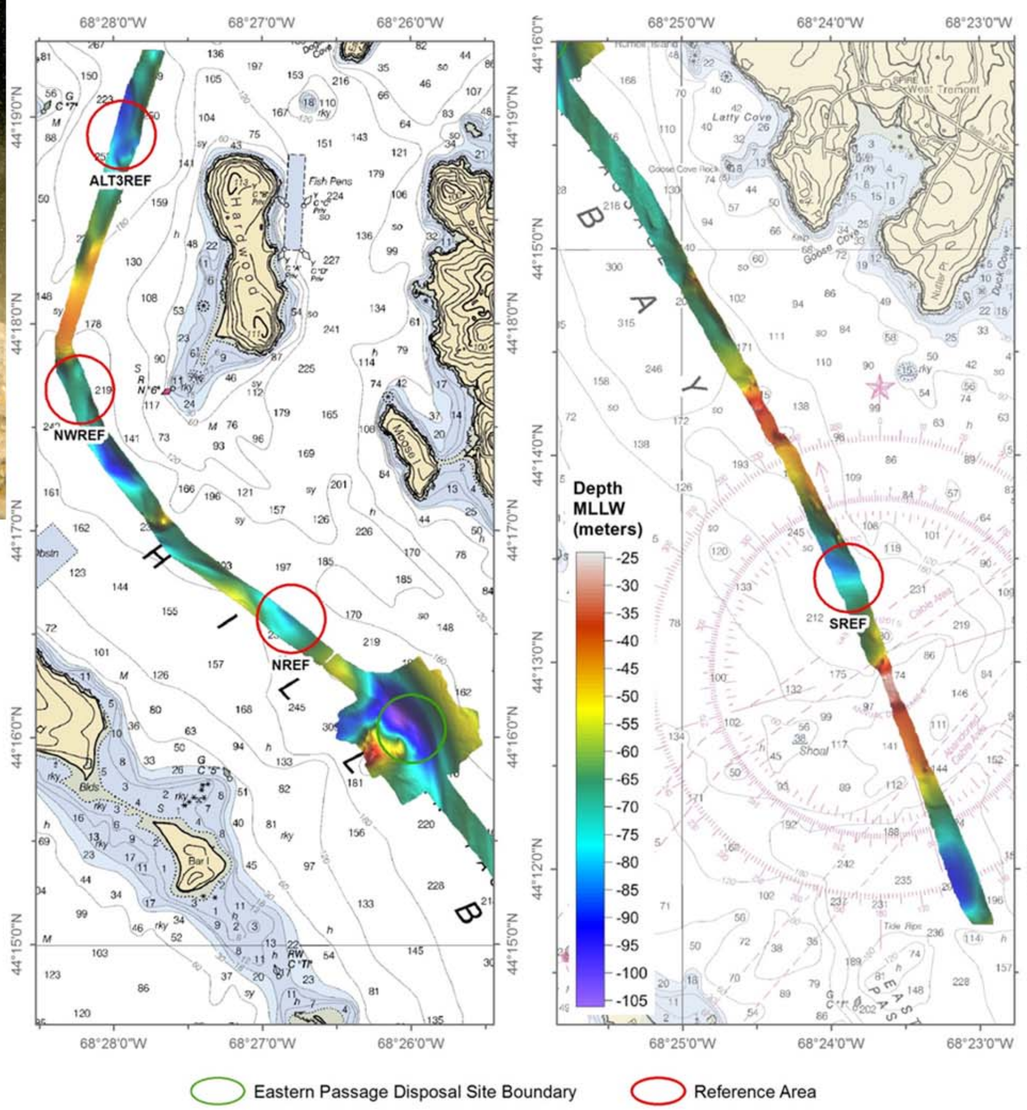
Monitoring Survey at the Eastern Passage Disposal Site
October 2012

Disposal Area Monitoring System DAMOS



D A M O S
DISPOSAL AREA MONITORING SYSTEM

Contribution 194
June 2013

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13. ABSTRACT

A monitoring survey was conducted in 2012 at the Eastern Passage Disposal Site (EPDS) as part of the Disposal Area Monitoring System (DAMOS) Program. The 2012 monitoring effort involved a high-resolution acoustic survey to characterize seafloor topography and dredged material distribution, as well as sediment-profile imaging (SPI) and plan-view imaging (PV) surveys to provide additional physical characterization and to assess benthic recolonization. The results of the 2012 surveys were used to document changes at EPDS since placement of approximately 52,000 m^3 of dredged material at the site.

EPDS is located in a trough in the tidal channel of Blue Hill Bay with hard rocky bottom to the southwest and a slope of soft sediment to the east. The high-resolution acoustic survey was conducted over a square-shaped area that incorporated the entire disposal site. A reconnaissance acoustic survey was conducted north and south of the disposal site to locate potential reference areas. The acoustic survey revealed a small deposit of dredged material near the center of the disposal site in the trough. The peak of the deposit was approximately 5 m above the surrounding seafloor, and the deposit covered an area of approximately 170 × 80 m. This deposit was consistent with expectations resulting from placement of a small amount of dredged material (~52,000 m^3) within a closely spaced series of release locations in over 100 m of water. SPI and PV images were collected from EPDS and four candidate reference areas, two suitable reference areas were selected from these candidate areas within the tidal channel of Blue Hill Bay. The suitable reference areas were selected for the presence of soft sediments similar to those located within the trough at EPDS.

The 2012 survey revealed two distinct sedimentary habitats and associated biological communities within EPDS: a fine-grained, soft-bottom infaunal community in the central trough and northeast shoal area, and a hard-bottom epifaunal fouling community in the southwest shoal area. The recent dredged material was placed primarily in the central trough area on fine-grained, soft-bottom substrata. The hard-bottom area was not intended to receive dredged material and stations collected in this area were excluded from comparison with reference area characteristics.

EPDS has experienced full recovery of the benthic community in the year and a half since cessation of dredged material placement activities. Given the complete recovery of the benthic infaunal community, it is predicted that the effects from any future disposal operations at EPDS would be transient and the infaunal community would quickly reestablish itself within 12–18 months following completion of disposal operations. Future dredged material placement should be limited to the central trough area due to the favorable topography and sediment types observed in this area. Future confirmatory survey work at EPDS is conditional on additional placement of a significant amount of dredged material. Two reference areas, SREF and ALT3REF, are recommended as suitable reference areas for future monitoring surveys.

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Frontispiece

Bass Harbor Navigation Project

Bass Harbor in Tremont, Maine, is a large cove located on the southwest side of Mount Desert Island in Blue Hill Bay, about 13 miles southwest of Bar Harbor. The Tremont sections of McKinley and Bernard abut the harbor and are home to a large commercial fishing fleet. The harbor also provides ferry and freight service to Frenchboro, Swans, and numerous other offshore islands.

The project in Bass Harbor consists of three adjoining anchorages off the Bernard shore, between Tryhouse Point at the entrance to the harbor and Johns Island about 2,000 feet inside the harbor. The central anchorage is 10 feet deep and eight acres in area and provides access from the harbor entrance to the ledge area south of Johns Island. The westernmost anchorage, six feet deep and six acres in area, is located between the central anchorage and the Bernard shore, immediately north of Tryhouse Point. The uppermost anchorage is six feet deep and 10 acres in area and extends from the central anchorage to Johns Island, then swings northeasterly around the island (USACE 2013).

Note on units of this report: As a scientific contribution, information and data are presented in the metric system. However, given the prevalence of English units in the dredging industry of the United States, conversions to English units are provided for general information in Section 1. A table of common conversions can be found in Appendix D.

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EXECUTIVE SUMMARY

A monitoring survey was conducted in 2012 at the Eastern Passage Disposal Site (EPDS) as part of the Disposal Area Monitoring System (DAMOS) Program. The 2012 monitoring effort involved a high-resolution acoustic survey to characterize seafloor topography and dredged material distribution, as well as sediment-profile imaging (SPI) and plan-view imaging (PV) surveys to provide additional physical characterization and to assess benthic recolonization. The results of the 2012 surveys were used to document changes at EPDS since placement of approximately 52,000 m^3 of dredged material at the site.

EPDS is located in a trough in the tidal channel of Blue Hill Bay with hard rocky bottom to the southwest and a slope of soft sediment to the east. The high-resolution acoustic survey consisted of multibeam bathymetric and acoustic backscatter data acquisition. The survey was conducted over a square-shaped area that incorporated the entire disposal site. A reconnaissance acoustic survey was conducted north and south of the disposal site to locate potential reference areas. Four candidate reference areas were selected along the tidal channel. The acoustic survey revealed a small deposit of dredged material near the center of the disposal site in the trough. The peak of the deposit was approximately 5 m above the surrounding seafloor, and the deposit covered an area of approximately 170 × 80 m.

This deposit was consistent with expectations resulting from placement of a small amount of dredged material (~52,000 m^3) within a closely spaced series of release locations in over 100 m of water. There is evidence in acoustic backscatter results that dredged material spread in a thin apron over a northeast shoal area within the disposal site due to placement in relatively deep water and potentially strong tidal currents present in the center of the disposal site.

SPI and PV images were collected from EPDS and four candidate reference areas, two suitable reference areas were selected from these candidate areas within the tidal channel of Blue Hill Bay. The suitable reference areas were selected for the presence of soft sediments similar to those located within the trough at EPDS.

The 2012 survey revealed two distinct sedimentary habitats and associated biological communities within EPDS: a fine-grained, soft-bottom infaunal community in the central trough and northeast shoal area, and a hard-bottom epifaunal fouling community in the southwest shoal area. The recent dredged material was placed primarily in the central trough area on fine-grained, soft-bottom substrata. The hard-bottom area was not intended to receive dredged material and stations collected in this area were excluded from comparison with reference area characteristics.

Evidence of Stage 3 successional status was present in all replicate images from all survey stations, suggesting that the benthic community at the disposal site had recovered and was equivalent to reference area benthic communities. Evidence of deep deposit-feeding infauna was present throughout the disposal site, and the aRPD depths within the disposal site boundary were slightly elevated compared to those found in the ambient sediments.

EPDS has experienced full recovery of the benthic community in the year and a half since cessation of dredged material placement activities. Given the complete recovery of the benthic infaunal community, it is predicted that the effects from any future disposal operations at EPDS would be transient and the infaunal community would quickly reestablish itself within 12–18 months following completion of disposal operations. Future dredged material placement should be limited to the central trough area due to the favorable topography and sediment types observed in this area. Future confirmatory survey work at EPDS is conditional on additional placement of a significant amount of dredged material. Two reference areas, SREF and ALT3REF, are recommended as suitable reference areas for future monitoring surveys.

1.0 INTRODUCTION

A monitoring survey was conducted at the Eastern Passage Disposal Site (EPDS) in October 2012 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS) Program. DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns surrounding the placement of dredged material at aquatic disposal sites throughout the New England region. An introduction to the DAMOS Program and EPDS, including brief descriptions of previous dredged material disposal and site monitoring activities, is provided below.

1.1 Overview of the DAMOS Program

The DAMOS Program features a tiered management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal are promptly identified and addressed (Germano et al. 1994). For over 35 years, the DAMOS Program has collected and evaluated disposal site data throughout New England. Based on these data, patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity have been documented (Fredette and French 2004).

DAMOS monitoring surveys fall into two general categories: confirmatory studies and focused studies. Confirmatory studies are designed to test hypotheses related to expected physical and ecological response patterns following placement of dredged material on the seafloor at established, active disposal sites. The data collected and evaluated during these studies provide answers to strategic management questions in determining the next step in the disposal site management process. Focused studies are periodically undertaken within the DAMOS Program to evaluate inactive/historical disposal sites or potential new sites and contribute to the development of dredged material placement and capping techniques. The resulting information is used to guide the management of disposal activities at each site. The 2012 EPDS investigation was a confirmatory study featuring monitoring of an area that had recently received dredged material.

Two primary goals of DAMOS confirmatory monitoring surveys are to document the physical location and stability of dredged material placed into the aquatic environment and to evaluate the biological recovery of the benthic community following placement of the dredged material. Several survey techniques are employed in order to characterize these responses to dredged material placement. Sequential acoustic monitoring surveys (including bathymetric and acoustic backscatter measurements and side-scan sonar) are made to characterize the height and spread of discrete dredged material deposits or mounds created at open water sites as well as the accumulation/consolidation of dredged material into confined aquatic disposal (CAD) cells. Sediment-profile imaging (SPI) and plan-view underwater camera photography (referred to as plan-view [PV] imaging) surveys are performed to provide further physical characterization of the material and to support evaluation of seafloor (benthic) habitat conditions and recovery over time. Each type of data collection activity is conducted periodically at disposal sites, and the conditions found after a defined period of disposal activity are compared with the long-term data set at a specific site to determine the next step in the disposal site management process (Germano et al. 1994). Focused DAMOS monitoring surveys may also feature additional types of data collection activities as deemed appropriate to achieve specific survey objectives, such as sub-bottom profiling, towed video, sediment coring, or grab sampling.

1.2 Introduction to the Eastern Passage Disposal Site

EPDS is a new dredged material disposal site selected under Section 404 of the Clean Water Act (USACE 2006). EPDS is located in the Eastern Passage of Blue Hill Bay between Bar Island and Dodge Point on Mt. Desert Island, Maine (Figure 1-1). EPDS is defined as a 610-m (2001-ft) diameter circle with its center 1.3 km (0.81 mi) from Dodge Point (Figure 1-2).

In 2006, a navigation improvement feasibility study and associated environmental assessment were conducted to evaluate a proposed dredging project in Bass Harbor on Mt. Desert Island (Figure 1-1). The 2006 Bass Harbor study concluded that EPDS was the most appropriate site to receive Bass Harbor dredged material. Its proximity to Bass Harbor made disposal economically feasible, the presence of similar substrate indicated a depositional environment, and there was reduced fishing activity at EPDS compared to alternative sites (USACE 2006).

In December 2009, an initial single-beam bathymetric survey was conducted to establish baseline conditions at EPDS. The survey found a relatively deep (90 to 105 m [300 to 340 ft]) central trough area along a northwest by southeast axis through the site with relatively steep slopes to shallower (55 to 70 m [180 to 230 ft]) areas in the northeast and southwest portions. Sediment grab samples were collected at five locations within EPDS and found dark-olive, sandy silt in the silt-sized range (USACE 2006).

1.3 Recent Dredged Material Disposal Activity

From October 2010 to April 2011, approximately 52,156 m^3 (68,223 yd^3) of dredged material from Bass Harbor maintenance and improvement projects was placed at

EPDS (Table 1-1). The material was characterized as primarily silty sand and included approximately 1,577 m^3 (2,063 yd^3) of rock. Bass Harbor was mechanically dredged and dredged material was placed at EPDS using two split-hulled barges. The recorded locations of individual disposal events for the October 2010 to April 2011 disposal period are shown in Figure 1-3.

1.4 2012 Survey Objectives

The 2012 confirmatory survey was designed to address the following two objectives:

- To characterize the seafloor topography and surficial features where the recent disposal activities occurred and over the full EPDS by completing a high-resolution acoustic survey, and

- To use SPI/PV imaging to further define the physical characteristics of surficial sediment and to assess the benthic recolonization status (recovery of bottom-dwelling biological community) of the area with recent disposal activity.

Table 1-1.

Estimated Volume of Dredged Material Placed at EPDS in 2010 and 2011

Project	Disposal Dates	Volume (m^3)	Volume (yd^3)
Bass Harbor maintenance	October–December 2010	7,428	9,716
Bass Harbor rock removal	October–December 2010	48	63
Bass Harbor improvement	March–April 2011	43,151	56,444
Bass Harbor rock removal	March–April 2011	1,529	2,000
Total volume		**52,156**	**68,223**

Reference: Personal communication of dredging history from internal USACE records.

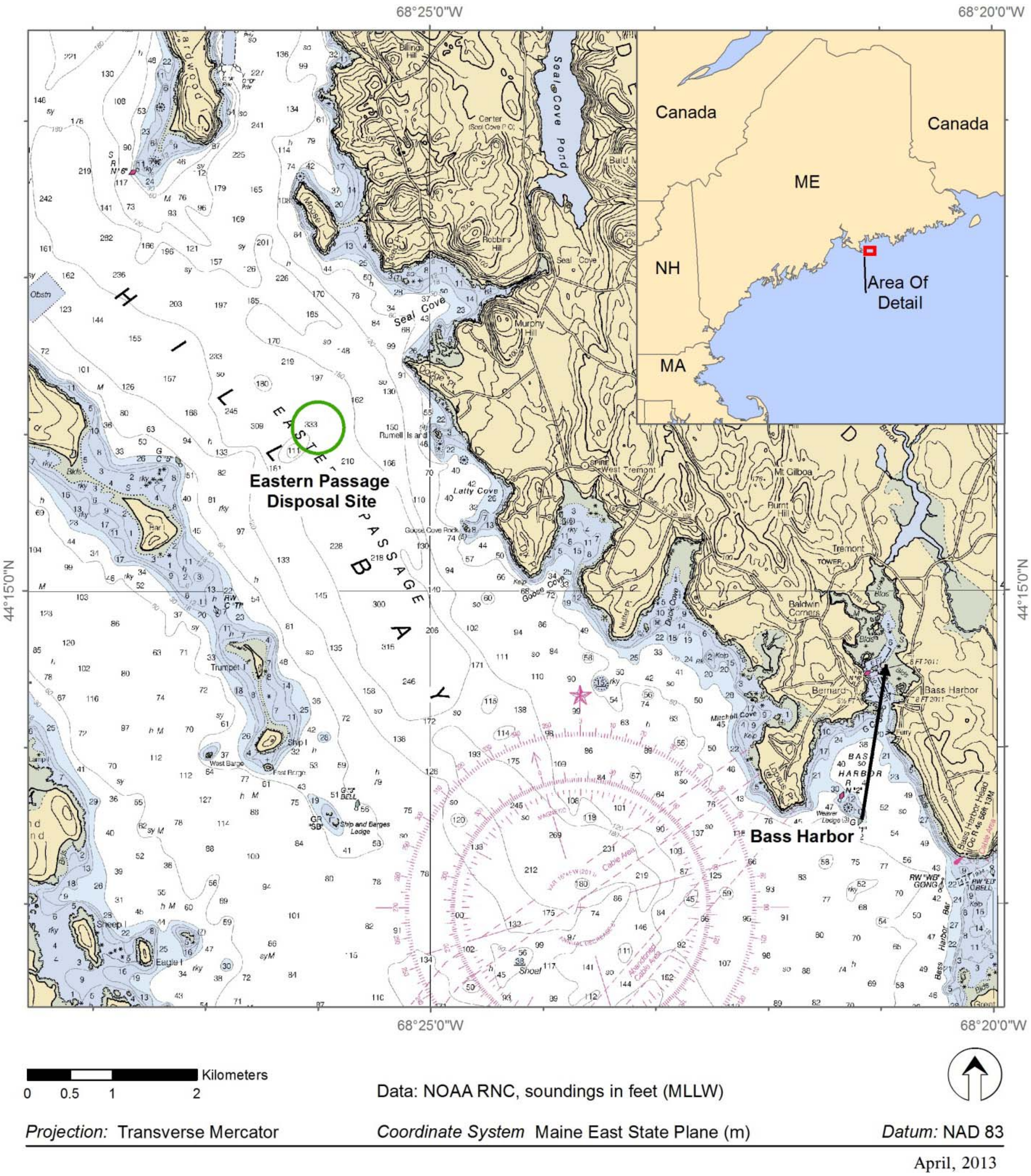


Figure 1-1. Location of the Eastern Passage Disposal Site

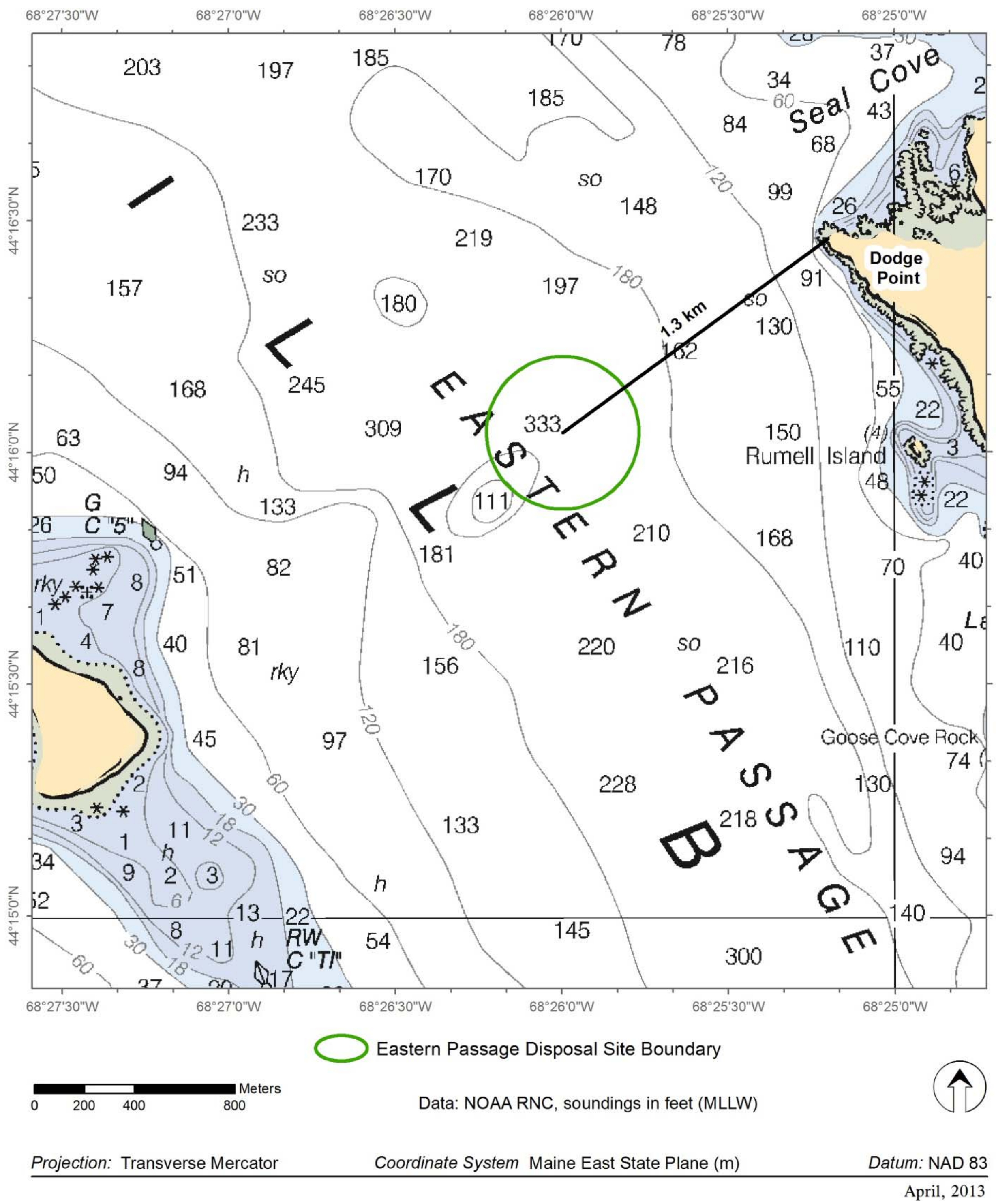


Figure 1-2. Disposal site boundary encompassing a deep area within Eastern Passage

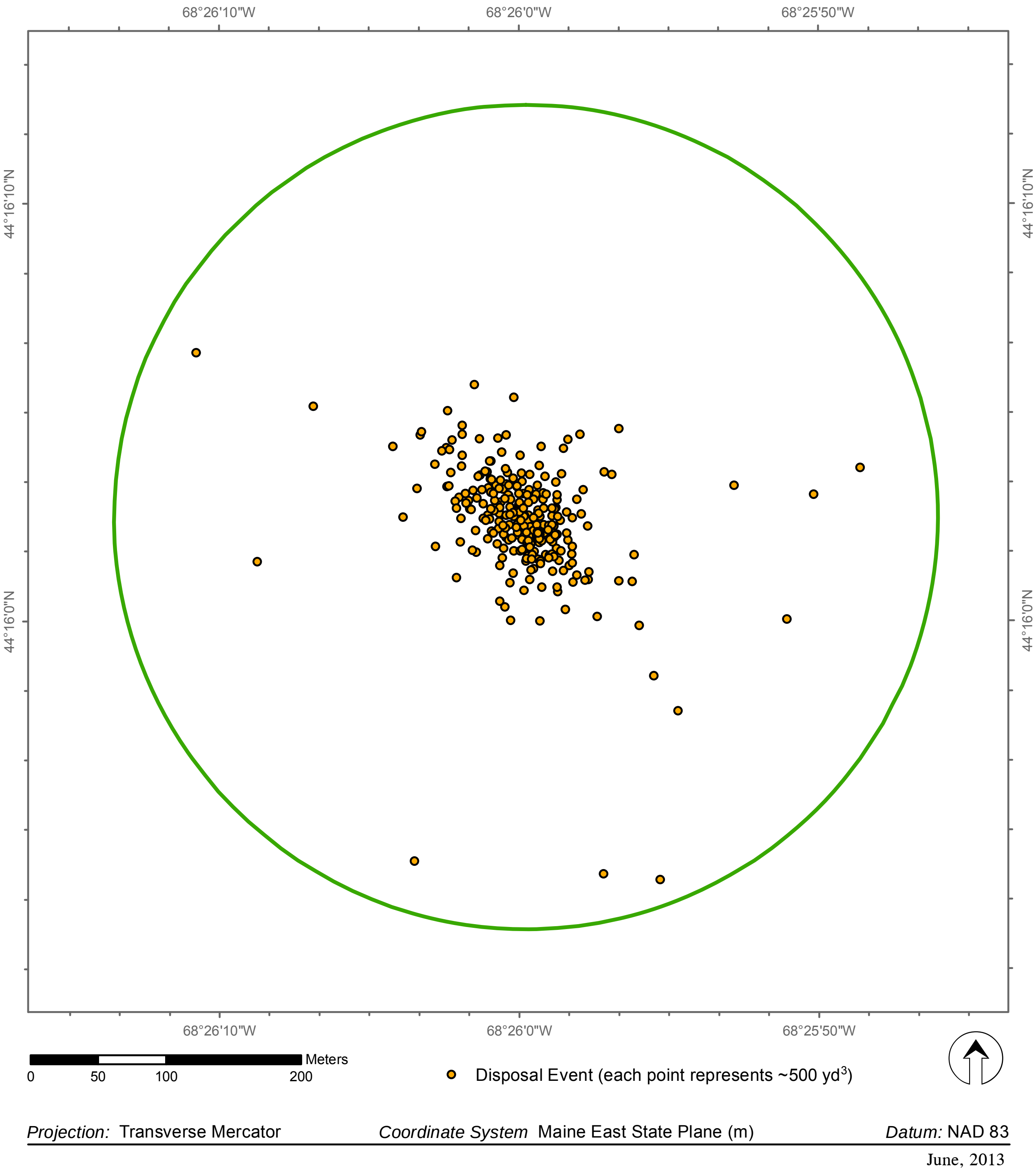


Figure 1-3. Location of disposal events at EPDS over the period of October 2010 to April 2011

2.0 METHODS

The October 2012 survey at EPDS was conducted by a team of investigators from CR Environmental and Germano & Associates aboard the R/V *Jamie Hanna*. The acoustic survey was conducted on 1 October 2012 to assess dredged material distribution at EPDS. The SPI/PV survey was conducted on 15 and 16 October 2012 to assess benthic conditions at EPDS. An overview of the methods used to collect, process, and analyze the survey data is provided below. Detailed Standard Operating Procedures (SOPs) for data collection and processing are available in Carey et al. (2013).

2.1 Navigation and On-Board Data Acquisition

Navigation for the surveys was accomplished using a Hemisphere 12-channel Differential Global Positioning System (DGPS) capable of receiving U.S. Coast Guard (USCG) Beacon corrections. Trimble DGPSs were available as backups. Both systems are capable of submeter horizontal position accuracy. The DGPS was interfaced to a laptop computer running HYPACK MAX® hydrographic survey software. HYPACK MAX® continually recorded vessel position and DGPS satellite quality and provided a steering display for the vessel captain to accurately maintain the position of the vessel along pre-established survey transects and targets.

Redundant vessel heading measurements were acquired using two compass systems, each capable of providing heading measurements accurate to within 0.05° up to 20 times per second. The primary heading device was a SG Brown Meridian Gyrocompass installed in the pilothouse to the port of the vessel's centerline. A dual-antenna Hemisphere VS-100 Crescent Digital compass and DGPS were installed above the pilot house as a backup for the gyrocompass. Both systems were interfaced to HYPACK® acquisition software.

The pulse-per-second (PPS) signals from DGPSs were hardware-interfaced to HYPACK MAX® using a translation circuit and provided microsecond-level accuracy of data stream time-tagging from each sensor.

2.2 Acoustic Survey

The acoustic survey in this study included bathymetric and backscatter data collection and processing. The bathymetric data provided measurements of water depth that, when processed, were used to map the seafloor topography. The processed data was also compared with previous surveys to track changes in the size and location of seafloor features. This technique is the primary tool in the DAMOS Program for mapping the distribution of dredged material at disposal sites. Backscatter data provided images that supported characterization of surficial topography, sediment texture, and roughness.

2.2.1 Acoustic Data Collection

The 2012 multibeam bathymetric survey of EPDS was conducted on 1 October 2012. Data layers generated by the surveys included multibeam bathymetric and sediment acoustic backscatter (beam time-series data) data.

The acoustic survey of EPDS was conducted over an 800 × 800 m area that included the entire site. The EPDS acoustic survey lines were spaced 40 to 80 m apart and oriented in a northeast–southwest direction (Figure 2-1). Transect lines were closer together over a shoal in the southwestern portion of the survey area to capture relatively steeper slopes. In addition, four cross-tie lines, oriented east–west and spanning the survey area, were occupied to assess data quality and the accuracy of tidal corrections (Figure 2-1). The acoustic survey also included a single reconnaissance line roughly north-south along the Eastern Passage to support identification of suitable reference areas (Figure 2-1).

Bathymetric and acoustic backscatter data were collected using a Reson 8101 Multibeam Echo Sounder (MBES). This 240-kHz system forms 101 1.5°-beams distributed equiangularly across a 150° swath. The MBES transducer was mounted amidships to the port rail of the survey vessel using a high-strength adjustable boom, and the primary DGPS antenna was attached to the top of the transducer boom. The transducer depth below the water surface (draft) was checked and recorded at the beginning and end of data acquisition.

The MBES topside processor was equipped with components necessary to export depth solutions and backscatter sonar signals to the HYPACK MAX® acquisition computer via Ethernet communications. HYPACK MAX® also received and recorded navigation data from the DGPS, motion data from a serially interfaced TSS DMS 3-05 motion reference unit (MRU), and heading data from the Meridian and Hemisphere compass systems. Several patch tests were conducted during the survey to allow computation of angular offsets between the MBES system components. The system was calibrated for speed-of-sound in the local water body by performing conductivity-temperature-depth (CTD) casts at frequent intervals throughout the survey day with a Seabird SBE-19 Seacat CTD profiler. Additional confirmations of proper calibration, including static draft, were obtained using the "bar check" method, in which a metal plate was lowered beneath the MBES transducer to known depths (e.g., 2.0 and 5.0 m) below the water surface. Bar-check calibrations were accurate to within 0.05 m in tests conducted at the beginning and end of each day.

Water depths over the survey area were recorded in meters and referenced to water levels recorded by the National Oceanic and Atmospheric Administration's (NOAA) Bar Harbor Tide Station (#8413320), located approximately 23 km northeast of the survey area.

2.2.2 Bathymetric Data Processing

Bathymetric data were processed using HYPACK HYSWEEP® software. Processing components are described below and included

- Adjustment of data for tide fluctuations
- Correction of ray bending associated with refraction in the water column
- Removal of spurious points associated with water column interference or system errors
- Development of a grid surface representing depth solutions
- Statistical estimation of sounding solution uncertainty
- Generation of data visualization products

Tidal adjustments were accomplished using a Tide Zoning Model calculated by NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) specifically for this survey area. The model applied corrections of +6 minutes and height × 0.96 to the six-minute Mean Lower Low Water (MLLW) data series acquired at the NOAA Bar Harbor Tide Station.

Correction of sounding depth and position (range and azimuth) associated with refraction due to water column stratification was conducted using a series of five sound-velocity profiles acquired by the survey team. The water column appeared well mixed during the survey, and data artifacts associated with refraction were relatively fine scale.

Data were filtered to accept only beams falling at an angular limit of 50°. Anomalous soundings were flagged or rejected based on the careful examination of data on a sweep-specific basis.

The 240-kHz Reson 8101 MBES system had a published nadir beam width of 1.5° across track and 1.5° along track. Assuming an average slant range of 80 m per channel and a maximum beam angle of 50°, the average diameter of the beam footprint has been calculated as approximately 3.3 × 5.1 m (16.5 m^2). Data were reduced to a cell (grid) size of 4.0 × 4.0 m, acknowledging the system's fine range resolution while accommodating beam position uncertainty. This data reduction was accomplished by calculating and exporting the average elevation for each cell in accordance with USACE recommendations (USACE 2002).

Within-cell standard deviations (1-sigma) ranged from 0 to 2.60 m (average 0.11). The average Root Mean Squared uncertainty at the 95th percentile confidence interval (1.96 - sigma) was 0.22 m. It is noteworthy that the most stringent National Ocean Service (NOS) and International Hydrographic Organization (IHO) standard for this project depth (Special Order 1A) would call for a 95th percentile confidence interval (95% CI) of 0.83 m at the maximum site depth and 0.56 m at the average site depth. The MBES data collected for this project were compliant with all applicable performance standards.

Reduced data were exported in ASCII text format with fields for Easting, Northing, and MLLW elevation (meters). All data were projected to the Maine State Plane (East 1801), North American Datum of 1983 (NAD83, metric). A variety of data visualizations were generated using a combination of IVS3D Fledermaus® (V.7), ESRI ArcMap® (V.10.1), and Golden Software Surfer® (V. 10). Visualizations and data products included

- ASCII databases of all processed soundings including MLLW depths and elevations

- Contours of seabed elevation (25-cm, 50-cm and 1.0-m intervals) in SHP format suitable for plotting using GIS (Geographic Information Systems) and CAD (Computer Aided Design) software

- 3-Dimensional surface maps of the seabed created using 5× vertical exaggeration and artificial illumination to highlight fine-scale features not visible on contour layers (delivered in grid and TIF formats)

- A relief map of the survey area created using 5× vertical exaggeration, delivered in georeferenced TIF format

2.2.3 Backscatter Data Processing

Backscatter data provide an estimation of surficial sediment texture based on sediment surface roughness and were extracted from cleaned files and converted to Generic Sensor Format (GSF). Mosaics of beam time-series (BTS) backscatter data were created using HYPACK®'s implementation of GeoCoder software developed by scientists at the University of New Hampshire/NOAA Center for Coastal and Ocean Mapping (UNH/NOAA CCOM). A mosaic of unfiltered BTS data were developed and exported in grayscale TIF format. BTS data were also exported in ASCII format with fields for Easting, Northing, and backscatter (dB). A Gaussian filter was applied to backscatter data to minimize nadir artifacts, and the filtered data were used to develop a grid of backscatter values using a 3-m node interval. The grid was delivered in ESRI binary GRD format to facilitate comparison with other data layers.

2.2.4 Side-Scan Sonar Data Processing

The side-scan sonar data were processed using both Chesapeake Technology, Inc. SonarWiz software and HYPACK®'s implementation of GeoCoder software. Individual georeferenced TIF images of each sonar file and georeferenced mosaics with resolutions of 0.1–0.2 m/pixel were generated. The mosaic side-scan sonar data were merged with bathymetric data and formatted for 3D display using Fledermaus® software.

2.2.5 Acoustic Data Analysis

The processed bathymetric grids were converted to rasters, and bathymetric contour lines and acoustic relief models were generated and displayed using GIS. GIS was also used to calculate depth difference grids between the previous bathymetric survey and the 2012 bathymetric dataset. The previous bathymetric survey at EPDS was conducted in 2009. The depth difference grids were calculated by subtracting the 2009 survey depth estimates from the 2012 survey depth estimates at each point throughout the grid. The resulting depth differences were contoured and displayed using GIS. Backscatter and side-scan sonar mosaics and filtered backscatter grids were combined with acoustic relief models in GIS to facilitate visualization of relationships between acoustic datasets (images and color-coded grids are rendered with sufficient transparency to allow three-dimensional acoustic relief model to be visible underneath).

2.3 Sediment-Profile and Plan-View Imaging Survey

2.3.1 Sediment-Profile Imaging

Sediment-profile imaging (SPI) is a monitoring technique used to provide data on the physical characteristics of the seafloor as well as the status of the benthic biological community. The technique involves deploying an underwater camera system to photograph a cross section of the sediment-water interface. In the 2012 survey at EPDS, high-resolution SPI images were acquired using a Nikon® D200 digital single lens reflex camera mounted inside an Ocean Imaging® Model 3731 pressure housing system. The pressure housing sat atop a wedge-shaped prism with a front faceplate and a back mirror. The mirror was mounted at a 45° angle to reflect the profile of the sediment-water interfaces the prism penetrated the seafloor, a trigger activated a time-delay circuit that fired an internal strobe to obtain a cross-sectional image of the upper 15–20 cm of the sediment column (Figure 2-2).

The camera remained on the seafloor for approximately 20 seconds to ensure that a successful image had been obtained. Details of the camera settings for each digital image are available in the associated parameters file embedded in each electronic image file. For this survey, the ISO-equivalent was set at 400, shutter speed was 1/20, f-stop was f14, and storage was in compressed raw Nikon Electronic Format (NEF) files (approximately 9 MB each). Electronic files were converted to high-resolution JPEG (8-bit) format files (3300 × 4900 pixels) using Nikon Capture® NX2 software (Version 2.2.7).

Test exposures of the Kodak® Color Separation Guide (Publication No. Q-13) were made on deck at the beginning and end of the 2012 survey to verify that all internal electronic systems were working to design specifications and to provide a color standard against which final images could be checked for proper color balance. After deployment of the camera at each station, the frame counter was checked to ensure that the requisite number of replicates had been obtained. In addition, a prism penetration depth indicator on the camera frame was checked to verify that the optical prism had actually penetrated the bottom to a sufficient depth. If images were missed or the penetration depth was insufficient, the camera frame stop collars were adjusted and/or weights were added or removed, and additional replicate images were taken. Changes in prism weight amounts, the presence or absence of mud doors, and frame stop collar positions were recorded for each replicate image.

Each image was assigned a unique time stamp in the digital file attributes by the camera's data logger and cross-checked with the time stamp in the navigational system's computer data file. In addition, the field crew kept redundant written sample logs. Images were downloaded periodically to verify successful sample acquisition and/or to assess what type of sediment/depositional layer was present at a particular station. Digital image files were renamed with the appropriate station names immediately after downloading as a further quality assurance step.

2.3.2 Plan-View Imaging

An Ocean Imaging® Model DSC16000 plan-view underwater camera (PV) system with two Ocean Imaging® Model 400-37 Deep Sea Scaling lasers mounted to the DSC16000 was attached to the sediment-profile camera frame and used to collect plan-view photographs of the seafloor surface; both SPI and PV images were collected during each “drop” of the system. The PV system consisted of a Nikon D-7000 encased in an aluminum housing, a 24 VDC autonomous power pack, a 500 W strobe, and a bounce trigger. A weight was attached to the bounce trigger with a stainless steel cable so that the weight hung below the camera frame; the scaling lasers projected two red dots that are separated by a constant distance (26 cm) regardless of the field-of-view of the PV system, which can be varied by increasing or decreasing the length of the trigger wire. The field-of-view for the PV images ranged from approximately 0.4 to 1.4 m^2 (Appendix C). As the camera apparatus was lowered to the seafloor, the weight attached to the bounce trigger contacted the seafloor prior to the camera frame hitting the bottom and triggered the PV camera (Figure 2-2). Details of the camera settings for each digital image are available in the associated parameters file embedded in each electronic image file; for this survey, the ISO-equivalent was set at 400. The additional camera settings used were as follows: shutter speed 1/20, f 14, white balance set to flash, color mode set to Adobe RGB, sharpening set to none, noise reduction off, and storage in compressed raw NEF files (approximately 20 MB each). Electronic files were converted to high-resolution JPEG (8-bit) format files (3264 × 4928 pixels) using Nikon Capture® NX2 software.

Prior to field operations, the internal clock in the digital PV system was synchronized with the GPS navigation system and the SPI camera. Each PV image acquired was assigned a time stamp in the digital file and redundant notations in the field and navigation logs. Throughout the survey, PV images were downloaded at the same time as the SPI images after collection and evaluated for successful image acquisition and image clarity.

The ability of the PV system to collect usable images was dependent on the clarity of the water column. To minimize the effects of turbid bottom waters, the bounce trigger cable was shortened to 1 m in order to decrease the distance between the camera focal plane and the seafloor. By limiting the distance between the camera lens port and the intended subject, picture clarity was improved. One major drawback to the relatively short trigger cable length and close distance between the PV system and the seafloor was that the field-of-view of the PV system was decreased so that a smaller area of the seafloor was photographed.

2.3.3 SPI and PV Data Collection

Prior to the SPI/PV survey, the preliminary October 2012 acoustic survey results were reviewed and analyzed. Within EPDS, a central trough area was selected as being most likely to have received dredged material given the recorded scow placement locations (Figure 1-3). Twelve stations were randomly selected within the central trough area, and three stations were randomly selected in each of two shoal areas to the northeast and southwest of the central trough area (Figure 2-3 and Table 2-1).

To support selection of reference areas, the acoustic reconnaissance survey was reviewed, and potentially suitable reference areas were selected based on several factors including sediment type and water depth. Four potentially suitable reference areas (identified as North [NREF], Northwest [NWREF], South [SREF] and Alternate3 [ALT3REF]) were selected, and six stations were randomly selected within each reference area (Figure 2-4). Target SPI/PV station locations are provided in Table 2-1, and actual SPI/PV station replicate locations are provided in Table 2-2.

The SPI/PV survey was conducted at EPDS on 15 and 16 October 2012 aboard the R/V *Jamie Hanna*. At each station, the vessel was positioned at the target coordinates and the camera was deployed within a defined station tolerance of 10 m. Four replicate SPI and PV images were collected at each of the stations (Table 2-2). The three replicates with the best quality images from each station were chosen for analysis (Appendices A and C).

The DGPS described above was interfaced to HYPACK® software via laptop serial ports to provide a method to locate and record target sampling locations. Throughout the survey, the HYPACK® data acquisition system received DGPS data. The incoming data stream was digitally integrated and stored on the PC's hard drive. Actual SPI/PV sampling locations were recorded as target files using this system.

2.3.4 SPI and PV Data Analysis

Computer-aided analysis of the resulting images provided a set of standard measurements to allow comparisons between different locations and different surveys. The DAMOS Program has successfully used this technique for over 30 years to map the distribution of disposed dredged material and to monitor benthic recolonization at disposal sites. For a detailed discussion of SPI methodology, see Germano et al. (2011).

Following completion of data collection, the digital images were analyzed using Adobe Photoshop® CS 5 Version 12.1. Images were first adjusted in Adobe Photoshop® to expand the available pixels to their maximum light and dark threshold range. Linear and areal measurements were recorded as number of pixels and converted to scientific units using the Kodak® Color Separation Guide for measurement calibration. Detailed records of all SPI results are included in Appendix A.

2.3.4.1 SPI Data Analysis

Analysis of each SPI image was performed to provide measurement of the following standard set of parameters:

Sediment Type–The sediment grain size major mode and range were estimated visually from the images using a grain size comparator at a similar scale. Results were reported using the phi scale. Conversion to other grain size scales is provided in Appendix B. The presence and thickness of disposed dredged material were also assessed by inspection of the images.

Penetration Depth–The depth to which the camera penetrated into the seafloor was measured to provide an indication of the sediment density or bearing capacity. The penetration depth can range from a minimum of 0 cm (i.e., no penetration on hard substrates) to a maximum of 20 cm (full penetration on very soft substrates).

Surface Boundary Roughness–Surface boundary roughness is a measure of the vertical relief of features at the sediment-water interface in the sediment-profile image. Surface boundary roughness was determined by measuring the vertical distance between the highest and lowest points of the sediment-water interface. The surface boundary roughness (sediment surface relief) measured over the width of sediment-profile images typically ranges from 0 to 4 cm, and may be related to physical structures (e.g., ripples, rip-up structures, mud clasts) or biogenic features (e.g., burrow openings, fecal mounds, foraging depressions). Biogenic roughness typically changes seasonally and is related to the interaction of bottom turbulence and bioturbational activities.

Apparent Redox Potential Discontinuity (aRPD) Depth–The aRPD depth provides a measure of the integrated time history of the balance between near-surface oxygen conditions and biological reworking of sediments. Sediment particles exposed to oxygenated waters oxidize and lighten in color to brown or light gray. As the particles are buried or moved down by biological activity, they are exposed to reduced oxygen concentrations in subsurface pore waters and their oxic coating slowly reduces, changing color to dark gray or black. When biological activity is high, the aRPD depth increases; when it is low or absent, the aRPD depth decreases. The aRPD depth was measured by assessing color and reflectance boundaries within the images.

Infaunal Successional Stage–Infaunal successional stage is a measure of the biological community inhabiting the seafloor. Current theory holds that organism-sediment interactions in fine-grained sediments follow a predictable sequence of development after a major disturbance (such as dredged material disposal), and this sequence has been divided subjectively into three stages (Rhoads and Germano 1982, 1986). Successional stage was assigned by assessing which types of species or organism-related activities were apparent in the images.

Additional components of the SPI analysis included calculation of means and ranges for the parameters listed above and mapping of means of replicate values from each station. Station means or maximums were calculated from three replicates from each station and used in statistical analysis.

Hard- or Soft-Bottom–Because EPDS included both a central trough and two shoal areas northeast and southwest of the trough, it was apparent that stations would include a mix of hard-bottom (rock, cobble, or large shells on the surface) and soft-bottom (very fine sand or silt) substrata. Stations were classified as "hard" or "soft" based on penetration depth and surface sediment characteristics visible in SPI and PV images.

2.3.4.2 PV Data Analysis

The PV images provided a much larger field-of-view than the SPI images and provided valuable information about the landscape ecology and sediment topography in the area where the pinpoint "optical core" of the sediment profile was taken. Unusual surface sediment layers, textures, or structures detected in any of the sediment-profile images can be interpreted in light of the larger context of surface sediment features; i.e., is a surface layer or topographic feature a regularly occurring feature and typical of the bottom in this general vicinity or just an isolated anomaly? The scale information provided by the underwater lasers allowed accurate density counts (number per square meter) of attached epifaunal colonies, sediment burrow openings, or larger macrofauna or fish which may have been missed in the sediment-profile cross section. Information on sediment transport dynamics and bedform wavelength were also available from PV image analysis. Analysts calculated the image size and field-of-view and noted sediment type; recorded the presence of bedforms, burrows, tubes, tracks, trails, epifauna, mud clasts, and debris; and included descriptive comments (Appendix C).

2.3.5 Statistical Methods

Statistical analysis was used to aid in the assessment of the benthic recolonization status of the recently formed deposit relative to reference conditions, and to support evaluation of selection of reference areas. The two SPI parameters which are most indicative of recolonization status, and which also lend themselves to quantitative analysis, are the depth of the aRPD (an indirect measure of the degree of biological reworking of surface sediments) and the infaunal successional stage. For the statistical analysis, the mean value for aRPD depth (based on $n = 3$ replicate images) was utilized, while the maximum value among the three replicates was used as the successional stage rank for each station. The successional stage ranks had possible values between 0 (no fauna present) and 3 (Stage 3); half ranks were also possible for the "in-between" stages (e.g., Stage 1 going to 2 had a value of 1.5).

Traditionally, study objectives have been addressed using point null hypotheses of the form "There is no difference in benthic conditions between the reference area and the disposal mound." An approach using bioequivalence or interval testing is considered to be more informative than the point null hypothesis test of "no difference." In reality, there is always some small difference, and the statistical significance of this difference may or may not be ecologically meaningful. Without an associated power analysis, this type of point null hypothesis testing provides an incomplete picture of the results.

In this application of bioequivalence (interval) testing, the null hypothesis presumes the difference is great, i.e., an inequivalence hypothesis (e.g., McBride 1999). This is recognized as a "proof of safety" approach because rejection of the inequivalence null hypothesis requires sufficient proof that the difference is actually small. The null and alternative hypotheses tested are:

H_0: $d \leq -\delta$ or $d \geq \delta$ (presumes the difference is great)

H_A: $-\delta < d < \delta$ (requires proof that the difference is small)

where d is the difference between the reference area and disposal deposit means.

If the null hypothesis is rejected, then it is concluded that the two means are equivalent to one another within $\pm\delta$ units. The size of δ should be determined from historical data and/or best professional judgment to identify a maximum difference that is within background variability/noise and is therefore not ecologically meaningful. Based on historical DAMOS data, δ values of 1 for aRPD depth and 0.5 for successional stage rank (on the 0–3 scale) have been established.

The test of the interval hypothesis can be broken down into two one-sided tests (TOST; McBride 1999 after Schuirmann 1987) which are based on the normal distribution, or, more typically, on Student's *t*-distribution when sample sizes are small and variances must be estimated from the data. The statistics used to test the interval hypotheses shown here are based on such statistical foundations as the Central Limit Theorem (CLT) and basic statistical properties of random variables. A simplification of the CLT says that the mean of any random variable is normally distributed. Linear combinations of normal random variables are also normal, so a linear function of means is also normally distributed. When a linear function of means is divided by its standard error the ratio follows a *t*-distribution with degrees of freedom associated with the variance estimate. Hence, the *t*-distribution can be used to construct a confidence interval around any linear function of means.

During the October 2012 survey, data were collected from EPDS and four distinct reference areas (NWREF, NREF, SREF, and ALT3REF). Multiple reference areas were surveyed to ensure that suitable reference areas would be available to support comparison to the disposal site data. An objective of the statistical analysis was to support selection of two reference areas as appropriate for comparison to EPDS. There were six stations at each of the four reference areas. At the disposal site, there were 12 stations in the trough, three stations on the northeast shoal, and three on the southwest shoal (Figure 2-3). The southwest shoal stations (16–18) were located in a rocky area that was not intended to be part of the dredged material placement activity, so summary statistics for the disposal site stations were limited to Stations 1 through 15. These stations were located on softer sediments and were within the area that received dredged material.

The reference areas collectively represented ambient conditions, but if there had been mean differences among these reference areas then pooling them into a single reference group would have increased the variance beyond true background variability. The effect of keeping the reference areas separate had little effect on the grand reference mean (when n was equal among these areas), but it maintained the variance as a true background variance for each individual population with a constant mean. Based on survey results (Section 3.2) of bottom type, the two reference areas considered to be appropriate for comparison to the disposal deposit stations were SREF and ALT3REF (Section 3.3).

The difference equations, $\hat{d}$, for the comparisons of interest were

$$[½(\text{Mean}_{\text{ALT3REF}} + \text{Mean}_{\text{SREF}}) - (\text{Mean}_{\text{EPDS}})] \qquad \text{[Eq. 1]}$$

where $\text{Mean}_{\text{EPDS}}$ was the mean of the disposal site stations (1–15), and $\text{Mean}_{\text{ALT3REF}}$ and $\text{Mean}_{\text{SREF}}$ were the means of the soft-bottom reference areas. The standard error of each difference equation was calculated from the fact that the variance of a sum is the sum of the variances for independent variables, or

$$se(\hat{d}) = \sqrt{\sum_j \left(S_j^2 c_j^2 / n_j\right)} \qquad \text{[Eq. 2]}$$

Where

c_j = coefficients for the j means in the difference equation, $\hat{d}$ [Eq. 1] (i.e., for equation 1 shown above, the coefficients were ½ for each of the two reference areas, and -1 for the disposal deposit).

S_j^2 = variance for the j^{th} area. If equal variances can be assumed, a single pooled residual variance estimate can be substituted for each group, equal to the mean square error from an ANOVA based on all three groups.

n_j = number of replicate observations for the j^{th} area.

The inequivalence null hypothesis was rejected (and equivalence concluded) if the confidence interval on the difference of means, $\hat{d}$, was fully contained within the interval [−δ , +δ]. Thus the decision rule was to reject H_0 if

$$D_L = \hat{d} - t_{\alpha,\upsilon} se(\hat{d}) > -\delta \quad \text{and} \quad D_U = \hat{d} + t_{\alpha,\upsilon} se(\hat{d}) < \delta \qquad \text{[Eq. 3]}$$

Where

$\hat{d}$ = observed difference in means between the reference areas and disposal site deposit

$t_{\alpha,\upsilon}$ = upper $100(1-\alpha)^{th}$ percentile of a Student's t-distribution with υ degrees of freedom

$se(\hat{d})$ = standard error of the difference (Eq. 2)

υ = degrees of freedom for the standard error. If a pooled residual variance estimate is used, it is the residual degrees of freedom from an ANOVA on all groups (total number of stations minus the number of groups); if separate variance estimates are used, degrees of freedom are calculated based on the Brown and Forsythe estimation (Zar 1996, p. 189).

Validity of the normality and equal variance assumptions were tested using Shapiro-Wilk's test for normality on the area residuals ($\alpha = 0.05$) and Levene's test for equality of variances among the three areas ($\alpha = 0.05$). If normality was not rejected but equality of variances was, then a parametric *t*-interval was used for the difference equation and the variance for the difference equation was based on separate variances for each group.

Table 2-1.

EPDS 2012 Survey Target SPI/PV Station Locations

Target Trough Station Locations			Target Reference Station Locations		
Station	Latitude (N)	Longitude (W)	Station	Latitude (N)	Longitude (W)
1	44° 16.123'	68° 26.054'	NREF-19	44° 16.580'	68° 26.987'
2	44° 16.040'	68° 26.000'	NREF-20	44° 16.671'	68° 26.753'
3	44° 16.060'	68° 26.081'	NREF-21	44° 16.539'	68° 26.698'
4	44° 16.034'	68° 25.932'	NREF-22	44° 16.667'	68° 26.693'
5	44° 16.152'	68° 26.039'	NREF-23	44° 16.498'	68° 26.750'
6	44° 16.114'	68° 25.982'	NREF-24	44° 16.701'	68° 26.876'
7	44° 16.143'	68° 25.988'	NWREF-25	44° 17.680'	68° 28.021'
8	44° 15.943'	68° 25.878'	NWREF-26	44° 17.560'	68° 28.104'
9	44° 16.111'	68° 26.120'	NWREF-27	44° 17.675'	68° 28.137'
10	44° 15.970'	68° 25.869'	NWREF-28	44° 17.799'	68° 28.283'
11	44° 16.067'	68° 25.927'	NWREF-29	44° 17.736'	68° 28.402'
12	44° 16.076'	68° 26.030'	NWREF-30	44° 17.637'	68° 28.123'
			SREF-31	44° 13.482'	68° 23.952'
Target Shoal Station Locations			SREF-32	44° 13.324'	68° 23.826'
13	44° 16.120'	68° 25.859'	SREF-33	44° 13.481'	68° 23.751'
14	44° 16.171'	68° 25.917'	SREF-34	44° 13.379'	68° 24.075'
15	44° 16.057'	68° 25.846'	SREF-35	44° 13.478'	68° 23.913'
16	44° 16.002'	68° 26.081'	SREF-36	44° 13.543'	68° 23.859'
17	44° 16.019'	68° 26.179'	REF-37	44° 11.990'	68° 23.058'
18	44° 15.936'	68° 26.036'	REF-38	44° 11.886'	68° 23.119'
			REF-39	44° 11.929'	68° 23.428'
			REF-40	44° 11.999'	68° 23.241'
			REF-41	44° 11.967'	68° 23.346'
			REF-42	44° 12.013'	68° 23.195'
			REF-43	44° 17.356'	68° 27.958'
			REF-44	44° 17.394'	68° 28.222'
			REF-45	44° 17.294'	68° 27.951'
			REF-46	44° 17.355'	68° 28.246'
			REF-47	44° 17.206'	68° 28.139'
			REF-48	44° 17.290'	68° 28.257'
			ALT3-49	44° 18.984'	68° 27.804'
			ALT3-50	44° 18.941'	68° 28.067'
			ALT3-51	44° 18.850'	68° 27.948'
			ALT3-52	44° 18.945'	68° 27.988'
			ALT3-53	44° 18.999'	68° 27.846'
			ALT3-54	44° 18.880'	68° 28.111'

Notes: Coordinate system NAD83

Table 2-2.

EPDS 2012 survey actual SPI/PV replicate locations.

Trough Locations			Trough Locations		
Replicate	Latitude (N)	Longitude (W)	Replicate	Latitude (N)	Longitude (W)
1A	44° 16.125'	68° 26.058'	10A	44° 15.968'	68° 25.867'
1B	44° 16.126'	68° 26.053'	10B	44° 15.970'	68° 25.866'
1C	44° 16.121'	68° 26.053'	10C	44° 15.969'	68° 25.869'
1D	44° 16.122'	68° 26.057'	10D	44° 15.969'	68° 25.868'
2A	44° 16.039'	68° 26.002'	11A	44° 16.066'	68° 25.928'
2B	44° 16.041'	68° 26.002'	11B	44° 16.066'	68° 25.932'
2C	44° 16.039'	68° 26.002'	11C	44° 16.068'	68° 25.932'
2D	44° 16.038'	68° 25.997'	11D	44° 16.065'	68° 25.930'
3A	44° 16.060'	68° 26.081'	12A	44° 16.075'	68° 26.029'
3B	44° 16.060'	68° 26.084'	12B	44° 16.075'	68° 26.031'
3C	44° 16.061'	68° 26.080'	12C	44° 16.075'	68° 26.028'
3D	44° 16.061'	68° 26.083'	12D	44° 16.073'	68° 26.029'
4A	44° 16.034'	68° 25.927'	Shoal Locations		
4B	44° 16.037'	68° 25.930'	13A	44° 16.117'	68° 25.861'
4C	44° 16.030'	68° 25.929'	13B	44° 16.116'	68° 25.858'
4D	44° 16.033'	68° 25.930'	13C	44° 16.121'	68° 25.856'
5A	44° 16.154'	68° 26.043'	13D	44° 16.120'	68° 25.860'
5B	44° 16.155'	68° 26.036'	14A	44° 16.167'	68° 25.916'
5C	44° 16.153'	68° 26.036'	14B	44° 16.172'	68° 25.916'
5D	44° 16.153'	68° 26.039'	14C	44° 16.173'	68° 25.920'
6A	44° 16.116'	68° 25.982'	14D	44° 16.172'	68° 25.913'
6B	44° 16.117'	68° 25.979'	15A	44° 16.057'	68° 25.842'
6C	44° 16.116'	68° 25.981'	15B	44° 16.059'	68° 25.845'
6D	44° 16.116'	68° 25.982'	15C	44° 16.060'	68° 25.842'
7A	44° 16.144'	68° 25.991'	15D	44° 16.057'	68° 25.847'
7B	44° 16.145'	68° 25.994'	16A	44° 16.002'	68° 26.077'
7C	44° 16.147'	68° 25.990'	16B	44° 16.000'	68° 26.083'
7D	44° 16.143'	68° 25.991'	16C	44° 16.000'	68° 26.078'
8A	44° 15.944'	68° 25.880'	16D	44° 15.998'	68° 26.079'
8B	44° 15.944'	68° 25.879'	17A	44° 16.017'	68° 26.175'
8C	44° 15.945'	68° 25.881'	17B	44° 16.018'	68° 26.180'
8D	44° 15.940'	68° 25.879'	17C	44° 16.018'	68° 26.177'
9A	44° 16.115'	68° 26.123'	17D	44° 16.015'	68° 26.176'
9B	44° 16.115'	68° 26.121'	18A	44° 15.935'	68° 26.035'
9C	44° 16.110'	68° 26.117'	18B	44° 15.934'	68° 26.031'
9D	44° 16.111'	68° 26.120'	18C	44° 15.934'	68° 26.037'
			18D	44° 15.935'	68° 26.034'

Table 2-2., continued

Reference Locations			Reference Locations		
Replicate	Latitude (N)	Longitude (W)	Replicate	Latitude (N)	Longitude (W)
NREF-19A	44° 16.581'	68° 26.990'	NWREF-27B	44° 17.675'	68° 28.135'
NREF-19B	44° 16.581'	68° 26.986'	NWREF-27C	44° 17.676'	68° 28.133'
NREF-19C	44° 16.582'	68° 26.986'	NWREF-27D	44° 17.677'	68° 28.131'
NREF-19D	44° 16.579'	68° 26.985'	NWREF-28A	44° 17.798'	68° 28.281'
NREF-20A	44° 16.669'	68° 26.750'	NWREF-28B	44° 17.796'	68° 28.280'
NREF-20B	44° 16.668'	68° 26.750'	NWREF-28C	44° 17.798'	68° 28.282'
NREF-20C	44° 16.670'	68° 26.751'	NWREF-28D	44° 17.796'	68° 28.281'
NREF-20D	44° 16.669'	68° 26.750'	NWREF-29A	44° 17.735'	68° 28.399'
NREF-21A	44° 16.539'	68° 26.696'	NWREF-29B	44° 17.734'	68° 28.400'
NREF-21B	44° 16.540'	68° 26.695'	NWREF-29C	44° 17.736'	68° 28.400'
NREF-21C	44° 16.540'	68° 26.699'	NWREF-29D	44° 17.736'	68° 28.397'
NREF-21D	44° 16.541'	68° 26.699'	NWREF-30A	44° 17.636'	68° 28.121'
NREF-22A	44° 16.665'	68° 26.692'	NWREF-30B	44° 17.636'	68° 28.122'
NREF-22B	44° 16.665'	68° 26.691'	NWREF-30C	44° 17.637'	68° 28.123'
NREF-22C	44° 16.665'	68° 26.688'	NWREF-30D	44° 17.635'	68° 28.124'
NREF-22D	44° 16.668'	68° 26.692'	SREF-31A	44° 13.480'	68° 23.952'
NREF-23A	44° 16.499'	68° 26.752'	SREF-31B	44° 13.479'	68° 23.954'
NREF-23B	44° 16.499'	68° 26.751'	SREF-31C	44° 13.478'	68° 23.951'
NREF-23C	44° 16.499'	68° 26.749'	SREF-31D	44° 13.482'	68° 23.954'
NREF-23D	44° 16.501'	68° 26.750'	SREF-32A	44° 13.323'	68° 23.827'
NREF-24A	44° 16.701'	68° 26.876'	SREF-32B	44° 13.322'	68° 23.827'
NREF-24B	44° 16.700'	68° 26.872'	SREF-32C	44° 13.324'	68° 23.826'
NREF-24C	44° 16.700'	68° 26.876'	SREF-32D	44° 13.321'	68° 23.824'
NREF-24D	44° 16.698'	68° 26.872'	SREF-33A	44° 13.481'	68° 23.751'
NWREF-25A	44° 17.682'	68° 28.018'	SREF-33B	44° 13.480'	68° 23.751'
NWREF-25B	44° 17.681'	68° 28.022'	SREF-33C	44° 13.481'	68° 23.756'
NWREF-25C	44° 17.682'	68° 28.018'	SREF-33D	44° 13.479'	68° 23.748'
NWREF-25D	44° 17.680'	68° 28.020'	SREF-34A	44° 13.372'	68° 24.072'
NWREF-26A	44° 17.562'	68° 28.102'	SREF-34B	44° 13.379'	68° 24.079'
NWREF-26B	44° 17.561'	68° 28.102'	SREF-34C	44° 13.377'	68° 24.076'
NWREF-26C	44° 17.560'	68° 28.100'	SREF-34D	44° 13.377'	68° 24.073'
NWREF-26D	44° 17.563'	68° 28.100'	SREF-35A	44° 13.476'	68° 23.915'
NWREF-27A	44° 17.677'	68° 28.135'	SREF-35B	44° 13.475'	68° 23.915'
			SREF-35C	44° 13.479'	68° 23.914'
			SREF-35D	44° 13.474'	68° 23.914'

Table 2-2., continued

Reference Locations		
Replicate	**Latitude (N)**	**Longitude (W)**
SREF-36A	44° 13.543'	68° 23.858'
SREF-36B	44° 13.541'	68° 23.859'
SREF-36C	44° 13.541'	68° 23.860'
SREF-36D	44° 13.543'	68° 23.853'
ALT3REF-49A	44° 18.986'	68° 27.802'
ALT3REF-49B	44° 18.984'	68° 27.809'
ALT3REF-49C	44° 18.985'	68° 27.806'
ALT3REF-49D	44° 18.987'	68° 27.804'
ALT3REF-50A	44° 18.941'	68° 28.066'
ALT3REF-50B	44° 18.941'	68° 28.066'
ALT3REF-50C	44° 18.941'	68° 28.065'
ALT3REF-50D	44° 18.943'	68° 28.066'
ALT3REF-51A	44° 18.851'	68° 27.942'
ALT3REF-51B	44° 18.851'	68° 27.948'
ALT3REF-51C	44° 18.854'	68° 27.946'
ALT3REF-51D	44° 18.848'	68° 27.944'
ALT3REF-51E	44° 18.854'	68° 27.950'
ALT3REF-51F	44° 18.852'	68° 27.945'
ALT3REF-51G	44° 18.849'	68° 27.945'
ALT3REF-51H	44° 18.851'	68° 27.947'
ALT3REF-52A	44° 18.946'	68° 27.988'
ALT3REF-52B	44° 18.945'	68° 27.989'
ALT3REF-52C	44° 18.946'	68° 27.986'
ALT3REF-52D	44° 18.946'	68° 27.986'
ALT3REF-53A	44° 18.996'	68° 27.847'
ALT3REF-53B	44° 18.996'	68° 27.842'
ALT3REF-53C	44° 18.998'	68° 27.845'
ALT3REF-53D	44° 18.999'	68° 27.846'
ALT3REF-54A	44° 18.883'	68° 28.109'
ALT3REF-54B	44° 18.879'	68° 28.110'
ALT3REF-54C	44° 18.881'	68° 28.110'
ALT3REF-54D	44° 18.880'	68° 28.110'

Notes: 1) Coordinate system NAD83
2) This table reflects all attempts to collect replicates at each target station. The three replicates with the best quality images were used for analysis.

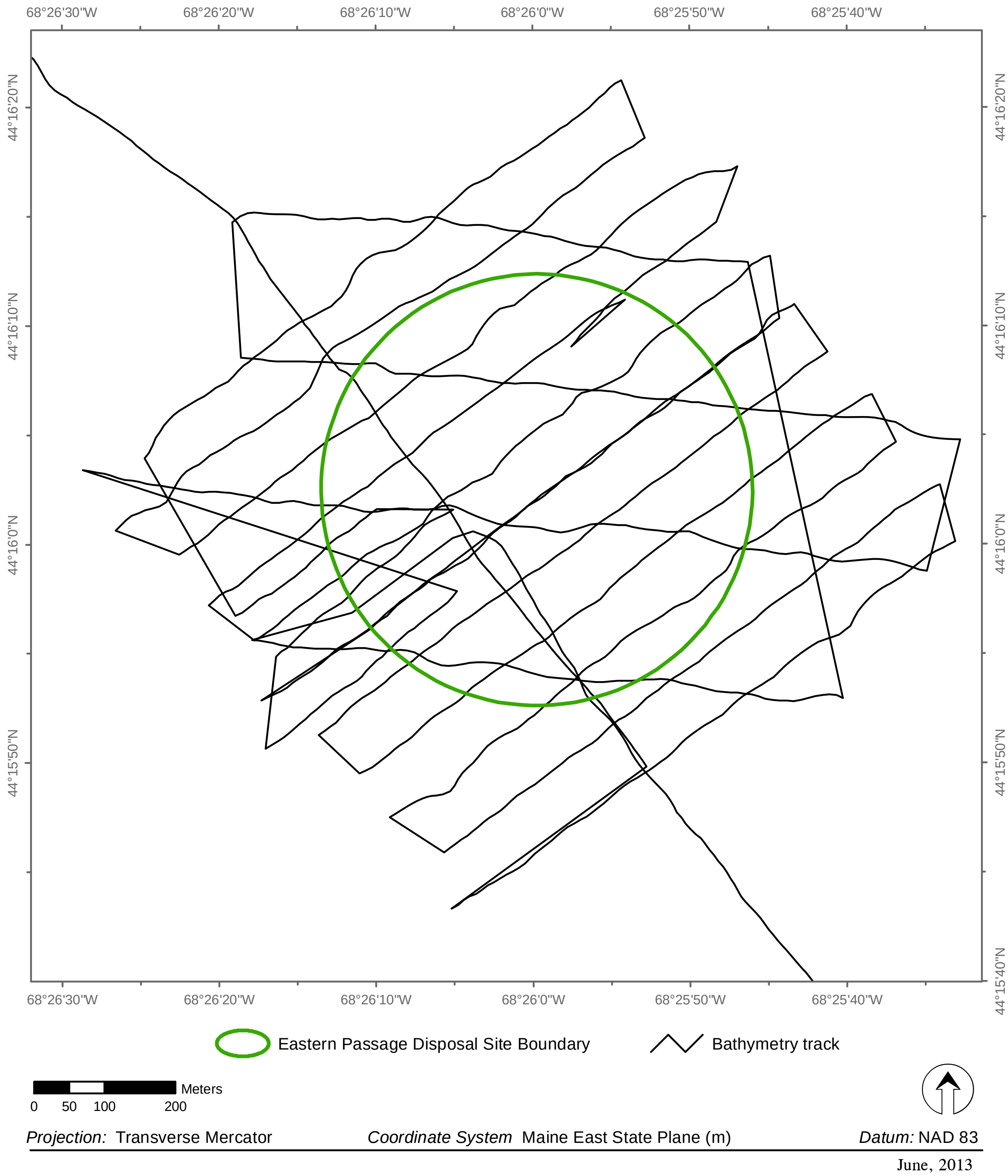


Figure 2-1. EPDS with bathymetric survey lines indicated

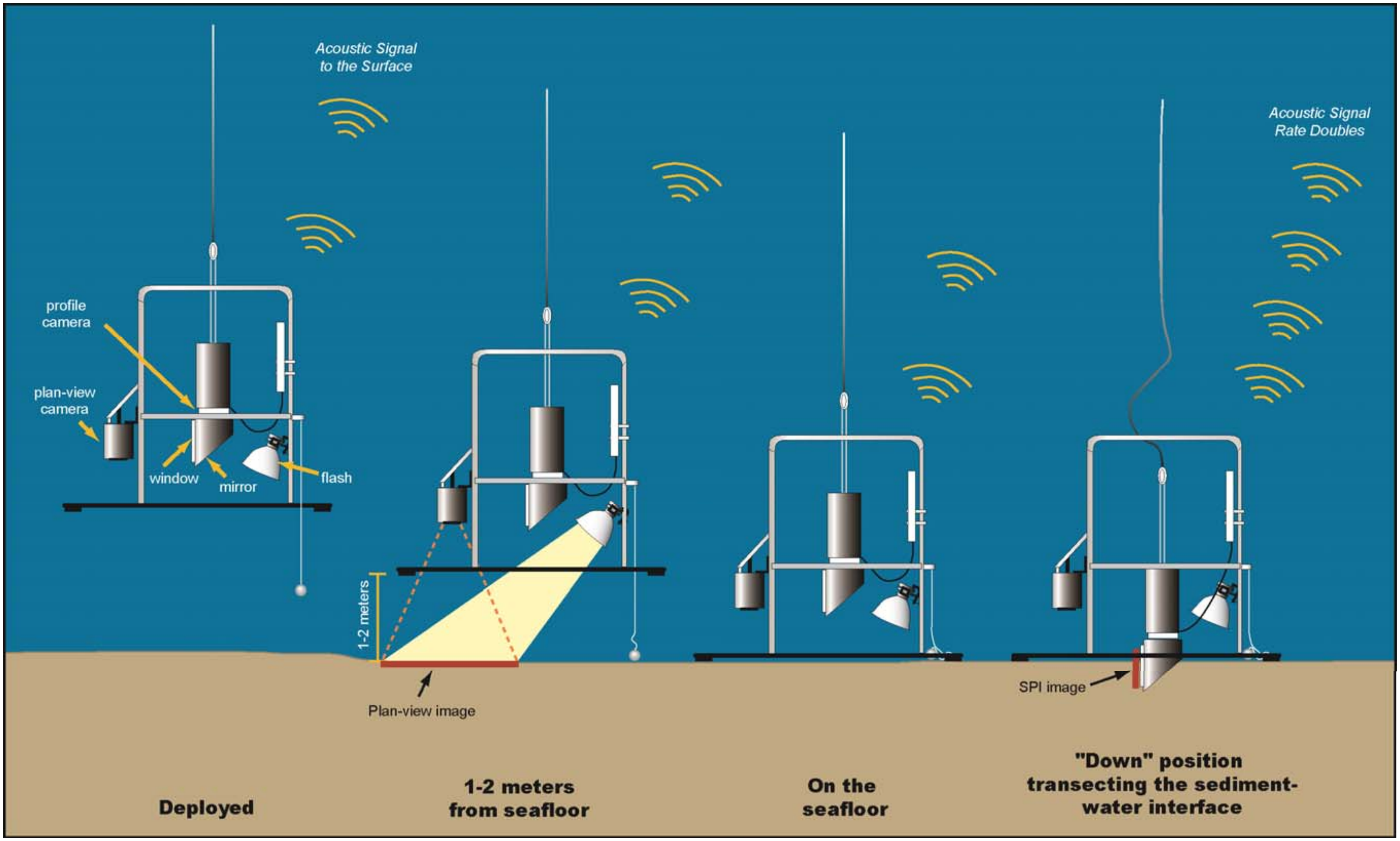


Figure 2-2. Schematic diagram of the SPI/PV camera deployment

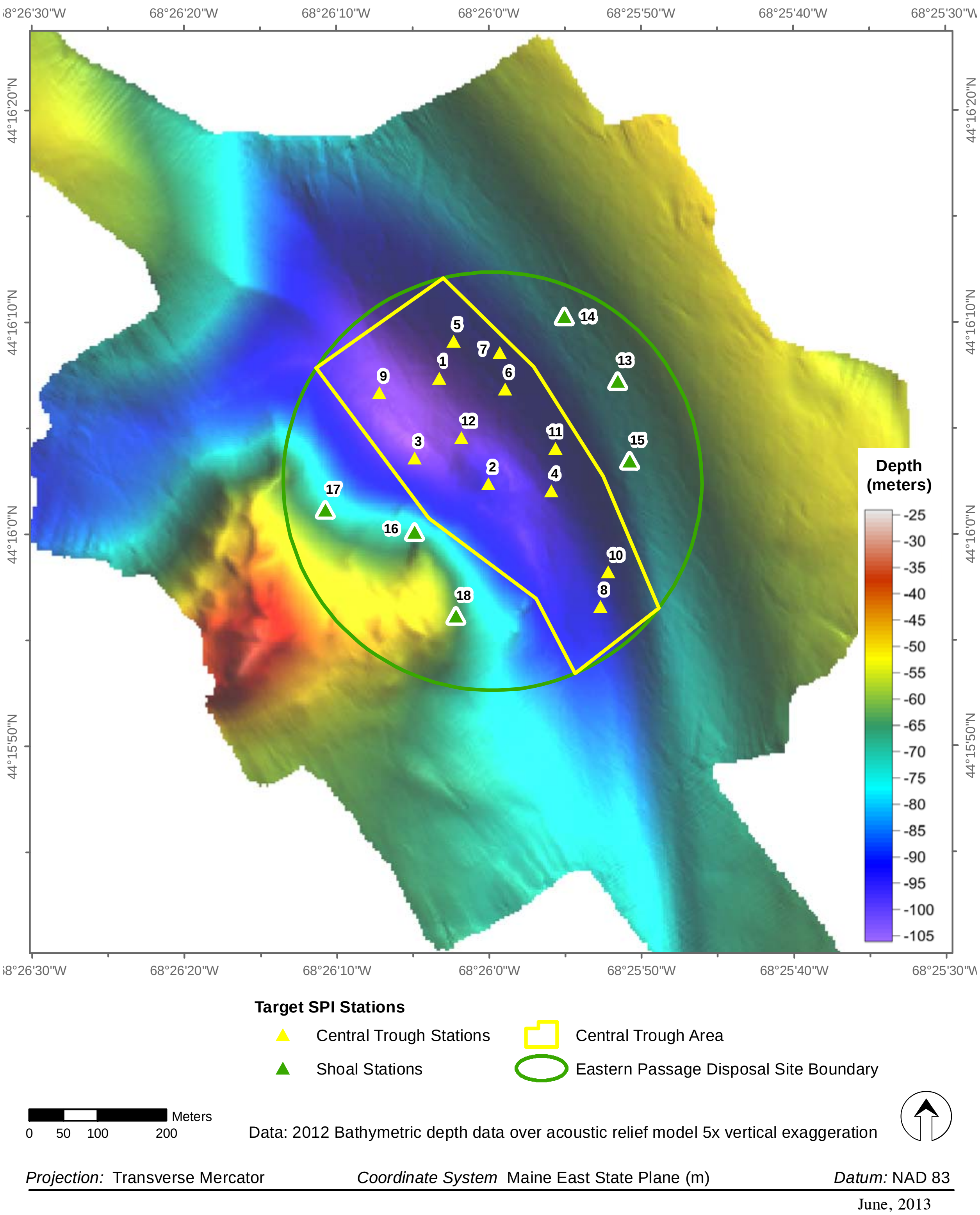


Figure 2-3. EPDS with target sediment-profile image stations indicated

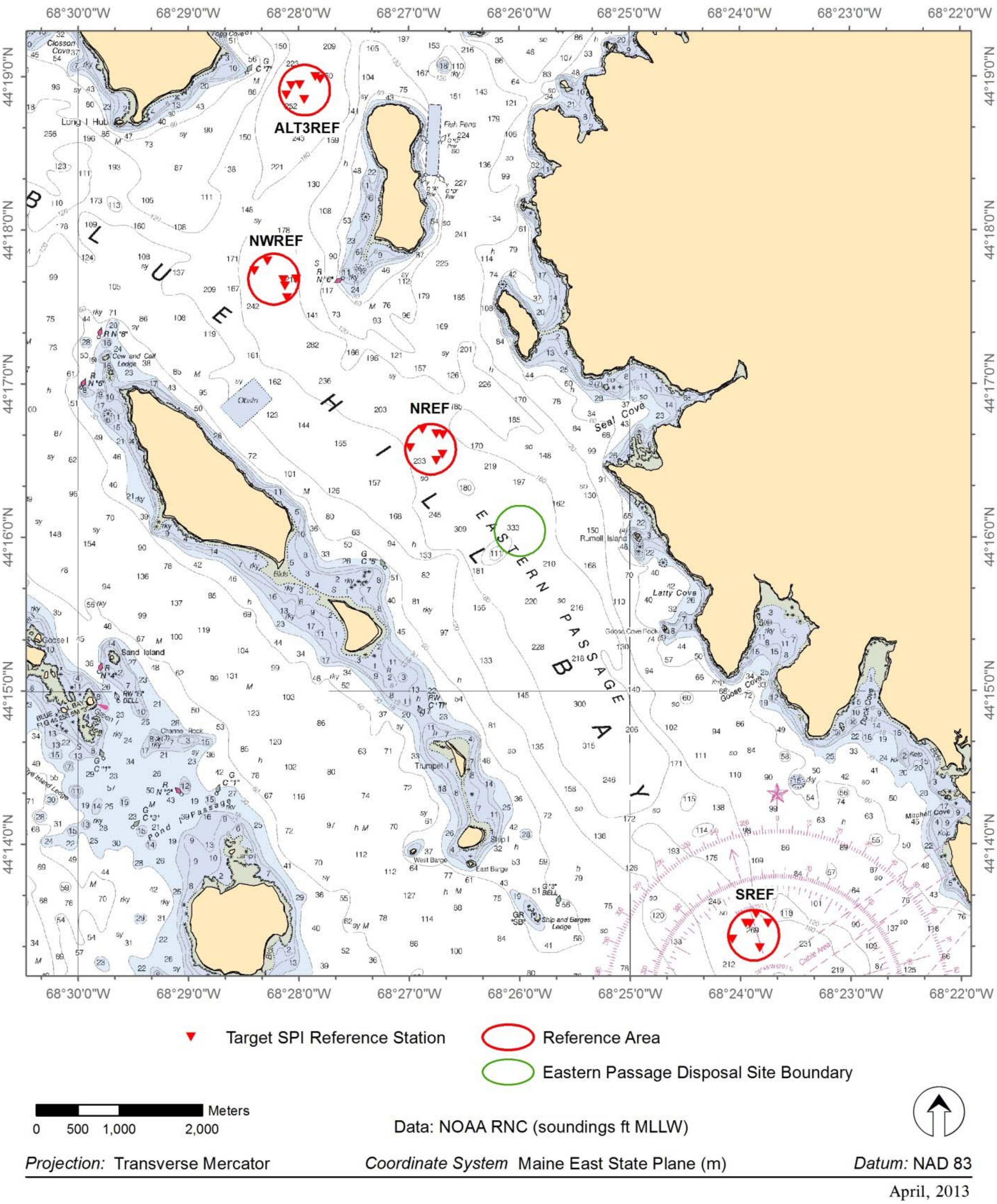


Figure 2-4. Reference areas with target sediment-profile image stations indicated

3.0 RESULTS

3.1 Acoustic Surveys

3.1.1 Existing Bathymetry

The bathymetry of EPDS as surveyed in 2012 revealed a relatively deep main channel along a northwest by southeast axis through the site with relatively steep slopes to shallower shoal areas in the northeast and southwest portions of the site (Figure 3-1). Water depths at EPDS ranged from approximately 50 m in the southwest shoal area to approximately 106 m in the central trough area. From the central trough to the northeastern shoal area, the bathymetric contour sloped uniformly from approximately 100 m in the channel to approximately 60 m at the northeastern edge. Toward the southwest, the slope from the main channel to the shoal area was steeper and more irregular reaching a minimum water depth of 50 m at the southwestern edge. A disposal mound was not readily observable in the bathymetric contour map.

Multibeam bathymetric data rendered as an acoustic relief model (grayscale with hillshading) provided a more detailed representation of the surface of the site (Figure 3-2). A small deposit apparently formed from dredged material was visible in the center of the disposal site at the base of the central trough. Rather than a distinct mound feature, the dredged material deposit appears more as an extension of the shallower southwestern area of the site into the deeper central portion (Figure 3-1). The shoal area to the southwest was marked by a several groups of rounded knobs with irregular surfaces surrounded by a very smooth surface. The shoal area to the northeast was a smooth slope marked by curved incised marks which were visible in and outside the disposal site. The margin of the acoustic relief model had fan-shaped linear marks that were interpreted as an artifact of data processing (Figure 3-2).

The acoustic reconnaissance survey characterized a highly varied bathymetry along the axis of Blue Hill Bay, with shoal areas of rock, sandbars, and depressions (Figure 3-3). Four candidate reference areas were selected from depressions that appeared to have similar characteristics to the disposal site, although none were as deep or large as the area selected for the disposal site.

3.1.2 Acoustic Backscatter

Acoustic backscatter data provided an estimation of surficial sediment texture (hard, soft, rough, smooth). The mosaic of unfiltered backscatter at EPDS showed harder returns over the shoal to the southwest and in the center of the channel within the disposal site (Figure 3-4). Backscatter returns on the shoal to the northeast were lower and indistinguishable from ambient seafloor further to the east. Within the disposal site, several circular patterns of backscatter were observed that were consistent with disposal impact features (Figure 3-4, Carey et al. 2012, Valente et al. 2012).

The backscatter data were filtered and gridded to minimize artifacts and create a quantitative assessment of backscatter intensity (Figure 3-5). The filtered and contoured backscatter results showed that average backscatter over the southwest shoal and disposal area at the base of the trough were similar (-10 to -15 dB, Figure 3-5). Average backscatter over the northeast shoal was much lower (-19 to -25 dB). Despite filtering, some of the circular features consistent with disposal impact were still visible on the northeast shoal (Figure 3-5).

3.1.3 Side-Scan Sonar

Side-scan sonar results also provided a clear representation of disposal activity, but with some distinct differences from the backscatter results (Figure 3-6). The side-scan sonar images were higher resolution but also included artifacts from data collection and slope that resulted in a mosaic less smooth than the backscatter mosaic (compare Figures 3-4 and 3-6). The same circular features from disposal impact were visible, but it was also possible to see more detail of the surface texture of the dredged material deposit (Figure 3-6).

3.1.4 Comparison with Previous Bathymetry

The 2009 single-beam bathymetric survey resulted in collection of a data set that was sufficient to support depth difference analysis (as described below), but produced a very coarse bathymetric contour map of EPDS. A depth difference analysis was conducted by subtracting the bottom elevations measured in the 2009 survey from the bottom elevations measured in the 2012 survey. The resulting depth difference map highlighted the apparent changes in bathymetry since the 2009 survey (Figure 3-7). The depth difference analysis revealed a small deposit at the center of the disposal site that corresponded to the deposit visible in the acoustic relief model (Figure 3-2). The deposit was elliptical in shape, approximately 170 × 80 m, and oriented along the axis of the central trough area. The peak height of the deposit extended approximately 5 m above the seafloor surface of the central trough (Figure 3-7).

A deposit volume estimate of 34,000 m^3 was calculated based on the depth difference analysis, with the calculation constrained to a 19,000-m^2 area including the deposit, apron, and a narrow buffer zone based on the uncertainty of the bathymetry measurements. The deposit depth difference was expected to contain an error of up to ±

0.5 m due to uncertainty associated with the 2009 bathymetric data. The deposit volume estimate of 34,000 m^3 was approximately two-thirds of the reported volume of dredged material placed at EPDS between October 2010 and April 2011 (52,156 m^3; Table 1-1). The difference between estimates of volumes placed and volumes measured at the site are similar to expected ranges for placement of a relatively small volume of dredged material in 100 m water depth in an area with strong tidal currents and the uncertainty in volume estimates. Dredged material placed at the site very likely spread in thin layers over a broad area of the northeast shoal area due to the orientation of bottom currents that change from a northwest-southeast orientation to north-south as they pass through the central trough area (see channel in Figure 3-7). These thin layers (or apron of the deposit) would likely fall within the estimated uncertainty in depth difference (± 0.5 m), and not be included in the volume calculation.

3.2 Sediment-Profile and Plan-View Imaging

The primary purpose of the SPI/PV survey at EPDS was to characterize the physical features of the surface sediments and assess the status of benthic recolonization on the disposal deposit 18 months after disposal operations ceased. In addition to characterizing seafloor conditions within the disposal site boundary, the study assessed which two of the four potential reference areas were most relevant for comparison with conditions within the disposal site boundary and performed those comparisons. Dredged material footprint delineation was not one of the SPI survey objectives; the 18 stations sampled within the site boundary were randomly placed within the site perimeter, with 12 of the stations in the central trough area, as defined by the multibeam survey results, and the remaining six stations split between the two shoal areas: one to the northeast where dredged material was placed and one southwest where dredged material was not placed (Figure 2-3). A station summary of some of the measured parameters from the profile images can be found in Tables 3-1 and 3-2, with a complete set of results in Appendix A (SPI)) and Appendix C (PV).

3.2.1 Reference Area Stations

Physical Sediment Characteristics: Because this was a new disposal site with no established reference areas, four different areas (three to the north, one to the south) that exhibited topographic and acoustic features similar to those at the disposal site were surveyed with SPI/PV to support selection and establishment of two suitable reference areas for the 2012 and future monitoring surveys. SPI and PV images were both evaluated for sediment type and particle size range in all four potential reference areas to determine which areas' sedimentary features most closely resembled those found at the disposal site.

Stations with penetration depth ≤7.5 cm and >7.5 cm were classified as hard and soft, respectively. One station had a mean penetration depth <7.5 cm but clearly was composed of fine sand over silt and was thus classified as soft (Table 3-1).

ALT3REF, located approximately 5 km northwest of EPDS, had soft sediments (major mode ≥4 phi) at all stations surveyed (Figure 3-8). All six ALT3REF stations had primarily silt/clay sediments with relatively low bearing strength that were highly bioturbated (Figure 3-9). Water visibility was extremely low at all the areas surveyed in this region, making surface features on the seafloor difficult to distinguish in PV images. The PV images from ALT3REF generally showed a relatively featureless, muddy seafloor with a few burrow openings from either deposit-feeding infauna or larger burrowing epifauna (Figure 3-10).

NWREF was situated roughly 2.25 km south of ALT3REF and was characterized by a mix of both poorly sorted sandy muds (sediment particle sizes ranging from silt/clay to cobble; Figure 3-11) and relatively uniform silt/clay bottoms that were heavily bioturbated (Figure 3-12).

NREF was geographically the closest reference area to EPDS, located approximately 1.5 km northwest of the disposal site (Figure 3-8). NREF sediments were similar to those of NWREF. Two of the NREF stations were a mixture of both cobble and sandy silt (Figure 3-13), while the remaining four stations surveyed had silt/clay bottoms with fairly uniform surfaces that were pockmarked with small burrow openings and epifaunal foraging tracks (Figure 3-14).

SREF was located approximately 5 km southeast of EPDS. Five SREF stations had a silty, very fine to fine-sand surface layer overlying a silt/clay foundation with varying degrees of shell armoring on the sediment surface (Figure 3-15). At one location (Station 36) the sediment surface was armored with shell hash (Figure 3-16).

Small-scale boundary roughness ranged from 0.4 to 2.6 cm over all four reference areas (Table 3-1); the majority of the small-scale surface topography was due to biogenic processes (Appendix A). None of the stations surveyed in any of the four reference areas displayed any evidence of low dissolved oxygen in the overlying water or signs of methane in the subsurface sediments.

<u>Biological Conditions and Benthic Recolonization:</u> Station values for the mean aRPD depths at the reference stations ranged from 0.8 to 5.2 cm (Table 3-1, Figure 3-17). Evidence of Stage 3 infaunal deposit feeders was found at all the reference stations (Figure 3-18), with bioturbation depths extending to the full depth of prism penetration at some of the locations (Figure 3-19, Appendix A).

3.2.2 Disposal Site Stations

SPI and PV images were collected at 18 EPDS stations. Disposal site stations were clustered into three different topographic regimes: 12 stations were randomly located in the central trough area where the bulk of the dredged material was placed, three stations were located on the northeast shoal area, and three stations were located on the southwest shoal area (Figure 3-20). Evidence of dredged material was found at all stations in the central trough area and on the northeast shoal (Stations 1–15), and at one replicate on the southwest shoal (Station 16A, Appendix A).

Physical Sediment Characteristics: Given the bathymetric profile of the area within the designated site boundary, it was not surprising to find a wide range of sediment types corresponding to topographic highs, slopes, and lows (Figure 3-21). The three stations in the area to the southwest (Stations 16–18) on the steep slope had firm sand and cobble bottoms (Figure 3-22) and had minimal to no camera prism penetration (Table 3-2); whereas within the central trough (Stations 1–12) and on the northeast shoal area (Stations 13–15) finer grained sediments were dominant. Areas with these silty, very-fine- to fine-sand sediments (Figure 3-23) transitioned to locations with fine-sand layers over silt/clay foundations (Figure 3-24) and to locations where the silt/clay sediment grain size major mode was ≥4 phi (Figure 3-25). Dredged material was apparent at all of the central trough and northeast shoal area stations but was only identified in one replicate of the three stations in the southwest area. The three stations from the southwest shoal area (Stations 16–18) are therefore excluded from summaries describing the disposal site.

Camera prism penetration depths ranged from 0 (Station 18, Figure 3-22) to 16.8 cm, with an overall disposal site mean (Stations 1–15) of 13.2 cm; stop collar and weight settings were constant at all of the stations within the disposal site except for Station 9, where the softer sediment required lower stop collar settings and fewer weights in the frame carriage (Appendix A). Boundary roughness values ranged from 0.4 to 5.8 cm with an overall site mean of 1.2 cm (Table 3-2), and as in the reference areas, the majority of the small-scale topographic elements were of biogenic origin (Appendix A). None of the locations sampled within the disposal site showed any evidence of low oxygen in the overlying waters or methane formation from excess organic enrichment in the subsurface sediments.

Biological Conditions and Benthic Recolonization: Station mean values for the aRPD depth at the disposal site ranged from 1.7 to 3.5 cm with an overall disposal site mean aRPD depth of 2.7 cm (Table 3-2, Figure 3-26). Evidence of mature, deposit-feeding assemblages (Stage 3 taxa) was found at all stations where the camera was able to get adequate penetration (Figure 3-27). The maximum depth of feeding void structures ranged from 4.0 to 16.0 cm, with well-defined voids visible even at locations in the center of the trough where dredged material deposits were the thickest (Figure 3-28).

3.3 Statistical Comparisons

Because of the complex depth and sediment relationships at EPDS and the lack of predefined reference areas, this survey addressed two interrelated questions: 1. Were conditions at EPDS comparable to conditions at other sites within Eastern Passage that did not receive dredged material? 2. Were suitable reference areas available to be used for future monitoring surveys?

Reconnaissance acoustic data was used to select four reference areas for consideration to address both questions (Figure 3-3). The stations located within the disposal site were segregated by depth into trough and shoal locations (Figure 2-3). All sampled stations were classified as hard or soft sediment type to facilitate comparison (Tables 3-1 and 3-2).

Most of the disposal site stations in the central trough and northeast shoal areas were on soft-bottom substrata, and the southwest shoal stations (Stations 16–18) were on hard-bottom substrata (Table 3-2). The reference areas also displayed a mix of soft- and hard-bottom surficial sediments (Table 3-1). Dredged material placement was directed to the central trough area and was intentionally not placed on the southwest shoal area. After assessment of the seafloor conditions, the southwest shoal stations were excluded from statistical comparison. Reference areas with the greatest number of soft-bottom surficial sediments (SREF and ALT3REF) were chosen for comparison with the remaining disposal site stations.

At each of the stations, there were results for three replicate drops of the SPI/PV camera. The mean of the three replicate observations was used for the station aRPD depth; the maximum among replicates was used as the successional stage rank for the station. Summaries of the mean aRPD depths and successional stage rank values by sampling location are shown in Table 3-3 and Figures 3-29 and 3-30. The potential reference areas' mean aRPD depths are compared in Figure 3-29. The suitable reference areas (based on number of stations with soft-bottom surficial sediments) are compared to disposal site stations in Figure 3-30.

3.3.1 Mean aRPD Depths

Mean aRPD depths for each disposal site station from the trough and the northeast shoal, with soft-bottom substrata, were compared to the mean aRPD depths of SREF and ALT3REF (Table 3-4, Figure 3-30). The residuals from the three groups were combined to assess normality and compare variances. Results for the normality test indicated that the area residuals (i.e., each observation minus the area mean) were normally distributed (Shapiro-Wilk's test p-value = 0.252). Levene's test for equality of variances was not rejected ($p = 0.32$) so a pooled variance estimate was used for the equivalence test. Results are shown in Table 3-4.

The mean of reference area means was less than the mean of disposal area stations (Table 3-3). The reference mean was approximately 0.5 cm less than the disposal area mean. This difference was statistically equivalent because both the upper and lower 95% confidence bounds were within the equivalence interval [-1, +1]. The reference area mean aRPD depth values were suitable for use in assessment of 2012 survey results. The results of statistical comparison support the future use of the soft-bottom portion of the disposal site for dredged material placement and use of SREF and ALT3REF for comparison in future surveys.

3.3.2 Successional Stage Ranks

All disposal site stations and reference areas indicated successional stages at Stage 3 or equivalent. With identical means and zero variance, no statistics were needed for comparisons between reference and disposal site stations in order to conclude statistical equivalence.

Table 3-1.

Summary of EPDS Reference Station SPI Results, October 2012

Station	Station Grain Size Major Mode (phi)	Station Mean Penetration Mean (cm)	Station Mean Boundary Roughness (cm)	Station Mean aRPD Depth (cm)	Methane Present?	Station Maximum Void Depth (cm)	Highest Successional Stage Present	Hard or Soft Sediment
NREF								
NREF-19	>4	20.6	0.6	4.7	no	21	1 on 3	S
NREF-20	>4 to 3	3.1	1.9	1.4	no	0	1 on 3	H
NREF-21	>4	14.4	0.6	2.7	no	14.9	2 on 3	S
NREF-22	4 to 3	2.7	1.9	1.3	no	3.2	1 on 3	H
NREF-23	>4	17.6	0.6	3.7	no	15.9	2 on 3	S
NREF-24	>4	7.5	1.4	2.5	no	7.8	1 on 3	H
Min	NA	2.7	0.6	1.3	NA	0.0	NA	
Max	NA	20.6	1.9	4.7	NA	21.0	NA	
Mean*	NA	11.0	1.2	2.7	NA	10.5	NA	
NWREF								
NWREF-25	>4	1.9	0.8	3.5	no	6.1	1 on 3	H
NWREF-26	4 to 3	5.6	0.8	2.4	no	4.7	1 on 3	H
NWREF-27	>4	7.6	2.2	2.1	no	5.9	1 on 3	S
NWREF-28	>4	19.4	0.9	3.3	no	16.1	1 on 3	S
NWREF-29	>4	20.4	0.8	5.2	no	7.1	1 on 3	S
NWREF-30	>4	2.5	2.1	0.8	no	ind	ind	H
Min	NA	1.9	0.8	0.8	NA	4.7	NA	
Max	NA	20.4	2.2	5.2	NA	16.1	NA	
Mean*	NA	9.6	1.3	2.9	NA	8.0	NA	
SREF								
SREF-31	4 to 3/>4	10.1	0.4	2.1	no	9.7	2 on 3	S
SREF-32	4 to 3/>4	10.3	1.1	1.4	no	7.8	2 on 3	S
SREF-33	4 to 3/>4	6.7†	1.2	1.9	no	3.8	2 on 3	H
SREF-34	4 to 3/>4	13.4	0.6	2.2	no	6.1	2 on 3	S
SREF-35	4 to 3/>4	9.5	0.5	1.8	no	9.4	2 on 3	S
SREF-36	4 to 3	1.5	2.6	ind	no	ind	ind	H
Min	NA	1.5	0.4	1.4	NA	3.8	NA	
Max	NA	13.4	2.6	2.2	NA	9.7	NA	
Mean*	NA	8.6	1.1	1.9	NA	7.4	NA	

Hard or Soft Classification:
Hard ≤7.5 cm penetration depth
Soft >7.5 cm penetration depth
† Station SREF-33 had a mean penetration depth of 6.7 cm but was firm sand over silt rather than hard-bottom.

*Under the DAMOS monitoring protocol, three replicate images are analyzed to compile a station mean, the mean of the means is reported here.

Table 3-1., continued

Station	Station Grain Size Major Mode (phi)	Station Mean Penetration Mean (cm)	Station Mean Boundary Roughness (cm)	Station Mean aRPD Depth (cm)	Methane Present?	Station Maximum Void Depth (cm)	Highest Successional Stage Present	Hard or Soft Sediment
ALT3REF								
ALT3REF-49	>4	20.2	1.0	2.9	no	19.5	1 on 3	S
ALT3REF-50	>4	14.0	0.6	2.5	no	14.6	2 on 3	S
ALT3REF-51	>4	20.6	0.6	3.0	no	19	1 on 3	S
ALT3REF-52	>4	15.1	0.7	2.7	no	8.3	1 on 3	S
ALT3REF-53	>4	20.9	0.9	2.3	no	19.8	1 on 3	S
ALT3REF-54	>4	13.9	0.7	2.2	no	7.7	1 on 3	S
Min	NA	13.9	0.6	2.2	NA	7.7	NA	
Max	NA	20.9	1.0	3.0	NA	19.8	NA	
Mean*	NA	17.5	0.7	2.6	NA	14.8	NA	

Hard or Soft Classification:
Hard ≤7.5 cm penetration depth
Soft >7.5 cm penetration depth

*Under the DAMOS monitoring protocol, three replicate images are analyzed to compile a station mean, the mean of the means is reported here.

Table 3-2.

Summary of EPDS Sediment-Profile Imaging Results, October 2012.

Station	Station Grain Size Major Mode (phi)	Station Mean Penetration Mean (cm)	Station Mean Boundary Roughness (cm)	Station Mean aRPD Depth (cm)	Methane Present?	Station Maximum Void Depth (cm)	Highest Successional Stage Present	Hard or Soft Sediment
01	>4 to 3	14.4	0.5	2.6	no	14	1 on 3	S
02	>4 to 3	2.6	5.8	ind	no	4.0	1 on 3	H
03	4 to 3	11.6	1.1	2.6	no	11.4	1 on 3	S
04	4 to 3/>4	14.8	0.7	3.1	no	14.1	2 on 3	S
05	4 to 3/>4	15.8	0.6	3.2	no	16.0	2 on 3	S
06	>4 to 3	16.3	0.4	2.8	no	12.1	2 on 3	S
07	>4 to 3	16.8	0.8	3.0	no	13.7	2 on 3	S
08	>4	15.5	0.6	2.3	no	15.3	2 on 3	S
09	4 to 3/>4	9.4	1.6	1.8	no	9.0	1 on 3	S
10	>4 to 3/>4	12.3	0.4	2.8	no	15.1	2 on 3	S
11	>4 to 3/>4	15.7	0.5	2.6	no	13.9	2 on 3	S
12	>4 to 3	8.8	1.9	1.7	no	8.5	1 on 3	S
13	>4	13.5	0.9	3.0	no	12.9	2 on 3	S
14	>4	16.2	0.9	3.5	no	15.6	2 on 3	S
15	>4	14.6	0.6	3.3	no	13.3	2 on 3	S
Min	NA	2.6	0.4	1.7	NA	4.0	NA	
Max	NA	16.8	5.8	3.5	NA	16.0	NA	
Mean*	NA	13.2	1.2	2.7	NA	12.6	NA	
Southwest Shoal								
16	3 to 2	5.6	2.5	3.2	no	14.3	1 on 3	H
17	<-1	0.1	1.2	ind	ind	ind	ind	H
18	ind	0.0	ind	ind	ind	ind	ind	H

<u>Hard or Soft Classification:</u>
Hard ≤7.5 cm penetration depth
Soft >7.5 cm penetration depth

*Under the DAMOS monitoring protocol, three replicate images are analyzed to compile a station mean, the mean of the means is reported here.

Table 3-3.

Summary of Station Means for Stations used in Statistical Comparison

Area	Mean aRPD Depth (cm)			Successional Stage Rank		
	No. of Stations[1]	Mean	Standard Deviation	No. of Stations[1]	Mean	Standard Deviation
Reference areas						
ALT3REF	6	2.61	0.32	6	3	0
SREF	5	1.88	0.30	6	3	0
Mean		2.24			3	
Disposal site						
Trough	11	2.57	0.51	12	3	0
NE shoal	3	3.24	0.26	3	3	0
Mean		2.91			3	

[1] Stations having sufficient penetration to determine aRPD depth and/or successional stage values.

Table 3-4.

Summary Statistics and Results of Inequivalence Hypothesis for aRPD Depth Values

Comparison	Observed Difference ($\hat{d}$)	SE($\hat{d}$)	df for SE ($\hat{d}$)	95% Lower Confidence Bound	95% Upper Confidence Bound	Conclude
Reference Mean – Disposal Site Mean	-0.48	0.458	22	-0.79	-0.15	s

s = reject the inequivalence hypothesis: the two group means are statistically equivalent.

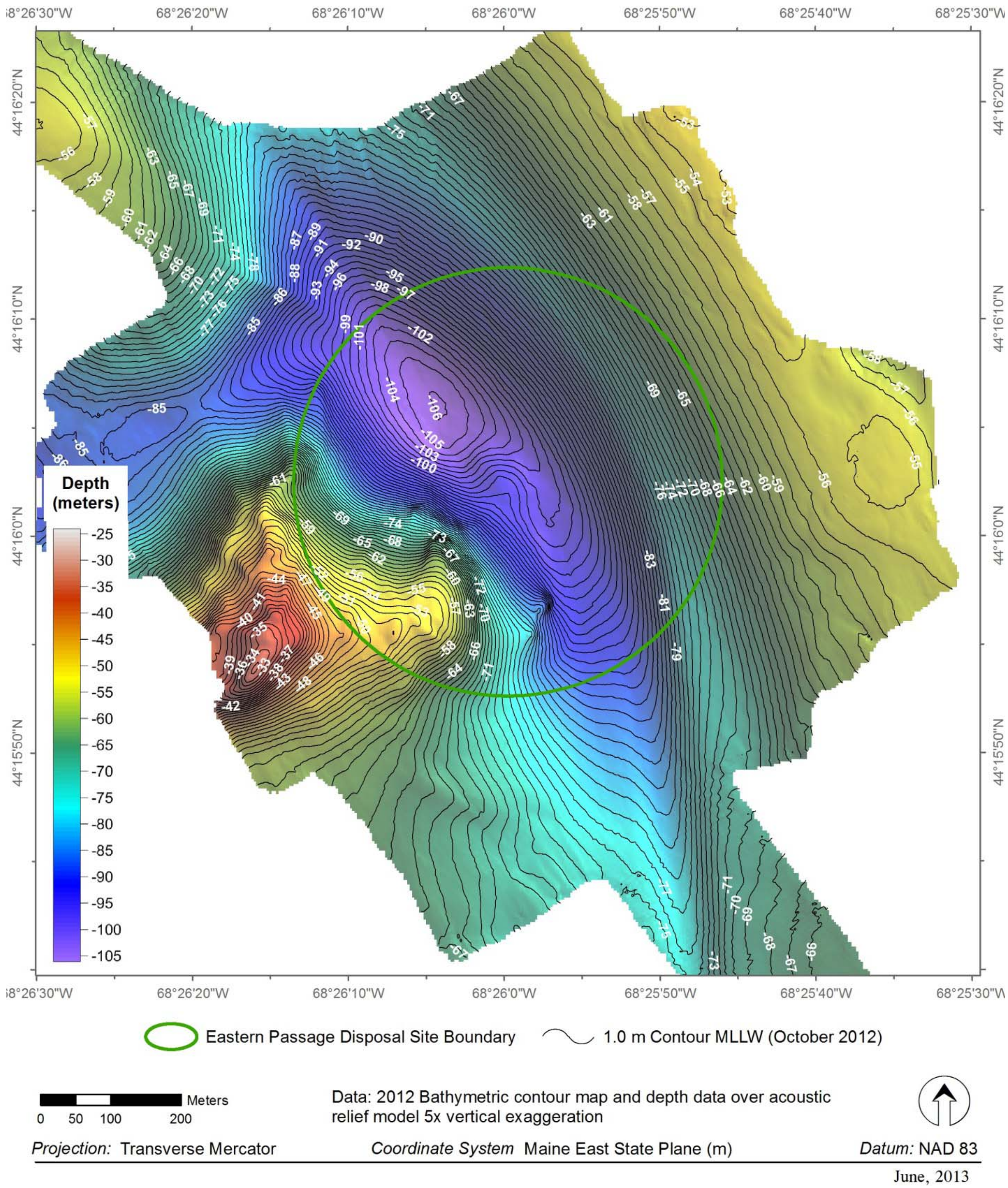


Figure 3-1. Bathymetric contour map of EPDS – October 2012

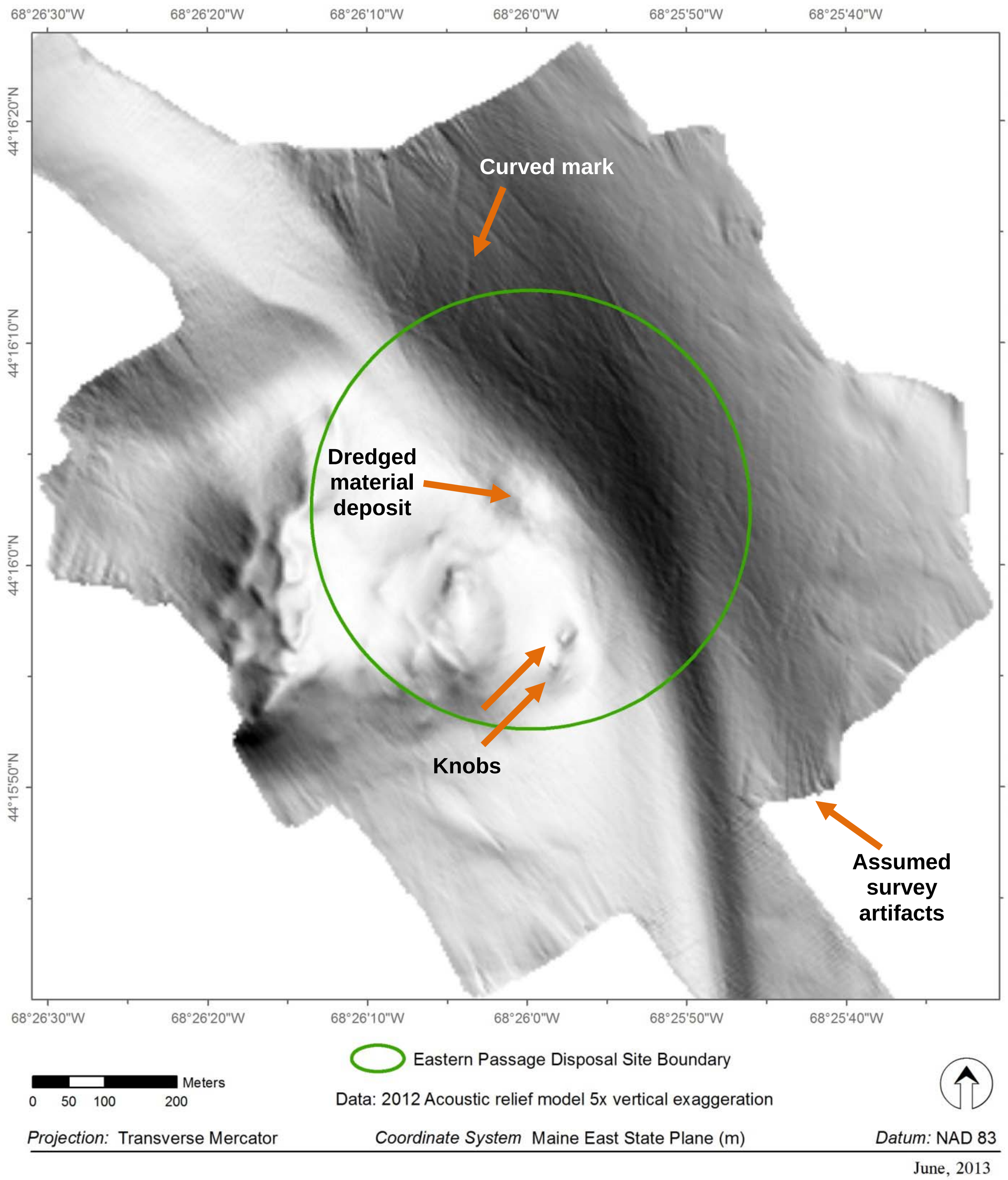


Figure 3-2. Acoustic relief model of EPDS

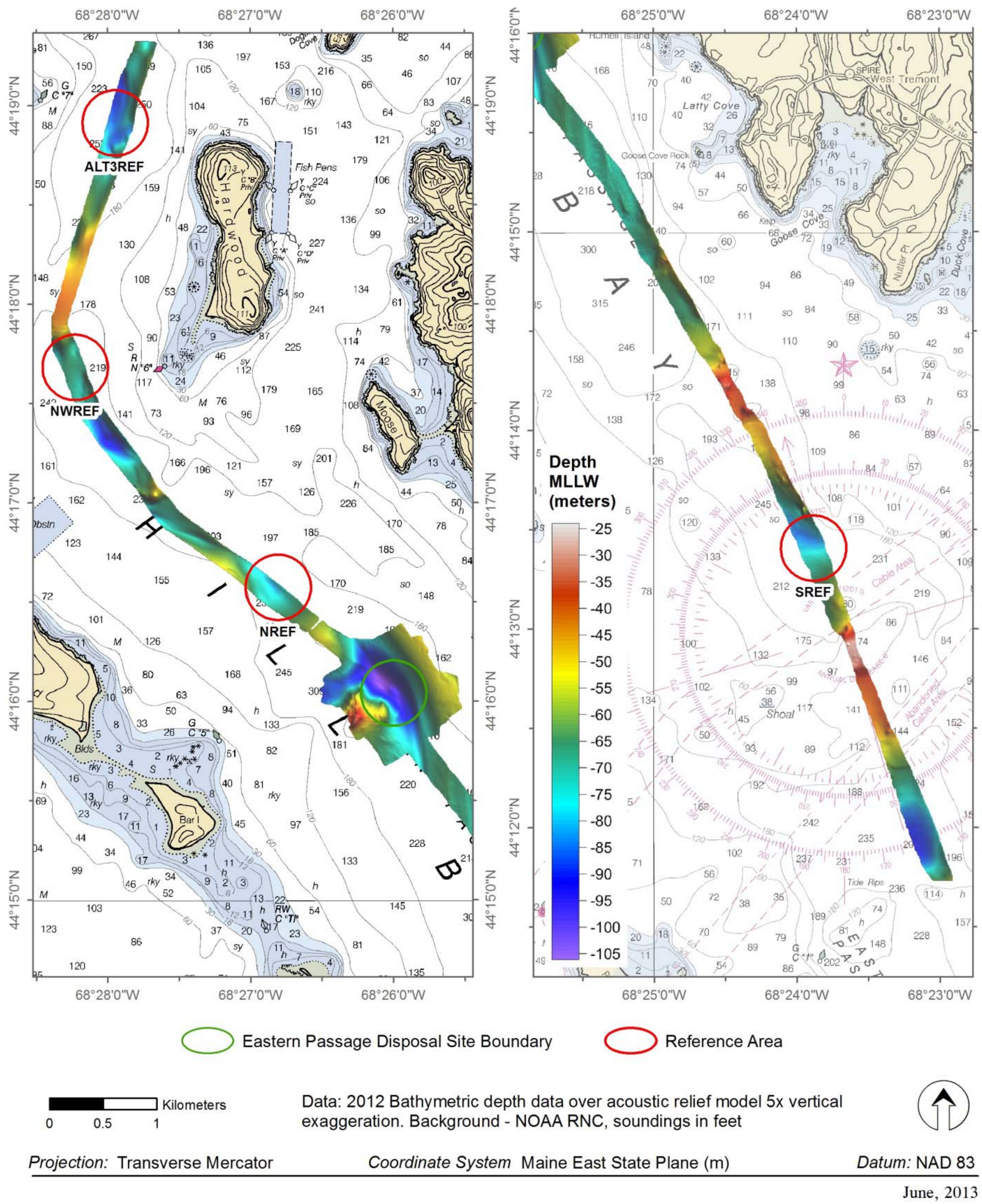


Figure 3-3. Reconnaissance bathymetry results for selection of candidate reference areas

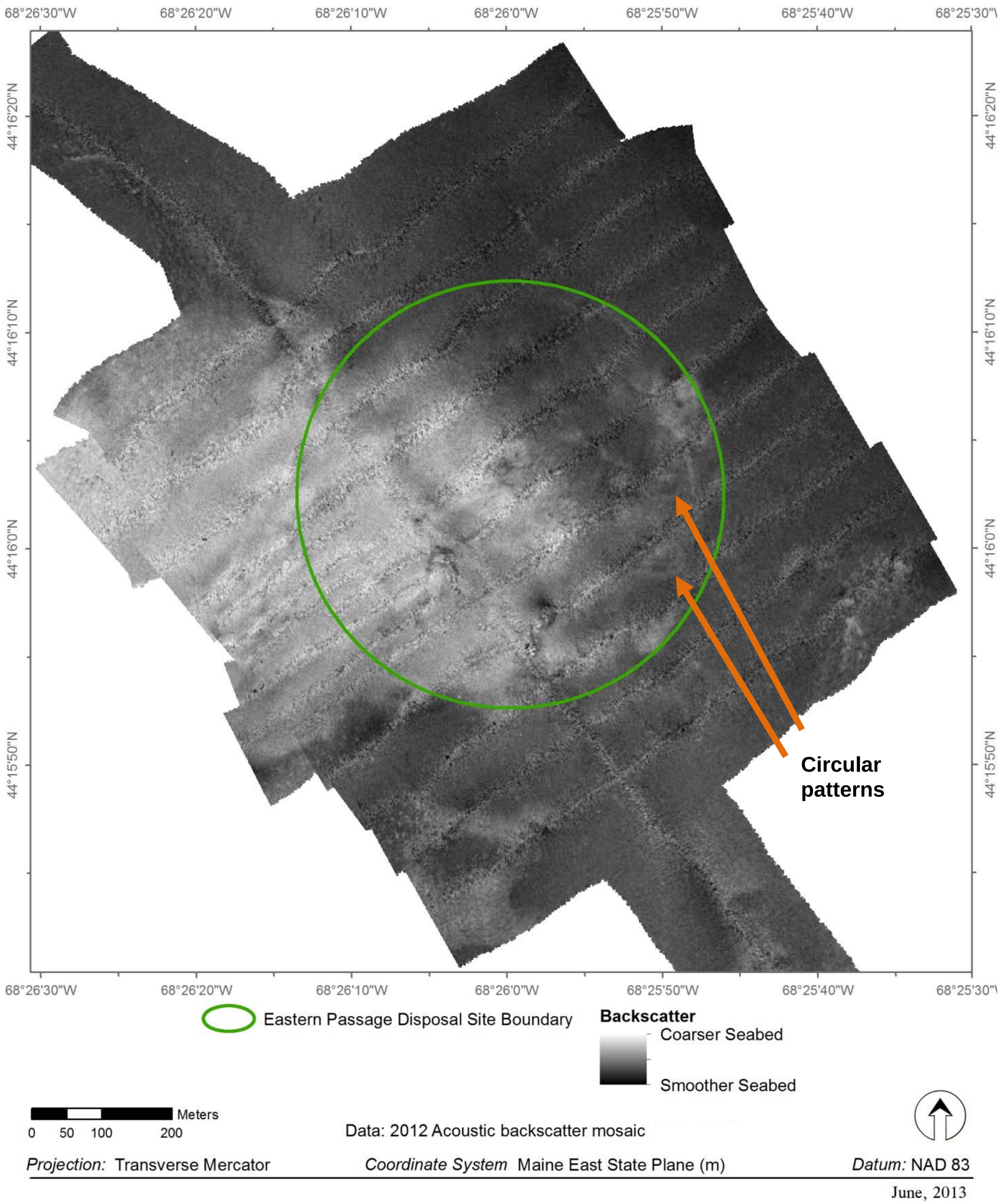


Figure 3-4. Mosaic of unfiltered backscatter data of EPDS

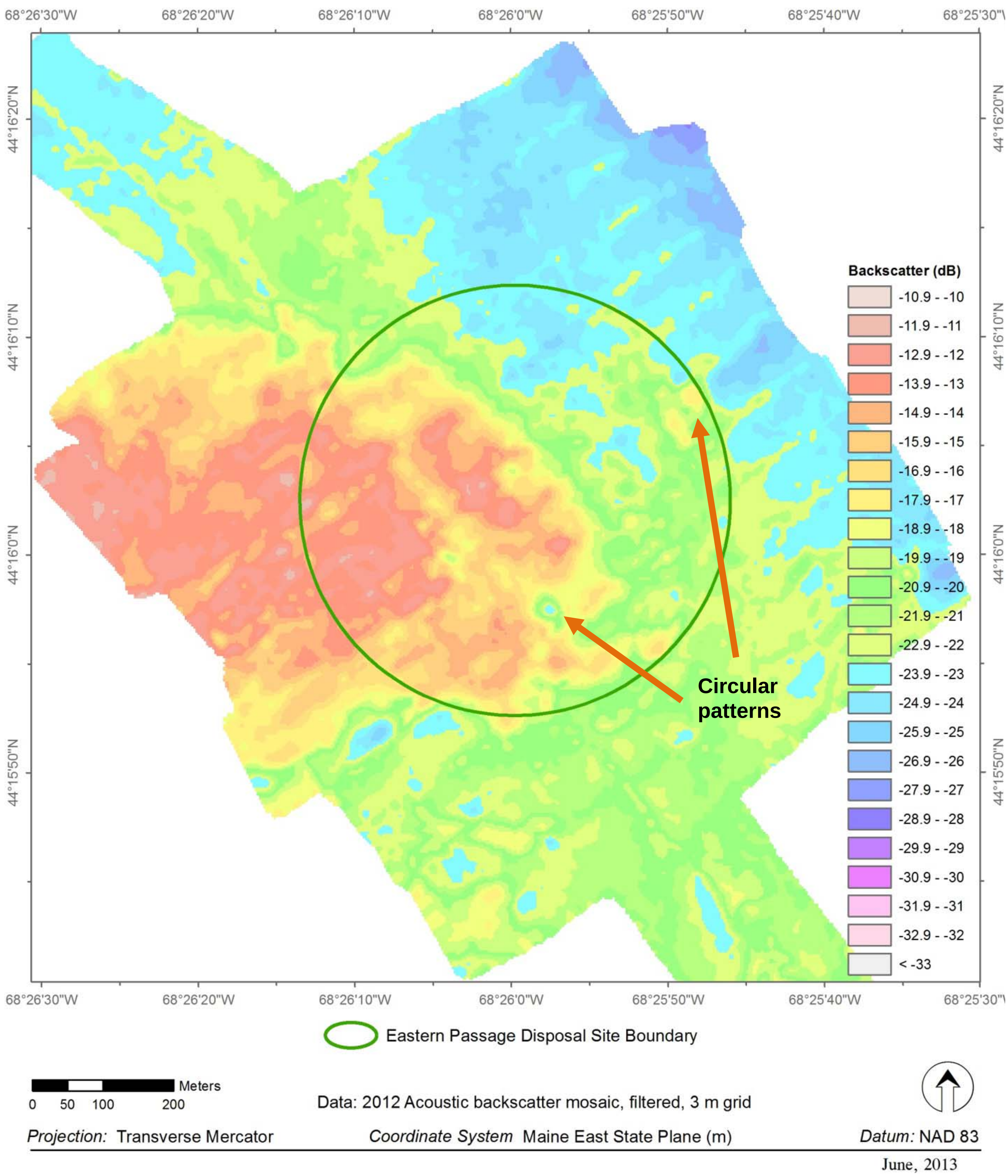


Figure 3-5. Filtered backscatter of EPDS

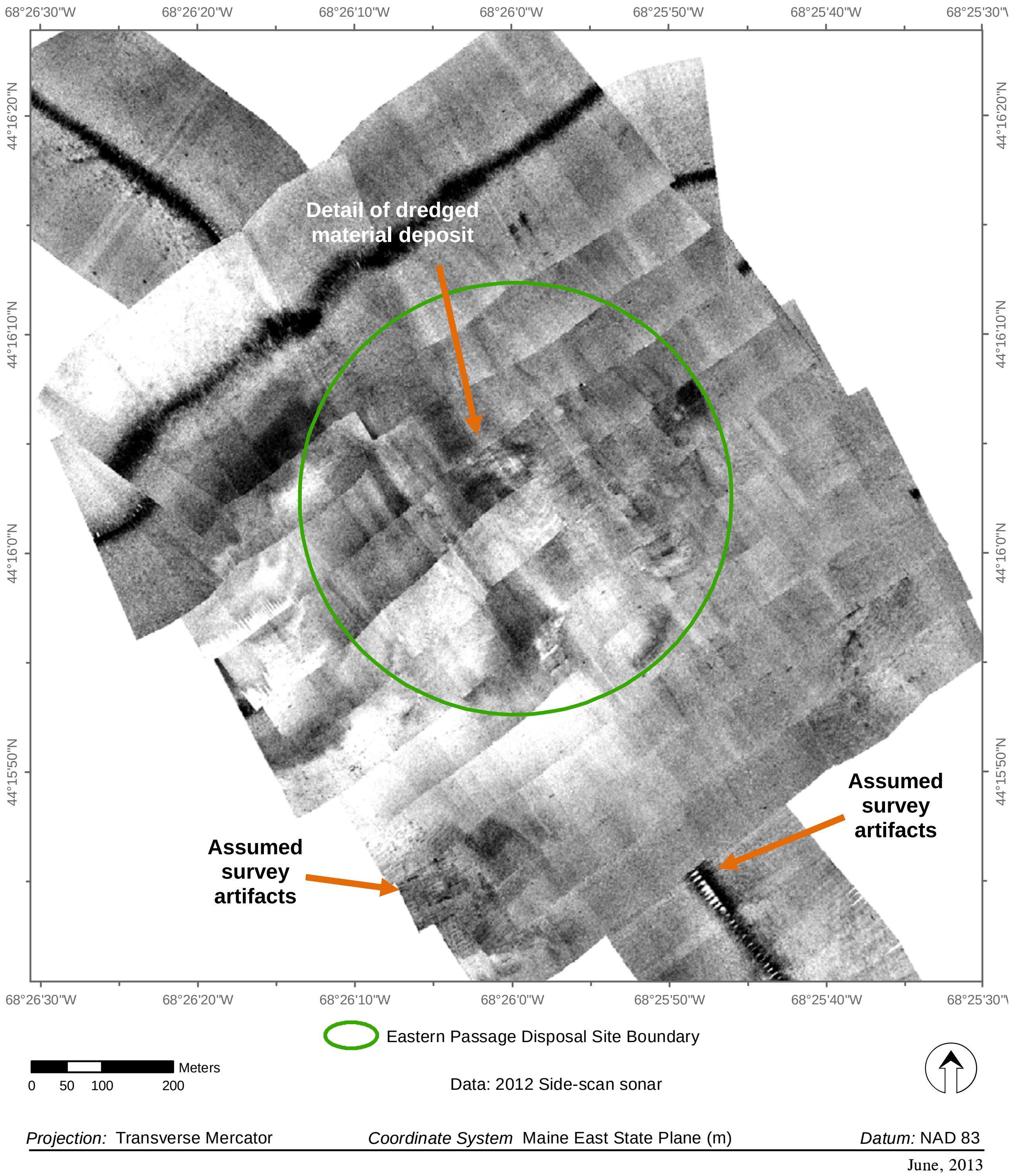


Figure 3-6. Side-scan sonar mosaic of EPDS

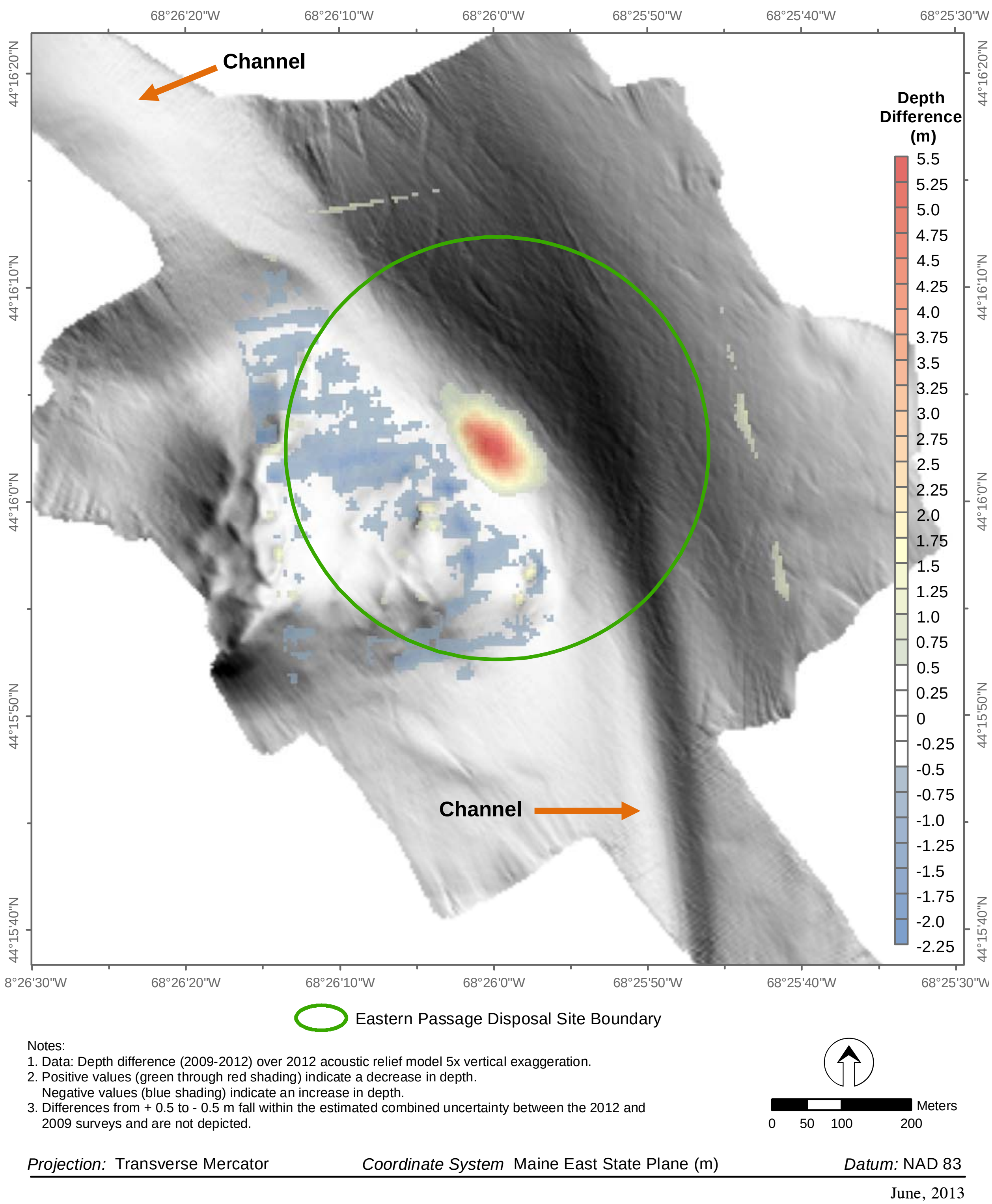


Figure 3-7. Depth difference contour map of EPDS: December 2009 vs. October 2012

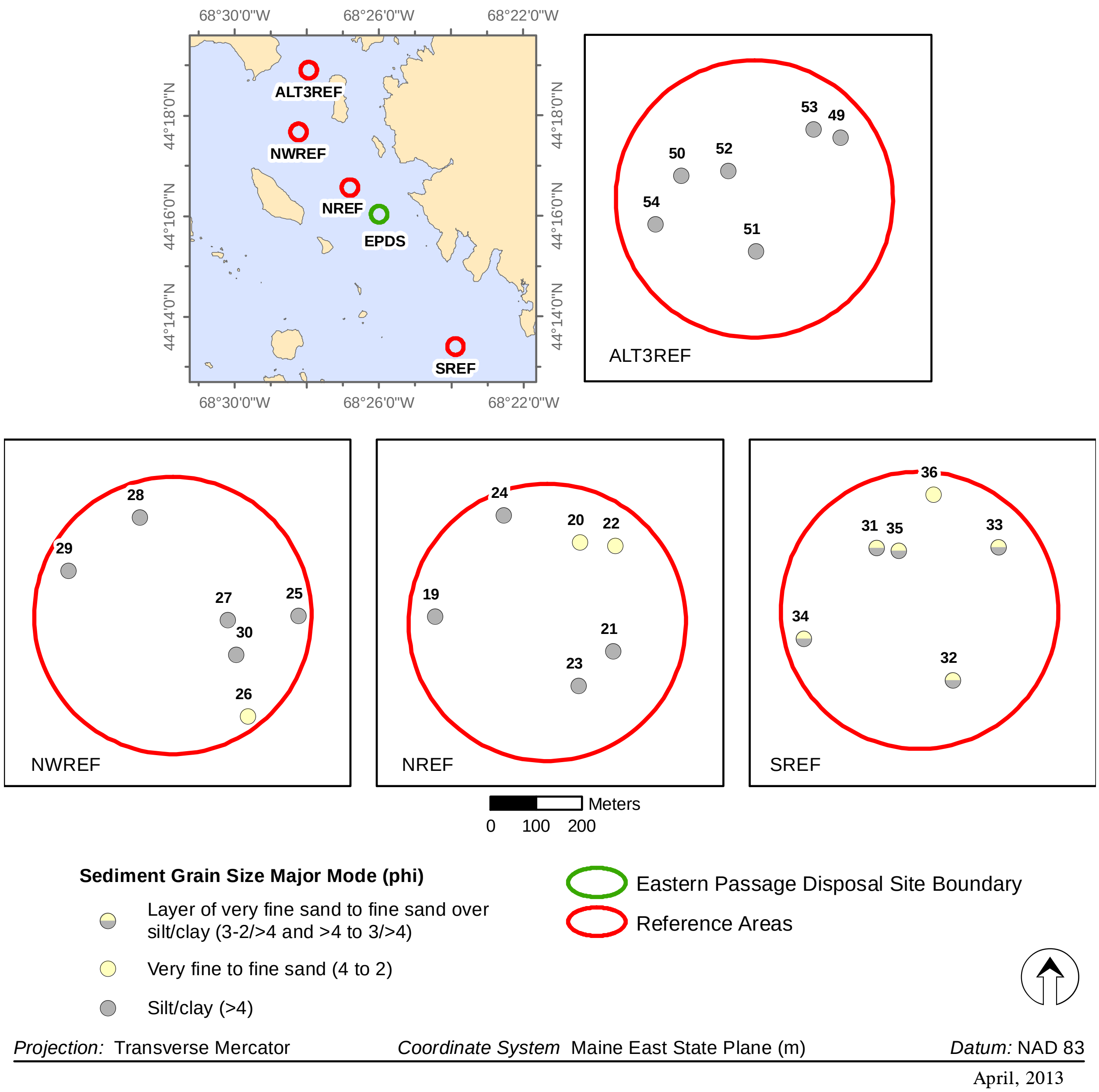


Figure 3-8. Sediment grain size major mode at the reference areas - October 2012

Figure 3-9. Sediment-profile image from Station 49 was typical of sediment particle size found at all stations surveyed in the northernmost reference area ALT3REF.

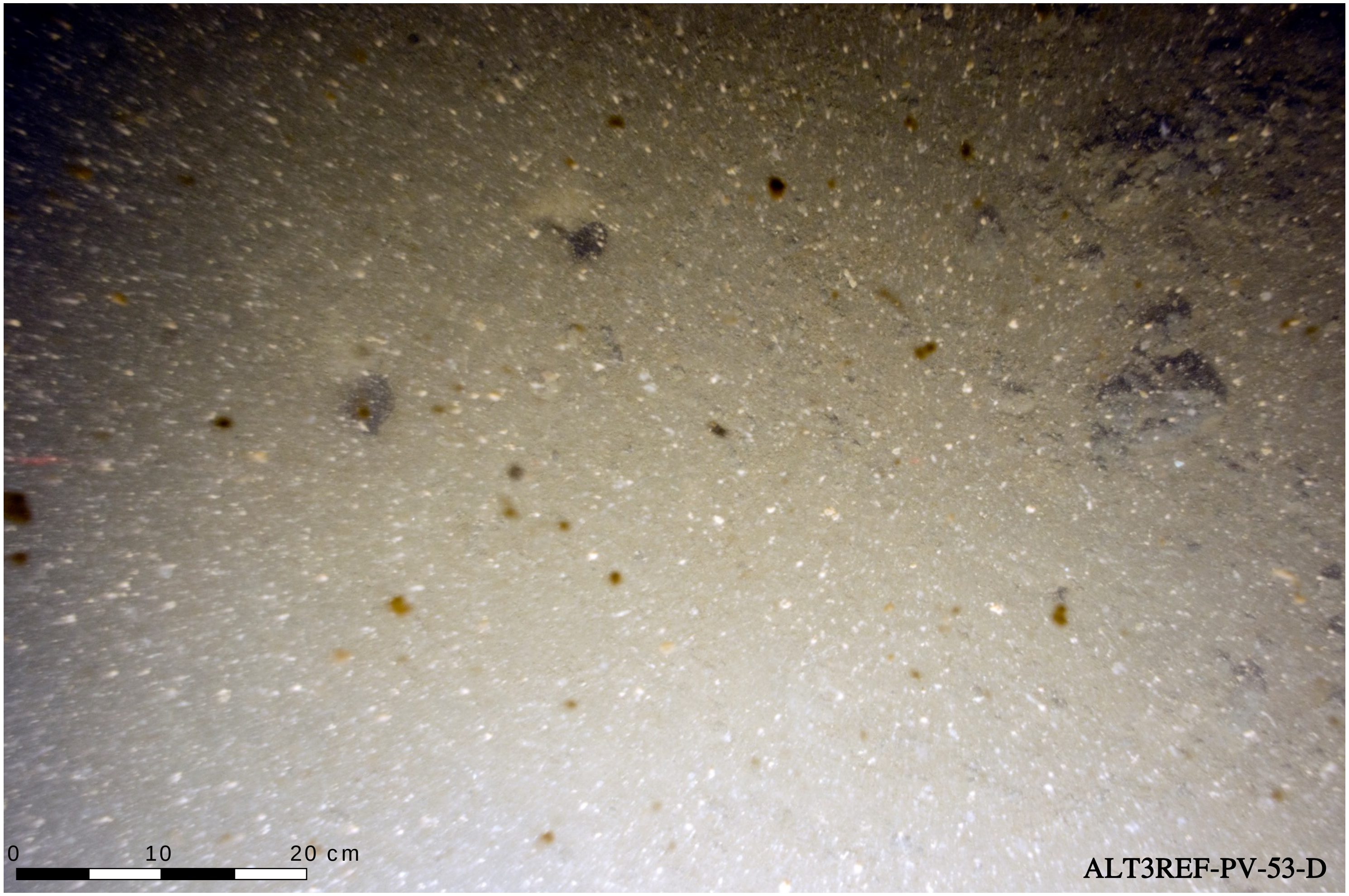


Figure 3-10. Plan-view image from Station 53 was a good example of the seafloor surface at ALT3REF; aside from the mud clast artifacts on the surface assumed to have fallen off the camera base sled, the only features visible on the silt/clay bottom were a few large burrow openings in the upper left quadrant of the image.

Figure 3-11. Plan-view images from NWREF Stations 26 (top) and 30 (bottom) showed a sandy silt bottom with varying densities of larger cobble and rocks on the sediment surface.

Figure 3-12. The silt/clay bottom in these plan-view and profile images from NWREF Station 28 showed a relatively narrow range of sediment particle sizes in contrast to those found in the previous image.

Figure 3-13. Plan-view images from NREF Stations 20 (top) and 22 (bottom) showed a mixture of fine and coarse-grained sediments which provided surfaces for sessile fouling organisms as well as attractive structures for larger motile epifaunal foragers.

Figure 3-14. Plan-view image from NREF Station 23 showed a dense covering of tiny tubicolous fauna as well as small burrow openings.

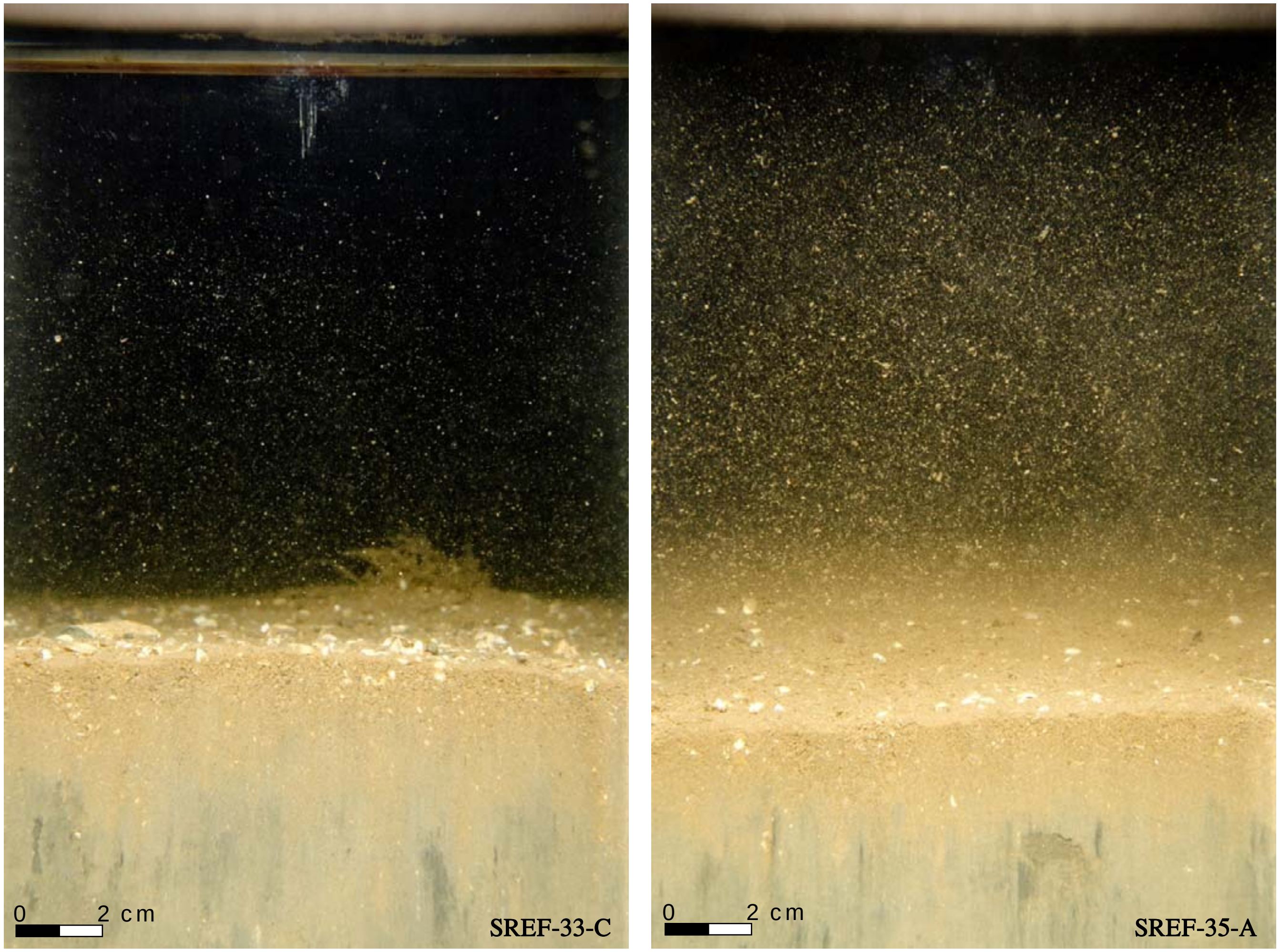


Figure 3-15. Sediment-profile images from SREF Stations 33 (left) and 35 (right) typified the sediment grain size major mode and range found at the majority of the south reference locations surveyed; note the varying degree of shell fragments on the sediment surface.

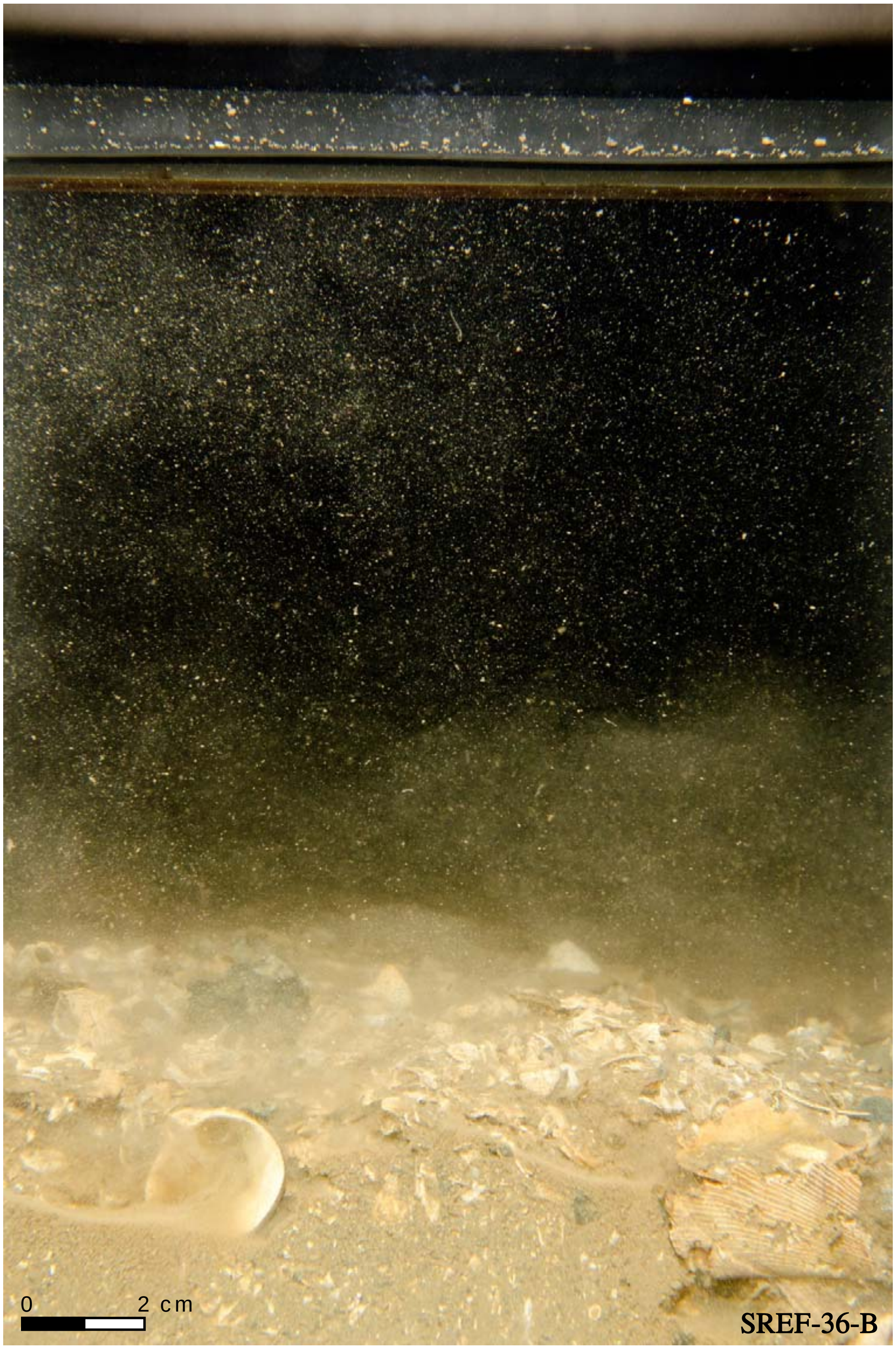
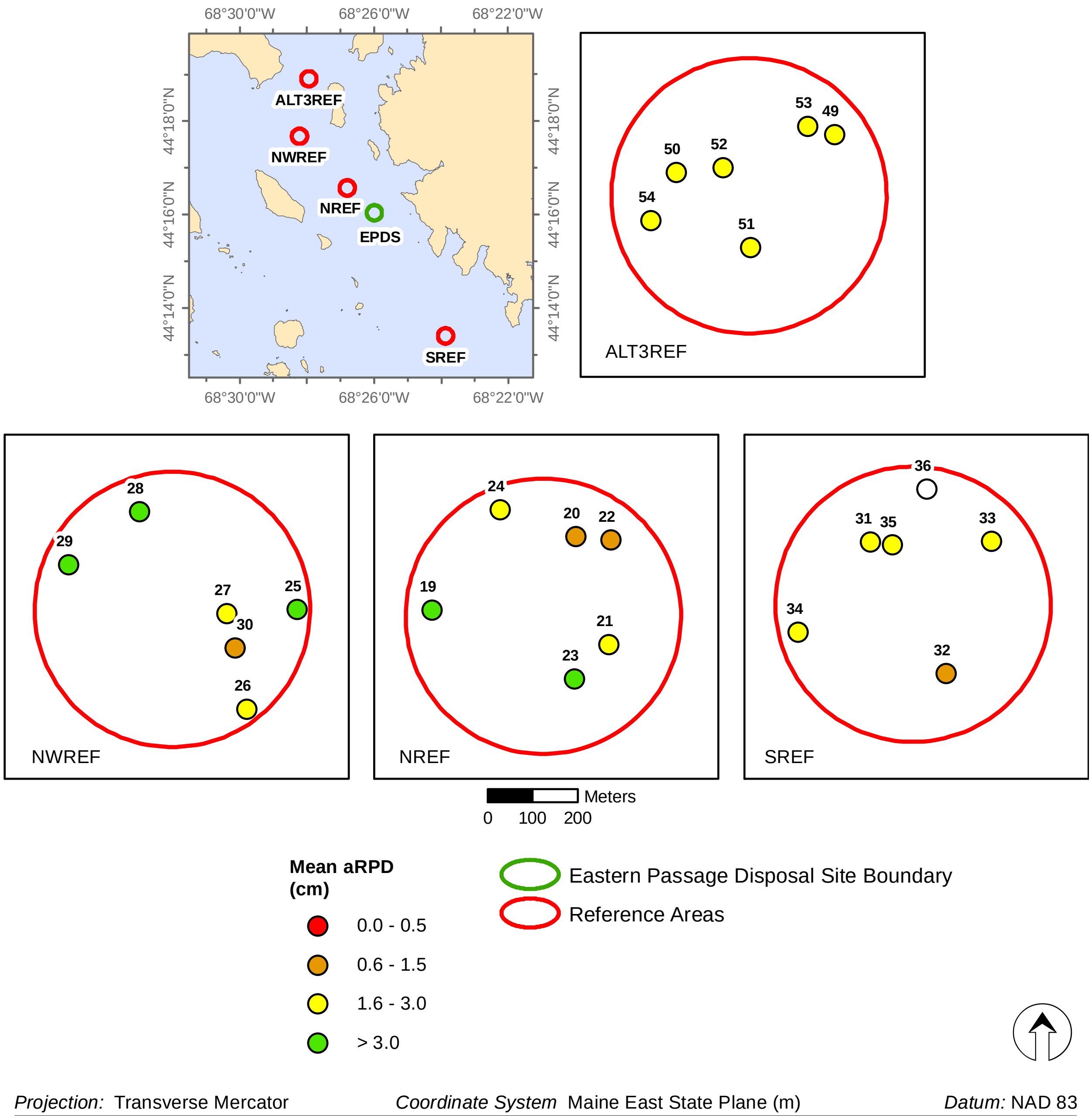
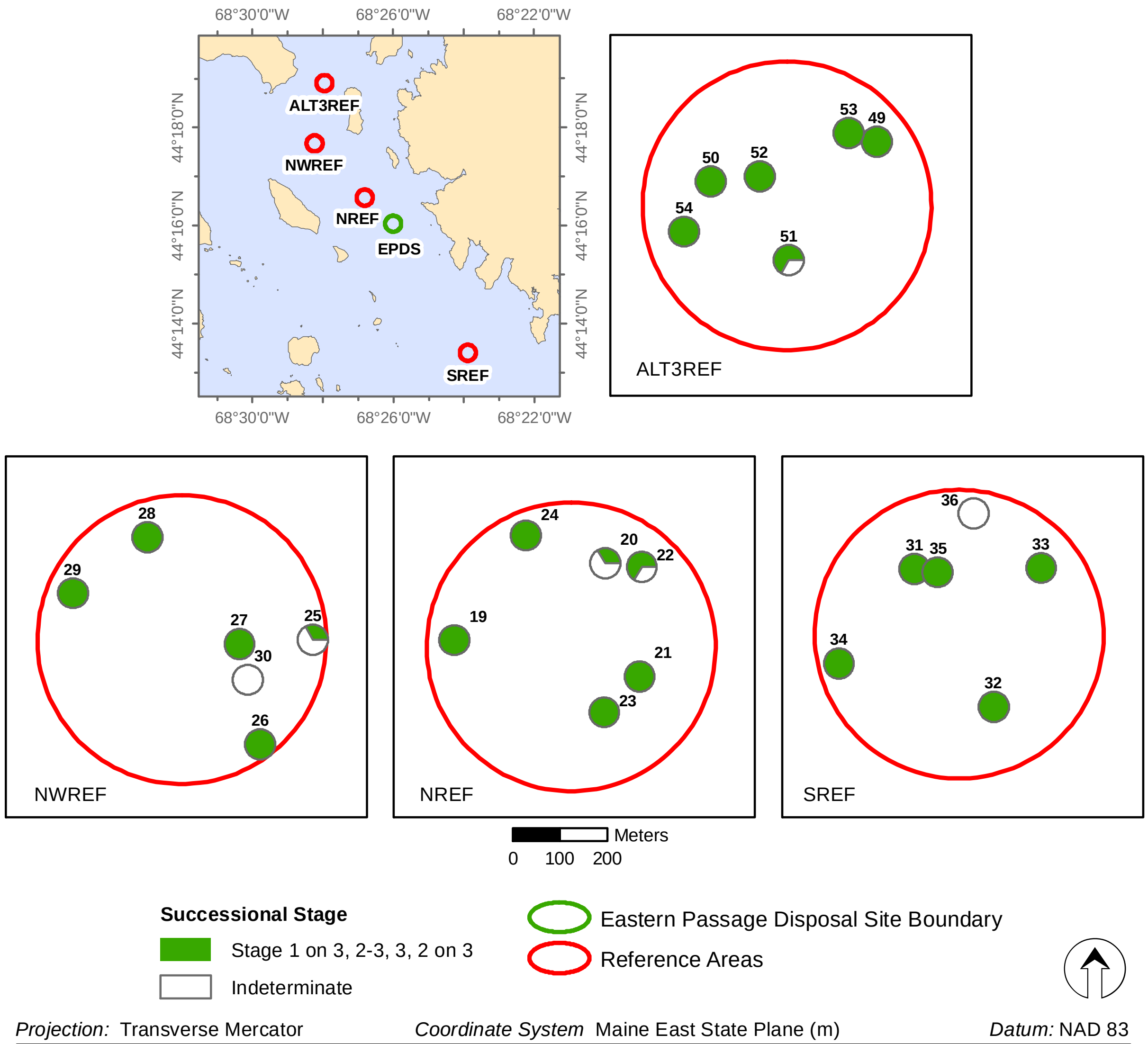


Figure 3-16. Sediment-profile image from SREF Station 36 showed the sediment surface armored with shell fragments which was an effective barrier to the camera prism penetration.



April, 2013

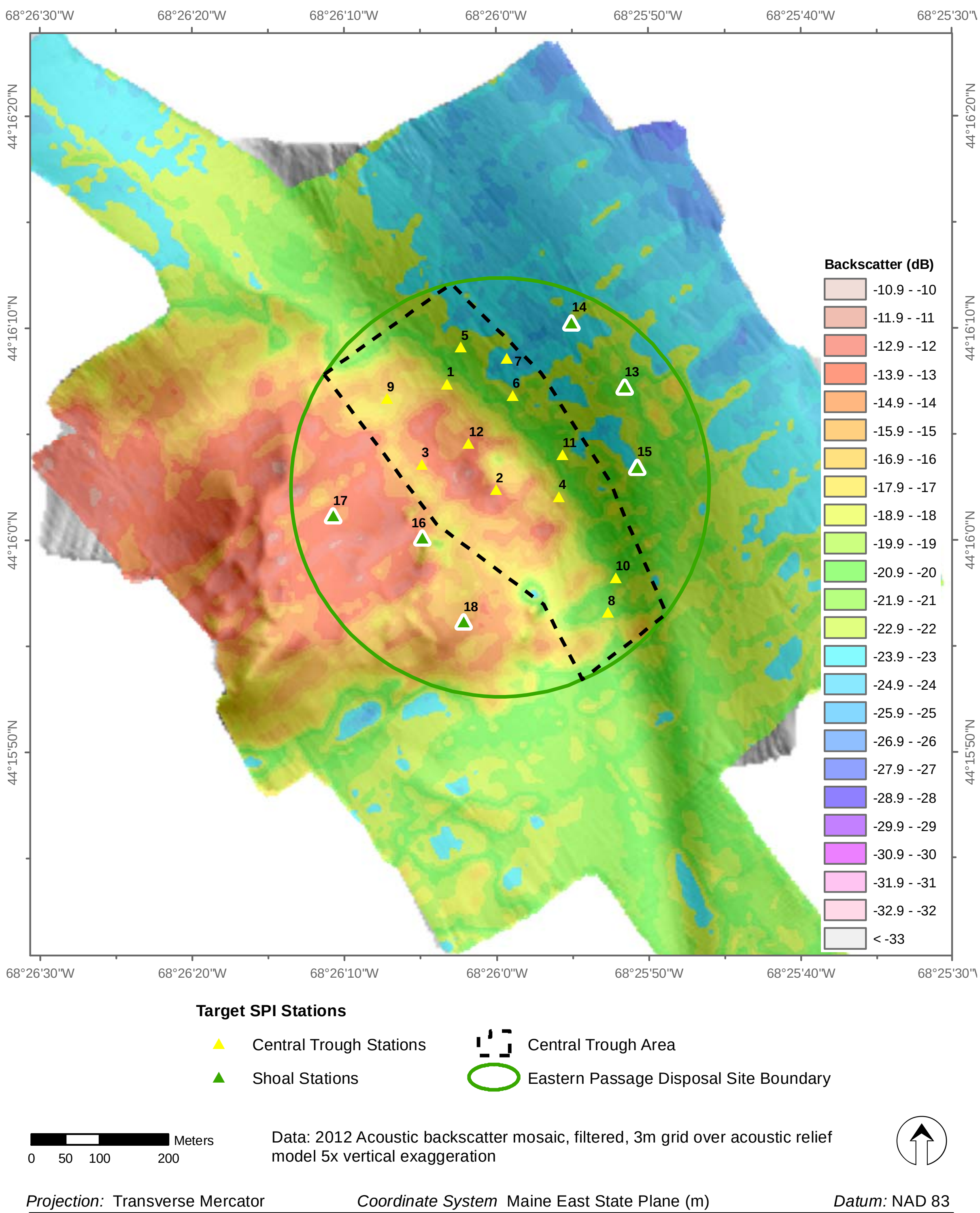
Figure 3-17. Average station depth (cm) of aRPD at the reference areas - October 2012



April, 2013

Figure 3-18. Infaunal successional stages found at the reference areas - October 2012

Figure 3-19. Sediment-profile image from NREF Station 19 showed evidence of infaunal activity to the full depth of the imaged cross-sectional area.



June, 2013

Figure 3-20. SPI/PV stations located in the central trough, the southwest shoal area, and the northeast shoal area

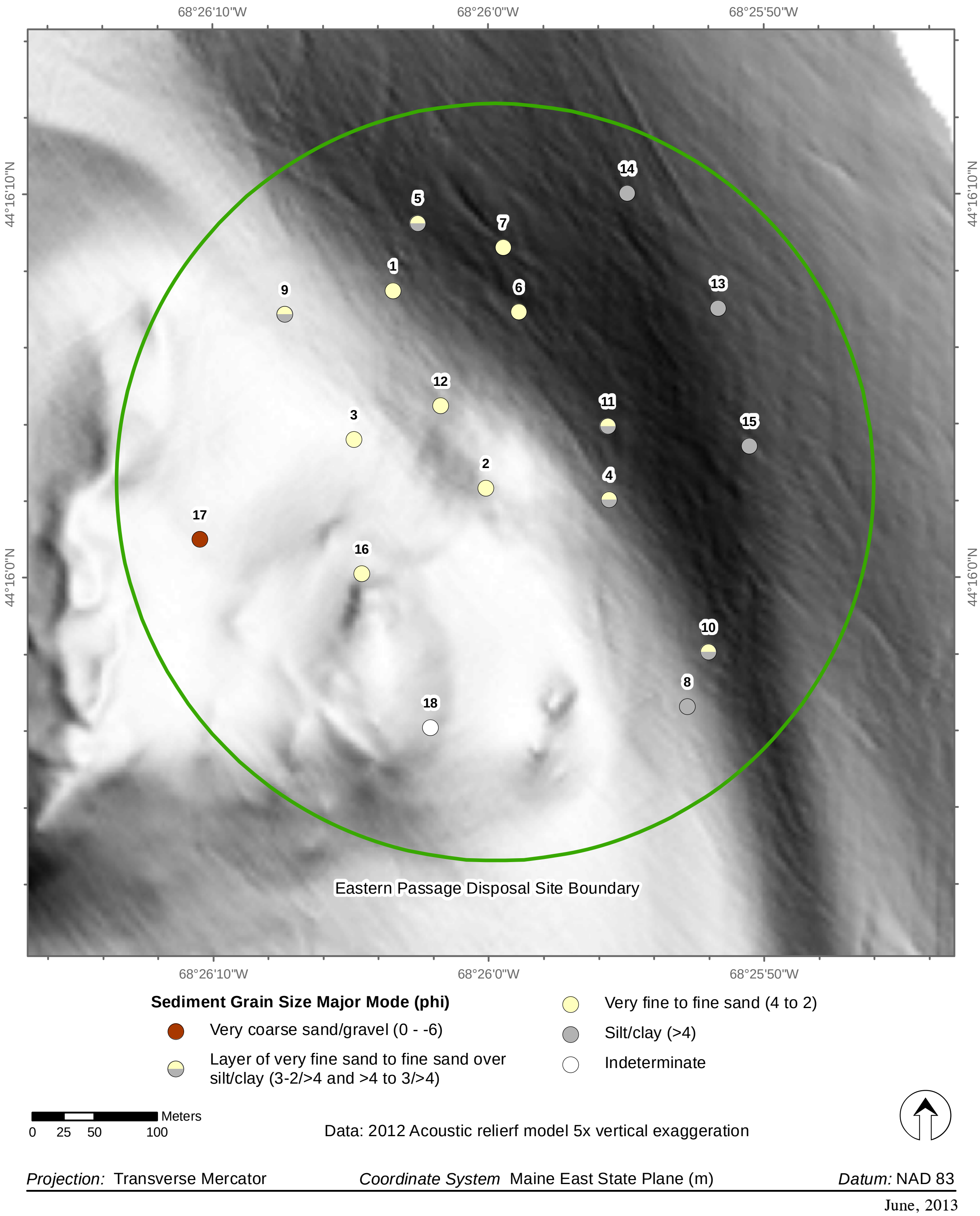


Figure 3-21. Sediment grain size major mode (phi units) at EPDS - October 2012

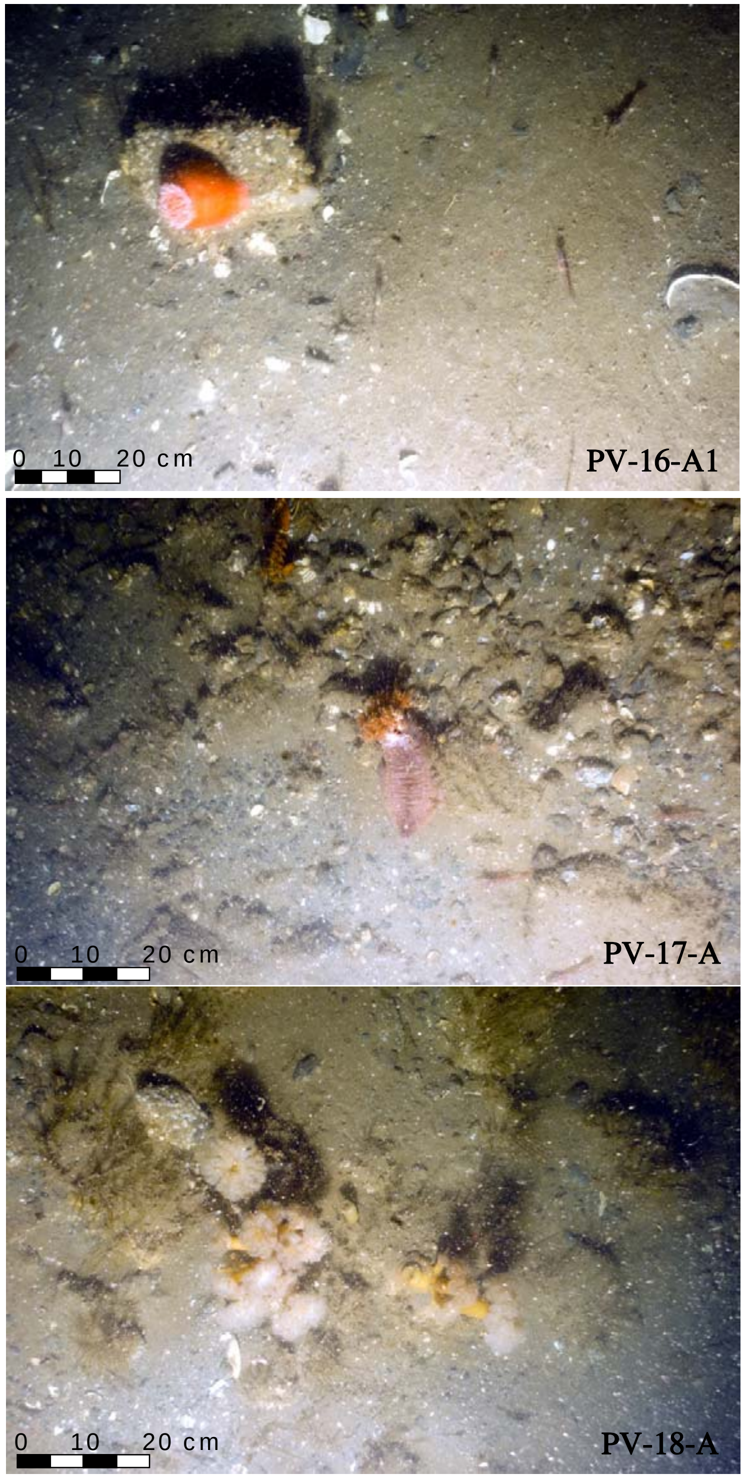


Figure 3-22. Plan-view images from Stations 16 (top), 17 (center) and 18 (bottom) on the western slope had rocky bottoms with complex topography that attracted larger, mobile epifauna.

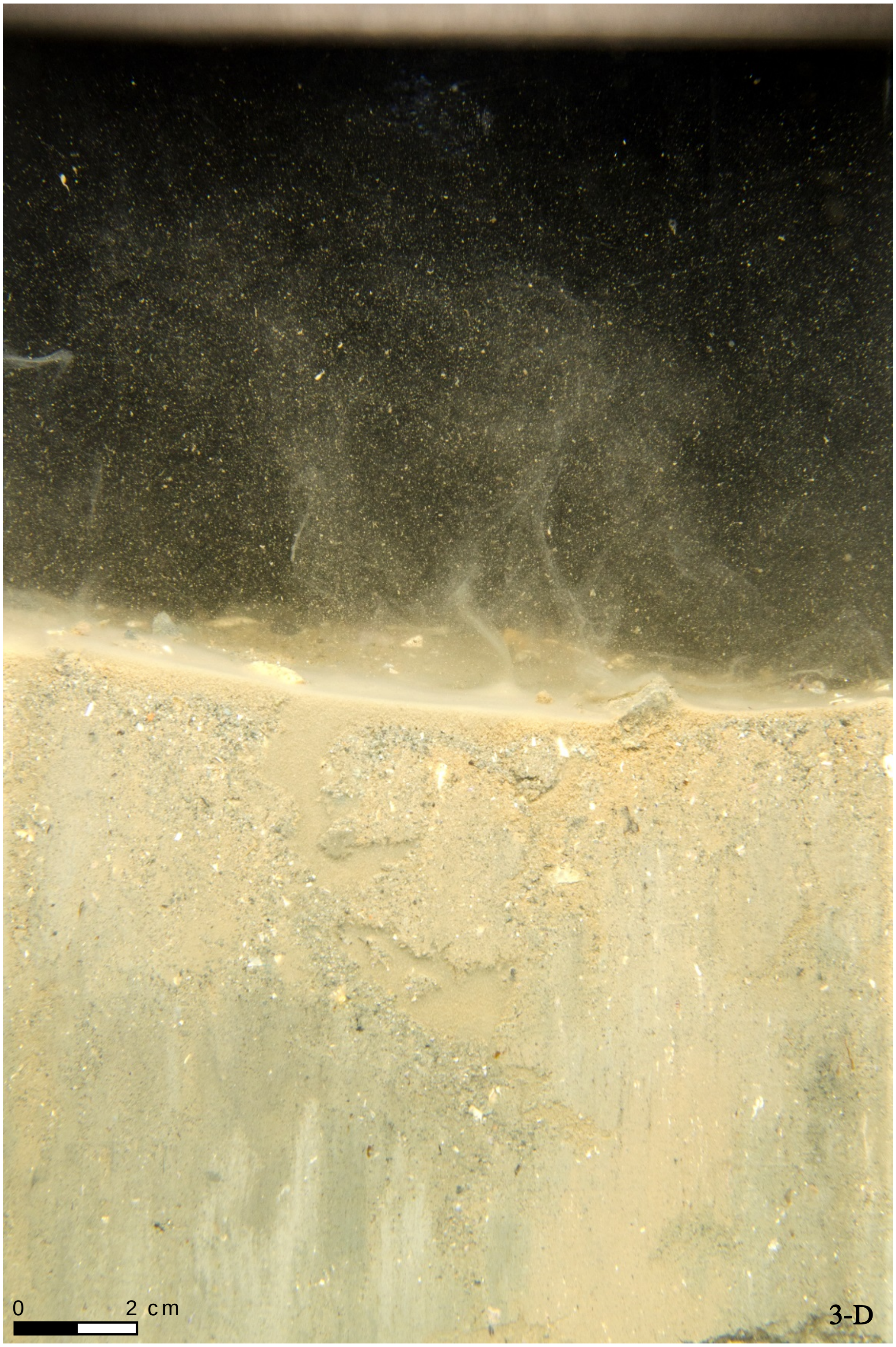


Figure 3-23. Sediment-profile image from Station 3 located on disposed material had silty, very-fine sands as a sediment grain size major mode (4-3 phi).

Figure 3-24. Sediment-profile image from Station 9 located on disposed material had a surface layer of silty fine sand overlying a basement foundation of silt/clay.

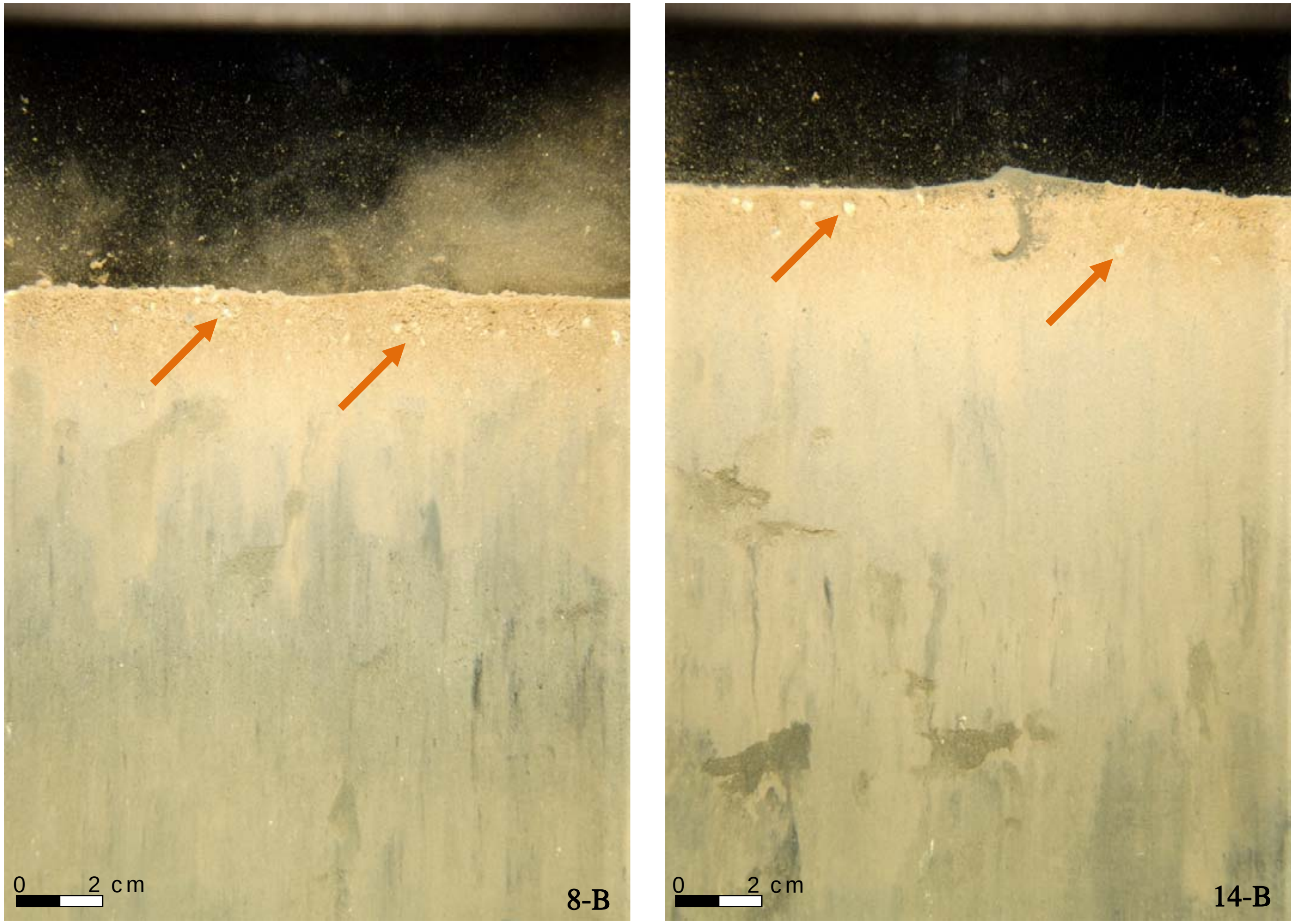


Figure 3-25. Sediment-profile images from Station 8 (left) located on disposed material and Station 14 (right) had a sediment grain size major mode of silt/clay (≥4 phi); arrows note the high densities of the coot clam, *Mulinia lateralis*, in the top 2 cm of the oxidized surface layer.

Figure 3-26. Sediment-profile image from Station 7 showed a dredged material layer exceeding prism penetration depth, yet there was a healthy oxidized surface layer of sediment (aRPD = 2.8 cm) with a relatively high density of *Mulinia* (arrows) near the sediment-water interface.

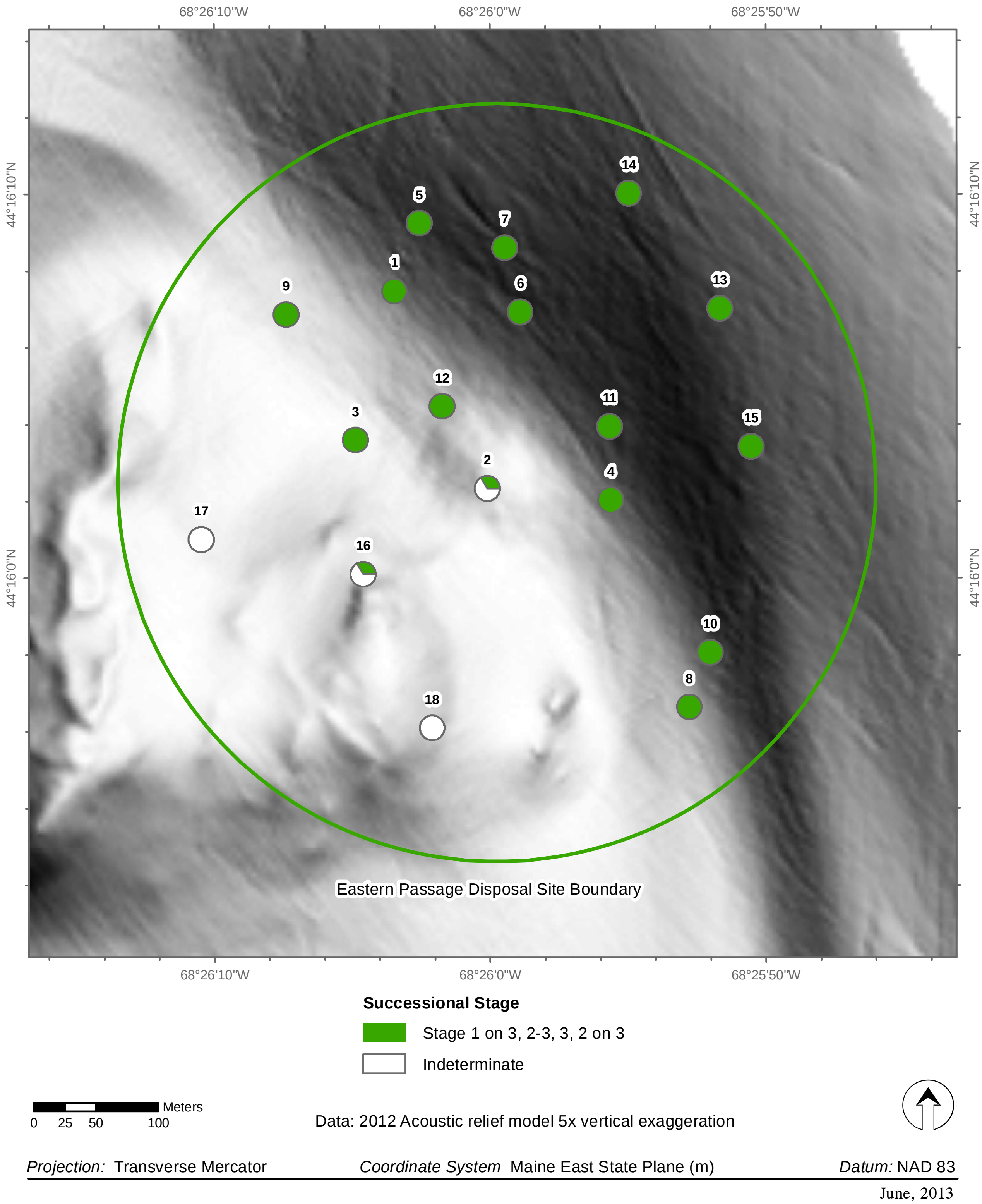


Figure 3-27. Infaunal successional stages found at EPDS - October 2012

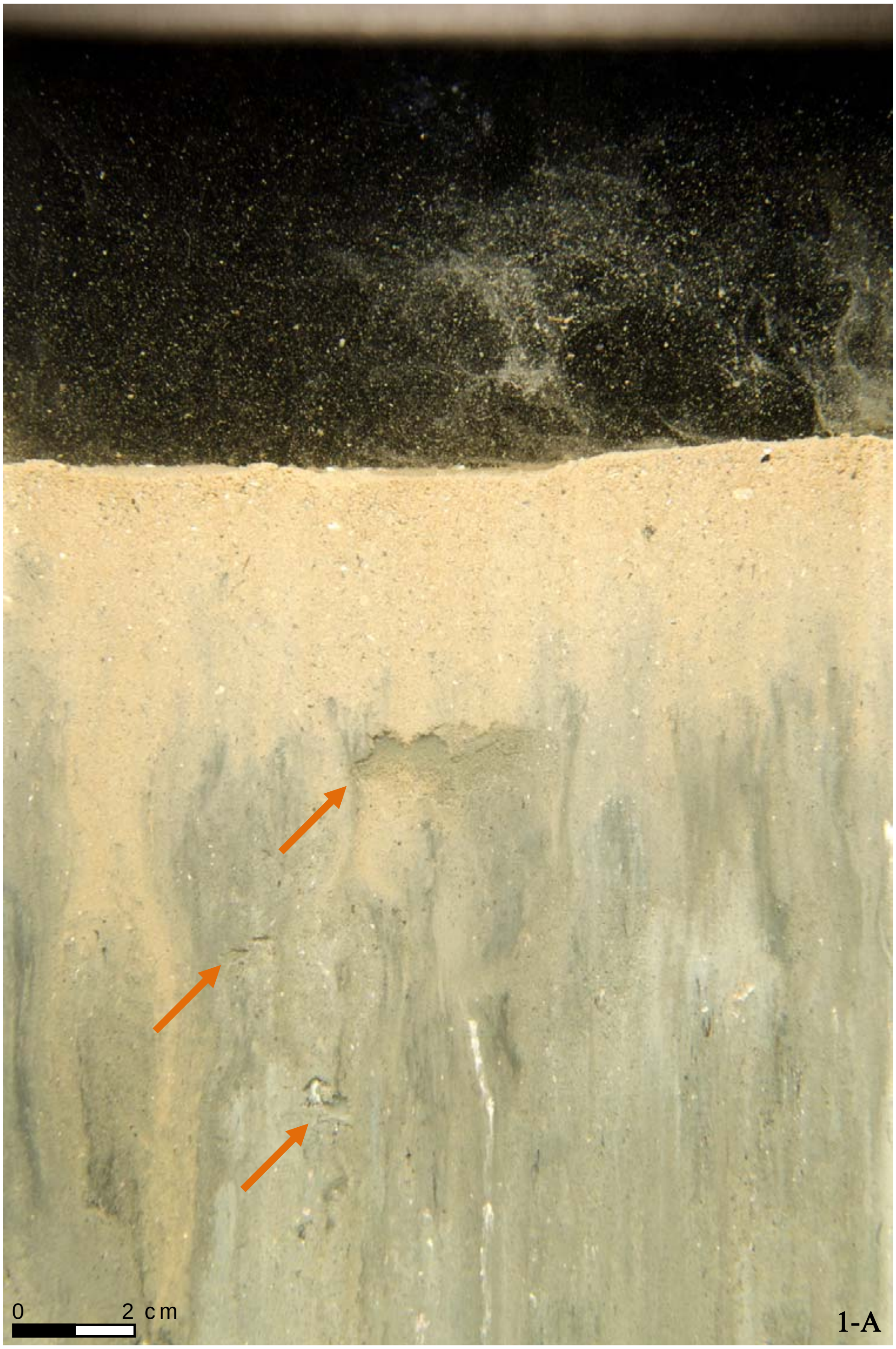


Figure 3-28. Sediment-profile image from Station 1, located in the deeper areas of the disposal site where the majority of the dredged material accumulated, showed active feeding voids (arrows) at depth.

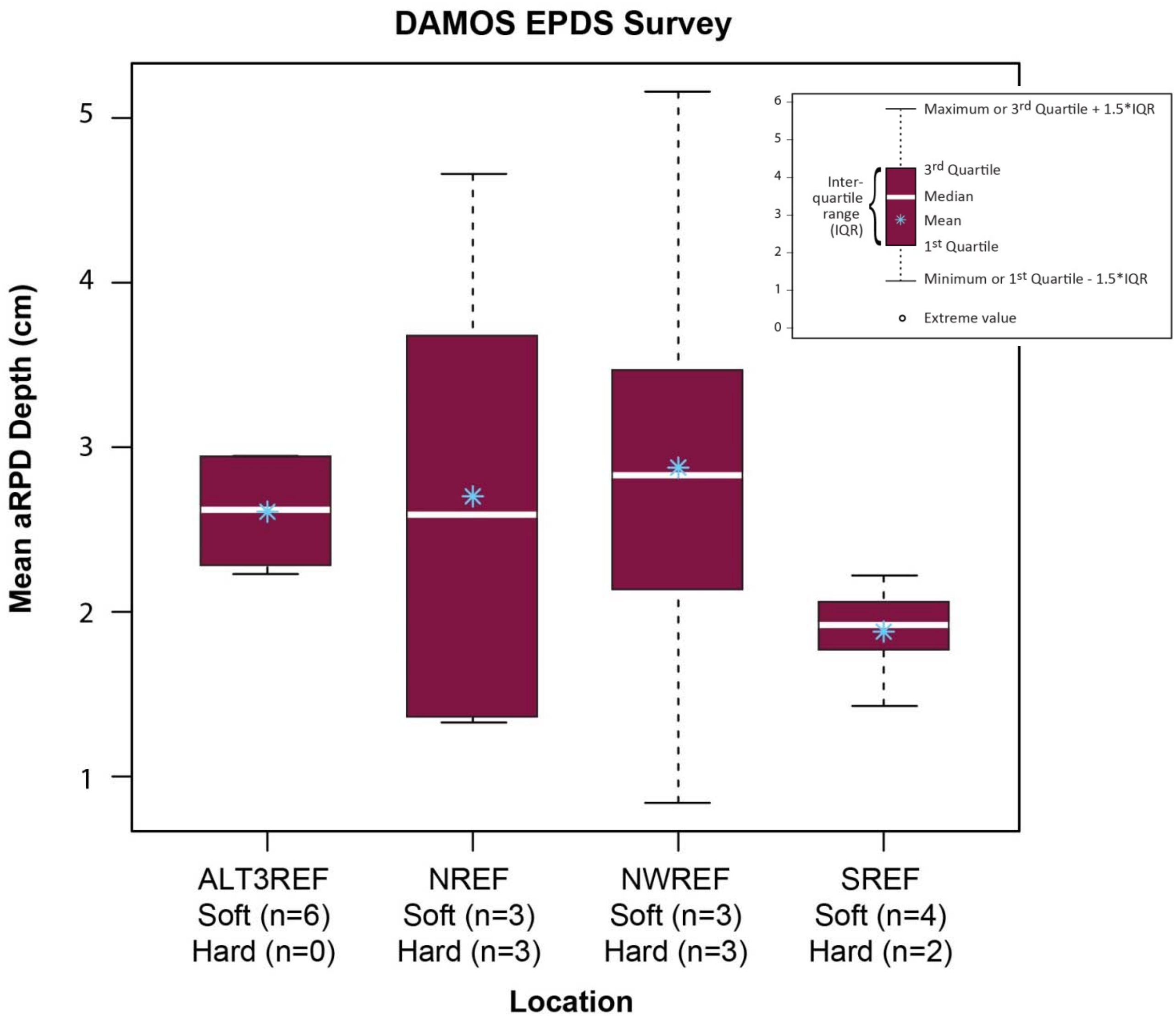


Figure 3-29. Boxplot showed distribution of station mean aRPD depths for 2012 EPDS potential reference areas. Station counts shown were the stations which had measurable aRPD depth values. Boxplots use ranges and quartiles to display relative differences in medians, dispersion and skewness among areas. These are graphical aids for visualizing the results of statistical tests on normality (contraindicated by lack of symmetry in the box and "whiskers"), and equality of variances (contraindicated by widely disparate ranges between boxplots for different areas).

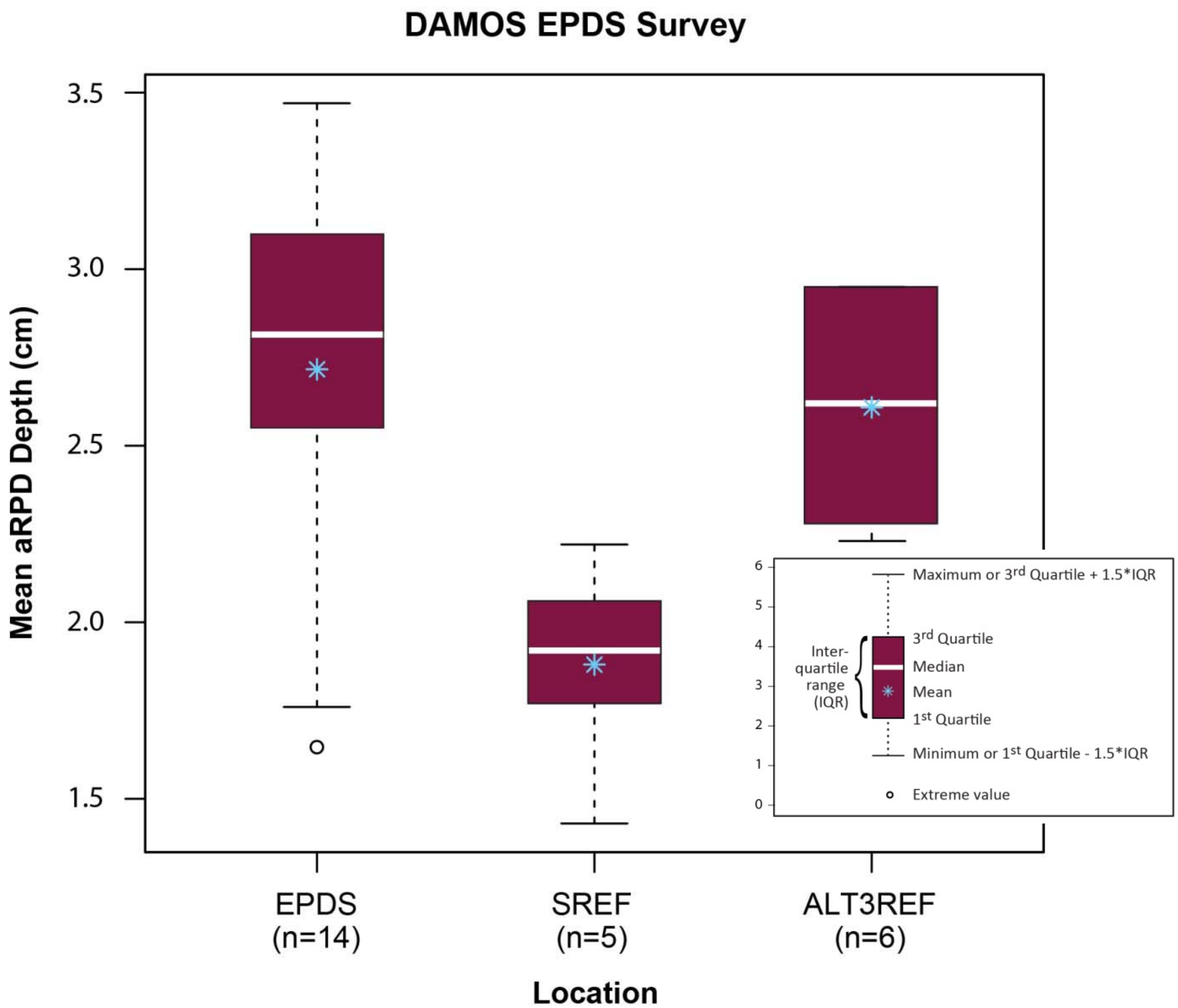


Figure 3-30. Boxplot showed distribution of station mean aRPD depths for 2012 Eastern Passage Disposal Site and the suitable reference areas. Station counts shown were the stations which had measurable aRPD depth values.

4.0 DISCUSSION

4.1 Physical Characterization of EPDS

EPDS encompasses a deep central trough of the tidal channel of Blue Hill Bay (Eastern Passage) as well as a large rock outcrop to the southwest and a smooth, steeply sloped shoal to the northeast (Figure 3-1). Dredged material placed at EPDS was difficult to distinguish in the bathymetric contour map (Figure 3-1), but a small deposit was readily apparent in the acoustic relief model (Figure 3-2), contoured filtered backscatter results (Figure 3-5) and in the depth difference results (Figure 3-7). The location of this deposit is more apparent with the recorded locations of dredged material placement overlaid on the 2012 bathymetry and backscatter results (Figure 4-1).

The deposit rose about 5 m high above the base of the channel with a footprint of 170 × 80 m forming an elliptical shape oriented along the axis of the channel. This deposit was consistent with expectations resulting from placement of a small amount of dredged material (~52,000 m^3) within a closely spaced series of release locations in over 100 m of water (Figure 4-1). There is evidence in backscatter and SPI/PV imaging that dredged material spread over a northeast shoal area due to placement in relatively deep water and potentially strong tidal currents present in the center of the disposal site (Figure 4-1). The curved marks seen in the acoustic relief model on the northeast shoal were consistent with bottom trawl disturbance marks and appeared to extend to the bottom of the trough but not over the deposit. If trawling did occur over the dredged material deposit, they would likely produce limited disturbance of surficial sediments.

The 2012 survey revealed two distinct sedimentary habitats and associated biological communities within EPDS: a fine-grained, soft-bottom infaunal community in the central trough and northeast shoal area, represented by Stations 1–15 (Figure 4-2), and a hard-bottom epifaunal fouling community in the southwest shoal area, represented by Stations 16–18 (Figures 3-21 and 4-3). The recent dredged material was placed primarily in the central trough area on fine-grained, soft-bottom substrata. One station (Station 2) on the dredged material deposit was classified as hard (≤ 7.5 cm penetration depth); some of the improvement material dredged on this project was coarse and rocky and may have limited penetration. The hard-bottom area in the southwest shoal was not intended to receive dredged material and was excluded from statistical comparison. The central trough area would likely be targeted for placement of any future dredged material at the site and should be matched to reference area characteristics.

Filtered acoustic backscatter provided evidence of dredged material distribution in the central trough area and northeast shoal area of the site (Figure 4-3). EPDS had not previously received dredged material, but without baseline backscatter data the contrast between native sediments and dredged material was inferred. The ambient trough backscatter was assumed to be in the -17 to -21 dB range; the northeast shoal in the -22 to -27 dB range, and the southeast shoal in the -10 to -18 dB range.

Higher backscatter values (-10 to -18 dB) were present over the elliptical-shaped dredged material deposit and the southwest shoal (Figure 4-3). The higher backscatter returns were consistent with 'hard' stations (2, 16, 17, 18; Figure 3-21) but also included 'soft' stations (3, 9, 12; Figures 3-22 and 3-23) located on the dredged material deposit. The higher return from a rough surface texture or the presence of shells, pebbles, or hard sand rather than rock or cobble is consistent with characteristics of other dredged material mounds (Carey et al. 2012). Moderate backscatter values (-15 to -22 dB) were present over the portion of the northeast shoal within the disposal sites, particularly in the southeast section of the site). These results suggested deposition of sediments coarser than the ambient fine sediments that form the shoal (Figure 4-3). The circular patterns in the backscatter results were consistent with placement impact features observed at other disposal sites in New England (Carey et al. 2012, Valente et al. 2012).

Side-scan sonar results revealed distinctive surface texture patterns over the dredged material deposit and more detail of the circular placement impact features on the northeast shoal (Figure 4-4).

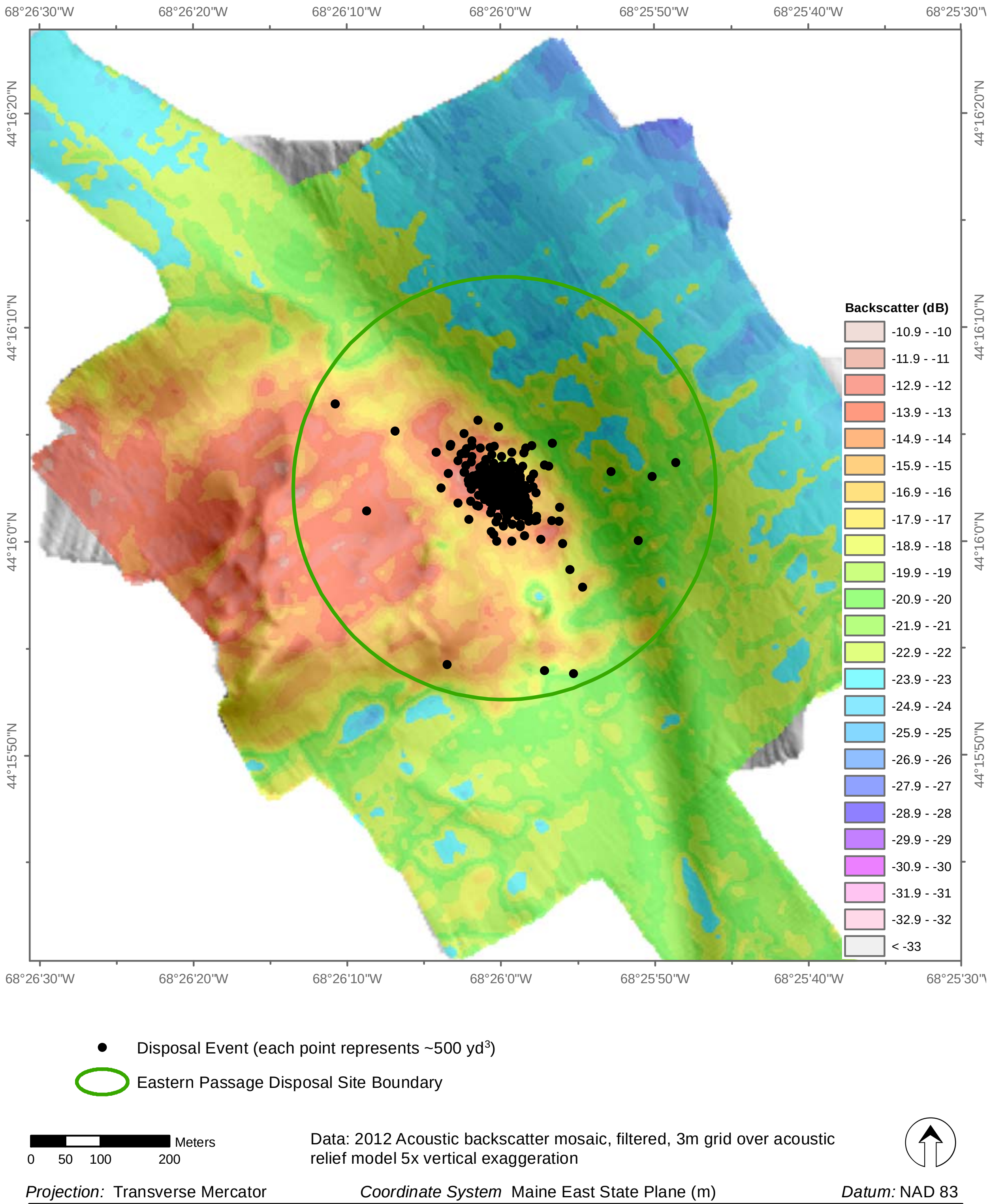
4.2 Reference Area Selection

EPDS is a new disposal site and as such did not have previously identified reference areas. The study area, located in the tidal channel of Blue Hill Bay, is characterized by complex topography and various surficial sediment types. Four potential candidate reference areas were identified and evaluated with the goal of selecting two suitable reference areas to support the 2012 and future EPDS monitoring surveys (Figure 4-5).

To support selection of suitable reference areas, substrata at each of the four reference areas were classified as hard or soft based on camera penetration (Figure 4-6), and the two distinct sedimentary habitats within the disposal site were classified (Figure 4-3). SREF and ALT3REF were found to be most representative of pre-impact EPDS central trough area conditions and are recommended as suitable reference areas (Figure 4-7).

4.3 Benthic Recolonization

EPDS last received dredged material 18 months prior to the October 2012 monitoring survey. The soft-bottom infaunal communities within the disposal site were observed to be fully recovered and similar to those found in the suitable reference areas (Figures 3-26 and 4-5). Also, the oxidized surface layers (aRPDs) within the disposal site were as deep as or slightly deeper than those found in the reference areas (Figure 3-30). The disposal site continued to be an active lobstering area (as evidenced by the frequent occurrence of the animals in the PV images and the traps deployed within the site [Figure 4-8] as well as trap density observed during the survey activities). Given the complete recovery of the benthic infaunal community, it is predicted that the effects from any future disposal operations at this site would be transient, and the infaunal community would quickly re-establish itself in a time frame of 12–18 months following completion of disposal operations.



June, 2013

Figure 4-1. Disposal events over backscatter and acoustic relief model

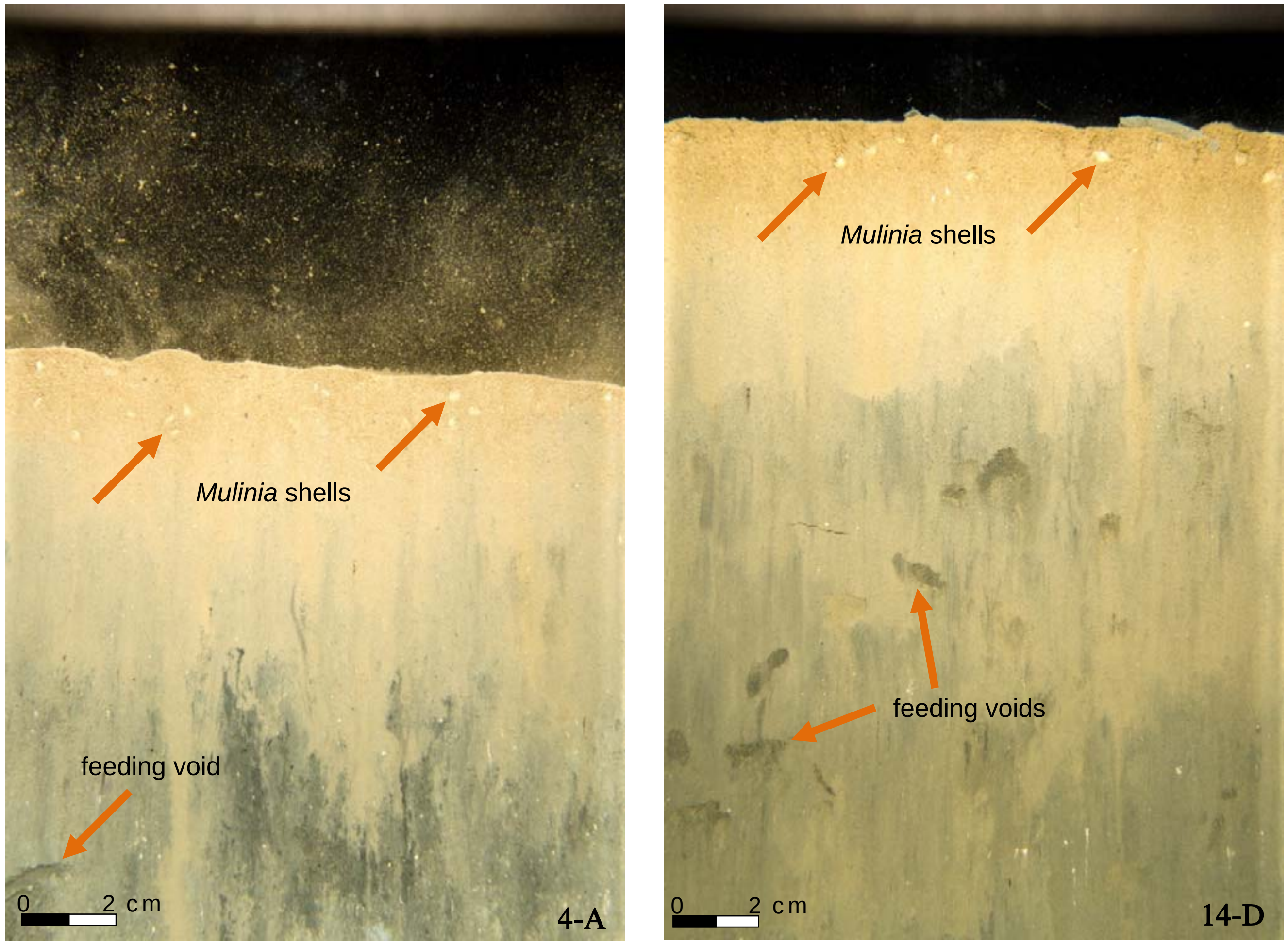


Figure 4-2. Sediment-profile images from Station 4 (left) located on the dredged material in the bathymetric trough within the disposal site and Station 14 (right) located in the shallower northeast corner of the site showed similar sediment type, aRPD depth, and successional assemblages (arrows note both the subsurface feeding voids as well as the presence of *Mulinia* shells in the upper oxidized layer).

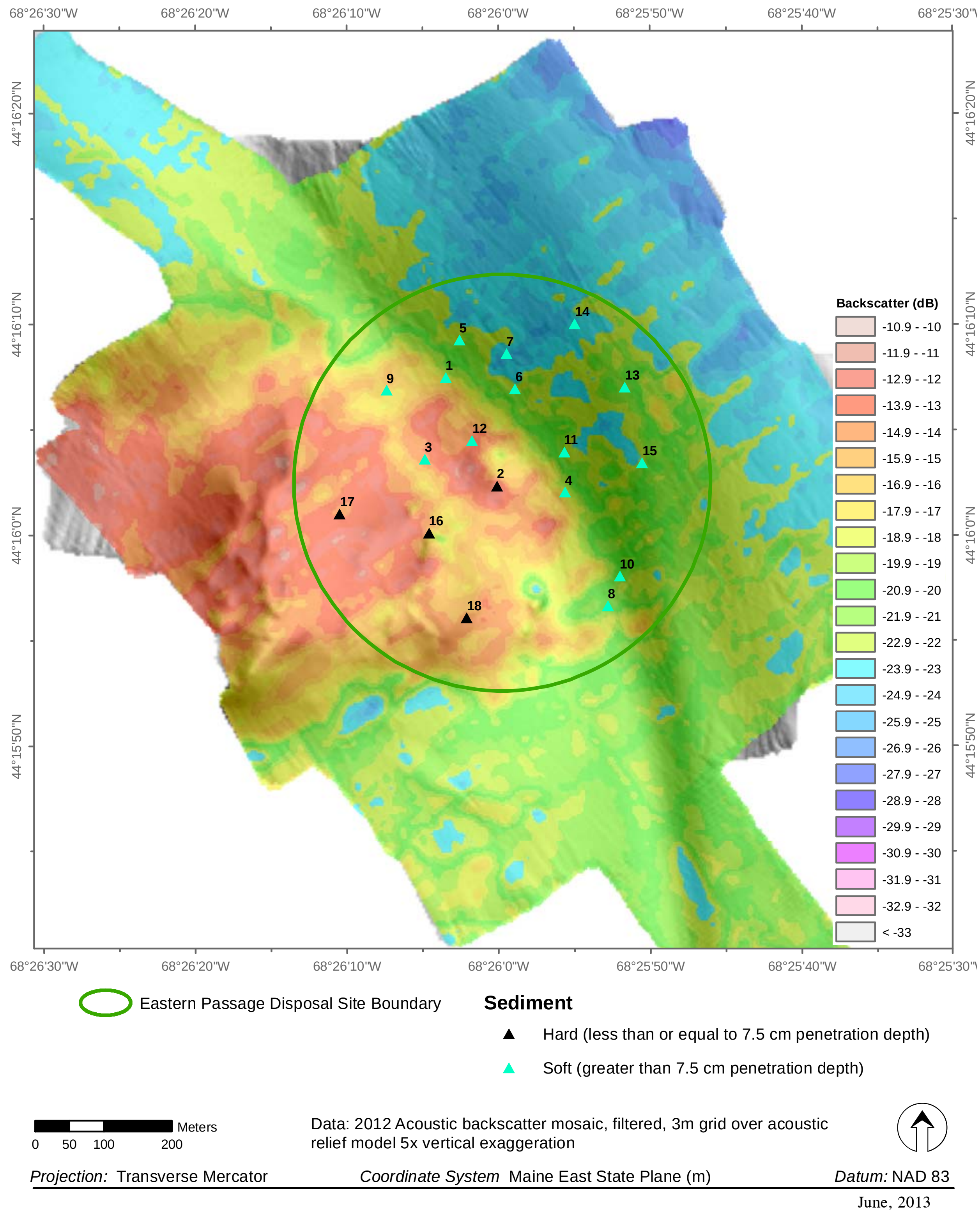


Figure 4-3. Sedimentary habitat type found at EPDS – October 2012

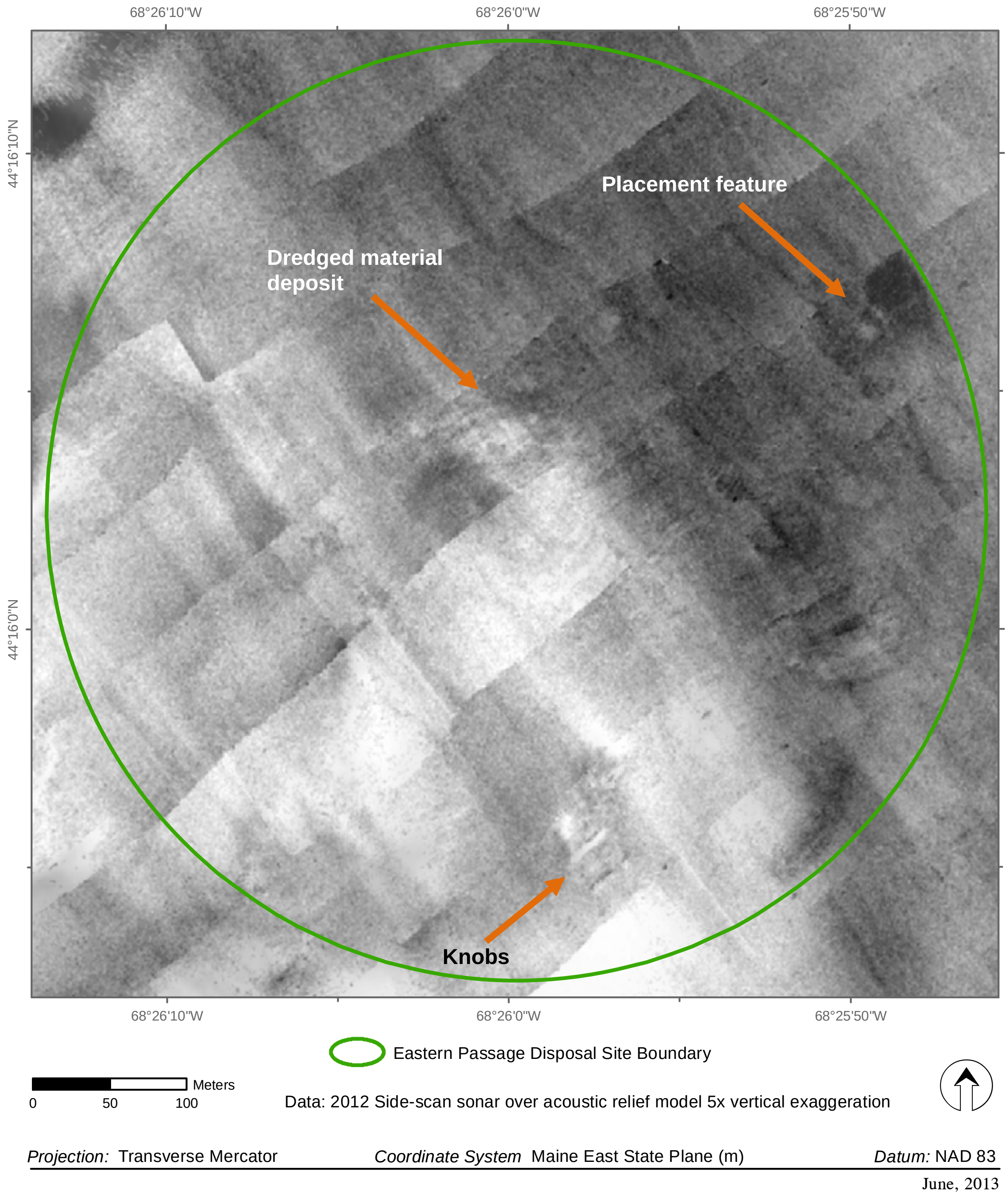


Figure 4-4. Side-scan sonar mosaic over acoustic relief model zoomed to extent of EPDS boundary - 2012

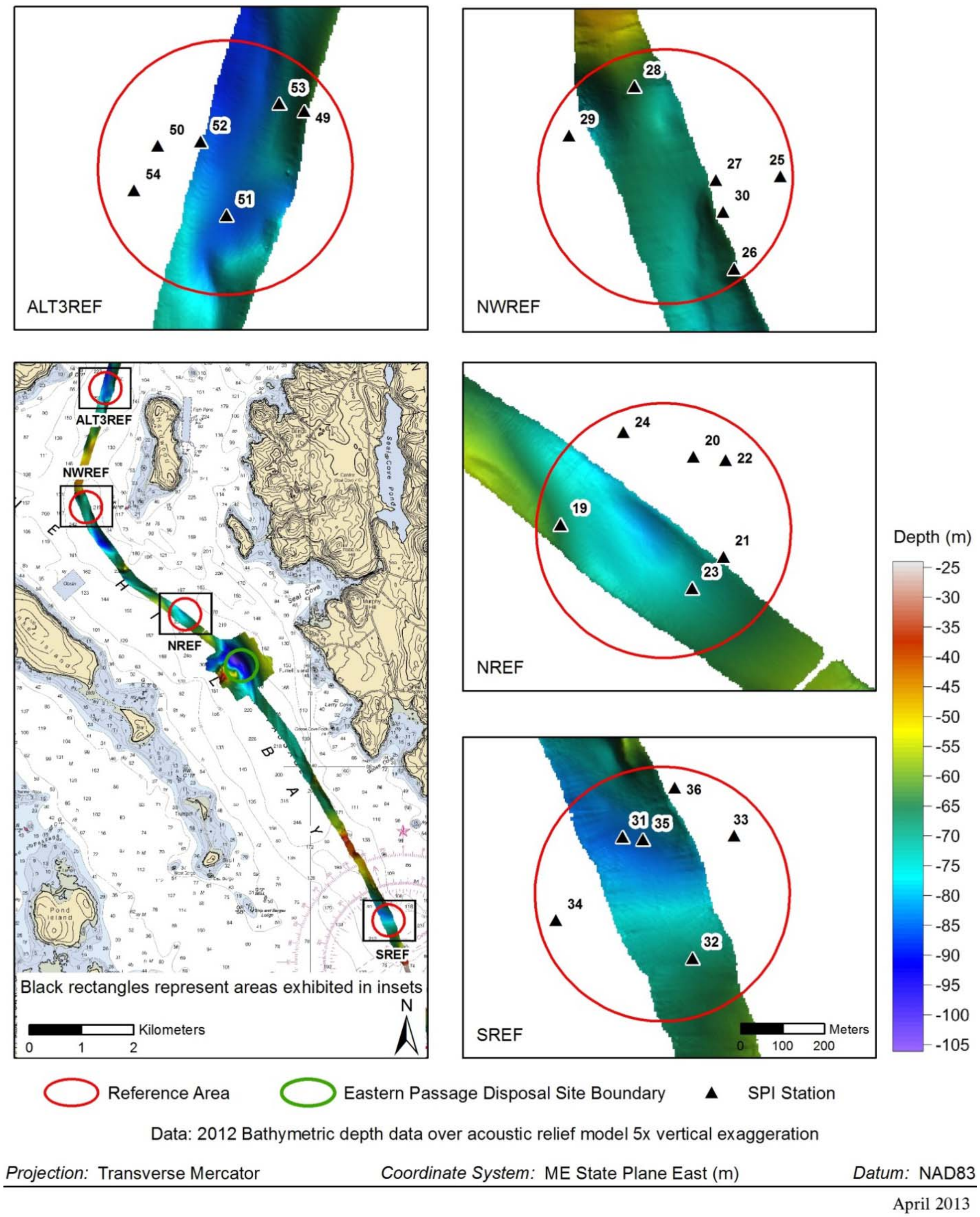


Figure 4-5. Reference area bathymetry with SPI/PV stations

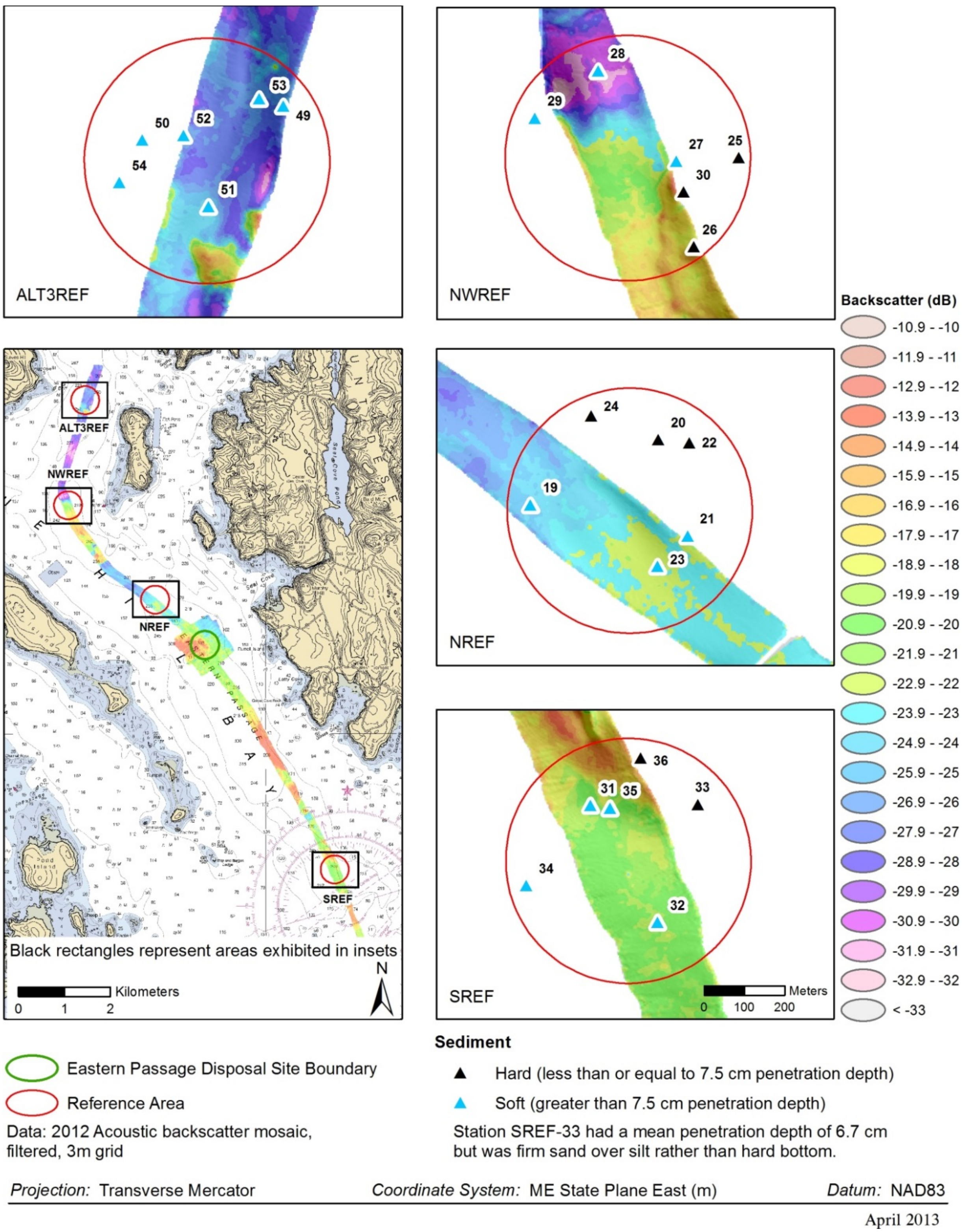


Figure 4-6. Sedimentary habitat type found at the reference areas – October 2012

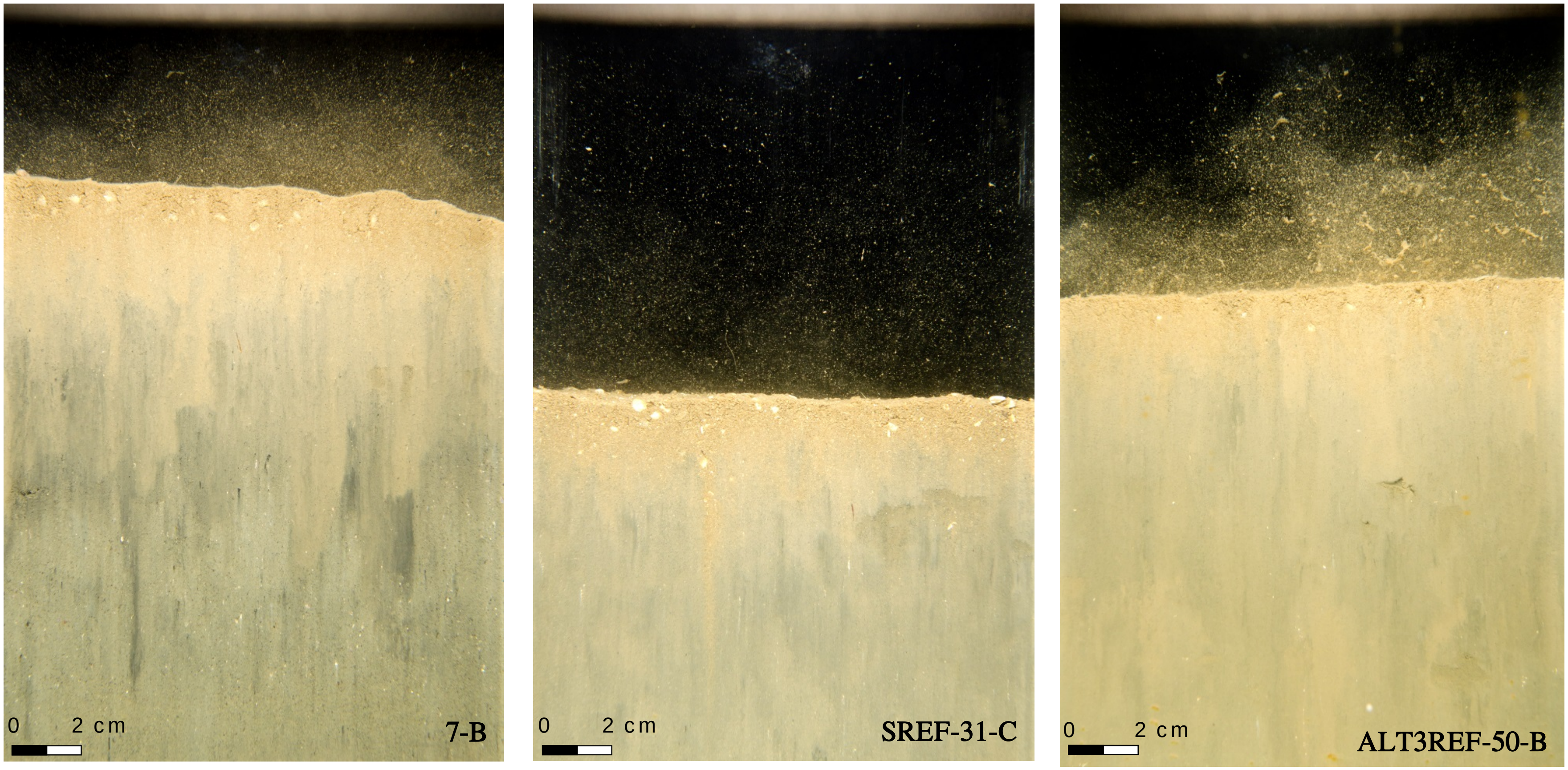


Figure 4-7. Sediment-profile images from Station 7 (left) located within EPDS, Station 31 (center) from SREF, and Station 50 (right) from the ALT3REF showed similar sediment type, aRPD depth, and successional assemblages (note both the sediment grain size as well as the presence of *Mulinia* shells in the upper oxidized layer).

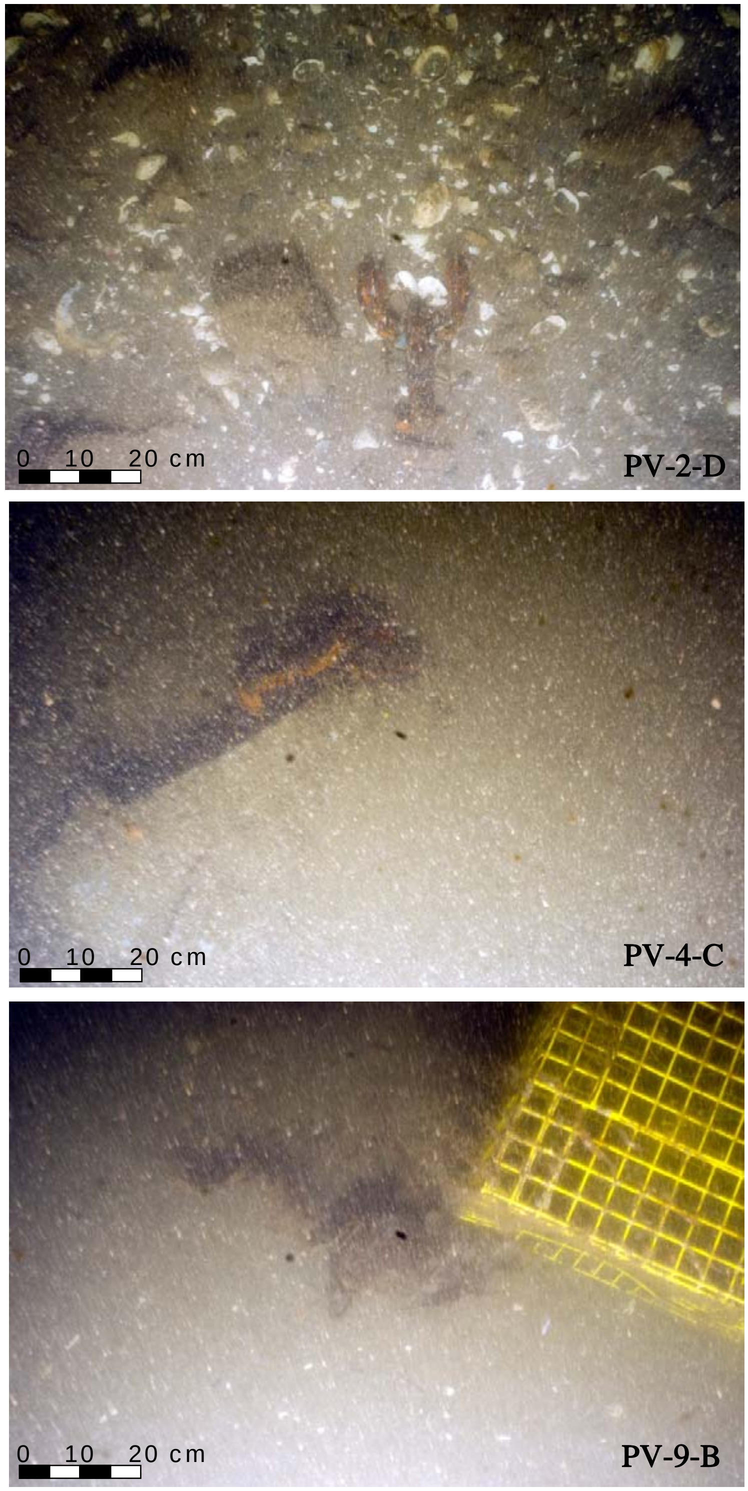


Figure 4-8. Plan-view images from Station 2 (top), Station 4 (center) and Station 9 (bottom) showed evidence of an active lobster/lobstering area had not been hampered by the disposal operation.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The combined acoustic and SPI/PV surveys performed at EPDS in October 2012 provided the following findings:

- EPDS is located in a trough in the tidal channel with hard rocky bottom to the southwest and a slope of soft sediment to the east. Placement of roughly 52,000 m^3 of dredged material in 100-m water depths in 2011 formed an elliptical deposit on the floor of the trough.
- Two suitable reference areas were selected from four candidate areas within the tidal channel of Blue Hill Bay. The suitable reference areas had predominantly soft sediments similar to those located within the trough at EPDS.
- The sediments on the surface of the dredged material deposit showed evidence of complete recovery of the benthic community characteristics typical of the surrounding seafloor (Stage 3 successional community assemblage). The surface sediments on the deposit had elevated aRPD depths compared to reference area values. Given the presence of a healthy equilibrium deposit-feeding assemblage, it is expected that the aRPD depths on the deposit will continue to meet or exceed reference area values.
- Given the complete recovery of the benthic infaunal community, it is predicted that the effects from any future disposal operations at EPDS would be transient, and the infaunal community would quickly re-establish itself in a time frame of 12-18 months following completion of disposal operations.

Based on the findings of the 2012 EPDS survey, the following recommendations are proposed:

R1) Future dredged material placement should be limited to the central trough area due to the favorable topography and sediment types observed in this area.

R2) High resolution acoustic surveys should be conducted if future dredged material placement activities are performed at the site to monitor the morphology and stability of the existing dredged material deposit as well as the formation of additional deposits.

R3) Two reference areas, SREF and ALT3REF, are recommended as suitable reference areas for future monitoring surveys.

R4) Benthic recolonization should be monitored with SPI/PV surveys at any future deposits formed as a result of placement activity.

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APPENDIX A

SEDIMENT-PROFILE IMAGE ANALYSIS RESULTS FOR EPDS SURVEY, OCTOBER 2012

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRpd Area (sq. cm)	Mean aRpd (cm)	Mud Clast Number	Mud Clast State
01	A	10/16/2012	8:56:19	14	2	347	14.6	>4 to 3	>4	0	208.3	14.3	14.2	14.9	0.7	biogenic	53.9	3.7	0	
01	B	10/16/2012	8:57:35	14	2	347	14.6	>4 to 3	>4	0	209.8	14.4	14	14.5	0.5	biogenic	28.6	2.0	0	
01	C	10/16/2012	8:59:01	14	2	347	14.6	>4 to 3	>4	0	211.7	14.5	14.4	14.7	0.3	biogenic	31.2	2.1	0	
02	B	10/16/2012	10:41:47	14	2	327	14.6	ind	ind	-8	0	0.0	0	0	0.0	ind	ind	ind	ind	
02	C	10/16/2012	10:42:56	14	2	327	14.6	-4	>4	-6	0	0.0	0	0	0.0	ind	ind	ind	ind	
02	D	10/16/2012	10:44:10	14	2	327	14.6	>4 to 3	>4	0	114.9	7.9	2.5	8.3	5.8	physical	ind	ind	0	
03	A	10/16/2012	10:23:38	14	2	332	14.6	4 to 3	>4	-3	156	10.7	9.5	11.1	1.6	biogenic	24.6	1.7	0	
03	B	10/16/2012	10:24:54	14	2	332	14.6	4 to 3	>4	0	178.7	12.2	11.8	12.7	0.9	biogenic	42.2	2.9	0	
03	C	10/16/2012	10:26:05	14	2	332	14.6	4 to 3	>4	-1	172.9	11.8	11.4	12.1	0.7	biogenic	45.1	3.1	0	
04	A	10/16/2012	9:52:32	14	2	330	14.6	4 to 3/>4	>4	0	196.6	13.5	12.9	14	1.1	biogenic	58.2	4.0	0	
04	B	10/16/2012	9:53:39	14	2	330	14.6	4 to 3/>4	>4	0	235.3	16.1	15.9	16.4	0.5	biogenic	43.8	3.0	0	
04	D	10/16/2012	9:55:44	14	2	330	14.6	4 to 3/>4	>4	1	216.5	14.8	14.7	15.3	0.6	biogenic	33.6	2.3	0	
05	B	10/16/2012	9:05:04	14	2	325	14.6	4 to 3/>4	>4	1	235.9	16.2	15.9	16.4	0.5	biogenic	40	2.7	0	
05	C	10/16/2012	9:06:34	14	2	325	14.6	4 to 3/>4	>4	1	230.9	15.8	15.6	16.1	0.5	biogenic	40.9	2.8	0	
05	D	10/16/2012	9:07:49	14	2	325	14.6	>4 to 3	>4	1	223.8	15.3	14.8	15.6	0.8	biogenic	58.6	4.0	0	
06	B	10/16/2012	9:25:58	14	2	320	14.6	>4	>4	1	238.8	16.4	16.3	16.6	0.3	biogenic	44.8	3.1	0	
06	C	10/16/2012	9:27:02	14	2	320	14.6	>4 to 3	>4	1	239.8	16.4	16.3	16.7	0.4	biogenic	36.6	2.5	0	
06	D	10/16/2012	9:28:04	14	2	320	14.6	>4 to 3	>4	1	236.4	16.2	15.7	16.2	0.5	biogenic	42.2	2.9	0	
07	A	10/16/2012	9:14:07	14	2	306	14.6	>4 to 3	>4	1	238.6	16.3	15.6	16.3	0.7	biogenic	46.9	3.2	0	
07	B	10/16/2012	9:15:22	14	2	306	14.6	>4 to 3	>4	1	249.7	17.1	15.7	17	1.3	biogenic	41.3	2.8	0	
07	C	10/16/2012	9:17:40	14	2	306	14.6	>4 to 3	>4	1	248.9	17.0	16.8	17.1	0.3	biogenic	43	2.9	0	
08	A	10/16/2012	11:01:46	14	2	310	14.6	>4	>4	1	226.2	15.5	15.2	15.7	0.5	biogenic	42.6	2.9	0	
08	C	10/16/2012	11:04:22	14	2	310	14.6	>4	>4	1	237.9	16.3	16.1	16.5	0.4	biogenic	32.1	2.2	0	
08	D	10/16/2012	11:05:35	14	2	310	14.6	>4	>4	1	214.4	14.7	14.4	15.2	0.8	biogenic	23.9	1.6	0	
09	B	10/16/2012	8:26:30	12.5	1	345	14.6	>4 to 3	>4	1	113	7.7	6.4	8.9	2.5	physical	31.9	2.2	0	
09	C	10/16/2012	8:28:12	12.5	1	345	14.6	4 to 3/>4	>4	0	155.3	10.6	9.4	11	1.6	biogenic	6.8	0.5	0	
09	D	10/16/2012	8:30:03	12.5	1	345	14.6	4 to 3/>4	>4	0	145.1	9.9	9.6	10.3	0.7	biogenic	38.2	2.6	0	
10	A	10/16/2012	10:54:47	14	2	310	14.6	>4 to 3/>4	>4	1	173.2	11.9	11.6	12.2	0.6	biogenic	36.9	2.5	0	
10	B	10/16/2012	10:55:50	14	2	310	14.6	>4 to 3/>4	>4	0	207.2	14.2	14	14.4	0.4	biogenic	47	3.2	0	
10	C	10/16/2012	10:57:14	14	2	310	14.6	>4 to 3/>4	>4	1	159.9	11.0	15.8	16	0.2	biogenic	39.3	2.7	0	

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRpd Area (sq. cm)	Mean aRpd (cm)	Mud Clast Number	Mud Clast State
11	A	10/16/2012	9:38:37	14	2	315	14.6	>4 to 3/>4	>4	1	234.4	16.1	16	16.3	0.3	biogenic	33.9	2.3	0	
11	B	10/16/2012	9:39:44	14	2	315	14.6	>4 to 3/>4	>4	1	211.9	14.5	14.2	14.8	0.6	biogenic	39.4	2.7	0	
11	C	10/16/2012	9:40:54	14	2	315	14.6	>4 to 3	>4	0	242.2	16.6	16.5	17	0.5	biogenic	40.6	2.8	0	
12	A	10/16/2012	10:32:41	14	2	347	14.6	>4 to 3	>4	-1	139.7	9.6	9.4	9.9	0.5	biogenic	34.2	2.3	0	
12	B	10/16/2012	10:33:44	14	2	347	14.6	>4 to 3	>4	-8	79.8	5.5	3.9	6.6	2.7	physical	9	0.6	0	
12	D	10/16/2012	10:36:22	14	2	347	14.6	>4	>4	0	167	11.4	9.8	12.4	2.6	biogenic	29.1	2.0	0	
13	A	10/16/2012	11:39:42	14	2	244	14.6	>4	>4	0	243.3	16.7	16.3	17.3	1.0	biogenic	41.2	2.8	1	oxidized
13	B	10/16/2012	11:40:45	14	2	244	14.6	>4	>4	1	180.2	12.3	11.9	12.8	0.9	biogenic	37.5	2.6	3	reduced
13	C	10/16/2012	11:46:59	14	2	244	14.6	>4	>4	2	168.3	11.5	11.1	12	0.9	biogenic	50.9	3.5	0	
14	A	10/16/2012	11:27:59	14	2	256	14.6	>4	>4	1	226	15.5	15.2	15.8	0.6	biogenic	63	4.3	0	
14	B	10/16/2012	11:29:20	14	2	256	14.6	>4	>4	1	257	17.6	17.4	18.1	0.7	biogenic	47.2	3.2	0	
14	C	10/16/2012	11:30:42	14	2	256	14.6	>4	>4	1	228.6	15.7	15	16.3	1.3	biogenic	41.7	2.9	0	
15	B	10/16/2012	12:07:31	14	2	256	14.6	>4	>4	1	209.8	14.4	14.1	14.6	0.5	biogenic	58.4	4.0	0	
15	C	10/16/2012	12:08:35	14	2	256	14.6	>4	>4	0	198.9	13.6	13.4	14.1	0.7	biogenic	42.6	2.9	0	
15	D	10/16/2012	12:10:10	14	2	256	14.6	>4	>4	1	230.6	15.8	15.6	16.1	0.5	biogenic	42.8	2.9	0	
16	A	10/16/2012	12:33:40	14	2	225	14.6	>4 to 3/>4	>4	1	201.6	13.8	12.9	14.3	1.4	biogenic	46.5	3.2	0	
16	B	10/16/2012	12:34:56	14	2	225	14.6	-7	>4	-7	0	0.0	0	0	0.0	ind	ind	ind	ind	
16	C	10/16/2012	12:36:21	14	2	225	14.6	3 to 2	>4	0	44.9	3.1	0.7	4.2	3.5	physical	ind	ind	0	
17	A	10/16/2012	12:46:50	14	2	230	14.6	<-1	>4	<-1	0	0.0	0	0	0.0	ind	ind	ind	ind	
17	B	10/16/2012	12:48:07	14	2	230	14.6	ind	>4	ind	0	0.0	0	0	0.0	ind	ind	ind	ind	
17	C	10/16/2012	12:49:14	14	2	230	14.6	ind	>4	-4	6.1	0.4	0	1.2	1.2	physical	ind	ind	0	
18	A	10/16/2012	12:20:33	14	2	220	14.6	ind	>4	<-1	0	0.0	0	0	0.0	ind	ind	ind	ind	
18	B	10/16/2012	12:22:34	14	2	220	14.6	ind	ind	ind	0	0.0	0	0	0.0	ind	ind	ind	ind	
18	C	10/16/2012	12:23:56	14	2	220	14.6	ind	>4	<-1	0	0.0	0	0	0.0	ind	ind	ind	ind	
NREF-19	A	10/16/2012	16:52:21	14	1	220	14.6	>4	>4	2	295.6	20.2	20	20.7	0.7	biogenic	48.6	3.3	0	
NREF-19	C	10/16/2012	16:55:49	14	1	220	14.6	>4	>4	2	301	20.6	20.3	20.9	0.6	biogenic	83	5.7	0	
NREF-19	D	10/16/2012	16:56:57	14	1	220	14.6	>4	>4	2	304.5	20.9	20.8	21.2	0.4	biogenic	72.4	5.0	0	
NREF-20	B	10/16/2012	17:19:53	14	1	220	14.6	4 to 3	>4	1	55	3.8	3	4.3	1.3	biogenic	25.2	1.7	0	
NREF-20	C	10/16/2012	17:21:20	14	1	220	14.6	>4 to 3	>4	-2	25.6	1.8	0.9	2.7	1.8	biogenic	ind	ind	0	
NREF-20	D	10/16/2012	17:22:32	14	1	220	14.6	-1 to -2	>4	-3	53.9	3.7	2.2	4.9	2.7	physical	14.6	1.0	0	

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRpd Area (sq. cm)	Mean aRpd (cm)	Mud Clast Number	Mud Clast State
NREF-21	A	10/16/2012	16:37:57	14	1	228	14.6	>4	>4	2	204.5	14.0	13.9	14.2	0.3	biogenic	25.2	1.7	0	
NREF-21	B	10/16/2012	16:39:06	14	1	228	14.6	>4	>4	1	201.5	13.8	13.6	14	0.4	biogenic	36.9	2.5	1	r
NREF-21	C	10/16/2012	16:40:15	14	1	228	14.6	>4	>4	1	225.9	15.5	15	16.2	1.2	biogenic	54.6	3.7	0	
NREF-22	B	10/16/2012	17:32:20	14	1	208	14.6	4 to 3	>4	0	20.8	1.4	1	1.7	0.7	biogenic	ind	ind	0	
NREF-22	C	10/16/2012	17:33:15	14	1	208	14.6	>4	>4	-5	49.8	3.4	1.7	4.9	3.2	physical	20.9	1.4	0	
NREF-22	D	10/16/2012	17:34:18	14	1	208	14.6	4 to 3	>4	-4	45.7	3.1	2	3.8	1.8	physical	18	1.2	0	
NREF-23	A	10/16/2012	16:15:33	14	2	235	14.6	>4	>4	2	248	17.0	16.8	17.3	0.5	biogenic	45.4	3.1	0	
NREF-23	B	10/16/2012	16:16:44	14	2	235	14.6	>4	>4	2	259.3	17.8	17.5	18.1	0.6	biogenic	53	3.6	0	
NREF-23	D	10/16/2012	16:19:01	14	2	235	14.6	>4	>4	2	261.9	17.9	17.7	18.4	0.7	biogenic	62.8	4.3	2	reduced
NREF-24	B	10/16/2012	17:06:52	14	1	250	14.6	4 to 3	>4	-3	102.9	7.0	5.6	8.1	2.5	physical	37.3	2.6	0	
NREF-24	C	10/16/2012	17:08:30	14	1	250	14.6	>4	>4	1	111.4	7.6	7	8.2	1.2	biogenic	34.9	2.4	0	
NREF-24	D	10/16/2012	17:09:32	14	1	250	14.6	>4	>4	1	112.8	7.7	7.4	8	0.6	biogenic	38.1	2.6	0	
NWREF-25	A	10/15/2012	13:33:22	12.5	1	182	14.6	>4	>4	-6	84.4	5.8	5.2	7.2	2.0	biogenic	50.6	3.5	0	
NWREF-25	B	10/15/2012	13:34:23	12.5	1	182	14.6	ind	ind	ind	0	0.0	0	0	0.0	ind	ind	ind	ind	
NWREF-25	D	10/15/2012	13:36:38	12.5	1	182	14.6	ind	>4	-6	0	0.0	0	0.5	0.5	ind	ind	ind	ind	
NWREF-26	A	10/15/2012	13:46:17	12.5	1	217	14.6	4 to 3	>4	-4	92.7	6.3	5.9	6.9	1.0	biogenic	29.2	2.0	0	
NWREF-26	B	10/15/2012	13:47:06	12.5	1	217	14.6	4 to 3	>4	-4	57.8	4.0	3.3	4.4	1.1	biogenic	40.5	2.8	0	
NWREF-26	D	10/15/2012	13:49:05	12.5	1	217	14.6	4 to 3	>4	1	94.7	6.5	6.4	6.8	0.4	biogenic	34.5	2.4	0	
NWREF-27	A	10/15/2012	13:19:34	12.5	1	218	14.6	>4	>4	2	47.6	3.3	0	4.6	4.6	biogenic	31	2.1	0	
NWREF-27	B	10/15/2012	13:20:25	12.5	1	218	14.6	>4	>4	2	134.8	9.2	8.5	10	1.5	biogenic	31.9	2.2	0	
NWREF-27	C	10/15/2012	13:21:21	12.5	1	218	14.6	>4	>4	2	151.5	10.4	10.2	10.6	0.4	biogenic	30.3	2.1	1	reduced
NWREF-28	A	10/15/2012	12:49:29	12.5	1	219	14.6	>4	>4	1	280.4	19.2	19	19.4	0.4	biogenic	34.4	2.4	0	
NWREF-28	B	10/15/2012	12:50:34	12.5	1	219	14.6	>4	>4	2	297.9	20.4	19.8	20.8	1.0	biogenic	50.9	3.5	0	
NWREF-28	C	10/15/2012	12:51:32	12.5	1	219	14.6	>4	>4	2	272.1	18.6	18	19.3	1.3	biogenic	58.2	4.0	3	reduced
NWREF-29	A	10/15/2012	13:01:27	12.5	1	242	14.6	>4	>4	2	313.1	21.4	21.4	21.4	ind	ind	ind	ind	ind	
NWREF-29	C	10/15/2012	13:03:25	12.5	1	242	14.6	>4	>4	2	269	18.4	18.2	19	0.8	biogenic	75.3	5.2	0	
NWREF-29	D	10/15/2012	13:04:31	12.5	1	242	14.6	>4	>4	2	313.1	21.4	21.4	21.4	ind	ind	ind	ind	ind	
NWREF-30	B	10/15/2012	13:13:40	12.5	1	208	14.6	>4	>4	-4	39.5	2.7	1	3.6	2.6	biogenic	ind	ind	0	
NWREF-30	C	10/15/2012	13:14:37	12.5	1	208	14.6	>4	>4	-5	19.4	1.3	0.4	2	1.6	physical	ind	ind	0	
NWREF-30	D	10/15/2012	13:15:39	12.5	1	208	14.6	>4	>4	-4	49.5	3.4	2.5	4.6	2.1	physical	12.2	0.8	0	

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRpd Area (sq. cm)	Mean aRpd (cm)	Mud Clast Number	Mud Clast State
SREF-31	A	10/16/2012	14:33:01	14	2	275	14.6	4 to 3/>4	>4	1	147.1	10.1	9.8	10.2	0.4	biogenic	30.6	2.1	0	
SREF-31	B	10/16/2012	14:34:14	14	2	275	14.6	4 to 3/>4	>4	1	144.1	9.9	9.7	10.2	0.5	biogenic	32.7	2.2	0	
SREF-31	C	10/16/2012	14:35:36	14	2	275	14.6	4 to 3/>4	>4	1	153	10.5	10.4	10.8	0.4	biogenic	26.9	1.8	0	
SREF-32	A	10/16/2012	14:45:11	14	2	233	14.6	4 to 3/>4	>4	1	124.4	8.5	7.8	8.8	1.0	biogenic	28.1	1.9	0	
SREF-32	B	10/16/2012	14:46:13	14	2	233	14.6	4 to 3/>4	>4	1	213.9	14.7	14.4	14.9	0.5	biogenic	34.6	2.4	0	
SREF-32	C	10/16/2012	14:47:38	14	2	233	14.6	>4	>4	1	111.6	7.6	6.6	8.5	1.9	physical	0	0.0	0	
SREF-33	A	10/16/2012	15:33:14	14	2	226	14.6	4 to 3/>4	>4	0	107.3	7.3	7	7.7	0.7	biogenic	27.7	1.9	0	
SREF-33	B	10/16/2012	15:34:25	14	2	226	14.6	4 to 3/>4	>4	0	88.8	6.1	5.2	7.3	2.1	physical	25.5	1.7	0	
SREF-33	C	10/16/2012	15:35:33	14	2	226	14.6	4 to 3/>4	>4	0	95.9	6.6	6.2	7	0.8	biogenic	31.1	2.1	0	
SREF-34	A	10/16/2012	15:00:41	14	2	254	14.6	4 to 3/>4	>4	0	192.2	13.2	13	13.4	0.4	biogenic	29.9	2.0	0	
SREF-34	B	10/16/2012	15:01:53	14	2	254	14.6	4 to 3/>4	>4	0	214.7	14.7	14.3	15	0.7	biogenic	36.1	2.5	0	
SREF-34	D	10/16/2012	15:05:20	14	2	254	14.6	4 to 3/>4	>4	0	180.4	12.4	12	12.6	0.6	biogenic	31.1	2.1	1	reduced
SREF-35	B	10/16/2012	14:14:42	14	2	278	14.6	4 to 3/>4	>4	0	143.3	9.8	9.5	10.1	0.6	biogenic	24.4	1.7	0	
SREF-35	C	10/16/2012	14:16:19	14	2	278	14.6	4 to 3/>4	>4	0	141.7	9.7	9.4	10	0.6	biogenic	20.3	1.4	0	
SREF-35	D	10/16/2012	14:18:17	14	2	278	14.6	4 to 3/>4	>4	0	132.4	9.1	8.9	9.2	0.3	biogenic	33	2.3	0	
SREF-36	A	10/16/2012	15:21:59	14	2	225	14.6	ind	>4	<-1	5.1	0.3	0	1	ind	ind	ind	ind	0	
SREF-36	B	10/16/2012	15:23:13	14	2	225	14.6	4 to 3	>4	<-1	35.6	2.4	1.8	3.7	1.9	physical	ind	ind	0	
SREF-36	C	10/16/2012	15:24:21	14	2	225	14.6	4 to 3	>4	<-1	26.6	1.8	0.4	3.6	3.2	physical	ind	ind	0	
ALT3REF-49	B	10/15/2012	10:59:42	12.5	1	220	14.6	>4	>4	2	288.4	19.8	19.3	20.4	1.1	biogenic	59.9	4.1	4	reduced
ALT3REF -49	C	10/15/2012	11:01:08	12.5	1	220	14.6	>4	>4	2	291.1	19.9	19.4	20.4	1.0	biogenic	38.9	2.7	0	
ALT3REF-49	D	10/15/2012	11:02:34	12.5	1	220	14.6	>4	>4	2	303.6	20.8	20.1	20.9	0.8	biogenic	30.3	2.1	0	
ALT3REF-50	A	10/15/2012	11:29:04	12.5	1	275	14.6	>4	>4	2	220	15.1	14.9	15.2	0.3	biogenic	39	2.7	0	
ALT3REF-50	B	10/15/2012	11:30:22	12.5	1	275	14.6	>4	>4	2	201.8	13.8	13.5	14.2	0.7	biogenic	29.1	2.0	0	
ALT3REF-50	D	10/15/2012	11:32:13	12.5	1	275	14.6	>4	>4	2	191.6	13.1	12.8	13.6	0.8	biogenic	41.1	2.8	3	reduced
ALT3REF-51	E	10/15/2012	10:29:56	14	2	290	14.6	>4	>4	2	288.8	19.8	19.8	20	0.2	biogenic	31.5	2.2	0	
ALT3REF-51	F	10/15/2012	10:31:32	14	2	290	14.6	>4	>4	2	312.9	21.4	21.4	21.4	ind	ind	ind	ind	ind	
ALT3REF-51	H	10/15/2012	10:34:14	14	2	290	14.6	>4	>4	2	302.5	20.7	20.1	21.1	1.0	biogenic	54.7	3.7	2	reduced
ALT3REF-52	A	10/15/2012	11:20:14	12.5	1	285	14.6	>4	>4	2	206.3	14.1	14	14.3	0.3	biogenic	49.9	3.4	0	
ALT3REF-52	B	10/15/2012	11:21:16	12.5	1	285	14.6	>4	>4	2	235.8	16.2	15.9	16.5	0.6	biogenic	27.1	1.9	0	
ALT3REF-52	C	10/15/2012	11:22:24	12.5	1	285	14.6	>4	>4	2	220.2	15.1	14.6	15.7	1.1	biogenic	43.3	3.0	0	

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

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ALT3REF-53	A	10/15/2012	11:07:59	12.5	1	259	14.6	>4	>4	2	303.1	20.8	20	21.4	ind	ind	33.6	2.3	0	
ALT3REF-53	B	10/15/2012	11:09:09	12.5	1	259	14.6	>4	>4	2	312.9	21.4	21.4	21.4	ind	ind	ind	ind	ind	
ALT3REF-53	C	10/15/2012	11:10:45	12.5	1	259	14.6	>4	>4	2	300.7	20.6	20.1	21	0.9	biogenic	33	2.3	1	reduced
ALT3REF-54	A	10/15/2012	11:40:33	12.5	1	255	14.6	>4	>4	0	204.9	14.0	13.7	14.2	0.5	biogenic	34.7	2.4	0	
ALT3REF-54	B	10/15/2012	11:41:31	12.5	1	255	14.6	>4	>4	1	202	13.8	13.3	14.3	1.0	biogenic	30.2	2.1	0	
ALT3REF-54	C	10/15/2012	11:42:43	12.5	1	255	14.6	>4	>4	2	203.3	13.9	13.8	14.4	0.6	biogenic	32.6	2.2	1	oxidized

Sediment-Profile Image Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
01	A	n	n	DM>pen; muddy fine sand/sandy mud w/ small shell frags; grey streaks; voids/burrows; vertical oxy burrow left; dense small worms	4	4.4	10.5	7.5	1 on 3
01	B	n	n	DM>pen; muddy sand/sandy mud w/ shell frags; partial voids/burrows visible in cross-section; biogenic mound@surf right; many cryptic reddish worms@depth	2	5.3	10.7	8.0	1 on 3
01	C	n	n	DM>pen; muddy fine sand/sandy mud w/ small shell frags; voids/burrows@left edge; biogenic microtopography; vertical oxy burrows; several reddish worms@depth	3	7.7	14	10.9	1 on 3
02	B	ind	ind	No pen=rock w/ epifauna in nearfield	ind	ind	ind	ind	ind
02	C	ind	ind	No pen=appears to be surface layer of larger shell frags+some rocks w/ epifauna; likely DM	ind	ind	ind	ind	ind
02	D	n	n	DM>pen; sandy mud/muddy sand; lrg+sml shell frags; large surf opening=burrow intersected; voids+worm@lwr right; rock w/ hydroid farfield, SWI disrupted by prism, aRPD ind	3	1.3	4	2.7	1 on 3
03	A	n	n	DM>pen; sandy mud/muddy sand; surf burrow opening@right; many small worms@depth; shell frags w/ epifauna; round rock@far right	1	8.8	9.1	9.0	1 on 3
03	B	n	n	DM>pen; sandy mud/muddy sand w/ shell frags; biogenic mounds@surf; distinct surf tubes; vertical oxy burrow; numerous subsurface worms	0				1 on 3
03	C	n	n	DM>pen; sandy mud/muddy sand w/ shell frags; possible DM layering; voids; several red worms	3	11	11.4	11.2	1 on 3
04	A	n	n	DM>pen; mostly silt/clay w/ some fine sand in upper lyr+shell frags; black/reduced@depth; many small white bivalves (*Nucula sp.)* below surf; deep vertical oxy burrow w/ mound@surf	1	12.1	13.2	12.7	2 on 3
04	B	n	n	DM>pen; s/m=muddy v. fine sand over silt/clay; shell frags; partial voids; multiple small white bivalves (*Nucula sp.)* below surface	3	5.1	6.9	6.0	2 on 3
04	D	n	n	DM>pen; slightly sandy in upper few cm; shallow vertical oxy burrows; moderately reduced@depth; 1-2 *Nucula sp.* visible in upper oxidized layer	1	11.1	14.1	12.6	2 on 3
05	B	n	n	DM over ambient; 9-11 cm surf lyr slightly sandy w/ black/grey streaks@bottom; voids+vertical oxy burrows; multiple *Nucula sp.*	3	5.2	16	10.6	2 on 3
05	C	n	n	DM over ambient; DM slightly sandy near surface; downward mixing of DM associated w/ deep voids; *Nucula sp.* near surf; vertical oxy burrows; biogenic mounds@surf; multiple subsurface worms	3	11.7	14.6	13.2	2 on 3
05	D	n	n	DM over ambient; surf tubes; multiple shallow bivalves=*Nucula sp.*	0				2 on 3
06	B	n	n	DM>pen; mud w/ v. fine sand; distinct DM layering=surface DM lyr is 11-12 cm over older sandy DM; multiple *Nucula sp.*; subsurface worms	1	3.2	3.3	3.3	2 on 3
06	C	n	n	DM>pen; sandy mud/muddy sand w/ some small shell frags; indistinct DM layering; multiple *Nucula sp.*; cryptic worms@depth; bivalve siphons@surf at right edge of image	1	11.8	12.1	12.0	2 on 3

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
06	D	n	n	DM>pen; sandy mud/muddy sand; small shell frags; indistinct DM layering; multiple *Nucula sp.*; several worms@depth; bivalve siphons@surf	0				2 on 3
07	A	n	n	Surface DM layer over ambient; DM is sandy mud w/ grey@depth over brown/tan silt/clay; partial voids; several *Nucula sp.*	3	5.3	13.7	9.5	2 on 3
07	B	n	n	Surface DM layer over ambient; muddy sand/sandy mud; multiple *Nucula sp.*@surf; several subsurface worms; biogenic mounds@surf; 1-2 gastropods	1	9.1	9.3	9.2	2 on 3
07	C	n	n	Surface DM layer over ambient; muddy sand/sandy mud; multiple *Nucula sp.*@surf; several subsurface worms; biogenic mounds@surf	3	5.2	8.7	7.0	2 on 3
08	A	n	n	Surface DM layer over ambient; DM slightly sandy; multiple voids; multiple *Nucula sp.*; small vertical burrows@surf w/ mounds	3	4.8	11.1	8.0	2 on 3
08	C	n	n	Surface DM layer over ambient; DM slightly sandy; large void/burrow@depth; worms@depth; dense *Nucula sp.* w/ multiple siphons visible@surf	3	3.7	15.3	9.5	2 on 3
08	D	n	n	Surface DM layer over ambient; DM slightly sandy; deep voids below DM layer; vertical oxy burrow left of center; long thin worm@right; multiple *Nucula sp.*	3	8	14.3	11.2	2 on 3
09	B	n	n	Surface DM layer over ambient; DM is muddy fine sand w/ shell frags; classic vertical oxy burrow@right; small/cryptic voids	3	6	6.3	6.2	1 on 3
09	C	n	n	Surface DM layer over ambient; DM is muddy very fine sand w/ dense shell frags; burrow opening@left w/ subsurface expression; subsurface orgs are small/cryptic; evidence of subsurface burrows	0				2 on 3
09	D	n	n	Surface DM layer over ambient; DM is muddy fine sand w/ shell frags near surface grading to silt/clay@depth; vertical burrow; several small/cryptic voids in lower left corner	4	7.2	9	8.1	1 on 3
10	A	n	n	Surface DM layer over ambient; DM=muddy sand; multiple *Nucula sp.* near surface; small shrimp@surf@right; voids and several subsurface worms	2	8.1	10.6	9.4	2 on 3
10	B	n	n	Surface DM layer over ambient; DM=muddy fine sand; multiple near surface *Nucula sp.*; several small worms@depth & evidence of subsurface burrows	0				2 on 3
10	C	n	n	Surface DM layer over ambient; DM=muddy fine sand/sandy mud; multiple voids; partial void@right; multiple *Nucula sp.*	5	4.5	15.1	9.8	2 on 3
11	A	n	n	DM>pen; 2 DM layers=upper 11-12 cm newer lyr over older grey clay DM; multiple *Nucula sp.*; vertical oxy burrow@center; multiple cryptic worms@depth	0				2 on 3
11	B	n	n	DM>pen; 2 DM layers=upper 11-12 cm newer lyr over older grey clay DM; a few *Nucula sp.*; vertical oxy burrows; deep void/burrow; several red worms; floccy surface	1	12.6	13.9	13.3	2 on 3

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
11	C	n	n	DM>pen; 2 DM layers=upper 11-12 cm newer lyr over older sandy clay DM; multiple *Nucula sp.*; numerous subsurface worms	0				2 on 3
12	A	n	n	DM>pen; muddy sand/sandy mud w/ shell frags over large patch of consolidated grey clay; large burrow; small worms@depth; small plant fibers mixed w/ sed	2	3.2	8.5	5.9	1 on 3
12	B	n	n	DM>pen; sandy mud/muddy sand w/ small and large shell frags; large rock (cobble/boulder)@surf w/ epifaunal growth+shrimp; larger-bodied worm@subsurface center; appears to be portion of a buried crab appendage just under SWI at right	0				1 on 3
12	D	n	n	DM>pen; slightly sandy silt/clay; prominent burrow w/ surf opening@left; several small worms; biogenic mound@surf@right	1	4.6	4.8	4.7	1 on 3
13	A	n	n	Subtle DM layering; upper 6-8 cm appears to be old/weathered DM layer over ambient or older DM; multiple voids; biogenic mound@left w/ underlying void/burrow	7	5.7	12.9	9.3	2 on 3
13	B	n	n	DM>pen; appears to be weathered DM; wiper clasts at SWI; void@right; several small cryptic worms, evidence of subsurface burrowing	1	7.7	8	7.9	1 on 3
13	C	n	n	Very fine sandy silt/clay with old/weather surf layer DM over ambient; multiple *Nucula sp.* +surf tubes; 1 thin void/burrow	1	6.4	6.6	6.5	2 on 3
14	A	n	n	Very fine sandy silt/clay with multiple *Nucula sp.* in upper 1-2 cm w/ intensive reworking; 1-2 cryptic subsurface worms	0				2 on 3
14	B	n	n	DM>pen; multiple subsurface voids; dense *Nucula sp.* w/ siphons visible in nearfield; biogenic mound of dark sed w/ underlying vertical burrow	7	6.8	15.6	11.2	2 on 3
14	C	n	n	DM>pen; several *Nucula sp.*+reworked upper 1 cm; partial voids+several small reddish worms@depth; vertical oxy burrow along left edge	3	2.3	8.8	5.6	2 on 3
15	B	n	n	Weathered DM >pen; multiple *Nucula sp.*@right; 1 subsurface void@center	1	6.6	6.9	6.8	2 on 3
15	C	n	n	DM>pen or DM layering; upper 5-6 cm is slightly sandy; void/burrow@center; other voids right; vertical org/burrow near left edge; vertical oxy burrow@far right	3	7	13.3	10.2	1 on 3
15	D	n	n	Layered muddy DM; slightly sandy; distinct sulfidic horizon@center of image w/ sandy horizon (former SWI); large void/burrow complex lower left w/ biogenic mound@surf above; a few *Nucula sp.*	2	9.3	12.5	10.9	2 on 3
16	A	n	n	DM>pen; sandy silt/clay w/ small shell frags over moderately reduced silt/clay@depth; multiple voids@left; biogenic mound; vertical oxy burrow left of center	3	12.9	14.3	13.6	1 on 3
16	B	ind	ind	No pen=hard bottom=rocks covered w/ hydroids/bryozoans, anemones	ind				ind
16	C	n	n	Low pen=muddy fine to very fine sand w/ shell frags+a few small pebbles>pen	0				ind
17	A	ind	ind	No pen=hard bottom=rocks covered w/ hydroids/bryozoans, anemones; looks like mostly cobbles on top of sand; shrimp in farfield	ind				ind

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
17	B	ind	ind	No pen=hard bottom=rocks covered w/ hydroids/bryozoans; pebbles in nearfield and cobble/boulder in farfield	ind				ind
17	C	ind	ind	Low pen=scattered small gravel w/ shell frags over muddy very fine sand; lead weight from plan-view drop trigger in farfield	ind				ind
18	A	ind	ind	No pen=hard bottom=rocks covered w/ hydroids/bryozoans, and several anemones; most likely *Metridium senile* - common name the plumose or frilled anemone	ind				ind
18	B	ind	ind	No pen=missed shot; based on previous rep it's likely hard bottom=boulder-sized rocks	ind				ind
18	C	ind	ind	No pen=hard bottom=scattered rocks+large shells over what appears to be sand in farfield	ind				ind
NREF-19	A	n	n	Homogenous soft ambient mud>pen; strong aRPD contrast w/ very black/reduced@depth; small voids@right; surf tubes; several worms@depth	3	2.7	6.5	4.6	1 on 3
NREF-19	C	n	n	Homogenous soft ambient mud>pen; strong aRPD contrast w/ black/sulfidic sed@depth; small voids; multiple cryptic worms@depth	4	2.7	10.2	6.5	1 on 3
NREF-19	D	n	n	Homogenous soft ambient mud>pen; partial overpenetration=aRPD is estimate; multiple partial voids+deep void/burrow; multiple small cryptic worms@depth	5	9.3	21	15.2	1 on 3
NREF-20	B	n	n	Low pen=firm silty very fine sand; clay looks very consolidated; rock or piece of week covered with epifauna@surf; several vertical burrows w/ surf openings, particularly on right; shell frags	0				1 on 3
NREF-20	C	n	n	Low pen=firm, poorly-sorted silty fine sand w/ numerous pebbles+shells+shell frags@surf; hydroids on shells+rocks	ind				ind
NREF-20	D	n	n	Low pen=firm consolidated silt/clay w/ some fine sand; mound of clay mixed with pebbles+shell frags in nearfield; PV shows imprint of base frame	ind				ind
NREF-21	A	n	n	Soft homogenous ambient silt/clay>pen; upper 1 cm is reworked w/ multiple *Nucula sp.* present; 1 obvious void and several cryptic/partial several worms@depth; shrimp or other creature w/ two eyes@surf	4	2.9	8.9	5.9	2 on 3
NREF-21	B	n	n	Soft homogenous ambient silt/clay>pen; upper 1-2 cm is reworked w/ multiple *Nucula sp.*; siphon visible near center; a few v. small cryptic orgs & evidence of burrowing @depth	0				2 on 3
NREF-21	C	n	n	Soft homogenous ambient silt/clay>pen; dense *Nucula sp.* w/ a few siphons above SWI; multiple large voids/burrows@depth; slight distortion due to prism movement	3	5.3	14.9	10.1	2 on 3
NREF-22	B	n	n	Low pen=firm muddy very fine sand w/ abundant shell frags@surf	ind				ind
NREF-22	C	n	n	Low pen=firm silt/clay w/ scattered pebbles/cobbles@surf; barnacle-covered large pebble@surf in nearfield; a few small cryptic worms@depth, accumulation of pellets in burrow opening	0				1 on 3
NREF-22	D	n	n	Low pen=firm, poorly-sorted silty fine sand; mound of pebbles and shell frags@surf in nearfield; a few cryptic worms subsurface; small void@bottom edge center	1	3	3.2	3.1	1 on 3

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
NREF-23	A	n	n	Homogenous soft ambient mud>pen; surf tubes+multiple *Nucula sp.* just below surface; multiple subsurface feeding voids; reworked surface layer	4	8	14.4	11.2	2 on 3
NREF-23	B	n	n	Homogenous soft ambient mud>pen; weak aRPD contrast; wiper clasts; multiple *Nucula sp.*; multiple subsurface voids/burrows; a few cryptic orgs	6	2	15.9	9.0	2 on 3
NREF-23	D	n	n	Homogenous soft ambient mud>pen; weak aRPD contrast grading to more reduced sed@depth; multiple *Nucula sp.*; wiper clasts; biogenic mound@left	3	4	13.8	8.9	2 on 3
NREF-24	B	n	n	Low pen=muddy very fine sand over consolidated grey clay; surface layer of rocks (angular grey pebbles)+shell frags mixed with brown sandy silt in nearfield; large-bodied worm in lwr left corner of image	0				1 on 3
NREF-24	C	n	n	Moderate pen=somewhat firm slightly sandy silt/clay>pen; several vertical oxy burrows; burrow w/ surf opening@left; voids; expelled subsurface sediment@surf on right	2	3.4	4.9	4.2	1 on 3
NREF-24	D	n	n	Moderate pen=somewhat firm slightly sandy silt/clay>pen; barnacles attached to pebble w/ hydroids@surf; vertical oxy burrows; several small worms@subsurface	1	7.5	7.8	7.7	1 on 3
NWREF-25	A	n	n	Moderate penetration=moderately firm light tan/brown poorly-sorted silt/clay with scattered pebbles/cobble; 2 rocks@surf w/ mud drape and epifauna; cryptic void lwr left; faint vertical burrows	1	5.9	6.1	6.0	1 on 3
NWREF-25	B	ind	ind	No pen=assume bottom is similar to previous rep - silt/clay w/ scattered rocks@surf; camera or prism resting on rock in this image	ind				ind
NWREF-25	D	ind	ind	No pen=assume bottom is similar to rep A; silt/clay w/ scattered pebbles+shell frag visible@surf in nearfield; rocks preventing penetration	ind				ind
NWREF-26	A	n	n	Moderate pen=somewhat firm, silty very fine sand; patches of consolidated grey clay@depth; a few pebbles@surf; shrimp@surf in nearfield; DM > penetration	0				1 on 3
NWREF-26	B	n	n	Low pen=firm silty very fine sand; 2 shallow burrows w/ surf opening@right and left; surf tubes; evidence of subsurface burrows	0				1 on 3
NWREF-26	D	n	n	Low pen=firm, silty very fine sand; surf tubes+1 void	1	4.2	4.7	4.5	1 on 3
NWREF-27	A	n	n	Low pen=firm homogenous silt/clay; large burrow w/ surf opening has been transected; burrow diameter=2 cm	0				1 on 3
NWREF-27	B	n	n	Homogenous silt/clay>pen; weak to moderate aRPD contrast; faint sulfidic horizon below aRPD; void/burrow@far right; small biogenic mounds; sed surf is reworked	1	5.2	5.9	5.6	1 on 3
NWREF-27	C	n	n	Homogenous silt/clay>pen; wiper clast; reworked surface w/ small biogenic mounds; 1 small void; vertical burrow w/ surf opening along right edge of image	1	2.9	2.9	2.9	1 on 3
NWREF-28	A	n	n	Homogenous soft silt/clay>pen; moderate aRPD contrast; faint sulfidic horizon below aRPD=bottom of old depositional layer; vertical oxy burrows, voids, and 1-2 small cryptic worms	5	3.3	16.1	9.7	1 on 3

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
NWREF-28	B	n	n	Homogenous soft silt/clay>pen; moderate aRPD contrast w/ faint sulfidic horizon; multiple subsurface feeding voids; surface tubes	6	4.4	12.6	8.5	1 on 3
NWREF-28	C	n	n	Homogenous soft silt/clay>pen; moderate aRPD contrast w. faint sulfidic horizon below; multiple subsurface voids+surf tubes; large reduced mud clasts@surf from camera base sled	4	2.8	13.1	8.0	1 on 3
NWREF-29	A	n	n	Overpen=several parameters ind; homogenous soft silt/clay>pen; multiple subsurface voids=assume Stage 1 on 3	7	ind	ind	ind	1 on 3
NWREF-29	C	n	n	Homogenous soft silt/clay>pen; reduced@depth; surf tubes+small bio mounds; voids/burrows	2	3.8	7.1	5.5	1 on 3
NWREF-29	D	n	n	Overpen=several parameters ind; pullaway of upper 5 cm or so; homogenous soft silt/clay>pen; multiple subsurface voids+one very large *Nephtys sp.*=assume Stage 1 on 3	8	ind	ind	ind	1 on 3
NWREF-30	B	n	n	Underpen=slightly sandy silt/clay w/ cobble & pebbles@surf; epifauna on rocks -- very poorly sorted, visible in PV image	0				ind
NWREF-30	C	n	n	Underpen=slightly sandy silt/clay w/ scattered pebbles@surf; epifauna on pebbles=barnacles+hydroids	0				ind
NWREF-30	D	n	n	Underpen=slightly sandy silt/clay w/ scattered small pebbles+shell frags@surf; surf tubes; epifauna on pebbles; weak aRPD contrast=estimate	0				ind
SREF-31	A	n	n	Upper 1-2 cm is muddy very fine sand w/ shell frags overlying homogenous silt/clay@depth; 2 partial voids; faint sulfidic horizon; floccy surface; a few cryptic worms@depth; high density of *Nucula sp.* in upper oxidized layer	2	5.4	9.7	7.6	2 on 3
SREF-31	B	n	n	Upper 2 cm is muddy very fine sand w/ shell frags & small bivalves overlying homogenous silt/clay@depth; faint sulfidic horizon; several larger-bodied worms@depth	0				2 on 3
SREF-31	C	n	n	Upper 1-2 cm is muddy fine sand w/ shell frags & small bivalves overlying homogenous silt/clay@depth; vertical oxy burrow left of center; a few worms@depth	0				2 on 3
SREF-32	A	n	n	Upper 1-2 cm is muddy fine sand w/ shell frags overlying homogenous silt/clay@depth; large vertical oxy burrow w/ surf opening+biogenic mound, bivalves in oxygenated surface layer	0				2 on 3
SREF-32	B	n	n	Upper 1-2 cm is muddy fine sand w/ small bivalves & shell frags overlying homogenous silt/clay@depth; sulfidic horizon@depth; voids+a few cryptic worms	4	2.6	6.1	4.4	2 on 3
SREF-32	C	n	n	Somewhat firm homogenous silt/clay>pen; thin sand/floccy layer@surf; zero aRPD=almost looks like upper oxy layer has been removed by previous camera deployment; large-bodied worm@right (*Nephtys sp.*); large void/burrow@left	1	6.2	7.8	7.0	1 on 3
SREF-33	A	n	n	Upper 1-2 cm is muddy fine sand w/ shell frags overlying homogenous silt/clay@depth; several vertical oxy burrows; 1-2 small worms@left; partially buried shrimp@surf@center (eyes and tail visible)	0				1 on 3
SREF-33	B	n	n	Upper 1-2 cm is muddy fine sand w/ shell frags overlying homogenous silt/clay@depth; large and small tubes@surf and evidence of subsurface burrowing	0				2 on 3

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
SREF-33	C	n	n	Upper 1-2 cm is muddy fine sand w/ abundant shell frags overlying homogenous silt/clay@depth; 1 partial void@left+1-2 cryptic small worms	1	3.7	3.8	3.8	1 on 3
SREF-34	A	n	n	Upper 1-2 cm is muddy fine sand w/ abundant shell frags overlying homogenous silt/clay@depth; 1 v. small void@right+1-2 cryptic small worms; faint sulfidic band below aRPD; *Nucula sp.* in upper layer	1	5	5.1	5.1	2 on 3
SREF-34	B	n	n	Upper 1-2 cm is muddy reworked fine sand w/ shell frags overlying homogenous silt/clay@depth; vertical oxy burrow; *Nucula sp.* shells+alive in upper 1-2 cm; clear sulfidic banding@depth= DM layering	4	2.5	6.1	4.3	2 on 3
SREF-34	D	n	n	Upper 1-2 cm is muddy reworked fine sand w/ shell frags overlying homogenous silt/clay@depth; vertical oxy burrow/tube w/ underlying org@center; *Nucula sp.* shells+alive in upper 1-2 cm; faint sulfidic banding below aRPD, mud clast is wiper blade artifact	0				2 on 3
SREF-35	B	n	n	Upper 1-2 cm is muddy reworked fine sand w/ shell frags overlying homogenous silt/clay@depth; subsurface burrows/voids; *Nucula sp.* shells+alive in upper 1-2 cm=siphons visible in farfield; faint sulfidic banding below aRPD	2	8	9.3	8.7	2 on 3
SREF-35	C	n	n	Upper 1-2 cm is muddy reworked fine sand w/ shell frags overlying homogenous silt/clay@depth; subsurface burrows/voids; *Nucula sp.* shells but no obvious live orgs; 1 partial and 1 full void/burrow@depth	2	3.1	9.4	6.3	2 on 3
SREF-35	D	n	n	Upper 1-2 cm is muddy reworked fine sand w/ shell frags overlying homogenous silt/clay@depth; subsurface burrows/voids; *Nucula sp.* shells+a few cryptic live organisms); vertical oxy burrows; 2-3 larger-bodied worms@depth	1	8.5	8.7	8.6	2 on 3
SREF-36	A	n	n	No pen=hard bottom-shell bed; sed surf covered w/ shell frags w/ mud drape;	ind				ind
SREF-36	B	n	n	No pen=very firm bottom=dense surface layers of shells+shell frags+scattered pebbles over muddy fine sand/sandy mud	ind				ind
SREF-36	C	n	n	No pen=very firm bottom=dense surface layers of shells+shell frags+scattered pebbles over muddy fine sand/sandy mud	ind				ind
ALT3REF-49	B	n	n	Soft homogenous ambient silt/clay>pen; reduced wiper clasts; reduced sed@depth; multiple vertical oxy burrows; multiple voids/burrows; small surf tubes	4	7.5	19.5	13.5	1 on 3
ALT3REF-49	C	n	n	Soft homogenous ambient silt/clay>pen;; reduced@depth; multiple vertical oxy burrows; multiple voids/burrows; small surf tubes; some sulfidic banding below aRPD	4	4.6	6.8	5.7	1 on 3
ALT3REF-49	D	n	n	Soft homogenous ambient silt/clay>pen; reduced@depth; multiple voids; prominent vertical oxy burrow left of center w/ voids+large pink fleshy org@depth	6	2.7	9.2	6.0	1 on 3
ALT3REF-50	A	n	n	Soft homogenous ambient silt/clay>pen; weak aRPD contrast/not reduced@depth; surf tubes+several deep voids/burrows	3	12.3	14.6	13.5	1 on 3

Sediment-Profile Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Methane	Low Do?	Comment	Feeding Void #	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
ALT3REF-50	B	n	n	Soft homogenous ambient silt/clay>pen; reworked surface; several *Nucula sp.* in upper 1 cm; a few small voids; faint sulfidic horizon at depth	3	5.7	11.4	8.6	2 on 3
ALT3REF-50	D	n	n	Soft homogenous ambient silt/clay>pen; reduced wiper clasts@surf; a few cryptic *Nucula sp.*; large horizontal burrow@depth	3	6	10.7	8.4	2 on 3
ALT3REF-51	E	n	n	Soft homogenous ambient silt/clay>pen; sed is dark/sulfidic below aRPD but lighter@depth=sulfidic horizon; looks like DM deposit; several small voids+vertical oxy burrows; small surf tubes	3	3.5	7.5	5.5	1 on 3
ALT3REF-51	F	n	n	Overpenetration=soft homogenous ambient silt/clay; succ stage is most likely 1 on 3; large sulfidic patches/streaks@depth	3	ind	ind	ind	ind
ALT3REF-51	H	n	n	Soft homogenous ambient silt/clay>pen; reduced wiper clasts; 2 partial voids+1 deep void lwr right corner; deep vertical oxy burrow w/ surf opening along extreme right edge of image	3	5.5	19	12.3	1 on 3
ALT3REF-52	A	n	n	Soft homogenous ambient silt/clay>pen; small surf tubes; long thin vertical oxy burrow@left; shallow burrow w/ surf opening containing polychaete @left	0				1 on 3
ALT3REF-52	B	n	n	Soft homogenous ambient silt/clay>pen; partial voids; a few small worms; small biogenic mound@right; small surf tubes	2	5	5.9	5.5	1 on 3
ALT3REF-52	C	n	n	Soft homogenous ambient silt/clay>pen; surf tubes; 1 small void@right and one larger worm@lwr left corner; small biogenic mound@surf right	1	8.2	8.3	8.3	1 on 3
ALT3REF-53	A	n	n	Soft homogenous ambient silt/clay>pen; partial overpenetration; distinct sulfidic band below aRPD; sed is lighter@depth; 1 large void/burrow@right w/ associated deep vertical burrow	1	7.4	9	8.2	1 on 3
ALT3REF-53	B	n	n	Overpen; looks like very soft homogenous ambient silt/clay>pen; visible voids+vertical oxy burrows	2	ind	ind	ind	1 on 3
ALT3REF-53	C	n	n	Soft homogenous ambient silt/clay>pen; multiple vertical oxy burrows; multiple voids/burrows; small surf tubes; wiper clast	8	3.1	19.8	11.5	1 on 3
ALT3REF-54	A	n	n	Soft homogenous ambient silt/clay>pen; faint sulfidic horizon; weak aRPD contrast+lack of reduced sed@depth unlike previous station; 1-2 small worms@depth; 1 *Nucula sp.*, evidence of subsurface burrowing	0				2 on 3
ALT3REF-54	B	n	n	Soft homogenous ambient silt/clay>pen; several *Nucula sp.* in upper 1 cm; small biogenic mounds@surf; faint sulfidic horizon below aRPD; several long thin cryptic worms@depth	0				2 on 3
ALT3REF-54	C	n	n	Soft homogenous ambient silt/clay>pen; multiple surf tubes; multiple subsurface voids; weak aRPD contrast; slightly reduced@depth	3	1.7	7.7	4.7	1 on 3

APPENDIX B

GRAIN SIZE SCALE FOR SEDIMENTS

APPENDIX B

Grain Size Scale for Sediments

Phi size	Size range (mm)	Size class (Wentworth class)
<-1	>2	Gravel
0 to −1	1 to 2	Very coarse sand
1 to 0	0.5 to 1	Coarse sand
2 to 1	0.25 to 0.5	Medium sand
3 to 2	0.125 to 0.25	Fine sand
4 to 3	0.0625 to 0.125	Very fine sand
>4	<0.0625	Silt/clay

APPENDIX C

PLAN-VIEW IMAGE ANALYSIS RESULTS FOR EPDS SURVEY, OCTOBER 2012

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m²)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
01	A	10/15/2012	8:56:44	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
01	B	10/15/2012	8:57:57	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
01	C	10/15/2012	8:59:25	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
02	B	10/15/2012	10:42:10	110.9	72.3	0.8	rocks over sand/mud	n	n	n	n	n	y	n	n	y	Very turbid; dense shells+shell frags mixed with cobbles overlying mud; 1 "cobble" is square=disposed debris
02	C	10/15/2012	10:43:20	111.7	73.9	0.8	rocks over sand/mud	n	n	n	n	n	y	n	n	n	Shells+shell frags and cobbles overlying sand/mud; pink shrimp in lower right corner
02	D	10/15/2012	10:44:32	130.3	86.2	1.1	rocks over mud/sand	n	n	n	n	n	y	n	n	n	Shells+shell frags and cobbles overlying sand/mud; 26 cm length lobster
03	A	10/15/2012	10:24:01	130.4	86.1	1.1	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	High turbidity and many resuspended shells; looks like shells+rocks over sand/mud, possible lobster at left of center
03	B	10/15/2012	10:25:16	129.8	85.4	1.1	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	High turbidity and many resuspended shells; looks like shells+rocks over sand/mud
03	C	10/15/2012	10:26:28	130.4	86.2	1.1	shells over mud/sand	n	n	ind	ind	ind	y	n	n	n	Moderate turbidity; dense shell frags+pebbles over sandy mud; pink shrimp just below center of image
04	B	10/15/2012	9:54:03	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
04	C	10/15/2012	9:55:09	ind	ind	ind	ind	ind	ind	ind	ind	ind	y	n	ind	y	High turbidity; lobster on top of elongated object, possibly wood debris
04	D	10/15/2012	9:56:09	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
05	A	10/15/2012	9:03:44	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
05	B	10/15/2012	9:05:27	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
05	C	10/15/2012	9:06:59	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
06	A	10/15/2012	9:25:07	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	y	High turbidity; possible rocks over sand w/ piece of white plastic debris
06	B	10/15/2012	9:26:22	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
06	C	10/15/2012	9:27:27	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
07	A	10/15/2012	9:14:31	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
07	B	10/15/2012	9:15:46	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
07	C	10/15/2012	9:18:05	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
08	A	10/15/2012	11:02:11	91.9	60.7	0.6	sand or mud	n	n	y	y	y	n	n	n	n	Some small shells over sandy mud/muddy sand
08	C	10/15/2012	11:04:47	117.8	78	0.9	sand or mud	n	y	y	y	y	y	n	n	n	Shell frags over sandy mud; 1 small fish just below center of image; rock w/ epifauna lower left corner
08	D	10/15/2012	11:05:59	123.9	81.6	1.0	muddy sand/sandy mud	n	y	y	n	n	n	n	n	n	Shell frags over sandy mud; camera frame imprints upper left
09	B	10/15/2012	8:26:54	122.8	80.3	1.0	muddy sand/sandy mud	n	ind	ind	ind	ind	y	n	n	n	Shells over sandy mud; rock w/ epifauna center; lobster trap w/ numerous shrimp on top
09	C	10/15/2012	8:28:37	ind	ind	ind	sandy mud	n	ind	y	ind	ind	ind	n	ind	n	Shells over sandy mud
09	D	10/15/2012	8:30:26	114.6	75.6	0.9	sandy mud/muddy sand	n	ind	ind	ind	ind	ind	n	ind	ind	High turbidity - shells over sandy mud
10	A	10/15/2012	10:55:12	117.5	77.7	0.9	sandy mud/muddy sand	n	y	y	y	y	n	n	n	n	Moderate turbidity; small shell frags over sandy mud w/ burrows+tubes
10	C	10/15/2012	10:57:39	118.3	78	0.9	sandy mud	n	y	y	y	y	n	y	n	n	Moderate turbidity; small shell frags over sandy mud w/ tubes+tracks; burrowing anemone upper center
10	D	10/15/2012	10:59:03	127	83.8	1.1	sandy mud	n	y	y	y	y	n	n	n	n	Moderate turbidity; small shell frags over sandy mud
11	B	10/15/2012	9:40:08	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
11	C	10/15/2012	9:41:18	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface ; 2 shrimp suspended above sed surf
11	D	10/15/2012	9:42:35	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
12	A	10/15/2012	10:33:05	115.4	76.1	0.9	sandy mud	n	n	y	n	n	y	n	n	n	Shells+shell frags over sandy mud; long object with epifaunal growth@top
12	B	10/15/2012	10:34:07	115.3	76.1	0.9	sandy mud	n	y	y	y	y	y	n	y	n	Shells+frags over sandy mud; large rock w/ epifauna@right; possible small fish upper center; reduced mud clasts=camera base sled artifact?
12	D	10/15/2012	10:36:47	115.4	75.5	0.9	sandy mud	y	n	y	n	n	y	n	n	n	Shells+frags over sandy mud; faint ripples; small shells/rocks w/ some epifauna
13	A	10/15/2012	11:40:08	112	74.2	0.8	sandy mud	n	y	y	y	y	y	n	n	n	Shells+frags over sandy mud; v. dense tracks+trails; shrimp upper right quadrant
13	C	10/15/2012	11:47:26	111.6	72.9	0.8	sandy mud	n	n	y	y	y	y	n	n	n	Moderate turbidity; shells+shell frags over sandy mud; 1 lobster 24 cm length

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m²)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
13	D	10/15/2012	11:50:52	110.4	72.8	0.8	sandy mud	n	y	y	y	y	y	n	n	n	shells+shell frags over sandy mud; 2 rocks w/ epifauna, partially buried crab upper right, many shrimp swimming above bottom
14	A	10/15/2012	11:28:24	108.3	71.6	0.8	sandy mud	n	y	y	y	y	y	n	n	n	shell+frags over sandy mud; several shrimp at surf+swimming above
14	B	10/15/2012	11:29:45	116.8	76.7	0.9	sandy mud	n	y	y	y	y	y	n	n	n	shell+frags over sandy mud; numerous trails+tracks; couple of shrimp at surf
14	D	10/15/2012	11:32:49	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface; hang weight visible; 1 red laser dot far right
15	A	10/15/2012	12:06:34	123.7	81.4	1.0	sandy mud	n	y	y	n	n	y	n	n	n	Moderate turbidity; sandy mud w/ shell frags; several small fish or shrimp
15	C	10/15/2012	12:08:58	112.5	74.3	0.8	sandy mud	n	y	y	y	n	y	n	n	n	Shells frags over sandy mud; burrows/biogenic depressions; a few small fish@sed surf
15	D	10/15/2012	12:10:35	99.7	65.9	0.7	sandy mud	n	y	y	n	n	y	n	n	n	Small shell frags over sandy mud; small burrow opening; several v. small fish@sed surf
16	A	10/15/2012	12:33:15	139.8	92.6	1.3	sandy mud	n	n	y	n	n	y	n	n	n	Dense shell frags of sandy mud; rocks w/ anemones+dense epifauna; 5 or 6 shrimp@sed surf
16	C	10/15/2012	12:36:46	109.4	72.5	0.8	pebbles+sand	n	n	n	n	n	y	n	n	n	Dense shell frags+pebbles over sandy mud; numerous shrimp; partial lobster claw upper edge of image
16	D1	10/15/2012	12:37:54	147.4	97.3	1.4	rocks mixed w/ sandy areas	n	n	n	y	n	y	n	n	n	Shells over sandy mud; numerous rocks covered in epifauna; 24 cm long lobster; several shrimp
17	A	10/15/2012	12:47:16	106.3	70.2	0.7	rocks	n	n	n	n	n	y	n	n	n	Dense rocks (gravel+cobbles) mixed w/ some shell frags; lots of mobile epifauna=sea cucumber, lobster, several shrimp lower right corner
17	B	10/15/2012	12:48:33	106.8	70.7	0.8	rocks	n	n	n	n	n	y	n	n	n	Dense rocks (gravel and cobbles); hydroids/algae, bryozoans, etc. on rocks; 1 scallop.
17	D	10/15/2012	12:51:07	109.7	72.5	0.8	rocks	n	n	n	n	n	y	n	n	n	Dense rocks (gravel and cobbles); hydroids/algae, bryozoans & other epifauna on rocks; several shrimp;

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
18	A	10/15/2012	12:20:58	108.9	72.1	0.8	rocks w/ muddy sand	n	n	n	n	n	y	n	n	n	Rocks w/ green algae+several anemones; gravel+muddy sand in between rocks
18	B	10/15/2012	12:22:06	74.9	49.5	0.4	rocks w/ muddy sand	n	y	y	n	n	y	n	n	n	Pebbles+cobbles w/ muddy patches; strands of green algae; several shrimp
18	C	10/15/2012	12:22:59	130.6	86.2	1.1	rocks	n	n	n	n	n	y	n	n	n	Pebble+cobbles+boulders; boulder w/ dense epifauna (anemones+hydroids), lobster in center
NREF-19	A	10/15/2012	16:52:44	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
NREF-19	B	10/15/2012	16:54:04	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface; several swimming shrimp are visible
NREF-19	C	10/15/2012	16:56:15	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
NREF-20	A	10/15/2012	17:19:14	117.9	77.9	0.9	sandy mud w/ scattered gravel	n	n	y	n	n	y	n	n	n	Sandy mud w/ shell frags+scattered gravel; several shrimp; epifauna growth on rocks
NREF-20	C	10/15/2012	17:21:46	117.8	77.7	0.9	sandy mud w/ scattered gravel	n	n	y	n	n	y	n	n	n	Poor visibility; Sandy mud w/ shell frags+scattered gravel; a few shrimp
NREF-20	D	10/15/2012	17:22:56	129	85	1.1	gravel+sandy mud	n	n	n	n	n	y	n	n	n	Mix of gravel and muddy sand; camera frame imprint bottom center; epifauna
NREF-21	A	10/15/2012	16:38:23	121.7	80.4	1.0	mud	n	y	y	n	n	n	n	n	n	Poor visibility; looks like flat mud w/ dense tubes
NREF-21	C	10/15/2012	16:40:41	120.5	79.6	1.0	mud	n	y	y	n	n	n	n	n	n	Poor visibility; looks like flat mud w/ dense tubes
NREF-21	D	10/15/2012	16:41:37	125.6	82.7	1.0	mud	n	y	y	y	n	n	n	n	n	Poor visibility; looks like flat mud w/ dense tubes+small burrows+tracks
NREF-22	A	10/15/2012	17:31:41	137.4	91	1.3	rocks+sandy mud	n	y	y	n	n	y	n	n	y	Assorted gravel w/ shell frags+sandy mud; lobster emerging from burrow; numerous shrimp; piece of rope lower left corner
NREF-22	B	10/15/2012	17:32:46	136.2	89.8	1.2	sandy gravel	n	n	y	y	n	y	n	n	n	Sandy assorted gravel w/ shell frags; 15 cm length lobster
NREF-22	C	10/15/2012	17:33:40	131.9	87	1.1	sandy mud w/ gravel	n	y	y	y	y	y	y	n	n	Sandy mud w/ some gravel+shells; dead man's fingers upper left corner; burrowing anemone; tracks; a few shrimp
NREF-23	A	10/15/2012	16:15:58	114.1	75.5	0.9	sandy mud	n	y	y	y	y	y	n	n	n	Uniform flat sandy mud; dense small burrow-like openings=pockmarked surface; tracks/trails; shell frags; shrimp+small fish

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
NREF-23	B	10/15/2012	16:17:08	117	77.1	0.9	sandy mud w/ shell frags	n	y	y	y	y	y	n	n	n	Uniform flat sandy mud; dense small pockmarks; 1 ophiuroid; dense small shrimp
NREF-23	C	10/15/2012	16:18:19	115.1	76	0.9	sandy mud	n	y	y	y	n	y	n	n	n	Uniform flat sandy mud; dense small pockmarks; numerous small shrimp
NREF-24	A	10/15/2012	17:06:16	105.8	69.8	0.7	gravel w/ sandy mud	n	n	y	n	n	y	n	n	n	Mixed gravel and shells interspersed w/ sandy mud; some rocks; 1 lobster 15 cm length
NREF-24	B	10/15/2012	17:07:17	136.4	90.1	1.2	mixed gravel shells and muddy sand	n	n	y	n	n	y	n	n	n	Mixed gravel and shells interspersed w/ sandy mud; epifaunal growth on shells/rocks
NREF-24	C	10/15/2012	17:08:53	137.8	91.2	1.3	muddy sand w/ gravel+shells	n	n	y	y	y	y	n	n	n	Mixed gravel and shells interspersed w/ sandy mud; some rocks; 1 lobster 15 cm length
NWREF-25	A	10/15/2012	13:33:47	85.6	56.5	0.5	muddy sand mixed w/ shells+gravel	n	n	y	n	n	y	n	n	n	Mixed gravel and shells interspersed w/ sandy mud; some rocks; 1-2 shrimp
NWREF-25	B	10/15/2012	13:34:48	114.9	75.8	0.9	muddy sand w/ scattered gravel	n	n	y	n	n	y	n	n	n	Sandy mud interspersed with gravel and shells; numerous shrimp at sed surf; epifauna on rocks
NWREF-25	C	10/15/2012	13:35:55	118.7	78.2	0.9	muddy sand w/ rocks+shells	n	n	n	y	y	y	n	n	n	Sandy mud w/ scattered rocks+shells; 1 shrimp; 1 partial lobster bottom of images
NWREF-26	A	10/15/2012	13:46:42	120.7	79.9	1.0	mixed gravel and muddy sand	n	n	y	n	n	y	n	n	y	Mix gravel muddy sand+shells; numerous shrimp; 1 crab 8 cm carapace width
NWREF-26	C	10/15/2012	13:48:24	107.3	70.9	0.8	mixed gravel w/ sandy mud	n	n	n	n	n	y	n	n	n	Mixed gravel+muddy sand; numerous shrimp; epifauna growing on rocks
NWREF-26	D	10/15/2012	13:49:29	106.4	70.3	0.7	sandy mud	n	y	y	y	y	y	n	n	n	Muddy fine sand w/ shells; a few small rocks; 1 shrimp
NWREF-27	A	10/15/2012	13:19:59	111.7	74	0.8	sandy mud w/ some buried rocks	n	y	y	n	n	y	n	n	n	Muddy fine sand w/ shell frags; several buried rocks; several shrimp upper right corner; epifauna on rocks
NWREF-27	B	10/15/2012	13:20:50	108.7	71.7	0.8	sandy mud	n	y	y	y	n	y	n	n	n	Muddy fine sand w/ shell frags; 1 crab and 1 shrimp
NWREF-27	C	10/15/2012	13:21:46	112.1	74	0.8	sandy mud+shell frags	n	y	y	y	y	y	n	n	n	Muddy sand w/ shell frags; tracks; 1 large burrow; a few shrimp
NWREF-28	A	10/15/2012	12:49:53	121.3	80.1	1.0	sandy mud w/ shell frags	n	y	y	y	y	n	n	n	n	Poor visibility; muddy sand w/ shells

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
NWREF-28	B	10/15/2012	12:50:59	117.3	77.7	0.9	sandy mud w/ shell frags	n	y	y	y	n	y	n	n	n	Muddy sand w/ shells; lobster emerging from burrow; lobster length=22 cm
NWREF-28	C	10/15/2012	12:51:58	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
NWREF-29	A	10/15/2012	13:01:52	101.4	67.1	0.7	mud	n	y	y	y	y	y	n	n	n	Flat sandy mud w/ some shell frags; burrows w/ expelled dark sed; many small shrimp; linear furrows=??
NWREF-29	C	10/15/2012	13:03:50	ind	ind		ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
NWREF-29	D	10/15/2012	13:04:55	101.5	67.2	0.7	mud	n	y	y	y	y	y	n	n	n	Flat sandy mud; many tracks/trails; macroalgae lower left corner; numerous small shrimp
NWREF-30	A	10/15/2012	13:13:14	122.5	80.9	1.0	mixed gravel+muddy sand	n	n	y	n	n	y	n	n	n	Mixed gravel+sandy mud; several shrimp; partial crab@left edge of image
NWREF-30	B	10/15/2012	13:14:05	122.2	78.9	1.0	mixed rocks+sandy mud	n	y	y	y	n	y	n	n	n	Mixed gravel+sandy mud; 1-2 shrimp
NWREF-30	C	10/15/2012	13:15:02	131.6	86.7	1.1	mixed gravel+sandy mud	n	n	y	n	n	y	n	n	n	Mixed gravel+sandy mud; a few shrimp
SREF-31	A	10/15/2012	14:33:25	111.5	73.7	0.8	mud w/ dense white shell hash	n	y	y	n	n	y	n	n	n	Mud w/ floccy organic drape; dense white shell hash; many small shrimp; small flounder=11 cm bottom edge
SREF-31	B	10/15/2012	14:34:39	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
SREF-31	C	10/15/2012	14:36:03	121.6	80.3	1.0	mud or sand w/ dense white shell frags	n	y	y	y	n	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; tracks; numerous small shrimp; rock lower left corner
SREF-32	A	10/15/2012	14:45:38	114.7	75.8	0.9	mud w/ white shell frags	n	y	y	y	n	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; tracks; numerous small shrimp, gastropods
SREF-32	C	10/15/2012	14:48:04	124.5	81.8	1.0	mud w/ white shell frags	n	y	y	y	n	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; tracks; numerous small shrimp
SREF-32	D	10/15/2012	14:50:26	124	82.1	1.0	mud w/ white shell frags	n	y	y	y	n	y	n	y	n	Flat muddy sand/sandy mud w/ dense white shell frags; tracks; numerous small shrimp; frame imprint and associated clasts

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m²)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
SREF-33	A	10/15/2012	15:33:38	135.3	89.4	1.2	mud w/ white shell frags	n	y	y	n	n	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; numerous small shrimp
SREF-33	B	10/15/2012	15:34:51	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
SREF-33	C	10/15/2012	15:35:59	130.4	86.1	1.1	mud w/ white shell frags	n	y	y	n	n	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; numerous small shrimp
SREF-34	A	10/15/2012	15:01:06	117.1	77.2	0.9	mud w/ white shell frags	n	y	y	n	n	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; numerous small shrimp
SREF-34	B	10/15/2012	15:02:19	113.7	75	0.9	mud w/ white shell frags	n	y	y	y	y	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; several small shrimp
SREF-34	C	10/15/2012	15:04:00	122.2	80.6	1.0	mud w/ white shell frags	n	y	y	y	y	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; several small shrimp; numerous tracks
SREF-35	A	10/15/2012	14:12:52	127.3	83.3	1.1	mud w/ white shell frags	n	y	y	y	y	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; several small shrimp
SREF-35	B	10/15/2012	14:15:07	109	72	0.8	mud w/ white shell frags	n	y	y	y	y	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; several small shrimp
SREF-35	C	10/15/2012	14:16:45	105.6	69.5	0.7	mud w/ white shell frags	n	y	y	y	y	y	n	n	n	Flat muddy sand/sandy mud w/ dense white shell frags; several small shrimp
SREF-36	A	10/15/2012	15:22:25	129.5	85.3	1.1	dense shell hash	n	n	n	n	n	y	n	n	n	Dense shell hash w/ scattered rocks; 2-3 shrimp; macroalgae@left corner
SREF-36	B	10/15/2012	15:23:13	145.5	96	1.4	mix of shell hash+rocks+sandy mud	n	n	n	n	n	y	n	n	n	Mix of shell hash+sandy mud+gravel w/ epifauna; several shrimp; crab in upper right corner
SREF-36	C	10/15/2012	15:24:46	133.7	88.4	1.2	mix of shell hash+rocks+sandy mud	n	n	y	n	n	y	n	n	n	Mix of shell hash+sandy mud+gravel w/ epifauna; several shrimp; crab in upper left corner
ALT3REF-49	A	10/15/2012	10:58:54	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
ALT3REF-49	B	10/15/2012	11:00:05	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
ALT3REF-49	C	10/15/2012	11:01:32	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
ALT3REF-50	A	10/15/2012	11:29:30	134.1	88.6	1.2	muddy sand	n	ind	ind	ind	ind	y	ind	ind	ind	Poor visibility; looks like mud w/ numerous shrimp
ALT3REF-50	B	10/15/2012	11:30:46	134	86.7	1.2	muddy sand	n	y	ind	y	n	ind	ind	ind	ind	Poor visibility; looks like mud w/ some burrows+tracks
ALT3REF-50	D	10/15/2012	11:32:38	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface

Plan-View Image Analysis Results for EPDS Survey, October 2012

Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View Imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Trails	Epifauna	Infauna	Mud Clasts	Debris	Comment
ALT3REF-51	E	10/15/2012	10:30:22	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface clearly
ALT3REF-51	F	10/15/2012	10:31:57	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
ALT3REF-51	H	10/15/2012	10:34:38	ind	ind	ind	mud and rocks	n	n	ind	ind	ind	ind	ind	ind	ind	poor visibility; looks like border between rock ledge+mud
ALT3REF-52	A	10/15/2012	11:20:39	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
ALT3REF-52	B	10/15/2012	11:21:42	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface; a couple of shrimp visible@right
ALT3REF-52	C	10/15/2012	11:22:49	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
ALT3REF-53	B	10/15/2012	11:09:33	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface; possibly one shrimp visible\
ALT3REF-53	C	10/15/2012	11:11:10	ind	ind	ind	mud	n	n	ind	ind	ind	y	ind	y	ind	Very poor visibility; 2 shrimp visible; mud clasts; burrows
ALT3REF-53	D	10/15/2012	11:12:20	ind	ind	ind	sandy mud w/ shell hash	n	n	ind	ind	ind	n	n	y	n	Poor visibility; mud clasts; looks like sandy mud w/ shell frags
ALT3REF-54	A	10/15/2012	11:40:56	115.1	76.2	0.9	sandy mud	n	y	y	y	n	y	n	n	n	Poor visibility; looks like muddy sand/sandy mud w/ shell hash; numerous shrimp@right side of image
ALT3REF-54	B	10/15/2012	11:41:57	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface
ALT3REF-54	C	10/15/2012	11:43:09	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	ind	Too turbid to see sed surface

APPENDIX D

TABLE OF COMMON CONVERSIONS

APPENDIX D

Table of Common Conversions

Metric Unit Conversion to English Unit		English Unit Conversion to Metric Unit	
1 meter 1 m	3.2808399 ft	1 foot 1 ft	0.3048 m
1 square meter 1 m^2	10.7639104 ft^2	1 square foot 1 ft^2	0.09290304 m^2
1 kilometer 1 km	0.621371192 mi	1 mile 1 mi	1.609344 km
1 cubic meter 1 m^3	1.30795062 yd^3	1 cubic yard 1 yd^3	0.764554858 m^3
1 centimeter 1 cm	0.393700787 in	1 inch 1 in	2.54 cm