 stations established over MADS were successfully sampled during the July 2002 survey.

Reference areas are typically sampled during DAMOS monitoring surveys to provide a comparative assessment of the environmental conditions existing on the ambient seafloor. Ten sediment-profile imaging stations were randomly distributed over two reference areas (NEREF and SWREF) in close proximity to MADS to provide a basis for comparison of the habitat conditions within the historic disposal site (Table 2-2; Figure 2-4). Five randomly selected stations were occupied within a 300 m radius of the center of reference area NEREF (44° 37.575´ N, 67° 19.294´ W, NAD83), and an additional five stations were randomly occupied within a 300 m radius of the center of SWREF (44°36.490´ N, 67°21.826´ W, NAD 83; Table 2-2; Figure 2-4). At each of the disposal site and reference area REMOTS® stations occupied in the July 2002 survey, the camera was lowered to the seafloor multiple times in an attempt to obtain at least three replicate images of suitable quality for subsequent analysis.

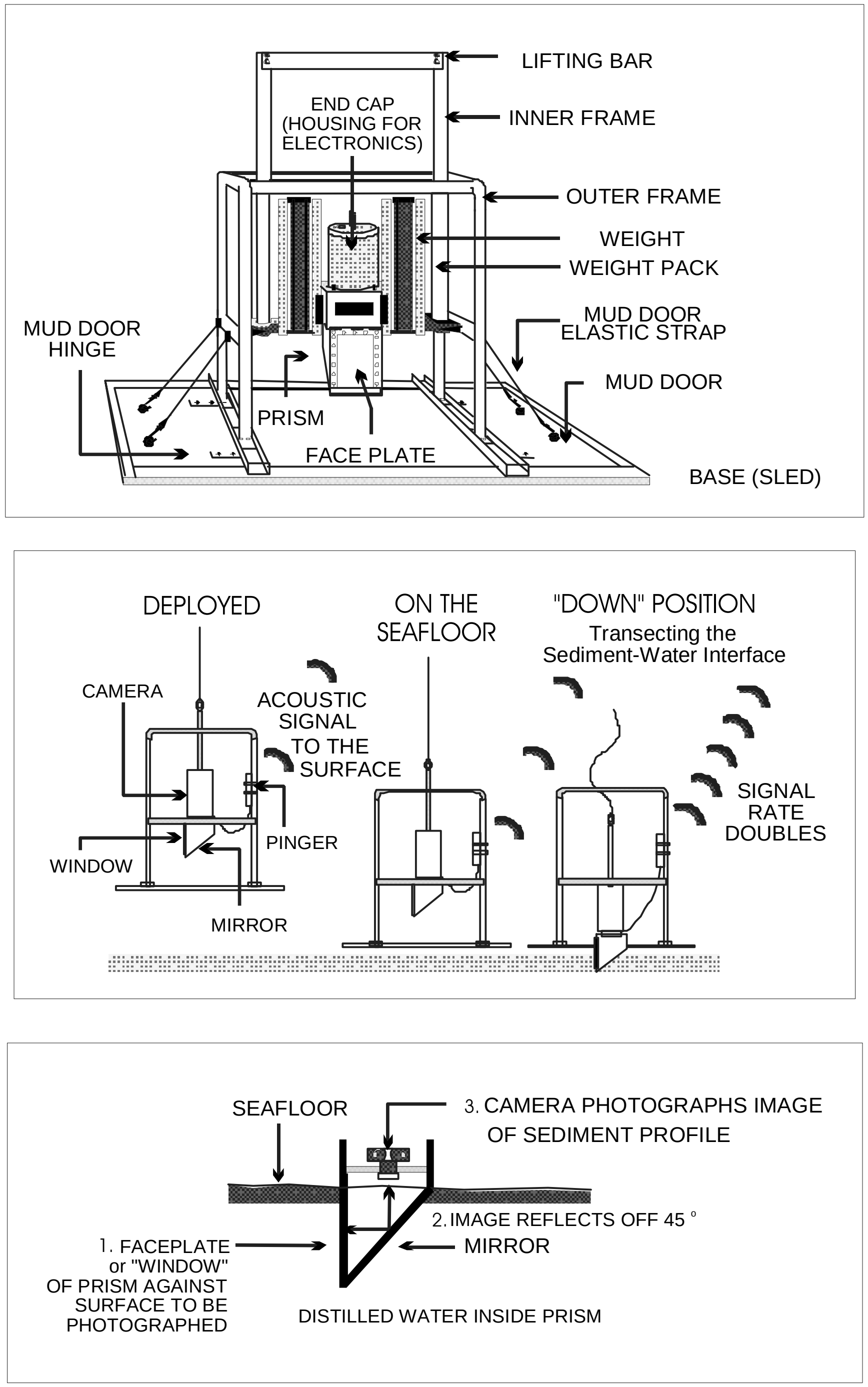


Figure 2-3. Schematic diagram of Benthos Inc. Model 3731 REMOTS® sediment-profile camera and sequence of operation on deployment

Table 2-1.

REMOTS® Station Locations over the Machias Bay Disposal Site

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
Machias Bay Disposal Site	1	44° 37.430´ N	67° 21.158´ W
	2	44° 37.428´ N	67° 20.969´ W
	3	44° 37.426´ N	67° 20.780´ W
	4	44° 37.424´ N	67° 20.591´ W
	5	44° 37.422 ´ N	67° 20.402´ W
	6	44° 37.295´ N	67° 21.162´ W
	7	44° 37.293´ N	67° 20.973´ W
	8	44° 37.291´ N	67° 20.784´ W
	9	44° 37.289´ N	67° 20.595´ W
	10	44° 37.287´ N	67° 20.406´ W
	11	44° 37.160´ N	67° 21.165´ W
	12	44° 37.158´ N	67° 20.976´ W
	13	44° 37.156´ N	67° 20.787´ W
	14	44° 37.154´ N	67° 20.598´ W
	15	44° 37.153´ N	67° 20.409´ W
	16	44° 37.025´ N	67° 21.168´ W
	17	44° 37.023´ N	67° 20.979´ W
	18	44° 37.021´ N	67° 20.791´ W
	19	44° 37.019´ N	67° 20.602´ W
	20	44° 37.018´ N	67° 20.413´ W
	21	44° 36.890´ N	67° 21.172´ W
	22	44° 36.888´ N	67° 20.983´ W
	23	44° 36.886´ N	67° 20.794´ W
	24	44° 36.884´ N	67° 20.605´ W
	25	44° 36.883´ N	67° 20.416´ W

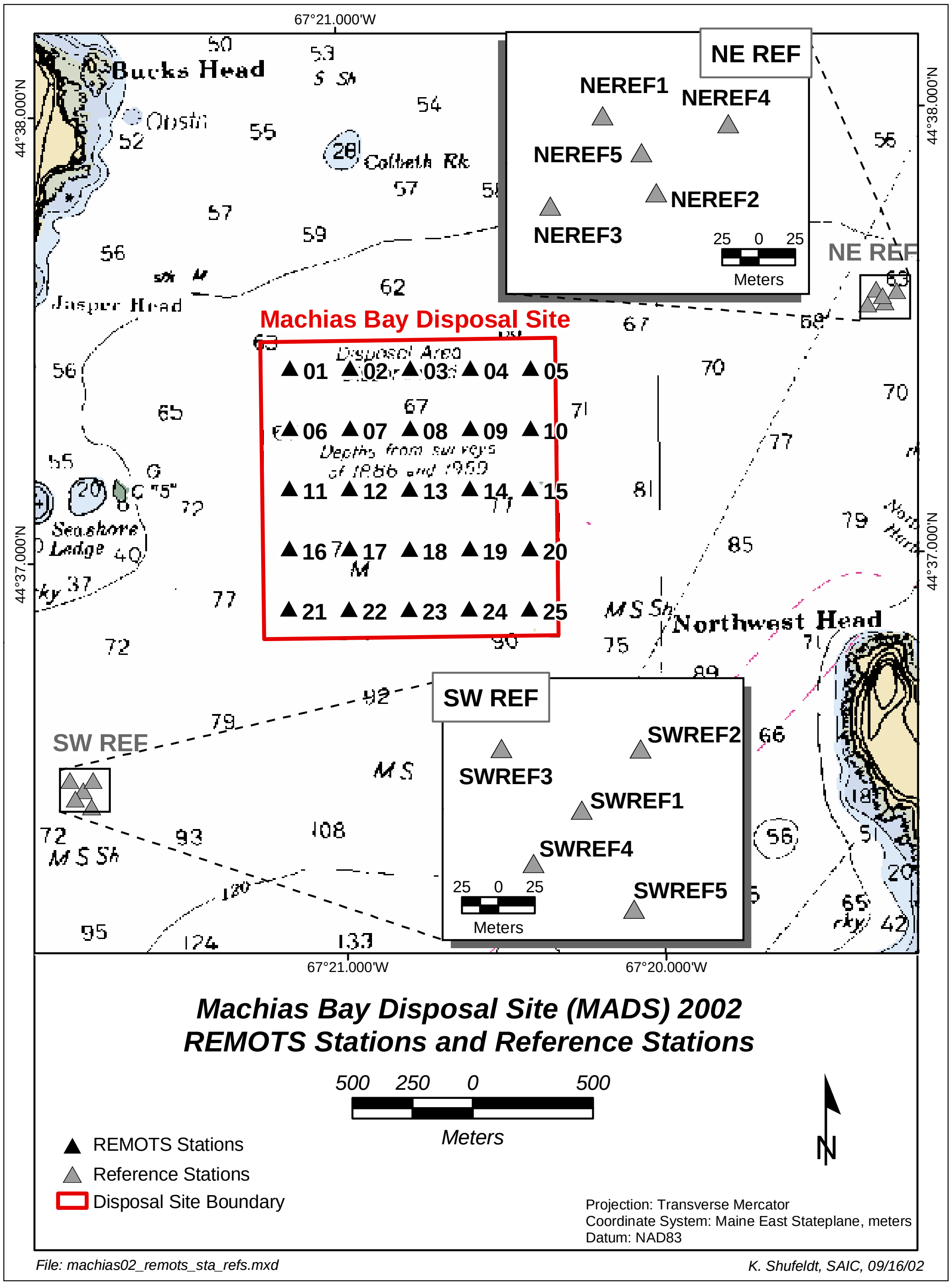


Figure 2-4. Map showing the REMOTS® stations occupied at the MADS and nearby reference areas (NEREF and SWREF) over NOAA Chart No. 13326

Table 2-2.

REMOTS® Station Locations over the Machias Bay Reference Areas

Area	Station	Latitude (NAD 83)	Longitude (NAD 83)
Northeast Reference	NE REF1	44° 37.588´ N	67° 19.313´ W
	NE REF2	44° 37.559´ N	67° 19.286´ W
	NE REF3	44° 37.555´ N	67° 19.340´ W
	NE REF4	44° 37.585´ N	67° 19.248´ W
	NE REF5	44° 37.574´ N	67° 19.293´ W
Southwest Reference	SW REF1	44° 36.489´ N	67° 21.826´ W
	SW REF2	44° 36.512´ N	67° 21.795´ W
	SW REF3	44° 36.512´ N	67° 21.867´ W
	SW REF4	44° 36.470´ N	67° 21.851´ W
	SW REF5	44° 36.452´ N	67° 21.799´ W

3.0 RESULTS

3.1 Bathymetry

As part of the July 2002 monitoring effort, a bathymetric survey was performed over the entire 1.5 km^2 area of MADS. The natural seafloor within MADS was relatively flat and featureless, sloping from a minimum depth of 18.75 m in the northwest corner of the survey area to a maximum depth of 27.25 m in the southeast corner (Figure 3-1). One disposal mound, located roughly in the center of the historic disposal site, was distinguishable relative to the surrounding flat seafloor (Figure 3-1). In addition, a smaller topographic feature was also distinguishable in the southwest corner of the survey, outside the disposal site boundary.

The largest bottom feature within the disposal site was the historic disposal mound. Between 1971 and 1974, an estimated barge volume of 55,300 m^3 of dredged material was deposited at MADS to create this mound. While the lack of baseline (i.e., predisposal) bathymetric data precludes an accurate depth difference, the relatively flat nature of the existing bottom at the site allows reasonable measurements of the mound dimensions. The depth over the mound apex was 20.5 m, and the depth at the base of the mound at its southeast end was approximately 22.5 m, indicating an approximate mound height of 2 m. The mound was slightly steeper at its SE end, sloping at a 1.3% grade, with a more gradual slope (1.1% grade) to the NW. The mound diameter was approximately 300 m along its NW-SE axis (between the 21.25 m and 22.5 m contours).

The roughly conical shape of the historic disposal mound allows for the estimation of dredged material volume on the MADS seafloor. Based on a disposal mound morphology (height of 2 m and width of 300 m), approximately 47,100 m^3 of sediment, or 85% of the reported disposal volume, was detected acoustically. Consolidation of the disposal mound over time and the volume of material residing in thin layers along the margins of the mound (mound apron) likely accounts for the 15% difference between the reported barge volume and the volume measured acoustically. The discrete configuration of the dredged material mound and high percentage of sediment volume detected nearly 30 years after its formation indicate that it is a stable feature on the Machias Bay seafloor.

A smaller seafloor feature was distinguishable in the southwest corner of the survey, outside the MADS boundary. The depth at this feature is approximately 22.5 m at the apex, roughly 1 m above the surrounding seafloor. Based on the distinct topographic break created on the bathymetric plot, this feature is likely a large boulder.

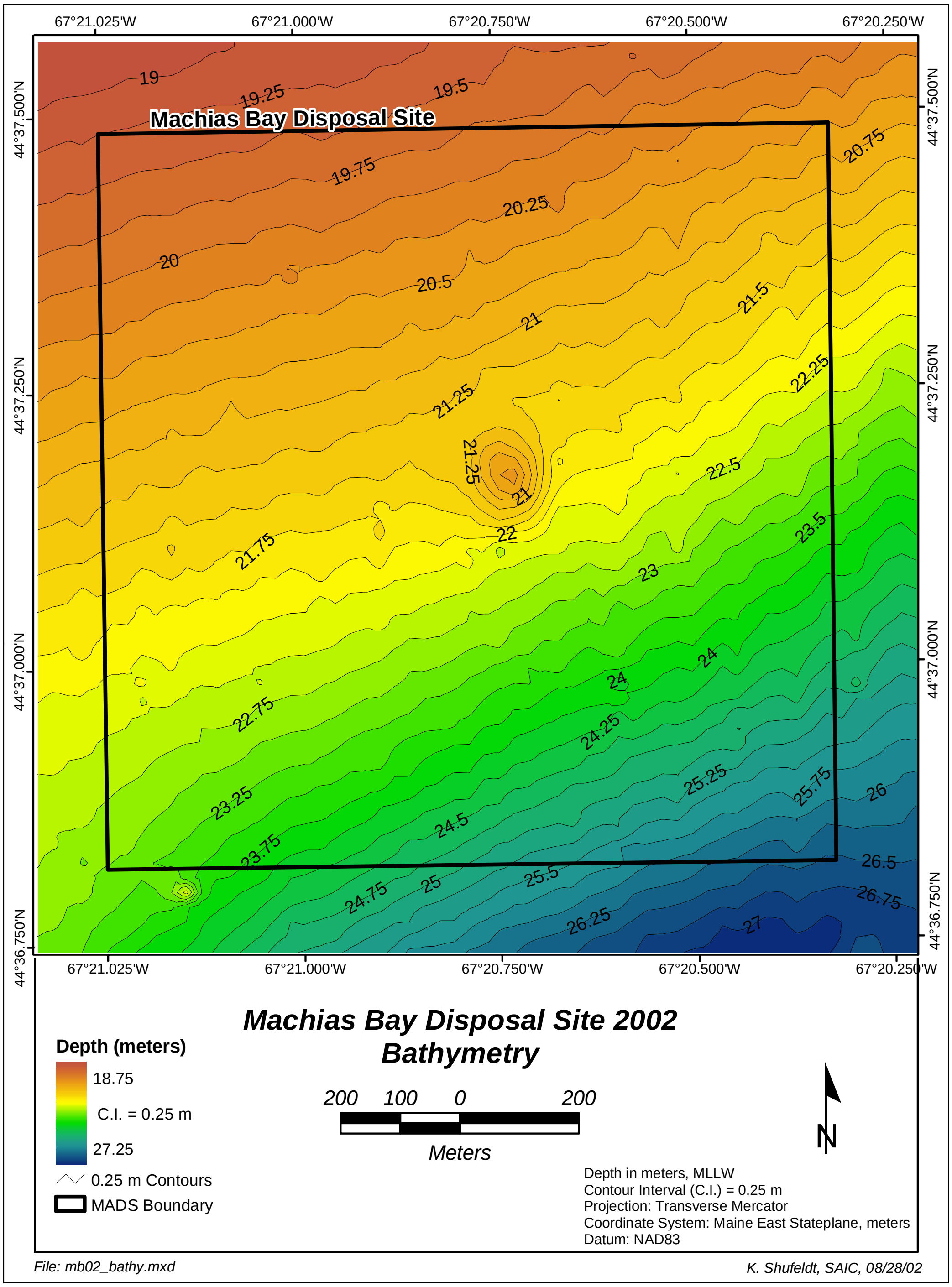


Figure 3-1. Bathymetric chart of the July 2002 survey area over the Machias Bay Disposal Site, 0.25 m contour interval

3.2 Side-Scan Sonar

A complete 100 kHz side-scan image mosaic, representing 200% bottom coverage, was created for the entire MADS survey area (Figure 3-2). The mosaic provided a useful overview of the disposal site and enabled a broad characterization of the seafloor across the entire survey area. In the mosaic, darker areas represent stronger acoustic returns (higher reflectance) and indicate harder substrate. The lighter areas of the mosaic represent weaker acoustic returns (low reflectance) and indicate softer seafloor surface sediments such as silt and clay.

Based on the full area mosaic, a large majority of the survey area is characterized by low reflectance, weaker acoustic returns that are indicative of softer, low density bottom sediments (Figure 3-2). Several individual targets can also be seen in the mosaic and may be large boulders or trawl lines of lobster traps (Figure 3-3). The most distinct feature in the mosaic is the historic disposal mound in the center of MADS (Figure 3-3). It is indicated by a slightly higher-reflectance acoustic return indicating a contrast in surface texture between the dredged material deposit and ambient bottom sediments. Because of its slightly higher acoustic return, the sediment covering the mound may be composed of coarser-grained or more densely packed sediment than the surrounding softer ambient sediment. Based on the side-scan mosaic the mound appeared to be oval-shaped and elongated along its north-northwest to south-southeast axis.

The historic disposal mound is more easily identified when the 2002 colorized bathymetry data are overlaid on the side-scan sonar mosaic (Figure 3-4A). The mound apex seen in the bathymetry (Figure 3-1) appears just east of the center of the feature seen in the mosaic, and the dimensions measured from the side-scan mosaic are similar to those measured on the bathymetric map. In addition, the small elevated feature seen in the southwest corner of the bathymetry also approximately corresponds to a target in the side-scan mosaic (Figure 3-4B). The feature in the side-scan mosaic, however, does not appear as large as the corresponding feature in the bathymetric contour plot, which may have been exaggerated by the gridding process.

3.3 REMOTS® Sediment Profile Imaging

The REMOTS® results for the July 2002 survey were used primarily to assess sediment composition and benthic habitat conditions at MADS. Complete REMOTS® image analysis results for the historic disposal site and the reference areas stations are provided in Appendix A, and are summarized in Tables 3-1 and 3-2.

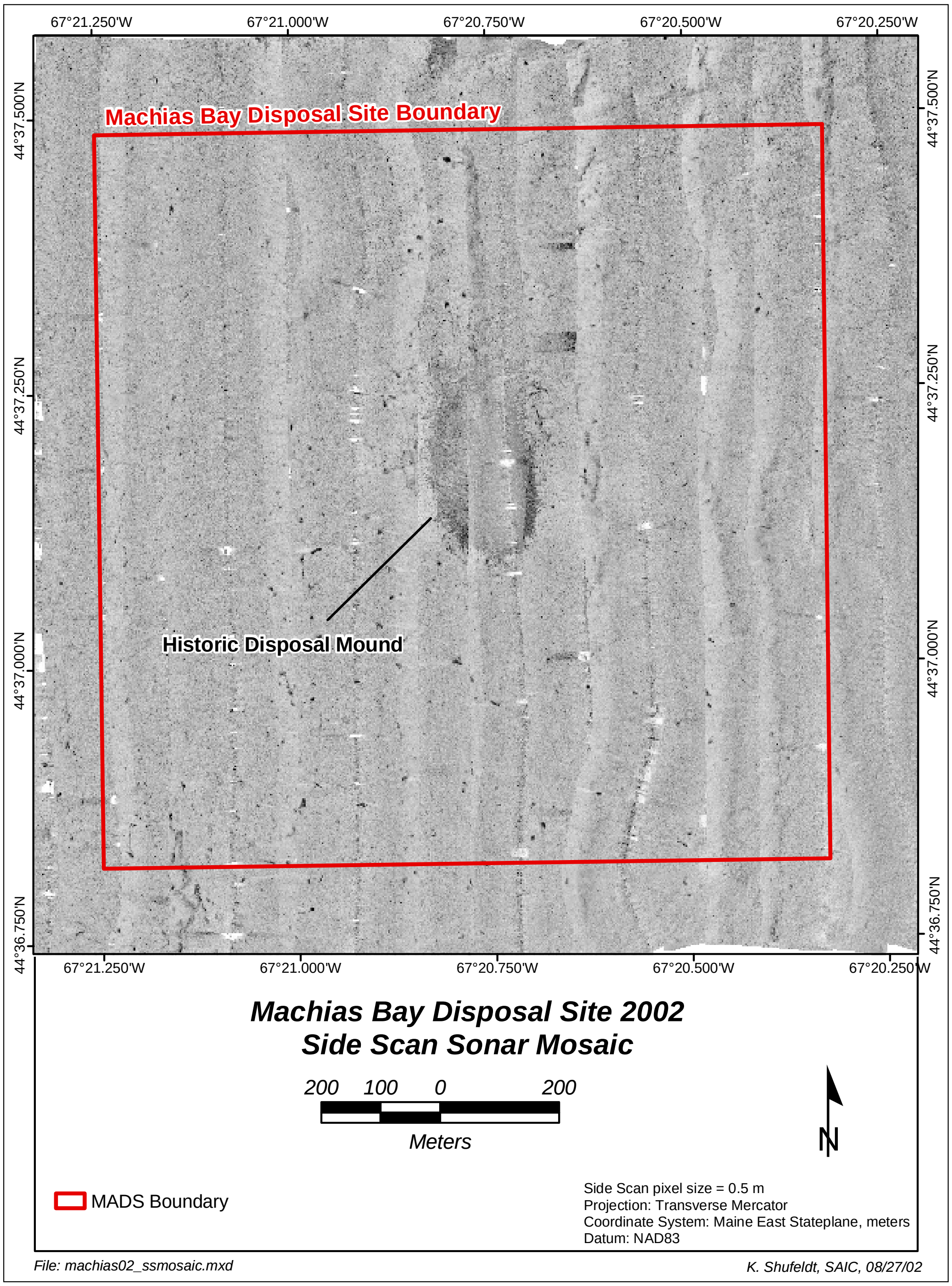


Figure 3-2. Map showing the side-scan sonar mosaic (100 kHz) over the 2002 Machias Bay survey area

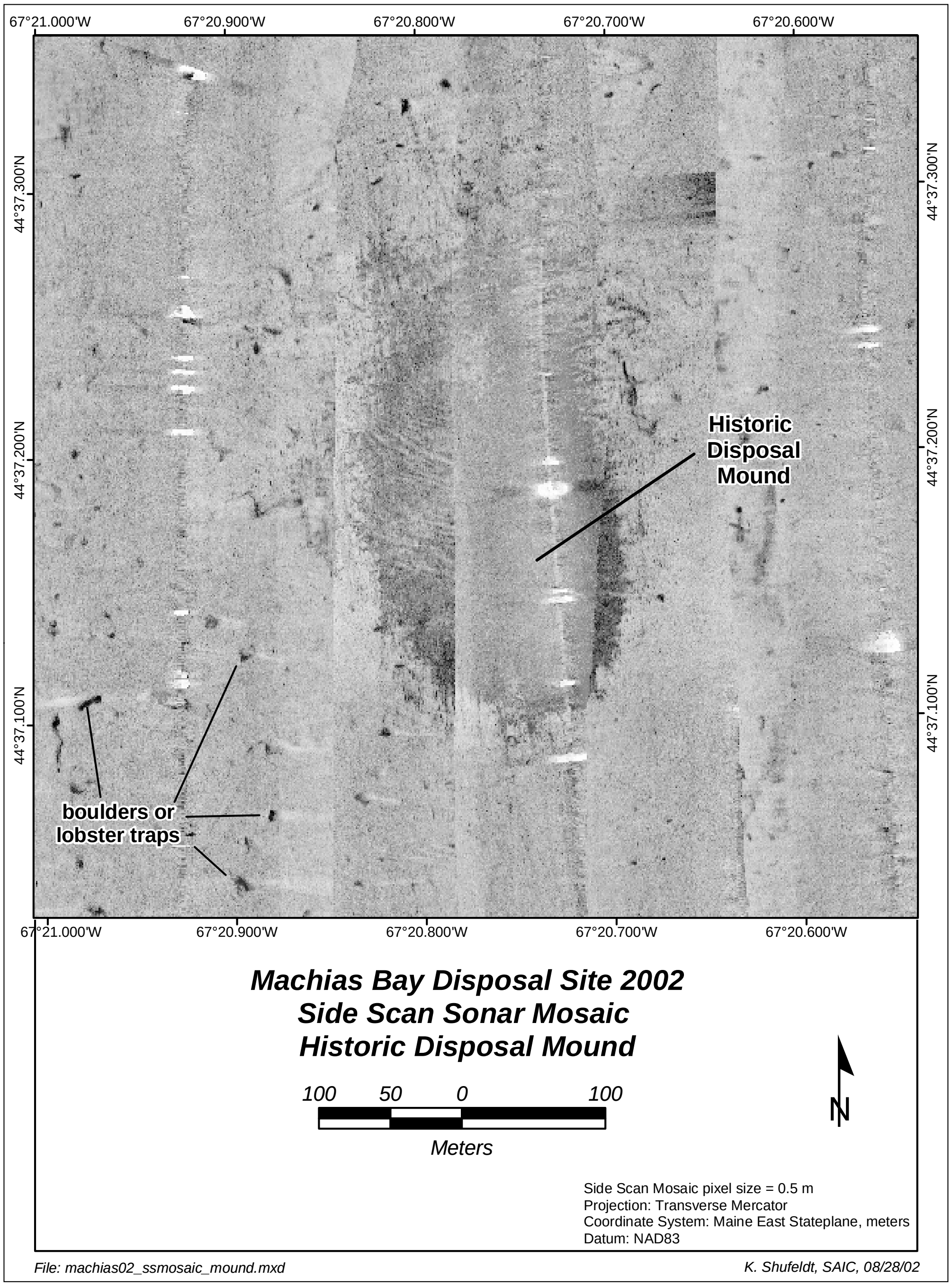


Figure 3-3. Map of the side-scan sonar mosaic showing detail of the historic disposal mound at the Machias Bay Disposal Site

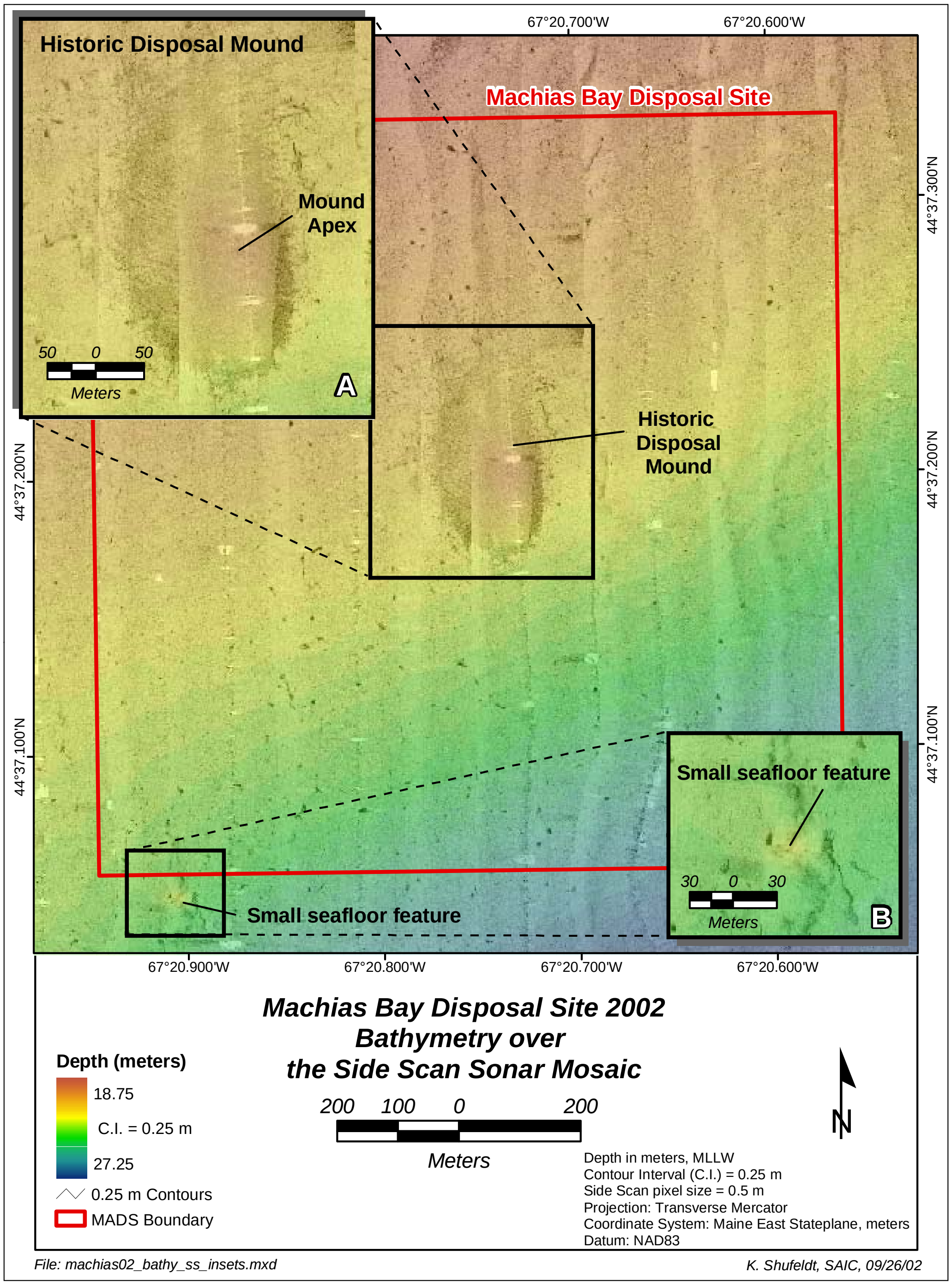


Figure 3-4. Map showing the bathymetric data overlaid on the side-scan sonar mosaic for the 2002 MADS survey area

Table 3-1.

Summary of the Machias Bay Disposal Site (MADS) REMOTS® Sediment-Profile Imaging Results, July 2002

Station	Grain Size Major Mode (phi) # of replicates	Camera Penetration Mean (cm)	Historic Dredged Material Thickness Mean (cm)	Number Of Reps with Historic Dredged Material	Boundary Roughness Mean (cm)	Successional Stages Present	Highest Stage Present	RPD Mean (cm)	OSI Mean	OSI Median
1	> 4 phi (2), 4-3 phi (1)	5.82	0.00	0	0.95	I	ST I	1.75	4.00	4
2	4-3 phi (3)	6.25	0.00	0	1.05	I,III	ST I on III	1.50	4.67	4
3	4-3 phi (2), 3-2 phi (1)	5.79	0.00	0	1.71	I,III	ST I on III	1.62	5.00	4
4	> 4 phi (2), 4-3 phi (1)	5.76	0.00	0	1.02	I,III	ST I on III	1.47	6.00	7
5	> 4 phi (2), 4-3 phi (1)	4.17	0.00	0	1.65	I,III	ST I on III	1.66	5.00	4
6	> 4 phi (3)	7.31	0.00	0	1.70	I,III	ST I on III	1.85	5.33	4
7	> 4 phi (3)	5.64	0.00	0	1.39	I	ST I	1.70	3.67	4
8	> 4 phi (2), 4-3 phi (1)	4.74	0.00	0	1.02	I	ST I	1.36	3.33	3
9	> 4 phi (3)	6.61	0.00	0	1.49	I,III	ST I on III	1.43	6.33	8
10	> 4 phi (2), 4-3 phi (1)	6.73	0.00	0	0.96	I,III	ST I on III	1.95	5.33	4
11	> 4 phi (3)	5.52	0.00	0	1.59	I,III	ST I on III	1.90	5.33	4
12	> 4 phi (3)	7.41	0.00	0	1.16	I,III	ST I on III	1.88	7.00	8
13	> 4 phi (2), 4-3 phi (1)	2.78	> 2.78	3	2.29	I,INDET	ST I	1.57	4.00	4
14	> 4 phi (3)	7.63	0.00	0	1.17	I,III	ST I on III	1.92	5.33	4
15	> 4 phi (2), 4-3 phi (1)	6.24	0.00	0	1.68	I	ST I	1.63	3.67	4
16	> 4 phi (2), 4-3 phi (1)	5.39	0.00	0	1.72	I,III	ST I on III	1.62	5.00	4
17	> 4 phi (3)	7.33	0.00	0	1.22	I,III	ST I on III	1.89	6.67	8
18	> 4 phi (1), 4-3 phi (2)	6.37	0.00	0	1.26	I,III	ST I on III	2.12	5.67	5
19	> 4 phi (3)	6.38	0.00	0	1.72	I	ST I	2.24	4.33	4
20	> 4 phi (3)	7.38	0.00	0	1.04	I,III	ST I on III	2.18	7.00	7
21	> 4 phi (3)	10.05	0.00	0	1.05	I,III	ST I on III	1.92	8.00	8
22	> 4 phi (3)	5.98	0.00	0	1.58	I,II,III	ST I on III	1.48	5.67	5
23	> 4 phi (3)	6.86	0.00	0	0.77	I,II,III	ST I on III	1.87	7.00	8
24	> 4 phi (2), 4-3 phi (1)	7.36	0.00	0	1.09	I,III	ST I on III	1.41	6.00	7
25	> 4 phi (2), 4-3 phi (1)	8.68	0.00	0	1.10	I,III	ST I on III	1.48	7.33	7
AVG		6.41			1.33			1.74	5.47	5.32
MAX		10.05			2.29			2.24	8.00	8
MIN		2.78			0.77			1.36	3.33	3

Table 3-2.

Summary of the MADS Reference Areas REMOTS® Sediment-Profile Imaging Results, July 2002

Station	Grain Size Major Mode (phi) # of replicates	Camera Penetration Mean (cm)	Boundary Roughness Mean (cm)	Successional Stages Present	Highest Stage Present	RPD Mean (cm)	OSI Mean	OSI Median
NEREF1	> 4 phi (3)	9.32	1.09	I,III	ST I on III	1.99	5.67	5
NEREF2	> 4 phi (3)	13.02	1.14	I,III	ST I on III	2.56	7.67	9
NEREF3	> 4 phi (3)	8.72	1.02	I,II	ST I to II	1.94	4.33	4
NEREF4	> 4 phi (3)	10.78	1.08	I,III	ST I on III	1.83	8.00	8
NEREF5	> 4 phi (3)	11.10	0.60	I,III	ST I on III	2.03	5.67	6
SWREF1	> 4 phi (3)	8.01	1.33	I,III	ST I on III	1.55	6.33	7
SWREF2	> 4 phi (3)	9.53	0.95	I,III	ST I on III	1.39	4.67	4
SWREF3	> 4 phi (3)	7.25	2.31	I,III	ST I on III	1.84	5.33	4
SWREF4	> 4 phi (3)	9.47	1.13	I	ST I	2.13	4.33	5
SWREF5	> 4 phi (3)	9.00	1.12	I,III	ST I on III	1.61	6.33	7
AVG		9.62	1.18			1.89	5.83	5.90
MAX		13.02	2.31			2.56	8.00	9
MIN		7.25	0.60			1.39	4.33	4

3.3.1 Machias Bay Disposal Site (MADS)

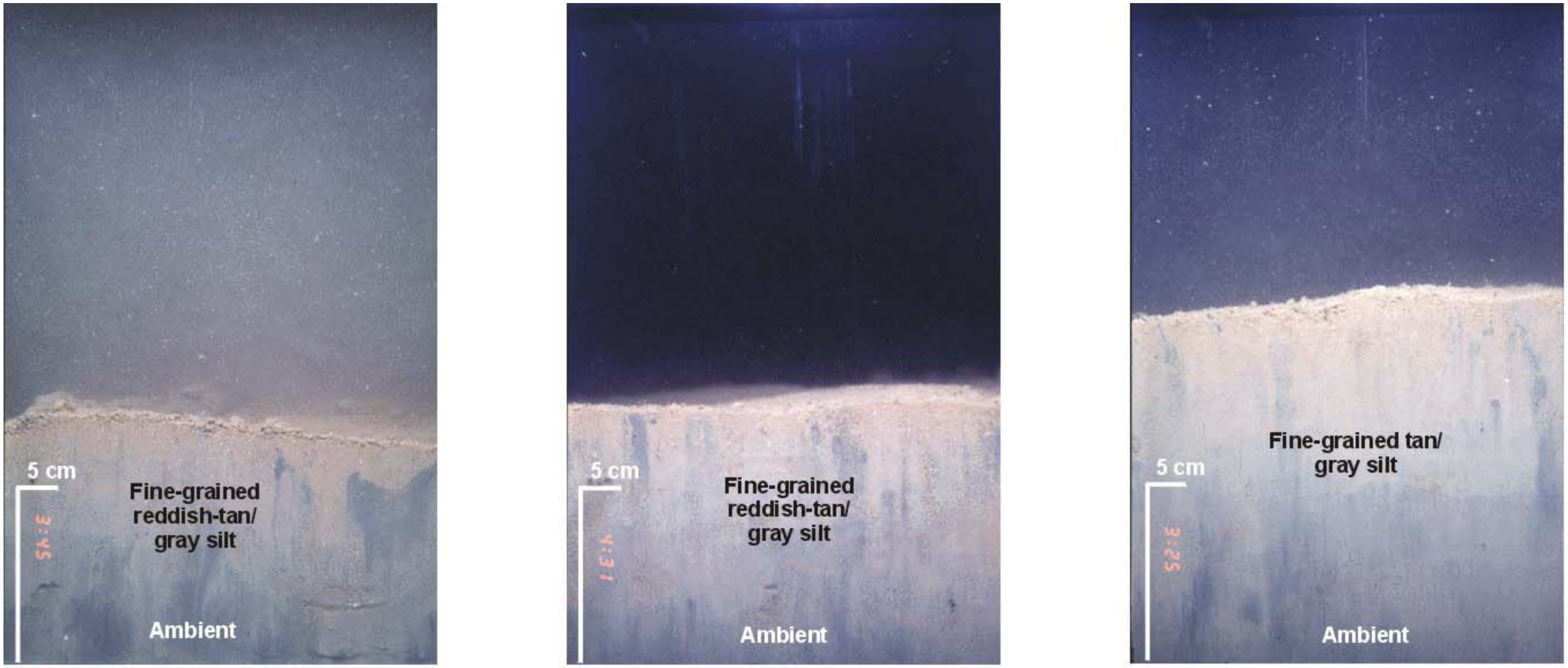
3.3.1.1 Historic Dredged Material Distribution and Physical Sediment Characteristics

Apparent historic or "relic" dredged material from past disposal (1974) was present at only 1 of the 25 disposal site stations (Table 3-1), Station 13, which was located on the southwest flank of the disposal mound feature detected in the bathymetric survey data. The dredged material thickness was greater than the camera penetration depth in all replicate images from this station (Table 3-1). The sediment at the other stations was indistinguishable from the ambient sediments of Machias Bay (Figure 3-5), with no evidence of dredged material. Given the fact that the material was disposed of at the site almost 30 years ago, it is reasonable to expect that relatively thin layers of dredged material at the margins of the mound would be indistinguishable from the ambient sediments.

The surface sediments within the disposal site were mostly fine-grained, composed primarily of reddish-tan over gray sandy silt. A number of replicate images also exhibited white clay chips at depth. A grain size major mode of > 4 phi was commonly detected within the disposal site; however, a higher presence of sand resulted in a slightly coarser grain size (grain size major mode of 4 to 3 phi) in various replicates of 13 stations (Table 3-1).

The historic dredged material observed at Station 13 on the flank of the disposal mound displayed a poorly sorted mix of pebbles, sand, silt, and shell fragments (Figure 3-6). While the overall grain size major mode determined from the replicate images at Station 13 was comparable to the ambient sediments, the coarse nature of the surface sediments at Station 13 help distinguish this station as dredged material, and also indicate an armored mound surface.

The penetration depth of the sediment-profile camera prism typically serves as a measure of sediment density or compaction. Replicate-averaged camera prism penetration depths for the disposal site ranged from 2.8 cm at Station 13 to 10.1 cm at Station 21, with an overall average of 6.4 cm (Table 3-1). These moderately low camera prism measurements indicate a relatively high proportion of sand present within the sediment that tended to resist deep penetration by the sediment-profile camera. The coarse surface sediments at Station 13 (historic dredged material) resulted in substantially lower camera penetration depths than most of the remaining survey stations, and prevented the analysis of key parameters (e.g., RPD, successional status, and OSI) in one of the replicate images from Station 13.



A **B** **C**

Figure 3-5. REMOTS® images from disposal site Stations 09 (A) and 20 (B), and reference area Station NEREF2 (C) displaying the similarity of sediment conditions at most of the disposal site stations and reference areas. There is no evidence of historic dredged material at Station 09 and Station 20 from the disposal site. Similar sediment characteristics (fine-grained reddish-tan over gray silt) were detected among all the surveyed areas.

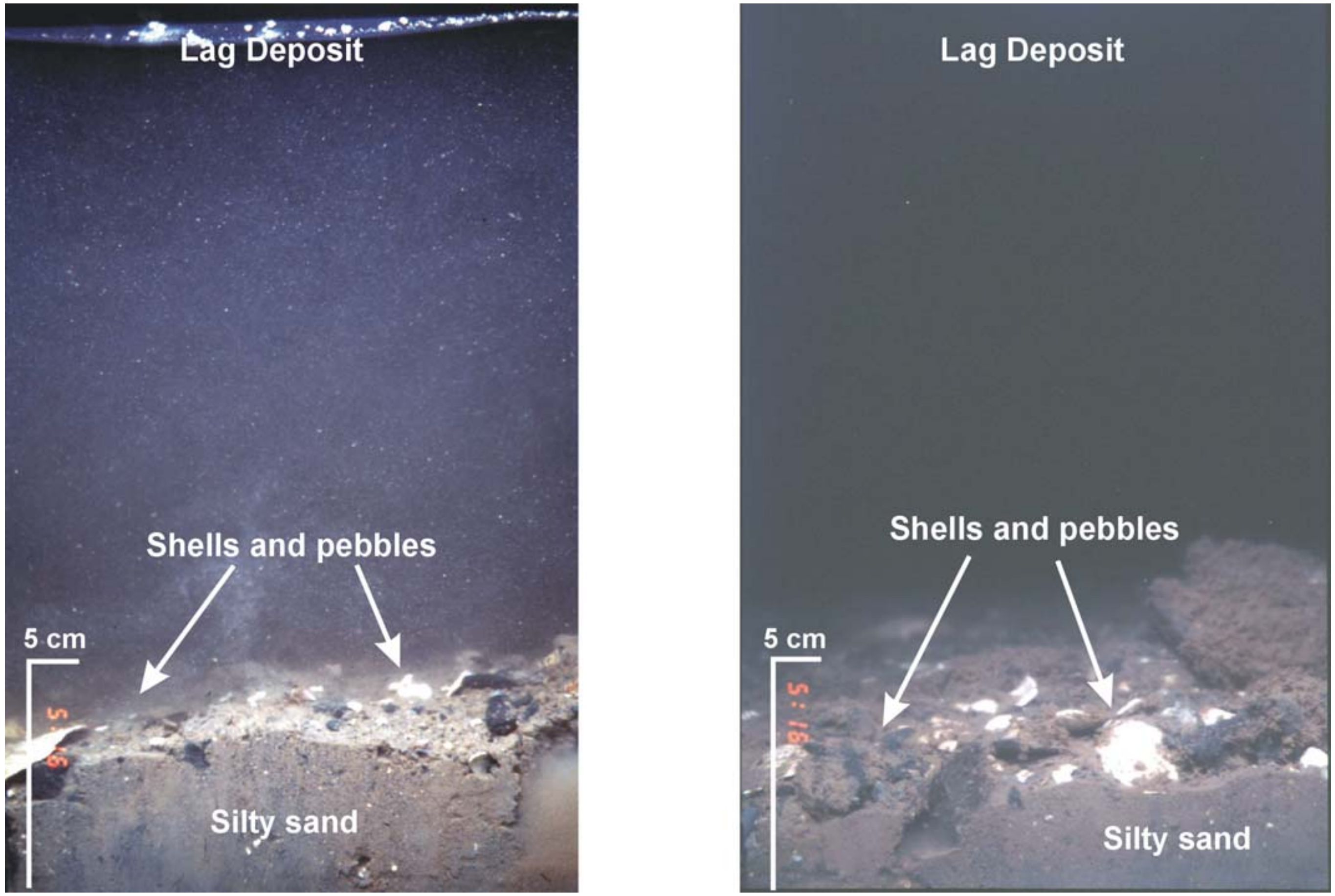


Figure 3-6. Two replicate REMOTS® images obtained at center Station 13 located at the southwest flank of the disposal mound illustrating apparent historic dredged material consisting of a poorly sorted mix of pebbles, sand, silt, and shell. The armored surface of the mound may represent a lag deposit (evidence of winnowing) visible at the sediment-water interface.

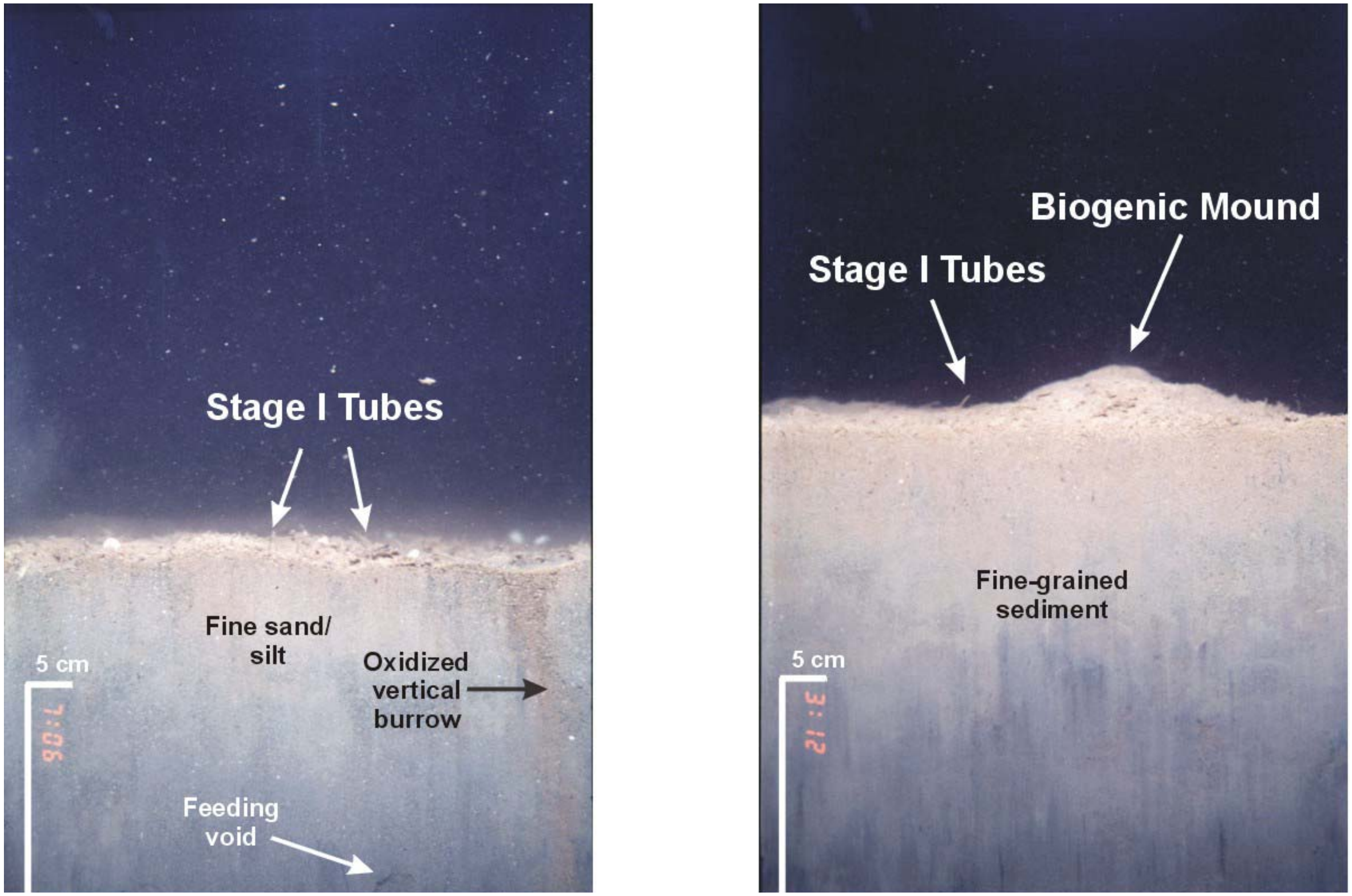
Replicate-averaged small-scale boundary roughness values for the disposal site stations ranged from 0.8 cm at Station 23 to 2.3 cm at Station 13, with an overall average of 1.3 cm (Table 3-1). There was no obvious pattern to these relatively low boundary roughness values at stations within the disposal site, with the exception that the maximum value of 2.3 cm occurred at Station 13, where historic dredged material was observed. The maximum replicate-averaged value for the remaining stations was 1.7 cm. The slightly greater surface relief at Station 13 can be attributed to the coarser surface deposits there, including poorly sorted pebbles and shells. Surface roughness at most stations was attributed primarily to physical factors at the sediment-water interface, including mud clasts and small-scale ripples. Stations among the northernmost row of the sampling grid all displayed evidence of sand ripples in water depths ranging from 19.5 to 21 m. These bedforms are more than likely the product of periodic increases in near-bottom current velocity (orbital flow) due to the passage of storm waves, rather than the product of consistent high-energy flow from tidal forcing. A few replicate images also exhibited biogenic surface roughness, including biogenic mounds and biological surface reworking by burrowing infauna (burrow openings) at the sediment-water interface (Figure 3-7).

Shells and shell fragments were observed at the sediment surface at several stations. Furthermore, Station 13, located on the southwest flank of the relic disposal mound, exhibited a surface composed of pebble and shell. The presence of this material at the sediment-water interface may represent shell lag armoring deposit derived through winnowing of fines over time.

3.3.1.2 Biological Conditions and Benthic Recolonization

Three parameters were used to assess the benthic recolonization status and overall benthic habitat conditions within the disposal site relative to the reference areas: apparent Redox Potential Discontinuity (RPD) depth, infaunal successional status, and Organism-Sediment Index (OSI; Figures 3-8 and 3-9).

The redox potential discontinuity (RPD) provides a measure of the apparent depth of oxygen penetration into the surface sediments and the degree of biogenic sediment mixing. The replicate-averaged RPD measurements for the disposal site stations ranged from 1.4 cm at Station 8 to 2.2 cm at Station 19 (Table 3-1; Figure 3-8). The overall average RPD value of 1.7 cm is considered indicative of moderately-oxygenated surface sediments within the disposal site and was comparable to the composite value calculated for the reference areas (1.9 cm). The RPD value for the station with historic dredged material observed (RPD of 1.6 cm at Station 13) was not distinct from the range of values at the other stations across the survey area (1.4–2.2 cm). None of the stations occupied within



A **B**

Figure 3-7. REMOTS® images from disposal site Station 24 (A) and reference area NEREF5 (B) displaying biogenic surface roughness as a result of tubiculous polychaetes, biological surface reworking by burrowing infauna (oxidized burrow opening), and a biogenic mound at the sediment-water interface.

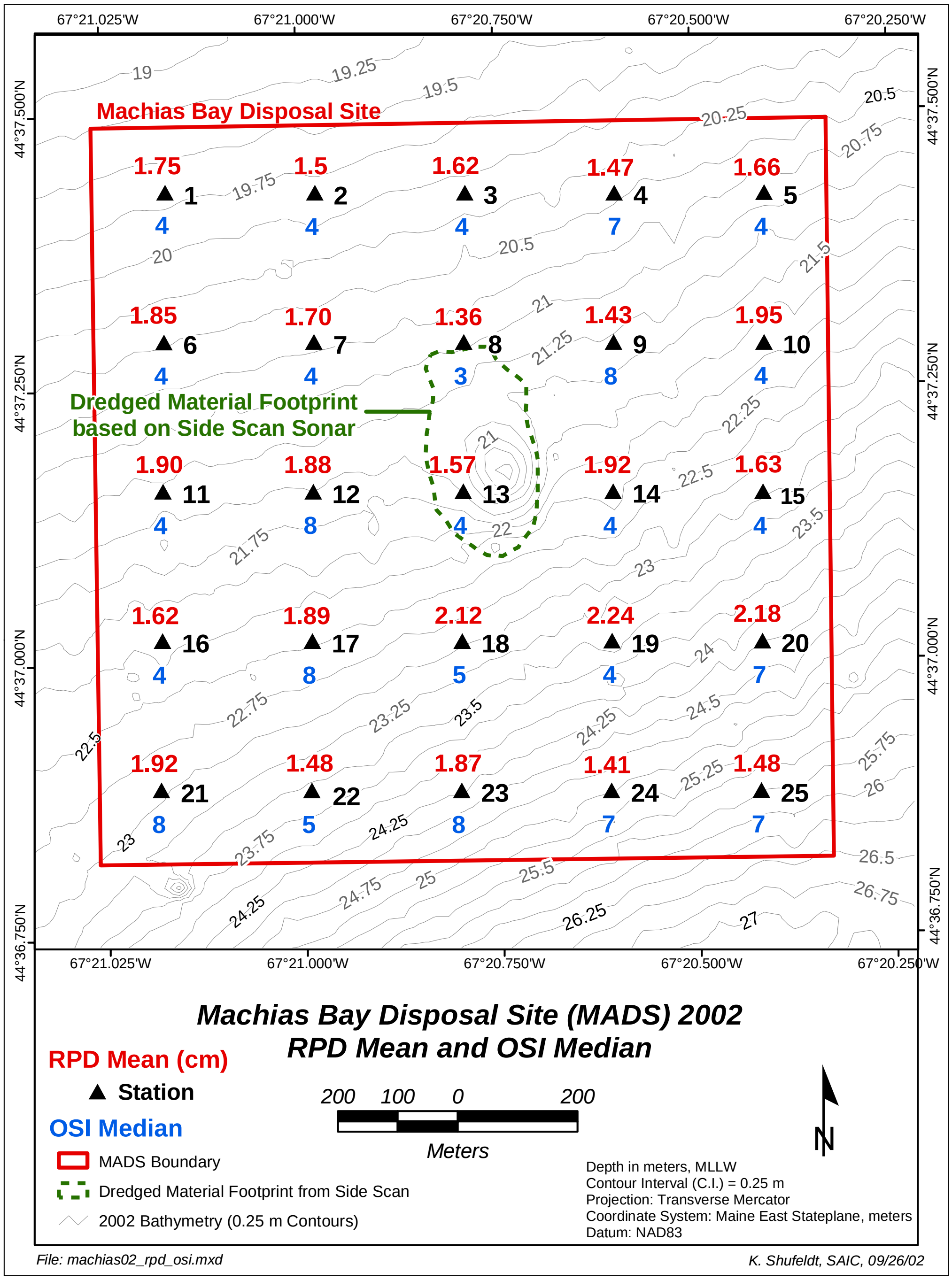


Figure 3-8. Map of replicate averaged RPD depths (red, in centimeters) and median OSI values (blue) detected within MADS relative to the historic dredged material footprint detected by side-scan sonar

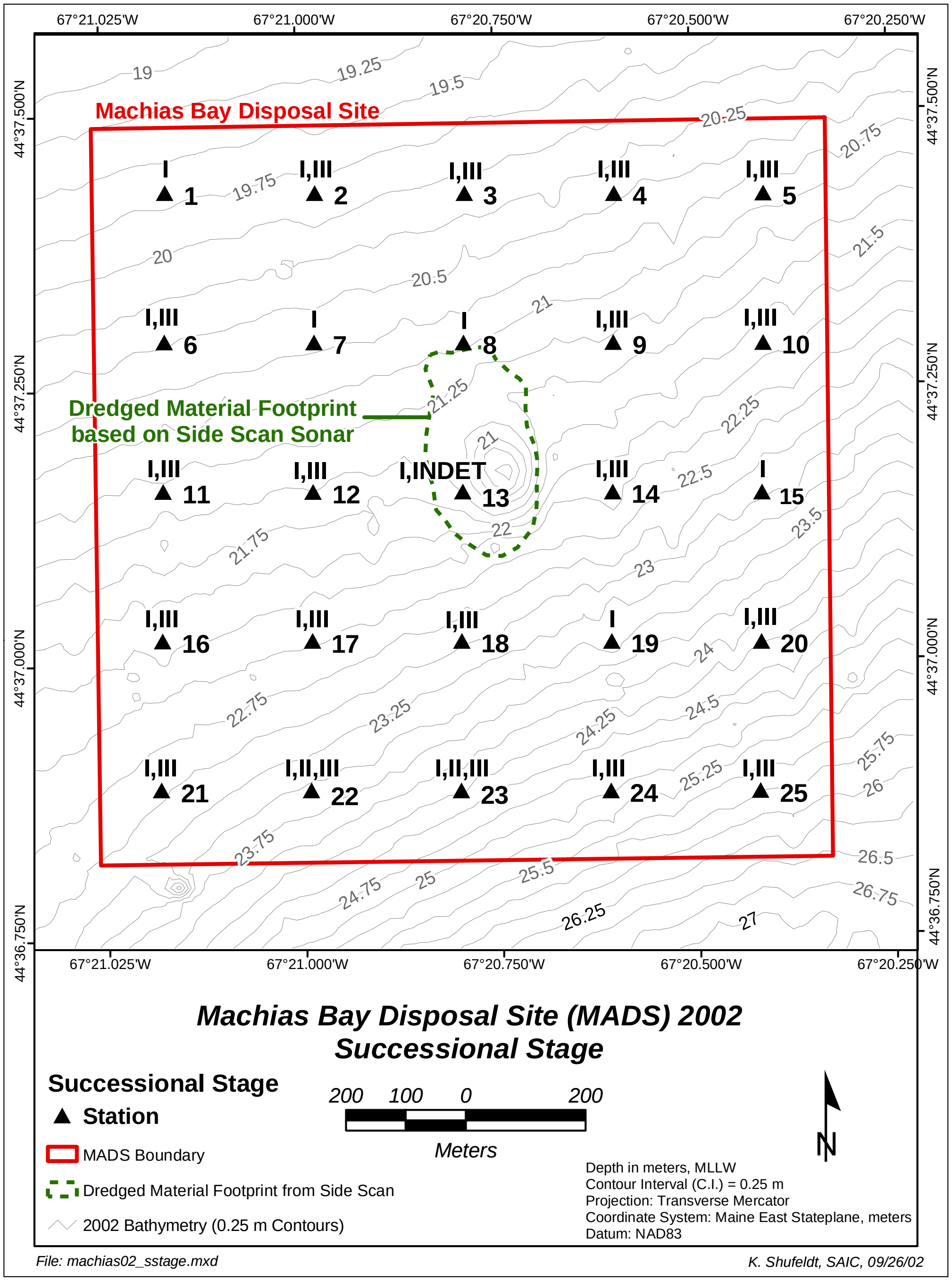


Figure 3-9. Map of successional stage status for the REMOTS® stations established within MADS relative to the historic dredged material footprint detected by side-scan sonar

the disposal site boundary displayed any evidence of low sediment dissolved oxygen conditions, visible redox rebounds, or methane gas bubbles.

The benthic community within the historic disposal site was in a relatively advanced stage of recolonization and included Stage I pioneering polychaetes and Stage III head-down, deposit-feeding infauna (Table 3-1; Figure 3-9). Overall, evidence of Stage III activity was detected in 19 of the 25 stations (76%). When present, Stage III activity was marked by active feeding voids in the subsurface sediments, and was consistently accompanied by Stage I taxa at the sediment-water interface (i.e., Stage I on III successional status; Figure 3-10). Low-order seres (Stage I taxa only) were present in all replicate images of Stations 1, 7, 8, 15, and 19 (20% of sampled stations; Figure 3-9). Successional status determination was not possible at one replicate of Station 13 characterized by hard bottom conditions. Stations within the reference area also exhibited relatively advanced successional status, with both Stage I and Stage III taxa present (Table 3-2). Similar to the historic disposal site stations, Stage III was present in 80% of the stations and always associated with Stage I individuals.

Median OSI values at the historic disposal site stations ranged from +3 at Station 8 to +8 at Stations 9, 12, 17, 21, and 23 (Table 3-1; Figure 3-8). The overall average OSI value of +5.3 calculated for the disposal site is generally indicative of moderately disturbed benthic habitat conditions; this value was slightly lower, but comparable to that calculated for the ambient sediments within the reference area (range of median values from +4 to +9 and average median value of +5.9; Table 3-2). There was no distinction in the OSI value for Station 13 where historic dredged material was observed (mean OSI of +4). Furthermore, there appeared to be a gradient in benthic habitat conditions (as reflected in higher OSI values) within the disposal site, with OSI values generally increasing as stations progressed to the south (Figure 3-8). The OSI values at the lower end of the scale (+3 to +6) reflect an absence of Stage II and III infauna and/or shallow RPD depths. OSI values greater than +6 were observed in 64% of the disposal site stations. Higher median OSI values reflect deeper mean RPD depths and the presence of Stage III organisms at several stations within the historic disposal site (Figure 3-11). Overall, although benthic habitat conditions appear to be moderately degraded, OSI values were similar at the disposal site and reference area stations.

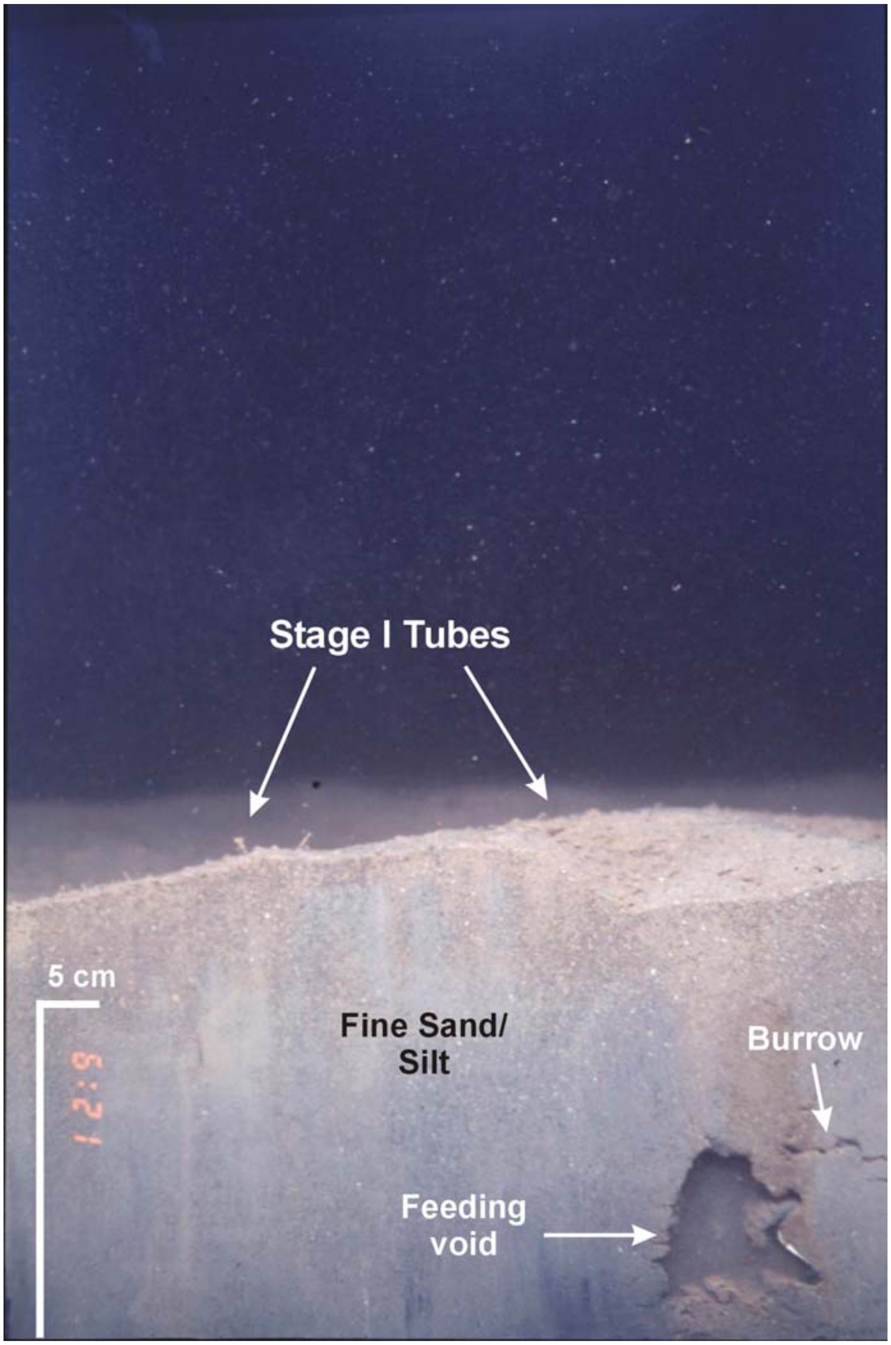


Figure 3-10. REMOTS® image collected from Station 10 illustrating a Stage I on III successional status in a fine sand and silt matrix due to Stage I polychaete tubes at the sediment-water interface and active feeding voids at depth. A large burrow is visible in the subsurface sediments.

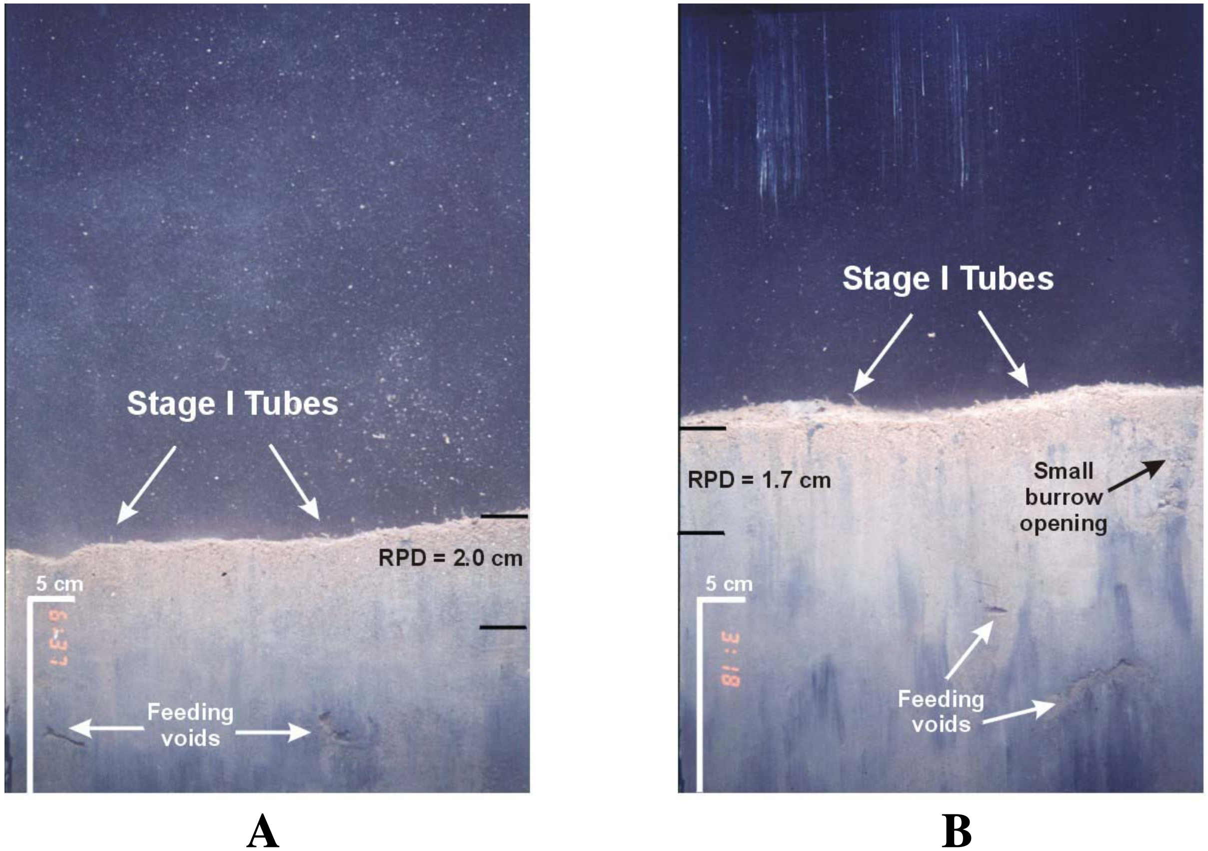


Figure 3-11. REMOTS® image from disposal site Station 21 (A) and MADS reference area Station NEREF4 (B) displaying similar benthic habitat quality within the ambient sediment. A Stage I on III successional status was determined in each image as a result of polychaete tubes at the sediment-water interface and Stage III feeding voids at depth. The depth of oxygenation is similar between the disposal site and reference area station, with mean RPD depths reflecting moderately-oxygenated surface sediments. An OSI of +8 was calculated for both images and is indicative of undisturbed benthic habitat quality.

3.3.2 Reference Areas

3.3.2.1 Physical Sediment Characteristics

Sediments at the reference area stations were similar to those within the disposal site and were characterized as fine-grained reddish-tan over gray sandy silt (major modal grain size of >4 phi; Table 3-2; Figure 3-5). There was no evidence of historic dredged material at any of the reference area stations. Mean camera prism penetration measurements ranged from 7.3 cm at Station SWREF3 to 13.0 cm at Station NEREF2, with an overall average of 9.6 cm (Table 3-2). The range of camera prism penetration measurements at the reference area stations was higher than the range of values observed at the disposal site stations, even when the particularly low camera penetration depths at Station 13 (historic dredged material observed) are not included in the comparison.

The average small-scale surface boundary roughness value for the reference areas (1.2 cm) was similar to that observed at the stations within the disposal site (1.3 cm) and suggests only minor small-scale surface relief exists within the surveyed area. As with the disposal site stations, the majority of reference area stations displayed physical surface roughness, with only 6 replicates exhibiting biogenic surface roughness. Mud clasts were present at every reference area station, indicating widespread physical reworking of surface sediments over the surveyed area, possibly due to fishing activity (Figure 3-12). Biogenic surface roughness was the result of the presence of polychaete worm tubes, biogenic mounds, and biological surface reworking by burrowing infauna at the sediment-water interface (Figure 3-7).

3.3.2.2 Biological Conditions

Replicate-averaged RPD measurements at the reference areas ranged from 1.4 cm at Station SWREF2 to 2.6 cm at Station NEREF2 (Table 3-2). The overall value of 1.9 cm was slightly higher than the overall value observed at the disposal site (1.7 cm), and likewise indicative of moderately-oxygenated surface sediments (Figure 3-13). There was no indication of low sediment dissolved oxygen conditions, methane gas bubbles, or visible redox rebounds at the reference area stations.

Similar to the disposal site stations, both Stage I and Stage III taxa were observed at the reference area stations, with Stage III activity evident at eight of the ten stations occupied (80%; Table 3-2). Reference area stations showed a slightly higher occurrence of advanced Stage III organisms (80%) than the disposal site stations (76%) and, similar to the disposal site stations, Stage III organisms were consistently associated with Stage I

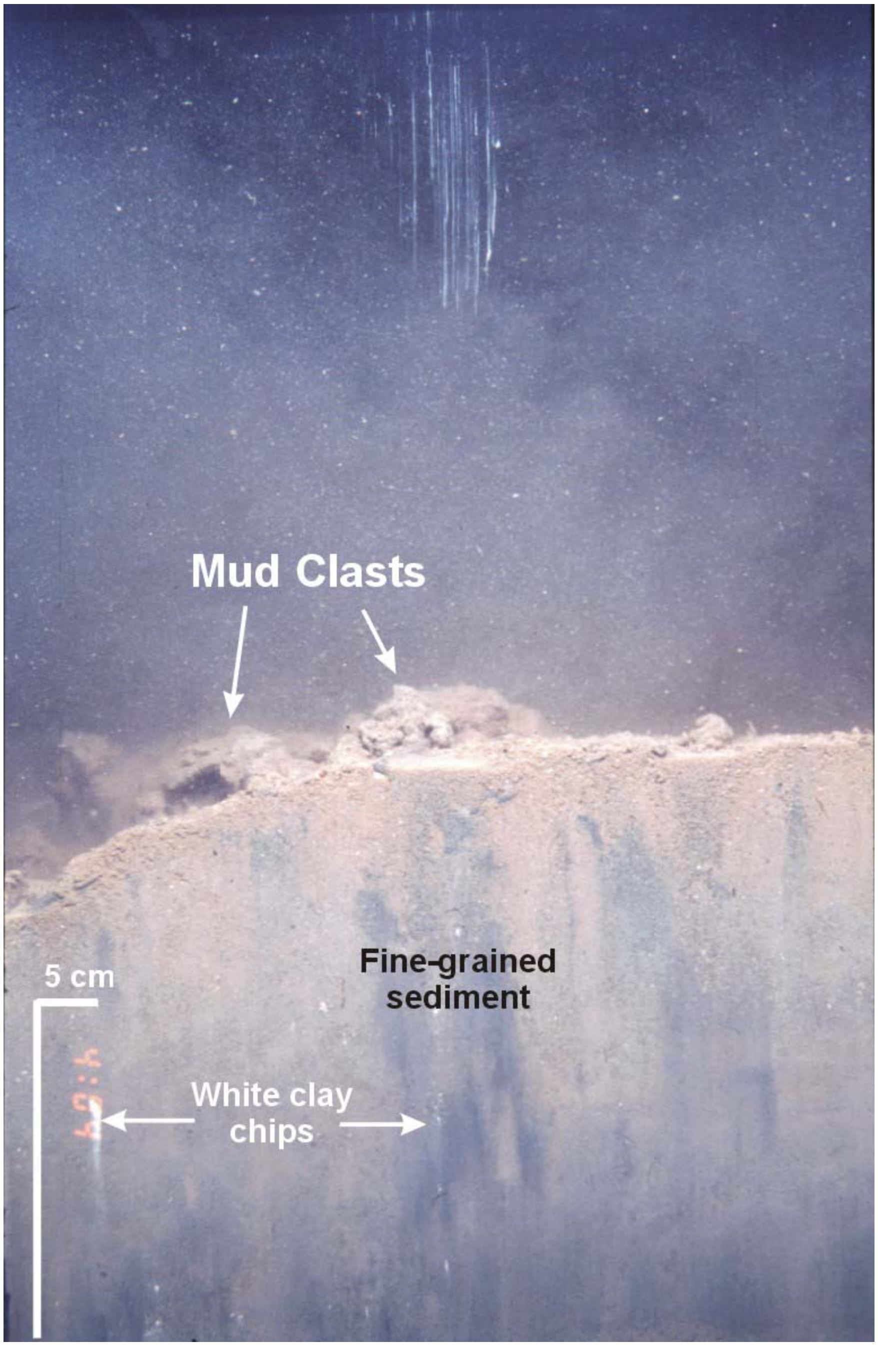


Figure 3-12. REMOTS® image obtained from MADS reference area Station SWREF3. Mud clasts and larger mud clumps visible at the sediment-water interface indicate physical reworking of the sediment, possibly from fishing activity in the region. White clay chips are also detected at depth within the ambient sediment.

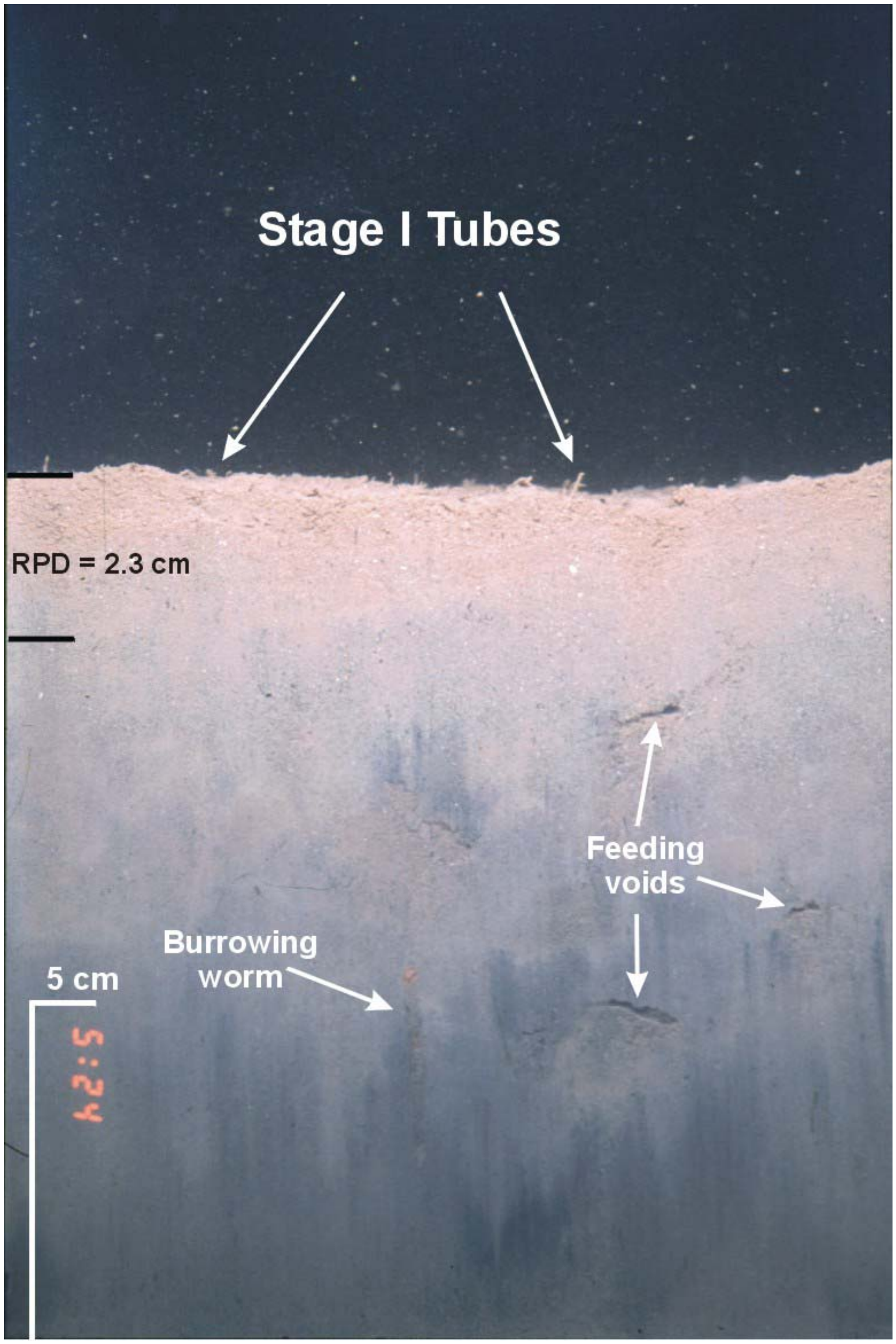


Figure 3-13. REMOTS® image from reference area Station NEREF2 displaying a Stage I on III successional status and a well-developed RPD resulting in an OSI of +9, indicative of undisturbed benthic habitat quality. Multiple feeding voids are visible at depth, while Stage I polychaete tubes are visible at the sediment-water interface.

pioneering polychaetes at the sediment-water interface (Figure 3-11). SWREF4 was the only reference area station displaying only Stage I taxa, indicating the successional status within the reference areas was relatively advanced at the time of the survey; and surface sediments were supporting a stable infaunal population.

Replicate-averaged OSI values for the reference area stations ranged from +4 at Stations NEREF3, SWREF2, and SWREF3, to +9 at Station NEREF2 (Table 3-2). The composite OSI value of +5.9 for the reference areas, indicative of slightly disturbed benthic habitat conditions, was only slightly higher than the overall value observed at the disposal site stations (+5.3). Somewhat deeper RPD depths (1.9 cm) and higher frequency of Stage III organisms (80%) promoted higher OSI values at the reference areas compared to the disposal site.

4.0 DISCUSSION

4.1 Historic Dredged Material Distribution

The July 2002 monitoring effort was the first survey performed over the 1.5 km^2 area of MADS under the DAMOS program to determine the suitability of this historic site for future dredged material disposal from projects in the region. One objective of the July 2002 survey over MADS was to document the distribution of historic dredged material on the seafloor resulting from the placement of approximately 49,400 m^3 of sediment from Machias River and Bucks Harbor in 1974. Results indicate that the seafloor within MADS was relatively flat and featureless with the exception of a historic disposal mound at the center of the site. A surface sediment composition of fine-grained sandy silt, as determined by REMOTS®, confirmed the depositional nature of the area. After approximately 30 years, the historic disposal mound created from those disposal events is still detectable in both the 2002 bathymetry and side-scan sonar mosaic (Figures 3-1 and 3-2). Based on bathymetry, the mound apex is approximately 2 m above the ambient seafloor and the roughly circular mound has an overall diameter of approximately 300 m along its NW-SE axis (Figure 3-1). In addition, strongly reflected acoustic energy in the side-scan sonar mosaic indicates that the surface of the historic disposal mound is composed of slightly coarser, denser surface sediments than the surrounding softer ambient sediment of Machias Bay. This was confirmed by REMOTS® with the presence of pebbles and cobble over the surface of the historic disposal mound.

The lack of baseline (i.e., predisposal) bathymetric data precludes any depth difference calculations, and as a result, the original mound height when disposal ceased in 1974 is indeterminate. However, because a distinct disposal mound is evident in both the bathymetry and side-scan sonar mosaic, it does not appear that there has been any significant sediment transport or redistribution of the dredged material placed within the disposal site.

Given the significant amount of time between the disposal activity (1974) and the summer 2002 monitoring events, it was expected that the sediments within the disposal site would be displaying characteristics similar to ambient sediments. It was difficult to identify any evidence of historic dredged material at any of the disposal site stations, with the exception of Station 13 at the southwest flank of the disposal mound. Most of the disposal site stations exhibited fine-grained (reddish-tan over gray) sediment, which was similar to the ambient sediment observed throughout the disposal site as well as at the reference area.

The historic dredged material within MADS has been in place on the seafloor for nearly 30 years. Thin layers of dredged material that may have been deposited around the perimeter of the disposal mound have been subjected to biological reworking and the natural seafloor processes over the years and would now appear to be indistinguishable from the ambient fine-grained sediment. However, Station 13 (positioned on the southwest flank of the disposal mound) displayed unique sediment characteristics with a mix of pebbles, sand, silt, and shell fragments at the sediment-water interface. This finding suggests that the dredged material placed near the center of MADS in the past may have been originally composed of coarser grained material, or has been subject to winnowing over time.

Winnowing is the selective removal of fine-grained sediment by the passage of near-bottom currents driven by either tidal forcing (linear flow) or wave passage (orbital flow). The coarser grains present at the sediment-water interface of Station 13 may represent a lag deposit resulting from minor winnowing of fine-grained material at the sediment-water interface, which served to armor the surface of the historic disposal mound. This armored surface provided the strong acoustic reflector detected in the side-scan data.

Sediment composition within MADS suggests that a low current regime exists over the majority of the surveyed area. The configuration of Machias Bay suggests bottom currents in the area would more likely be wave-driven, rather than tide-driven. It is possible that orbital currents generated by passing storm-induced waves have winnowed some finer-grained material from the disposal mound over the past three decades and exposed the larger pebbles, sand, and rocks. In addition, the considerable presence of sand in the sediment-profile images within MADS suggests that some winnowing of >4 phi sediments could have occurred throughout the area. Without information regarding the characteristics of dredged material deposited over MADS in the past, the surface of the mound may only indicate that the deposited sediments were composed of coarser grained material. However, the presence of ripples at stations in the northern portion of MADS indicates that wave-induced winnowing may provide a feasible explanation for armoring of the disposal mound. The ripples were evident at stations ranging from 19.5 to 21 m water depths, which constitutes comparable depths to the upper portion of the disposal mound (20.5 m depth at apex).

In general, the size and distinct configuration of the mound suggest that any winnowing of material from the surface of the mound likely affected only a very small fraction of the dredged material deposit. The bulk of the dredged material persists as a discrete mound and does not appear to be subject to substantial erosion or reworking by currents.

The presence of relatively large mud clumps and smaller mud clasts at the sediment-water interface (e.g., Figure 3-12) were the primary evidence of physical surface roughness at MADS and the surrounding reference areas. Such mud clumps and clasts, resulting from physical disturbance or reworking of the in-place sediments, may be the result of the placement and retrieval of lobster gear in the area. During the July 2002 survey, an abundance of lobster pot surface buoys were noted within the surveyed area. Dragging lobster gear (i.e., lobster pots) along the seafloor can act to break up muddy, cohesive surface sediments into the discrete clumps or clasts observed in the sediment-profile images obtained in July 2002 (Messieh et al. 1991; Thrush et al. 1995).

4.2 Biological Conditions

A second objective of the July 2002 survey over MADS was to assess the benthic community status within the confines of the disposal site relative to existing seafloor conditions at two nearby reference areas. The July 2002 survey over MADS provided the opportunity to examine an area of seafloor subjected to a relatively small volume of dredged material (an estimated 55,300 m^3) approximately 30 years after the benthic disturbance.

The July 2002 REMOTS® results indicate that surface sediments comprising the historic mound and surrounding disposal site stations support a diverse benthic community consisting of both surface-dwelling and deeper-dwelling infauna. This community appeared to be comparable to that observed in the reference areas. Evidence of advanced benthic community status (Stage III) was observed in 76% of the stations sampled within MADS, compared to 80% of the stations sampled within the reference areas, indicating that biological conditions within the disposal site are similar to those of ambient sediment.

The OSI values provide a summary measure of overall benthic habitat conditions. The disposal site stations showed variability in benthic habitat conditions, with median OSI values ranging from moderately degraded (OSI +3 to +6) to non-degraded (OSI > +6). The higher OSI values generally occurred at the southern stations located within deeper water. The overall median OSI of +5.3 at MADS, indicating moderately degraded benthic habitat conditions, reflects moderate mean RPD depths (overall RPD mean of 1.7 cm) and a scattered presence of advanced Stage III organisms in replicate images. Similarly, a composite OSI of +5.9 calculated at the reference areas also reflects moderate RPD depths (overall RPD mean of 1.9 cm) and a mixture of both Stage I surface-dwelling and Stage III deeper-dwelling infauna in replicate images.

Benthic habitat conditions appear to be quite similar at both the disposal site (overall median OSI +5.3) and reference area stations (overall median OSI +5.9). These midrange OSI values do not necessarily reflect disturbed benthic habitat conditions or a stressed environment, but rather suggest benthic conditions are not conducive to supporting large numbers of Stage III deposit-feeding organisms. Numerous stations (13 of the 25 disposal site stations) displayed grain sizes reflecting a noticeable sand content (grain size major modes of 4 to 3 and 3 to 2 phi) within the subsurface sediment. Stations displaying OSI values of less than +6 (less productivity) generally correlated with stations with a higher sand content.

Both the apparent historic dredged material and ambient sediments within the disposal site were often comprised of muddy sand. A limited amount of organic material, the food source for primary consumers, is typically found in a sandy environment. Low numbers of Stage III organisms are expected in these sandy areas due to the limitations in the amount of organic matter contained within the sediment. When Stage III taxa were present within the subsurface sediments, the feeding voids were often very small and indistinct, suggesting that the Stage III infaunal organisms were smaller and less abundant (Figures 3-11 and 4-1). These organisms would not cause deep bioturbation within the sandy sediment and as a result, would not produce deep RPD depths. Furthermore, the observed gradient in benthic habitat conditions across the disposal site may be a function of an increased fine-grained sediment fraction with depth (see Figure 3-9).

Another possible explanation for the apparent reduced benthic habitat conditions within the surveyed area may be the effects of year-round colder bottom waters in the Machias Bay area. Machias Bay has open access to cold ocean waters and experiences cold water influence for much of the year. The metabolic rate of benthic infauna and the intensity of bioturbation (foraging) within the sediments are directly related to bottom water temperatures. As a result of colder bottom waters, bioturbation by benthic infauna would be slower, even in the summer months, and would promote less biological mixing of the surface sediment. The level of oxygenation was similar in both the disposal site (overall mean RPD 1.7 cm) and reference area stations (overall mean RPD 1.9 cm) and was indicative of moderately aerated surface sediments. These values may reflect regional effects of constant colder bottom waters. In future monitoring of MADS, it may be beneficial to survey the area in late summer/early fall when bottom waters are at their warmest and infaunal metabolic activity is at its peak.

Overall, the benthic habitat conditions (as reflected in OSI values) throughout the historic disposal site and surrounding reference areas appear to be moderately disturbed. However, the benthic environment seems to be supporting a stable advanced infaunal population and there is no evidence that benthic habitat conditions are affected by the historic dredged material. There does not appear to have been any long-term impact from past disposal within the confines of the disposal site, but rather the reduced OSI values would be expected in a sandy environment with associated limitations on infaunal organisms, as well as the effects of cold bottom waters in the Machias Bay area. The placement of small volumes of organically enriched sediment (i.e., dredged material) within the confines of MADS in the future may serve to stimulate the productivity of the seafloor.

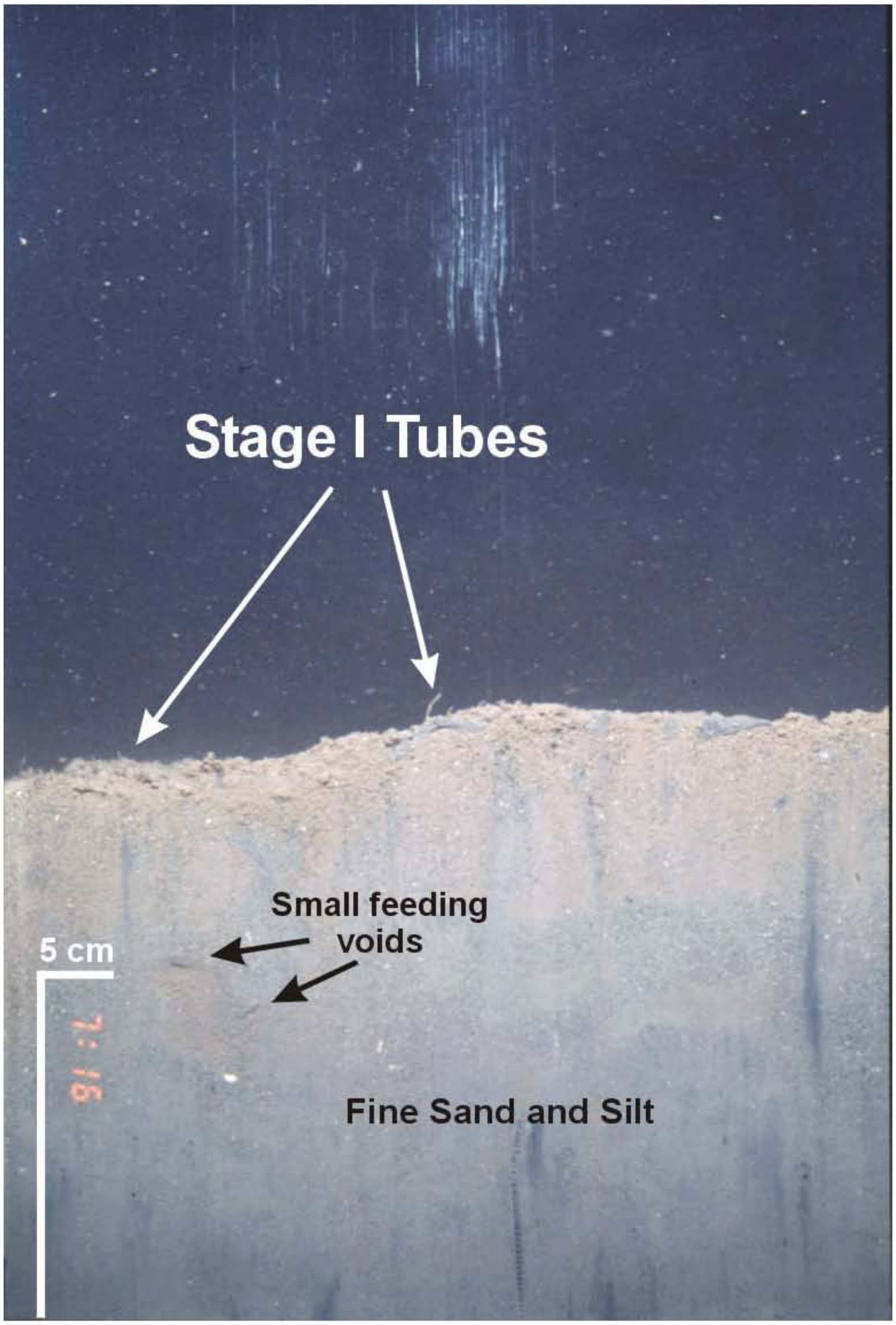


Figure 4-1. REMOTS® image collected from Station 25 illustrating small, indistinct Stage III feeding voids in the ambient subsurface sediments

5.0 CONCLUSIONS

- The July 2002 bathymetry and side-scan survey documented the presence of a historic sediment deposit in the center of MADS resulting from the disposal of sediment from Machias River and Bucks Harbor in 1974. This roughly circular historic mound displayed a height of approximately 2 m and an estimated diameter of 300 m, based on bathymetry. Side-scan sonar and REMOTS® sediment-profile imaging data indicates that the surface of the historic mound is composed of coarser, denser material than the surrounding ambient sediment of Machias Bay, and appears to be a stable feature on the seafloor.

- Historic dredged material was observed at Station 13, on the southwest flank of the disposal mound. There is no evidence of historic dredged material at the remaining REMOTS® sampling stations. The historic disposal mound has an armored surface composed of pebbles and shells that may reflect the coarser nature of the intitial dredged material deposit, and/or small-scale winnowing of fines from the surface of the mound over the past 28 years.

- Cohesive mud clumps or clasts were observed at the sediment surface at both the disposal site and reference area stations, likely due to a regional source of physical seafloor disturbance such as lobster fishing activity.

- Benthic habitat conditions within MADS (OSI value of +5.3) are similar to the reference area stations (OSI value of +5.9). The relatively low OSI values were due to moderate RPD depths and a mixture of both Stage I and Stage III organisms, and do not appear to be influenced by the historic dredged material. The OSI values reflect a noticeable sand fraction in the subsurface sediments, the limited amount of organic matter contained within the sediment, and the effects of year-round cold bottom water temperatures on infaunal metabolic activities. In future monitoring of MADS, it may be beneficial to survey the area in late summer/early fall when bottom waters are at their warmest and infaunal metabolic activity is at its peak.

- Although benthic habitat conditions appear to be moderately disturbed throughout the historic disposal site and surrounding reference areas, the benthic environment appears to be supporting a small, but advanced and stable infaunal population; there has been no long-term impact from past disposal within MADS. Based on the findings of the July 2002 survey, future placement of organically enriched sediment may, in fact, stimulate the productivity of the seafloor.

6.0 REFERENCES

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APPENDIX

Appendix A1

Machias Bay Disposal Site (MADS) REMOTS® Sediment-Profile Imaging Data from the July 2002 Survey

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Maj Mode	Benthic Habitat	Mud Clasts Count	Mud Clasts Avg. Diam	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
01	C	7/1/2002	14:50	ST I	> 4 phi	3-2 phi	> 4 phi	UN.SS	0	0	5.46	6.07	0.61	5.77	0	0	0	0	0	0
01	D	7/2/2002	17:52	ST I	> 4 phi	3-2 phi	> 4 phi	UN.SI	0	0	5.96	7.3	1.34	6.63	0	0	0	0	0	0
01	F	7/2/2002	17:53	ST I	> 4 phi	4 to 3 phi	4-3 phi	UN.SS	3	0.19	4.59	5.5	0.91	5.05	0	0	0	0	0	0
02	B	7/1/2002	14:58	ST I on III	> 4 phi	3-2 phi	4-3 phi	UN.SS	0	0	5.7	6.64	0.94	6.17	0	0	0	0	0	0
02	C	7/1/2002	14:59	ST I	> 4 phi	3-2 phi	4-3 phi	UN.SS	1	0.29	5.32	5.98	0.66	5.65	0	0	0	0	0	0
02	E	7/2/2002	17:59	ST I	> 4 phi	3-2 phi	4-3 phi	UN.SS	6	0.12	6.16	7.7	1.54	6.93	0	0	0	0	0	0
03	A	7/1/2002	15:04	ST I	> 4 phi	2-1 phi	3-2 phi	SA.F	0	0	3.27	6.07	2.8	4.67	0	0	0	0	0	0
03	B	7/1/2002	15:04	ST I on III	> 4 phi	3-2 phi	4-3 phi	UN.SS	6	0.56	6.16	7.32	1.16	6.74	0	0	0	0	0	0
03	D	7/2/2002	18:03	ST I	> 4 phi	3-2 phi	4-3 phi	SA.F	0	0	5.38	6.54	1.16	5.96	0	0	0	0	0	0
04	A	7/1/2002	15:13	ST I on III	> 4 phi	3-2 phi	4 to 3 phi	UN.SS	0	0	5.07	5.77	0.7	5.42	0	0	0	0	0	0
04	B	7/1/2002	15:14	ST I	> 4 phi	3-2 phi	> 4 phi	UN.SI	10	0.17	6.18	7.14	0.96	6.66	0	0	0	0	0	0
04	C	7/1/2002	15:14	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	6	0.19	4.5	5.89	1.39	5.19	0	0	0	0	0	0
05	C	7/1/2002	15:24	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SS	0	0	5.52	6.45	0.93	5.98	0	0	0	0	0	0
05	D	7/2/2002	18:13	ST I	> 4 phi	4 to 3 phi	4 to 3 phi	UN.SS	4	0.97	3.84	4.64	0.8	4.24	0	0	0	0	0	0
05	G	7/3/2002	17:38	ST I	> 4 phi	4 to 3 phi	4 to 3 phi	SA.F	1	0.21	0.68	3.89	3.21	2.29	0	0	0	0	0	0
06	E	7/2/2002	17:46	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	5	0.28	6.18	7.04	0.86	6.61	0	0	0	0	0	0
06	F	7/2/2002	17:47	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SS	0	0	5.89	8.21	2.32	7.05	0	0	0	0	0	0
06	G	7/2/2002	17:47	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	7.32	9.23	1.91	8.27	0	0	0	0	0	0
07	A	7/1/2002	16:47	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	6.09	6.77	0.68	6.43	0	0	0	0	0	0
07	B	7/1/2002	16:48	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	3	0.23	2.89	5.86	2.97	4.38	0	0	0	0	0	0
07	C	7/1/2002	16:49	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	5.86	6.39	0.53	6.12	0	0	0	0	0	0
08	B	7/1/2002	15:52	ST I	> 4 phi	4 to 3 phi	4-3 phi	UN.SS	2	0.21	5	6.02	1.02	5.51	0	0	0	0	0	0
08	C	7/1/2002	15:53	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	4.52	5.32	0.8	4.92	0	0	0	0	0	0
08	E	7/2/2002	18:48	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	3.18	4.41	1.23	3.8	0	0	0	0	0	0
09	A	7/1/2002	15:44	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	5.8	6.93	1.13	6.36	0	0	0	0	0	0
09	B	7/1/2002	15:45	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	25	0.31	6.91	8	1.09	7.45	0	0	0	0	0	0
09	C	7/1/2002	15:46	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	10	0.2	4.88	7.14	2.26	6.01	0	0	0	0	0	0
10	D	7/2/2002	18:21	ST I on III	> 4 phi	3-2 phi	4-3 phi	UN.SS	0	0	6.77	7.7	0.93	7.23	0	0	0	0	0	0
10	E	7/2/2002	18:22	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	5.16	5.96	0.8	5.56	0	0	0	0	0	0
10	F	7/2/2002	18:23	ST I	> 4 phi	3-2 phi	> 4 phi	UN.SI	8	0.19	6.82	7.96	1.14	7.39	0	0	0	0	0	0
11	A	7/1/2002	17:01	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	3	0.13	6.86	7.55	0.69	7.2	0	0	0	0	0	0
11	B	7/1/2002	17:02	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	3	0.12	4.04	6.04	2	5.04	0	0	0	0	0	0
11	C	7/1/2002	17:02	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	2	0.17	3.27	5.34	2.07	4.31	0	0	0	0	0	0
12	A	7/1/2002	17:08	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	5.91	6.93	1.02	6.42	0	0	0	0	0	0
12	E	7/2/2002	17:24	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SS	0	0	6.73	7.68	0.95	7.2	0	0	0	0	0	0
12	F	7/2/2002	17:25	ST I	> 4 phi	3-2 phi	>4 phi	UN.SS	1	0.5	7.86	9.38	1.52	8.62	0	0	0	0	0	0
13	A	7/1/2002	17:16	ST I	> 4 phi	2 to 1 phi	>4 phi	UN.SI	0	0	2.11	4.59	2.48	3.35	>2.11	>4.59	>3.35	0	0	0
13	D	7/2/2002	17:16	INDET	> 4 phi	<-1 phi	>4 phi	UN.SI	0	0	0.96	3.16	2.2	2.06	>0.96	>3.16	>2.06	0	0	0
13	E	7/2/2002	17:17	ST I	> 4 phi	4 to 3 phi	4 to 3 phi	UN.SS	0	0	1.84	4.02	2.18	2.93	>1.84	>4.02	>2.93	0	0	0
14	B	7/1/2002	17:24	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	3	0.42	6.29	7.7	1.41	6.99	0	0	0	0	0	0
14	E	7/2/2002	18:38	ST I	> 4 phi	4 to 3 phi	>4 phi	UN.SI	0	0	7.8	9.12	1.32	8.46	0	0	0	0	0	0
14	F	7/2/2002	18:39	ST I	> 4 phi	4 to 3 phi	>4 phi	UN.SI	3	0.17	7.07	7.84	0.77	7.45	0	0	0	0	0	0
15	A	7/1/2002	17:31	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	12	0.39	4.54	6.73	2.19	5.64	0	0	0	0	0	0
15	D	7/2/2002	18:28	ST I	> 4 phi	4 to 3 phi	4 to 3 phi	UN.SS	2	0.33	5.7	7.5	1.8	6.6	0	0	0	0	0	0
15	E	7/2/2002	18:29	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	7	2.34	5.96	7	1.04	6.48	0	0	0	0	0	0
16	A	7/1/2002	18:30	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	5	0.26	4.54	7.34	2.8	5.94	0	0	0	0	0	0
16	B	7/1/2002	18:30	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	2	0.26	3.57	4.3	0.73	3.93	0	0	0	0	0	0
16	C	7/1/2002	18:31	ST I	> 4 phi	3-2 phi	4-3 phi	UN.SS	0	0	5.48	7.11	1.63	6.3	0	0	0	0	0	0
17	A	7/1/2002	18:23	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	6.64	8.27	1.63	7.45	0	0	0	0	0	0
17	B	7/1/2002	18:24	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	6.02	7.62	1.6	6.82	0	0	0	0	0	0
17	C	7/1/2002	18:25	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	3	0.14	7.52	7.95	0.43	7.73	0	0	0	0	0	0
18	A	7/1/2002	18:16	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	3	0.19	5.23	6.18	0.95	5.7	0	0	0	0	0	0
18	D	7/2/2002	16:17	ST I	> 4 phi	4 to 3 phi	4 to 3 phi	UN.SS	5	0.21	6.21	7.12	0.91	6.66	0	0	0	0	0	0
18	E	7/2/2002	16:18	ST I	> 4 phi	4 to 3 phi	4 to 3 phi	UN.SS	0	0	5.8	7.71	1.91	6.76	0	0	0	0	0	0
19	B	7/1/2002	17:47	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	6.04	7.04	1	6.54	0	0	0	0	0	0
19	D	7/1/2002	17:53	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	6.09	7.12	1.03	6.61	0	0	0	0	0	0
19	E	7/2/2002	16:24	ST I	> 4 phi	4 to 3 phi	> 4 phi	UN.SS	0	0	4.43	7.55	3.12	5.99	0	0	0	0	0	0
20	A	7/1/2002	17:39	ST I on III	> 4 phi	4 to 3 phi	>4 phi	UN.SS	0	0	6.21	6.95	0.74	6.58	0	0	0	0	0	0
20	D	7/2/2002	16:30	ST I	> 4 phi	2-1 phi	> 4 phi	UN.SI	0	0	6.34	8.27	1.93	7.31	0	0	0	0	0	0
20	E	7/2/2002	16:31	ST I on III	> 4 phi	3-2 phi	> 4 phi	UN.SS	2	0.14	8.02	8.48	0.46	8.25	0	0	0	0	0	0
21	A	7/1/2002	18:37	ST I on III	> 4 phi	3-2 phi	> 4 phi	UN.SI	0	0	6.3	7.62	1.32	6.96	0	0	0	0	0	0
21	B	7/1/2002	18:40	ST I on III	> 4 phi	2-1 phi	> 4 phi	UN.SS	15	0.45	14.98	15.57	0.59	15.27	0	0	0	0	0	0
21	C	7/1/2002	18:41	ST I on III	> 4 phi	3-2 phi	> 4 phi	UN.SS	5	0.28	7.3	8.54	1.24	7.92	0	0	0	0	0	0
22	A	7/1/2002	18:49	ST I to II	> 4 phi	3-2 phi	> 4 phi	UN.SI	0	0	4.7	6.89	2.19	5.8	0	0	0	0	0	0
22	B	7/1/2002	18:50	ST I on III	> 4 phi	3-2 phi	> 4 phi	UN.SS	0	0	4.02	5.8	1.78	4.91	0	0	0	0	0	0
22	C	7/1/2002	18:50	ST I to II	> 4 phi	3-2 phi	> 4 phi	UN.SI	3	0.18	6.86	7.62	0.76	7.24	0	0	0	0	0	0
23	A	7/1/2002	18:55	ST I on III	> 4 phi	3-2 phi	> 4 phi	UN.SI	8	0.09	5.82	6.79	0.97	6.31	0	0	0	0	0	0
23	B	7/1/2002	18:57	ST I on III	> 4 phi	3-2 phi	> 4 phi	UN.SI	15	0.31	7.55	8.36	0.81	7.95	0	0	0	0	0	0
23	C	7/1/2002	18:58	ST I to II	> 4 phi	4 to 3 phi	> 4 phi	UN.SI	0	0	6.07	6.59	0.52	6.33	0	0	0	0	0	0
24	A	7/1/2002	19:04	ST I on III	> 4 phi	2-1 phi	> 4 phi	UN.SS	3	0.14	7.54	8.41	0.87	7.97	0	0	0	0	0	0
24	B	7/1/2002	19:05	ST I	> 4 phi	4 to 3 phi	4 to 3 phi	UN.SS	0	0	5.3	6.95	1.65	6.12	0	0	0	0	0	0
24	C	7/1/2002	19:06	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SS	0	0	7.62	8.38	0.76	8	0	0	0	0	0	0
25	A	7/1/2002	19:15	ST I on III	> 4 phi	2-1 phi	4-3 phi	UN.SS	0	0	8.52	9.5	0.98	9.01	0	0	0	0	0	0
25	B	7/1/2002	19:15	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	UN.SS	0	0	7.07	8.09	1.02	7.58	0	0	0	0	0	0
25	C	7/1/2002	17:16	ST I on III	> 4 phi	3-2 phi	>4 phi	UN.SS	8	0.25	8.8	10.09	1.29	9.44	0	0	0	0	0	0

Appendix A1 (continued)

Machias Bay Disposal Site (MADS) REMOTS® Sediment-Profile Imaging Data from the July 2002 Survey

Station	Replicate	Date	Time	Apparent RPD Thickness (cm)			Methane			OSI	Surface	Low	Comments
				Min	Max	Mean	Count	Mean Depth	Diam.		Roughness	DO	
01	C	7/1/2002	14:50	0.65	3.51	1.84	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, white shell frags @ surf
01	D	7/2/2002	17:52	0.14	3.22	1.73	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes
01	F	7/2/2002	17:53	0.65	2.94	1.69	0	0	0	4	Biogenic	NO	Ambient reddish-tan/gry muddy fine sand, ox clasts, burrow opening?
02	B	7/1/2002	14:58	0.29	4.74	2.07	0	0	0	8	Biogenic	NO	Ambient reddish-tan/gry fine sand & silt, tubes, voids, burrows-opening, wiper clast, biogenic mounds?
02	C	7/1/2002	14:59	0.07	3.02	0.73	0	0	0	2	Physical	NO	Ambient reddish-tan/gry muddy fine sand, sm tubes, ox clast, wiper clasts, red sed @z
02	E	7/2/2002	17:59	0.72	3.95	1.71	0	0	0	4	Physical	NO	Ambient reddish-tan/gry fine sand & silt, ox & red clasts, tubes, red sed @z, worm @z
03	A	7/1/2002	15:04	0.51	3.33	1.31	0	0	0	3	Biogenic	NO	Ambient reddish-tan.gry fine sand&silt, lg vertical burrow-opening, sm tubes
03	B	7/1/2002	15:04	0.29	3.81	1.53	0	0	0	8	Physical	NO	Ambient reddish-tan/gry&blk sandy m, sm tubes, ox m clasts, void, red sed @z
03	D	7/2/2002	18:03	0.14	3.67	2.02	0	0	0	4	Physical	NO	Ambient reddish tan/gry fine sand & silt, void?, white shells@surf, sand ripple?
04	A	7/1/2002	15:13	0.22	1.94	0.89	0	0	0	7	Physical	NO	Ambient reddish-tan/gry muddy fine sand, voids
04	B	7/1/2002	15:14	0.07	4.67	2.19	0	0	0	4	Physical	NO	Ambient reddish-tan/gry&blk sandy m, sm tubes, ox & red clasts, lg worm @z, wiper clast, red sed @z, wht clay chips @z
04	C	7/1/2002	15:14	0.22	3.67	1.33	0	0	0	7	Biogenic	NO	Ambient reddish-tan/gry&blk sandy m, sm tubes, ox & red clasts, burrow opening@z, red sed patch @z, biogenic mound
05	C	7/1/2002	15:24	1.01	3.45	1.90	0	0	0	8	Physical	NO	Reddish-tan/gry fine sand&silt, sm tubes, voids, burrow, shell -far
05	D	7/2/2002	18:13	0.86	3.36	1.77	0	0	0	4	Physical	NO	Ambient reddish-tan.gry sandy m, ox clasts, sm tubes
05	G	7/3/2002	17:38	0.07	2.70	1.31	0	0	0	3	Biogenic	NO	Ambient reddish-tan/gry fine sand&silt, burrow opening, red clast
06	E	7/2/2002	17:46	0.43	3.84	1.81	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, ox & red clasts, voids
06	F	7/2/2002	17:47	0.43	2.70	1.63	0	0	0	4	Physical	NO	Ambient reddish-tan/gry fine sand & silt, wiper clast, sm tubes, worms @z
06	G	7/2/2002	17:47	0.92	4.05	2.11	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, worms @z, wht clay chips @z
07	A	7/1/2002	16:47	0.43	3.98	2.04	0	0	0	4	Physical	NO	Reddish-tan/gry sandy m, sm tubes, red sed @z
07	B	7/1/2002	16:48	0.21	3.91	1.29	0	0	0	3	Biogenic	NO	Ambient reddish-tan/gry sandy m, burrow opening, ox & red clasts, v sm void?, wiper clasts, red sed @surf @ & z
07	C	7/1/2002	16:49	0.21	3.20	1.76	0	0	0	4	Physical	NO	Reddish-tan/gry sandy m, sm tubes, red sed @z, sm worms @z
08	B	7/1/2002	15:52	0.07	3.77	1.91	0	0	0	4	Physical	NO	Reddish-tan fine sand/gry silt, sm tubes, ox clasts, vertical burrow, sm worms @z?
08	C	7/1/2002	15:53	0.28	2.92	1.06	0	0	0	3	Physical	NO	Reddish-tan/gry sandy m, sm tubes, patchy RPD, sm white shell @ surf-farfield
08	E	7/2/2002	18:48	0.28	2.20	1.10	0	0	0	3	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, lg shell @ surf, underpen
09	A	7/1/2002	15:44	1.07	3.84	1.93	0	0	0	8	Physical	NO	Ambient reddish-tan/gry&blk sandy m, tubes, voids or cracks?, burrow, fecal mound?, wht clay chips @z
09	B	7/1/2002	15:45	0.57	3.41	1.61	0	0	0	8	Physical	NO	Reddish-tan/gry&blk sandy m, red sed @z, clast layer, voids, m clumps-far, sm worms @z
09	C	7/1/2002	15:46	0.21	3.84	0.76	0	0	0	3	Physical	NO	Ambient reddish-tan/blk sandy m, red sed-wiper clasts, shallow & patchy RPD, ox&red clasts, burrow opening, lg burrow@z
10	D	7/2/2002	18:21	0.07	3.84	1.77	0	0	0	8	Physical	NO	Ambient reddish-tan/gry fine sand & silt, tubes, lg void or burrow?
10	E	7/2/2002	18:22	0.64	4.34	1.92	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, sm white shell@surf
10	F	7/2/2002	18:23	0.64	4.13	2.16	0	0	0	4	Physical	NO	Ambient reddish-tan fine sand/gry silt, ox & red clasts, bivalve shells @surf, sm tubes
11	A	7/1/2002	17:01	1.64	4.05	2.58	0	0	0	9	Physical	NO	Ambient reddish-tan/gry sandy m, void, ox clasts, sm tubes
11	B	7/1/2002	17:02	1.00	3.13	1.73	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, tubes, ox clasts, shells-far?
11	C	7/1/2002	17:02	0.64	3.06	1.39	0	0	0	3	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, red clasts
12	A	7/1/2002	17:08	1.49	4.05	2.30	0	0	0	9	Physical	NO	Ambient reddish-tan/gry sandy m, tubes, voids, shell frags @surf, worms @z
12	E	7/2/2002	17:24	0.07	3.65	1.55	0	0	0	8	Physical	NO	Reddish-tan/gry&blk sandy m, red sed @surf=wiper smear, sm tubes, void lwr right, worms @z
12	F	7/2/2002	17:25	0.14	4.41	1.78	0	0	0	4	Physical	NO	Ambient reddish-tan/gry&blk fine sand&silt, patchy RPD, red clast, tubes, wht clay chips @z, worm @z, red sed @z, surf rework?
13	A	7/1/2002	17:16	0.57	3.06	1.62	0	0	0	4	Physical	NO	Historic DM=poorly sorted mix of shell frgs, pebbles, mud, burow opening?, void?
13	D	7/2/2002	17:16	0.36	2.01	1.08	0	0	0	99	Physical	NO	Historic DM=poorly sorted mix shell frags, black pebbles, mud, underpen, shell layer @surf, bryozoans
13	E	7/2/2002	17:17	1.71	3.70	2.01	0	0	0	4	Physical	NO	Historic DM=poorly sorted mix shell frags, pebbles, sand, mud, underpen, shell lag, burrow opening, fecal layer, bryozoans
14	B	7/1/2002	17:24	0.43	3.77	1.68	0	0	0	8	Physical	NO	Reddish-tan/gry sandy m, sm tubes, ox & red clasts, voids, red sed-wiper clast
14	E	7/2/2002	18:38	0.79	4.00	2.22	0	0	0	4	Physical	NO	Ambient reddish-tan/gry fine sand & silt, sm tubes, worms @z, shell frag
14	F	7/2/2002	18:39	0.28	4.48	1.86	0	0	0	4	Physical	NO	Ambient reddish-tan/gry fine sand & silt, ox clasts, red sed, sm wht clay chips
15	A	7/1/2002	17:31	0.07	3.08	1.42	0	0	0	3	Physical	NO	Ambient reddish-tan/gry fine sand & silt, clast layer, graded bedding m/s/m, burrow opening
15	D	7/2/2002	18:28	0.28	3.70	1.67	0	0	0	4	Physical	NO	Reddish-tan/gry fine sand & silt, tubes, void?, wiper clast, ox & red clasts, biogenic mound-farfield, worm @z
15	E	7/2/2002	18:29	0.07	3.49	1.79	0	0	0	4	Physical	NO	Ambient tan/gry sandy m, sm tubes, ox m clasts, worm @z
16	A	7/1/2002	18:30	0.07	2.85	1.18	0	0	0	7	Physical	NO	Ambient reddish-tan/gry sandy m, tubes, voids, shell frags @ surf, ox m clasts, wiper clast
16	B	7/1/2002	18:30	0.43	3.06	1.56	0	0	0	4	Physical	NO	Ambient reddish tan/gry& blk sandy m, red sed @ surf & @ z, red clasts, worm @z
16	C	7/1/2002	18:31	0.78	4.13	2.12	0	0	0	4	Physical	NO	Ambient reddish-tan/gry muddy fine sand, worms @z, sm tubes
17	A	7/1/2002	18:23	0.36	4.05	2.13	0	0	0	8	Physical	NO	Ambient reddish-tan/gry&blk sandy m, tubes, voids, worm @z
17	B	7/1/2002	18:24	0.14	3.77	1.66	0	0	0	8	Physical	NO	Ambient reddish-tan/gry & blk sandy m, sm tubes, void, sm worms @z
17	C	7/1/2002	18:25	0.07	3.91	1.88	0	0	0	4	Physical	NO	Ambient reddish-tan/gry& blk sandy m, sm tubes, worms @z, patchy RPD, org @ surf=worm?
18	A	7/1/2002	18:16	1.00	4.05	2.21	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy m, ox & red clasts, sm tubes, void, lg m clump-far, sm worm @z
18	D	7/2/2002	16:17	0.14	5.48	2.62	0	0	0	5	Physical	NO	Ambient reddish-tan & gry fine sand & silt, sm tubes, ox & red clasts
18	E	7/2/2002	16:18	0.21	3.06	1.53	0	0	0	4	Physical	NO	Ambient reddish-tan/gry fine sand & silt, sm tubes, shell frags, white shells=living small bivalve?
19	B	7/1/2002	17:47	0.28	4.20	2.49	0	0	0	5	Physical	NO	Ambient reddish-tan/gry sandy silt, sm tubes, shell bits, sm void?
19	D	7/1/2002	17:53	0.71	3.70	2.14	0	0	0	4	Physical	NO	Ambient reddish-tan/gry&blk sandy m, sm tubes, shell frag @z
19	E	7/2/2002	16:24	0.21	4.05	2.10	0	0	0	4	Physical	NO	Ambient reddish-tan/gry&blk fine sand & silt, tubes, wht clay chip @z
20	A	7/1/2002	17:39	0.07	2.85	1.39	0	0	0	7	Physical	NO	Reddish-tan/gry muddy fine sand & silt, sm tubes, voids, worm @z
20	D	7/2/2002	16:30	0.14	4.98	2.46	0	0	0	5	Biogenic	NO	Ambient reddish-tan/gry sandy m, sm tubes, red sed @ surf-wiper clast, oxidized burrow-opening, worm @z
20	E	7/2/2002	16:31	0.85	4.84	2.70	0	0	0	9	Physical	NO	ambient Reddish-tan/gry sandy m, tubes, voids, ox clasts, worms @ z, wiper clasts
21	A	7/1/2002	18:37	0.07	3.52	2.01	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy m, surf tubes, voids, sm worms @z
21	B	7/1/2002	18:40	0.07	4.20	2.19	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy mud, tubes, ox m clasts, void @bottom, mud clumps-far, worm @z, significant fine sand component mixed with mud
21	C	7/1/2002	18:41	0.14	3.79	1.57	0	0	0	8	Biogenic	NO	ambient reddish-tan/gry sandy m, tubes,ox&red clasts, void/burrow, wht clay chips@z,burrowing polychaetes@z,shell frag@surf, mound=burrow open.?
22	A	7/1/2002	18:49	1.22	3.79	1.83	0	0	0	5	Physical	NO	Ambient reddish-tan/gry sandy m, tubes=poly and amp??, worms @z, shell frag @surf,biogenic mound?
22	B	7/1/2002	18:50	0.07	2.72	1.02	0	0	0	7	Physical	NO	Ambient reddish-tan/gry sandy m, void, red m clasts-far, sm tubes, some red sed patches @z
22	C	7/1/2002	18:50	0.36	3.41	1.59	0	0	0	5	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, ox & red m clasts, red sed patches@z, burrow openings, biogenic reworking of upper 1 cm lyr=amps?
23	A	7/1/2002	18:55	0.36	3.77	1.83	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, wiper clasts, oxidized voids, ox & red m clasts
23	B	7/1/2002	18:57	0.64	4.34	2.11	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, voids, ox & red clasts, burrow openings, wiper clast
23	C	7/1/2002	18:58	0.43	3.98	1.68	0	0	0	5	Biogenic	NO	Ambient reddish-tan/gry sandy m, surf tubes, biogenic rewrking of surface lyr, white spots @ depth = bivalves or clay chips?
24	A	7/1/2002	19:04	0.07	4.33	1.87	0	0	0	8	Physical	NO	Ambient reddish-tan/gry fine sand & silt, sm tubes, voids/burrow opening@depth, wiper clast, red sed patches @z, ox m clasts
24	B	7/1/2002	19:05	0.07	2.85	1.21	0	0	0	3	Physical	NO	Ambient reddish-tan/gry fine sand & silt, sm tubes, sm worm @z, biogenic surface reworking
24	C	7/1/2002	19:06	0.07	3.06	1.14	0	0	0	7	Biogenic	NO	Ambient tan/gry sandy m, significant fine sand component, tubes, void, oxidized burrow-opening, white shells/bivalves @ surf
25	A	7/1/2002	19:15	0.22	2.74	1.14	0	0	0	7	Physical	NO	Ambient tan/gry fine sand & silt, tubes, voids right side, red sed @z, sm worms @z, white shells @ surf?
25	B	7/1/2002	19:15	0.07	3.52	1.42	0	0	0	7	Physical	NO	Ambient tan/gry fine sand & silt, tubes, void, white shell@ surf
25	C	7/1/2002	17:16	0.29	4.24	1.88	0	0	0	8	Physical	NO	Ambient tan/gry muddy fine sand & silt, tubes, ox & red clasts, sm voids, worms @z, reduced wiper clasts

Appendix A2

Machias Bay Disposal Site (MADS) Reference Area REMOTS® Sediment-Profile Imaging Data from the July 2002 Survey

Station	Replicate	Date	Time	Successional Stage	Grain Size (phi) Min	Grain Size (phi) Max	Grain Size (phi) Maj Mode	Mud Clasts Count	Mud Clasts Avg. Diam	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
NEREF1	A	7/2/2002	15:05	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	0	0	9.45	11.14	1.69	10.3	0	0	0	0	0	0
NEREF1	B	7/2/2002	15:06	ST I	> 4 phi	4 to 3 phi	> 4 phi	8	0.29	8.02	8.93	0.91	8.48	0	0	0	0	0	0
NEREF1	C	7/2/2002	15:06	ST I	> 4 phi	4 to 3 phi	> 4 phi	12	0.38	8.86	9.52	0.66	9.19	0	0	0	0	0	0
NEREF2	C	7/2/2002	15:25	ST I	> 4 phi	4 to 3 phi	> 4 phi	5	0.17	10.8	11.86	1.06	11.33	0	0	0	0	0	0
NEREF2	D	7/3/2002	17:24	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	0	0	13.34	13.86	0.52	13.6	0	0	0	0	0	0
NEREF2	E	7/3/2002	17:25	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	3	0.41	13.21	15.04	1.83	14.12	0	0	0	0	0	0
NEREF3	A	7/2/2002	15:29	ST I	> 4 phi	4 to 3 phi	> 4 phi	0	0	9.7	10.62	0.92	10.16	0	0	0	0	0	0
NEREF3	B	7/2/2002	15:30	ST I to II	> 4 phi	3-2 phi	> 4 phi	3	0.25	7.27	8.34	1.07	7.81	0	0	0	0	0	0
NEREF3	C	7/2/2002	15:30	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	7.64	8.71	1.07	8.18	0	0	0	0	0	0
NEREF4	A	7/2/2002	15:16	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	8	0.6	10.48	12.09	1.61	11.28	0	0	0	0	0	0
NEREF4	B	7/2/2002	15:17	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	0	0	10.55	11.09	0.54	10.82	0	0	0	0	0	0
NEREF4	C	7/2/2002	15:18	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	0	0	9.71	10.79	1.08	10.25	0	0	0	0	0	0
NEREF5	A	7/2/2002	15:12	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	11	11.43	0.43	11.22	0	0	0	0	0	0
NEREF5	B	7/2/2002	15:13	ST I	> 4 phi	3-2 phi	> 4 phi	0	0	9.7	10.07	0.37	9.89	0	0	0	0	0	0
NEREF5	C	7/2/2002	15:13	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	2	0.27	11.7	12.7	1	12.2	0	0	0	0	0	0
SWREF1	A	7/2/2002	15:57	ST I on III	> 4 phi	3-2 phi	> 4 phi	0	0	8.5	8.93	0.43	8.72	0	0	0	0	0	0
SWREF1	B	7/2/2002	15:58	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	0	0	5.16	7.96	2.8	6.56	0	0	0	0	0	0
SWREF1	C	7/2/2002	15:59	ST I	> 4 phi	4 to 3 phi	> 4 phi	3	0.14	8.38	9.14	0.76	8.76	0	0	0	0	0	0
SWREF2	A	7/1/2002	19:36	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	5	0.45	8.8	9.55	0.75	9.18	0	0	0	0	0	0
SWREF2	B	7/1/2002	19:36	ST I	> 4 phi	4 to 3 phi	> 4 phi	0	0	8.71	9.43	0.72	9.07	0	0	0	0	0	0
SWREF2	C	7/1/2002	19:37	ST I	> 4 phi	4 to 3 phi	> 4 phi	5	0.28	9.66	11.04	1.38	10.35	0	0	0	0	0	0
SWREF3	A	7/2/2002	16:02	ST I	> 4 phi	4 to 3 phi	> 4 phi	18	0.65	7.07	8.14	1.07	7.61	0	0	0	0	0	0
SWREF3	B	7/2/2002	16:03	ST I on III	> 4 phi	3-2 phi	> 4 phi	4	0.28	4.55	7.55	3	6.05	0	0	0	0	0	0
SWREF3	C	7/2/2002	16:04	ST I	> 4 phi	3-2 phi	> 4 phi	5	0.73	6.66	9.52	2.86	8.09	0	0	0	0	0	0
SWREF4	A	7/2/2002	15:51	ST I	> 4 phi	4 to 3 phi	> 4 phi	0	0	8.93	10.23	1.3	9.58	0	0	0	0	0	0
SWREF4	B	7/2/2002	15:52	ST I	> 4 phi	3-2 phi	> 4 phi	3	0.15	9.89	10.98	1.09	10.43	0	0	0	0	0	0
SWREF4	C	7/2/2002	15:53	ST I	> 4 phi	4 to 3 phi	> 4 phi	2	0.31	7.89	8.88	0.99	8.39	0	0	0	0	0	0
SWREF5	A	7/1/2002	19:42	ST I on III	> 4 phi	4 to 3 phi	> 4 phi	0	0	9.48	10.12	0.64	9.8	0	0	0	0	0	0
SWREF5	B	7/1/2002	19:43	ST I on III	> 4 phi	3-2 phi	> 4 phi	0	0	7.32	9.59	2.27	8.45	0	0	0	0	0	0
SWREF5	C	7/1/2002	19:44	ST I	> 4 phi	3-2 phi	> 4 phi	2	0.23	8.52	8.98	0.46	8.75	0	0	0	0	0	0

Appendix A2 (continued)

Machias Bay Disposal Site (MADS) Reference Area REMOTS® Sediment-Profile Imaging Data from the July 2002 Survey

Station	Replicate	Date	Time	Apparent RPD Thickness (cm)			Methane			OSI	Surface	Low	Comments
				Min	Max	Mean	Count	Mean Depth	Diam.		Roughness	DO	
NEREF1	A	7/2/2002	15:05	0.29	4.97	2.34	0	0	0	9	Physical	NO	Ambient tan/gry sandy m, surf tubes, sm voids
NEREF1	B	7/2/2002	15:06	0.50	4.32	2.34	0	0	0	5	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, ox & red clasts, sm void, red sed @z, sm worms @z
NEREF1	C	7/2/2002	15:06	0.14	3.35	1.29	0	0	0	3	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, ox & red m clasts, wht shells @z, sm worms @z, lg burrowing polychaete @z, patchy RPD
NEREF2	C	7/2/2002	15:25	0.71	5.76	2.96	0	0	0	5	Biogenic	NO	Ambient tan/gry sandy m, sm tubes, ox & red clasts, worms @z
NEREF2	D	7/3/2002	17:24	1.22	4.03	2.26	0	0	0	9	Physical	NO	Ambient reddish-tan/gry&blk sandy m, tubes, voids, red sed @z, worms @z, surf reworking
NEREF2	E	7/3/2002	17:25	0.65	4.53	2.45	0	0	0	9	Physical	NO	Ambient tan/gry sandy m, tubes, ox & red m clasts, voids, oxidized burrow
NEREF3	A	7/2/2002	15:29	0.57	4.27	2.25	0	0	0	4	Physical	NO	Ambient tan/gry sandy m, sm tubes
NEREF3	B	7/2/2002	15:30	0.92	3.27	1.79	0	0	0	5	Physical	NO	Ambient tan/gry sandy m, tubes, wiper clasts-obscured & patchy RPD, burrow mound farfield?
NEREF3	C	7/2/2002	15:30	0.28	4.05	1.79	0	0	0	4	Physical	NO	Ambient tan/gry sandy m, tubes, sm worms @z
NEREF4	A	7/2/2002	15:16	0.21	4.34	2.19	0	0	0	8	Physical	NO	Ambient tan/gry sandy m, ox & red m clasts, tubes, v sm void, worms @z, burrowing anemone?? @z
NEREF4	B	7/2/2002	15:17	0.07	4.27	1.64	0	0	0	8	Physical	NO	Ambient tan/gry sandy m, sm tubes, wiper clasts, sm voids, burrows, red sed patches@z
NEREF4	C	7/2/2002	15:18	0.14	4.34	1.66	0	0	0	8	Physical	NO	Ambient tan/gry&blk sandy m, surf tubes, voids, sm burrow-opening, biogenic surf rewking, red sed patches @ depth
NEREF5	A	7/2/2002	15:12	1.49	5.19	3.08	0	0	0	6	Biogenic	NO	Ambient reddish-tan/gry sandy m, surf tubes, biogenic mound-far=fecal mound?, sm worms @z
NEREF5	B	7/2/2002	15:13	0.21	4.05	1.74	0	0	0	4	Biogenic	NO	Ambient tan/gry sandy m, tubes, fecal mound?, sm worms @z
NEREF5	C	7/2/2002	15:13	0.28	3.13	1.28	0	0	0	7	Physical	NO	Ambient tan/gry sandy m, sm tubes, ox & red m clasts, voids, sm worms @z, biogenic surf reworking, small void
SWREF1	A	7/2/2002	15:57	0.07	4.05	1.71	0	0	0	8	Biogenic	NO	Ambient reddish-tan/gry sandy m, tubes, voids, worms @z, biogenic mound, burrow
SWREF1	B	7/2/2002	15:58	0.07	3.13	1.24	0	0	0	7	Physical	NO	Ambient reddish-tan/gry sandy m, tubes, voids, patchy RPD
SWREF1	C	7/2/2002	15:59	0.07	3.41	1.70	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, small surf tubes, worms @z, ox clasts
SWREF2	A	7/1/2002	19:36	0.07	3.79	1.75	0	0	0	8	Biogenic	NO	Ambient reddish-tan/gry sandy m, tubes, ox voids, ox & red clasts, shell frag
SWREF2	B	7/1/2002	19:36	0.22	3.77	0.69	0	0	0	2	Biogenic	NO	Ambient reddish-tan/gry sandy m, tubes, worms @z, burrow opening?
SWREF2	C	7/1/2002	19:37	0.21	3.71	1.73	0	0	0	4	Physical	NO	Ambient tan/gry sandy m, tubes, ox & red clasts, wiper clast
SWREF3	A	7/2/2002	16:02	0.07	4.16	1.65	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, worms @z, ox & red clasts, red sed @surf & @z, patchy RPD, m clumps-far
SWREF3	B	7/2/2002	16:03	0.43	3.84	1.83	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy m, irreg topo, tubes, voids??, ox & red clasts, worms @z
SWREF3	C	7/2/2002	16:04	0.07	4.69	2.03	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, tubes, ox & red m clasts,wht clay chips @z, mud clasts=physical disturbance=trawling?
SWREF4	A	7/2/2002	15:51	0.36	5.19	2.48	0	0	0	5	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes
SWREF4	B	7/2/2002	15:52	0.28	5.19	2.58	0	0	0	5	Physical	NO	Ambient reddish-tan/gry sandy m, tubes, ox clasts, sm burrow,bio rewrking of surf lyr
SWREF4	C	7/2/2002	15:53	0.14	3.91	1.32	0	0	0	3	Biogenic	NO	Ambient reddish-tan/gry sandy m, sm tubes, ox & red clasts, burrow opening, biogenic mound farfield?
SWREF5	A	7/1/2002	19:42	0.07	4.38	1.75	0	0	0	8	Physical	NO	Ambient reddish-tan/gry sandy m, tubes, sm void, wiper clast
SWREF5	B	7/1/2002	19:43	0.07	3.72	1.01	0	0	0	7	Physical	NO	Ambient reddish-tan/gry&blk sandy m, sm tubes, voids, burrows, shell frag @ surf, red sed @surf & @z, patchy RPD
SWREF5	C	7/1/2002	19:44	0.57	4.48	2.08	0	0	0	4	Physical	NO	Ambient reddish-tan/gry sandy m, sm tubes, ox clasts, burrow-opening

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