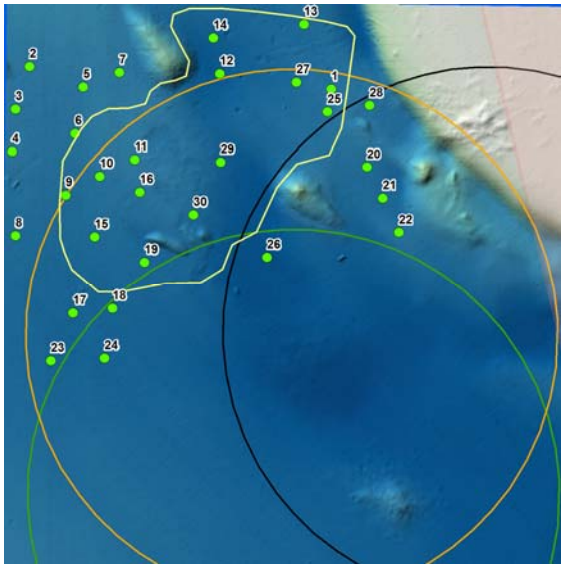
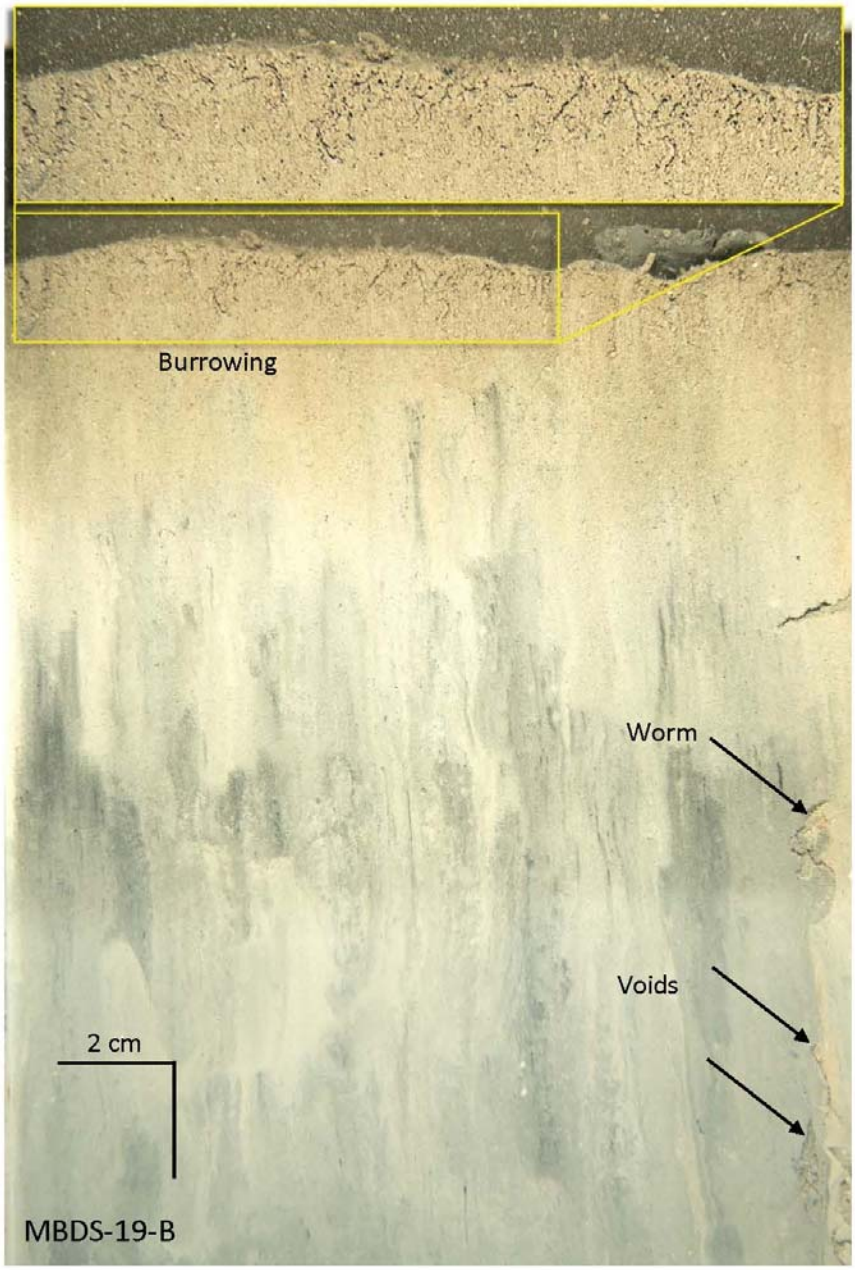
Baseline Seafloor Assessment Survey for the Proposed Expansion of the Massachusetts Bay Disposal Site September/October 2015

# Disposal Area Monitoring System - DAMOS






D A M O S
DISPOSAL AREA MONITORING SYSTEM

Contribution 201
January 2017

US Army Corps of Engineers ®
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As part of a multidisciplinary sampling program, scientists from DAMOSVision conducted a baseline assessment of the seafloor at the Massachusetts Bay Disposal Site (MBDS). Specifically, a combined Sediment-Profile and Plan-View Imaging (SPI/PV) survey was conducted at the area in Massachusetts Bay known as the historical Industrial Waste Site (IWS) to characterize the benthic environment. The U.S. Environmental Protection Agency (USEPA) is currently pursuing expanding the boundary of the existing MBDS to include the directly abutting portion of the historical IWS in preparation for the potential placement of improvement material (or navigation-project dredged material) dredged from the planned Boston Harbor deepening project. USACE has proposed a Potential Restoration Area within the expanded boundary to place dredged material suitable for open ocean disposal.

Researchers conducted a multibeam echosounder (MBES) survey prior to the SPI/PV survey to provide high-resolution bathymetry of the survey area. The MBES survey covered an area of 4 × 4 km, encompassing the IWS, a portion of the MBDS, and some surrounding areas. To assess the overall condition of the benthic habitat, sediment profile images were collected from stations randomly distributed in and around the IWS, and at three reference areas to the south (the reference areas were not mapped with multibeam). This approach allowed for an accurate spatial assessment of the seafloor in and around the IWS, and the reference areas served as a comparison for ambient seafloor conditions. 45 SPI/PV stations were planned, with 30 stations located in the proposed disposal site expansion area, and 5 stations in each of the three reference areas (FG-23, MBD-REF, and SE-REF). Four replicate images were collected from each station with three images targeted for analysis. Finally, an ROV was used to provide video footage of specified targets on the seafloor for identification of artifacts in the IWS (shipwrecks, barrels, and debris).

The high-resolution bathymetric survey revealed the persistence of disposal mounds previously identified in earlier assessments of MBDS and documented dredged material disposal activity in the potential restoration area. Historical disposal activity in the potential restoration area was confirmed by the SPI/PV survey which documented the presence of layers of dredged material (>15 cm in thickness) at the majority of stations in and around the potential restoration area. Stations where dredged material was not present tended to be located in the western portion of the MBDS survey area. Two shipwrecks were also documented in the MBDS survey area but were not identifiable.

The benthic characteristics of stations in the potential restoration area did not differ from those observed on the ambient seafloor aside from the presence of dredged material. However, there was no apparent adverse impact to the infaunal community associated with the presence of dredged material. Stations in the potential restoration area demonstrated a stable benthic structure or advanced stages of recolonization (Stage 3). The presence of Stage 3 fauna at stations containing dredged material indicates that despite the legacy of disposal in the potential restoration area, the benthic community has recovered. These results show how over time, and after disposal stops, dredged material will eventually be reworked to background by infauna.

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# BASELINE SEAFLOOR ASSESSMENT SURVEY FOR THE PROPOSED EXPANSION OF THE MASSACHUSETTS BAY DISPOSAL SITE SEPTEMBER/OCTOBER 2015

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***Note on units of this report***: As a scientific data summary, 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 A.

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# LIST OF ACRONYMS

| | |
|---|---|
| 1080P | 1080 horizontal lines of vertical resolution |
| aRPD | Apparent redox potential discontinuity |
| ASCII | American Standard Code for Information Interchange |
| BOEM | Bureau of Ocean Energy Management |
| CI | Confidence interval |
| DAMOS | Disposal Area Monitoring System |
| DO | Dissolved oxygen |
| DOE | Department of Energy |
| DVD | Digital video disc |
| EGN | Empirical Gain Normalization |
| FADS | Foul Area Disposal Site |
| FDA | Food and Drug Administration |
| Fisheye FIX | Product name (underwater video lights) |
| GIS | Geographic information system |
| GPS | Global Positioning System |
| GRD | Gridded data |
| H.264 | MPEG-4 Part 10 Advance video coding format |
| HD | High definition |
| IWS | Industrial Waste Site |
| LLRW | Low level radioactive waste |
| LUX | Unit of measure. The amount of light that falls on a surface is measured in lux. One lux is the light obtained from a source of one lumen over an area of one square meter. |
| MADPH | Massachusetts Department of Public Health |
| MBDS | Massachusetts Bay Disposal Site |
| MBES | Multibeam echosounder |
| MLLW | Mean Lower Low Water |
| MPEG | Moving Picture Experts Group (pronounced EHM-pehg) video format. Moving Picture Experts Group develops standards for digital video and digital audio compression. It operates under the auspices of the International Organization for Standardization (ISO). |
| MRU | Motion reference unit |

| | |
|---|---|
| NAD83 | North American Datum of 1983 |
| NAE | USACE, New England Division |
| NEF | Nikon Electronic Format |
| NOAA | National Oceanic and Atmospheric Association |
| NOS | National Ocean Service |
| PSD | Photoshop Document |
| PV | Plan-View |
| ROV | Remotely operated vehicle |
| RTK | Real time kinematic GPS - vertical accuracy is approximately 2 cm, enabling use for tide corrections in some circumstances. RTK GPS is suitable for both horizontal and centimeter level vertical positioning, including tide corrections |
| R/V | Research vessel |
| SD | Standard deviation |
| SPI | Sediment-Profile Imaging |
| TIF | Tagged image file |
| TVL | Television lines (TVL) is a specification of an analog camera's or monitor's horizontal resolution power. It is alternatively known as Lines of Horizontal Resolution (LoHR) or lines of resolution. |
| USACE | U.S. Army Corps of Engineers |
| USBL | Ultra short baseline |
| USEPA | U.S. Environmental Protection Agency |
| VDATUM | Vertical Datum Transformation |

# EXECUTIVE SUMMARY

As part of a multidisciplinary sampling program, scientists from DAMOSVision conducted a baseline assessment of the seafloor at the Massachusetts Bay Disposal Site (MBDS). Specifically, a combined Sediment-Profile and Plan-View Imaging (SPI/PV) survey was conducted at the area in Massachusetts Bay known as the historical Industrial Waste Site (IWS) to characterize the benthic environment. The U.S. Environmental Protection Agency (USEPA) is currently pursuing expanding the boundary of the existing MBDS to include the directly abutting portion of the historical IWS in preparation for the potential placement of improvement material (or navigation-project dredged material) dredged from the planned Boston Harbor deepening project. USACE has proposed a Potential Restoration Area within the expanded boundary to place dredged material suitable for open ocean disposal.

Researchers conducted a multibeam echosounder (MBES) survey prior to the SPI/PV survey to provide high-resolution bathymetry of the survey area. The MBES survey covered an area of 4 × 4 km, encompassing the IWS, a portion of the MBDS, and some surrounding areas. To assess the overall condition of the benthic habitat, sediment profile images were collected from stations randomly distributed in and around the IWS, and at three reference areas to the south (the reference areas were not mapped with multibeam). This approach allowed for an accurate spatial assessment of the seafloor in and around the IWS, and the reference areas served as a comparison for ambient seafloor conditions. 45 SPI/PV stations were planned, with 30 stations located in the proposed disposal site expansion area, and 5 stations in each of the three reference areas (FG-23, MBD-REF, and SE-REF). Four replicate images were collected from each station with three images targeted for analysis. Finally, an ROV was used to provide video footage of specified targets on the seafloor for identification of artifacts in the IWS (shipwrecks, barrels, and debris).

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The benthic characteristics of stations in the potential restoration area did not differ from those observed on the ambient seafloor aside from the presence of dredged material. However, there was no apparent adverse impact to the infaunal community associated with the presence of dredged material. Stations in the potential restoration area demonstrated a stable benthic structure or advanced stages of recolonization (Stage 3). The presence of Stage 3 fauna at stations containing dredged material indicates that despite the legacy of disposal in the potential restoration area, the benthic community has recovered. These results show how over time, and after disposal stops, dredged material will eventually be reworked to background by infauna.

Conclusions & Recommendations

- Historical dredged material disposal activity has taken place in and around the potential restoration area, identified by bathymetric features, and confirmed by the presence of visible dredged material in the SPI/PV survey.
- The majority of SPI stations in the potential restoration area contained historical dredged material deposits.
- Despite the presence of historical dredged material deposits, benthic characteristics on the seafloor in the potential restoration area did not differ from ambient seafloor conditions.
- Given the complete recovery of the benthic infaunal community in the restoration area to previous disposal activity, the effects from any future disposal operations are expected to be transient, and the infaunal community would quickly reestablish itself following completion of disposal operations.
- As a precaution, until further identification of the two shipwrecks is conducted, avoidance of any impacts is recommended. A buffer of a minimum 50-meter radius from the outside edge of both vessels is recommended during any disposal activity.

# 1.0 INTRODUCTION

A focused baseline seafloor assessment survey was conducted at the Massachusetts Bay Disposal Site (MBDS), specifically at the area known as the historical Industrial Waste Site (IWS), as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS). The USEPA is currently pursuing expanding the boundary of the existing MBDS to include the directly abutting portion of the historical IWS in preparation for the potential placement of improvement material (or navigation-project dredged material) dredged from the planned Boston Harbor deepening project.

DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns associated with use of aquatic disposal sites throughout the New England region. An overview of the DAMOS Program, an introduction to MBDS, a brief history of the IWS and the 2008-2009 Restoration Demonstration, and a description of previous dredged material disposal activities and a description of the previous monitoring surveys are 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 the disposal site management process. 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, acoustic backscatter, and side-scan sonar measurements) are conducted to characterize the height and spread of discrete dredged material deposits or mounds created at open water sites.

Sediment-profile (SPI) and plan-view (PV) imaging surveys are often performed in both confirmatory and focused studies 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 specific sites to determine the next step in the disposal site management process (Germano et al. 1994).

Focused studies are periodically undertaken within the DAMOS Program to evaluate inactive or historical disposal sites and contribute to the development of dredged material techniques and management planning. Focused DAMOS monitoring surveys often feature additional types of data collection activities as deemed appropriate to achieve specific survey objectives, such as grab sampling of sediment for physical and biological analysis, sub-bottom profiling, sediment coring, towed video, or video collection via a remotely operated vehicle (ROV).

The 2015 MBDS/IWS survey was a focused baseline study for the potential expansion of MBDS to allow targeted placement of improvement material dredged from the planned Boston Harbor deepening project on portions of the IWS (USACE 2015). This survey included a baseline acoustic survey, a SPI/PV imaging survey, and an ROV survey.

## 1.2 Introduction to the Massachusetts Bay Disposal Site

MBDS is centrally located within Massachusetts Bay accessible from Boston Harbor as well as harbors along the northern and southern shorelines of the Bay (Figure 1-1). MBDS was officially designated an ocean dredged material disposal site (ODMDS) by the USEPA in 1993 (USEPA 1992; USEPA 1993; USEPA/USACE 2009). MBDS is situated approximately 22.2 km (11.9 nm) southeast of Gales Point, Manchester, Massachusetts and is directly adjacent to the Stellwagen Bank National Marine Sanctuary. The site is circular in shape and occupies a 10.75 km² (3.13 nmi²) area on the seafloor (Figure 1-1), and receives sediments from dredging projects along coastal Massachusetts. The site was relocated from the interim disposal site (Foul Area Disposal Site [FADS]), used for the disposal of dredged material from 1977 to 1993, to its current position centered at 42° 25.106' N, 70° 34.969' W (NAD 83) (Figures 1-2 and 1-3; USACE 2015). The current location was also selected to avoid the northern part of the IWS, closed by USEPA in 1977, where past disposal of debris and a wide range of industrial wastes (including containers of low-level radioactive waste) had occurred (SAIC 1997a and 1997b).

Water depths at MBDS slope gradually from approximately 82 m (270 ft) along the southwestern boundary towards a shallow depression (approximately 92 m [300 ft] in depth) in the northeast quadrant of the site (Figure 1-4). North of the depression and outside of the MBDS boundary is a distinct topographic high (approximately 67 m [220 ft] in depth).

Since January 1994, the management strategy at MBDS has featured the controlled placement of small to moderate volumes of sediment to form individual disposal mounds

arranged around the natural seafloor depression in the northeast quadrant of the site. The goal of this approach is to construct the boundary of a containment cell over time. Once complete, the containment cell may be used to limit the lateral spread of future dredged material. By late 2012, nine dredged material disposal mounds had been constructed within MBDS (MBDS-A through MBDS-I; Figure 1-5). A brief description of the mounds and their origin is provided in Section 1.4 below.

## 1.3 History of the Industrial Waste Site and the 2008-2009 Restoration Demonstration Project

As Massachusetts Bay is accessible from Boston Harbor and a host of other industrial harbors along the Massachusetts coastline, the disposal site was used for offshore waste disposal from the 1940s until 1977 (Figure 1-3; USACE 2015). The historical IWS received materials ranging from construction debris and dredged material to munitions and hazardous waste. In 1952, the IWS was designated by the Atomic Energy Commission to receive low level radioactive waste (LLRW) sealed in drums with 4-6 inch concrete liners. Records indicate that approximately 4,000 containers of LLRW were disposed at the IWS before offshore disposal operations ceased in 1959. However, undocumented disposals from years before 1952 suggest that the number was likely much higher. Prior investigations suggest that the number of barrel-like containers present in the IWS may be as high as 20,000, and the condition of these containers has deteriorated with the contents likely exposed to the environment (Table 1-1). Investigations have not identified any unacceptable human health or environmental risks sufficient to initiate a remediation effort (USACE 2015). Despite documented analytical results of no definitive contamination, public and congressional concern remain over the potential risk to human and environmental health from the LLRW disposed at the IWS (USACE 2015).

In order to address potential risk to human or environmental health, the USEPA Region 1 and USACE New England District are proposing a cost-effective approach to cover a portion of the historical IWS, referred to as the Potential Restoration Area, by using a large volume of sediment (approximately 12 million $yds^3$/9.2 million $m^3$) that will be dredged from deepening the Boston Harbor, possibly starting in 2017 (Figure 1-6, USACE 2015). This approach was developed and investigated by the DAMOS Program in cooperation with USEPA Region 1 via a restoration demonstration project performed between 2008 and 2009, in a portion of MBDS with no known waste containers but with a similar water depth, currents, and bottom type to the IWS (Figure 1-2). Prior to the restoration demonstration project, a baseline multibeam survey was completed, with a subsequent multibeam survey in 2012 (Table 1-2).

The restoration demonstration project established that accurate, sequential placement of dredged material could be achieved at MBDS without increasing the costs of a dredging project. The experiment also demonstrated that a sequential approach to placement, beginning operations outside of the barrel field to build a protective berm followed by

placements on the berm deposit, could effectively protect the in-place sediments and waste barrels from impact forces and develop a cover layer over the barrels. Data generated through this demonstration project has been used to design a full-scale restoration approach for the Industrial Waste Site and eliminate the long-term potential environmental and human health risk posed by the LLRW barrels still exposed at the site (USACE 2015).

## 1.4 Historical and Recent Dredged Material Disposal Activity

Disposal of dredged material in the vicinity of MBDS dates back more than 60 years. Since designation in 1993, the site has received over 12 million $m^3$ (15.7 million $yd^3$) of dredged material from Boston Harbor and other surrounding harbors (through January 2015). Site management focused on creation of distinct disposal mounds (MBDS-A through MBDS-I; USEPA 2009).

The MBDS-A mound was formed from the disposal of fine-grained material, including consolidated clay, originating from the Third Harbor Tunnel Project between 1992 and 1994. The MBDS-B mound was formed from the disposal of sediment dredged from channels and harbors in the region from December 1994 through November 1998. The three subsequent disposal mounds (MBDS-C, MBDS-D, and MBDS-E) were constructed over a short period of time (1998-2000), consisting primarily of Boston Blue Clay dredged as part of the Boston Harbor Navigation Improvement Project. The MBDS-C mound is the largest of the disposal mounds, formed by the placement of nearly 1.4 million $m^3$ (1.8 million $yd^3$) of dredged material between November 1998 and August 1999. The MBDS-D mound is the smallest mound, formed by the disposal of approximately 386,000 $m^3$ (505,000 $yd^3$) of dredged material from Boston Harbor placed at the site over a 2.5-month period (August – October 1999). The fifth mound, MBDS-E, resulted from the disposal of over 750,000 $m^3$ (980,000 $yd^3$) of dredged material from October 1999 through June 2000. A sixth mound, MBDS-F, was initiated in September 2000, and received just over 2.0 million $m^3$ (2.6 million $yd^3$) of dredged material between September 2000 and August 2007. A seventh mound, MBDS-G, received approximately 550,000 $m^3$ (720,000 $yd^3$) of dredged material deposited between September 2006 and August 2007, and another 1.5 million $m^3$ (2 million $yd^3$) of dredged material deposited in 2008 (Figure 1-7). During the 2009-2012 disposal seasons two new deposits were identified as MBDS-H and MBDS-I. MBDS-H was not discernible as a mound in the bathymetry (Figure 1-5) despite the location receiving over 100,000 $m^3$ (130,000 $yd^3$) of dredged material between November 2009 and March 2010 (Figure 1-7; Carey et al. 2013). The deposits at MBDS-I were also not discernible in the bathymetry, but the location received less than 50,000 $m^3$ (65,000 $yd^3$) of dredged material between November 2010 and September 2012 (Figure 1-7; Carey et al. 2013). Since September 2012, MBDS-I received an additional 68,000 $m^3$ (89,000 $yd^3$; Figure 1-8; Appendix B).

While regular permitted general maintenance dredging and disposal at MBDS has occurred since the last confirmatory survey in 2012 (Figure 1-8; Carey et al. 2013), this

report only presents acoustic data of this activity, a future confirmatory survey/report will collect and present benthic assessment data of disposal activities since 2012.

## 1.5 Previous Monitoring Events at MBDS

Monitoring surveys have been conducted at or near the site that is currently known as MBDS since the early 1980s. Monitoring events that have occurred since MBDS was designated by USEPA in 1993 are summarized in Table 1-3. Mounds at MBDS have been monitored individually to assess stability, thickness of dredged material, and benthic recolonization status relative to previous survey results and in comparison with nearby reference areas.

## 1.6 2015 Survey Objectives

The September/October 2015 survey was designed to meet the following objectives:

- Characterize the seafloor topography and surficial features of the potential expanded MBDS by completing an acoustic survey (bathymetry, backscatter, and side-scan sonar).
- Use SPI/PV imaging to further define the physical characteristics of surficial sediment and to make a baseline characterization of the benthic community over the proposed expanded portion of MBDS and associated reference sites.
- Use an ROV to provide video footage of specified targets on the seafloor for identification of artifacts in the IWS (shipwrecks, barrels, and debris). Based on analysis of potential archaeological significance of any shipwreck finds, there may be a need to avoid specific areas during the potential placement of material at the IWS.

**Table 1-1.**

Survey Chronology at IWS (USACE 2015)

| Agency | Date | Survey Type | Reference |
|---|---|---|---|
| USACE | 1973 | Underwater video survey | Cited in Keith et al. 1999 |
| USEPA, FDA, NOAA | 1981-1982 | Side-scan sonar<br>Radiological analysis of sediment<br>Radiological analysis of biota<br>Radiological analysis of marketplace seafood samples | Lockwood et al. 1982, Curtis and Mardis 1984 |
| USEPA, International Wildlife coalition | 1991 | Side-scan sonar<br>ROV inspection of waste containers | Wiley et al. 1992 |
| USEPA, FDA, NOAA, DOE, MADPH | 1992 | Chemical and radiological analysis of sediment<br>Chemical and radiological analysis of tissue<br>Chemical and radiological analysis of marketplace seafood samples<br>ROV and manned submersible inspection of waste containers<br>ROV and manned submersible in situ radiological measurements | NOAA 1996<br>Keith et al. 1999 |
| USEPA | 2006 & 2010 | Side-scan sonar | USACE 2015 |

**Table 1-2.**

Survey Chronology at the Restoration Demonstration Area at MBDS

| Agency | Date | Survey Type | Reference | DAMOS Contribution No. |
|---|---|---|---|---|
| USACE | 2007 | Restoration Demonstration baseline acoustic, multibeam, SPI and grab survey | AECOM 2010 | 181 |
| USACE | 2008-2009 | Restoration Demonstration initial and follow-up acoustic, multibeam, side-scan sonar, SPI, coring and sub-bottom surveys | USACE 2015 | 198 |
| USACE | 2012 | Multibeam survey | Carey et al. 2013 | 195 |

**Table 1-3.**

Overview of Survey Activities at MBDS since 1992

| Date | Purpose of Survey | Bathymetry Area (m × m) and type | # SPI Stations | Sediment Grabs (#) and Analyses | Additional Studies | Reference | DAMOS Contribution No. |
|---|---|---|---|---|---|---|---|
| 9/1993 | Baseline of reconfigured site | 4000 × 4075 Single beam | | Grain size, metals, PAHs, pesticides, PCBs, TOC (26) | Side-scan | DeAngelo and Murray 1997 | 115 |
| 8/1994 | Periodic site monitoring | | 76 | | | SAIC 1997a | 116 |
| 9/1998 | Demonstration area-baseline | 800 × 800 Single beam | 91 | Grain size, color, consistency, other (13) | Side-scan | SAIC 2003 | 147 |
| 12/1998 | Demonstration area-single barge | 800 × 800 Single beam | 82 | | Side-scan | SAIC 2003 | 147 |
| 3/1999 | Pre-placement demonstration | 800 × 800 Single beam | 30 | Grain size, color, consistency, other (13) | Side-scan | SAIC 2003 | 147 |
| 9/2000 | Post-placement demonstration | 800 × 800 Single beam | 33 | Grain size, tracers | Side-scan, sediment cores (12) | SAIC 2003 | 147 |
| 8–10/2000 | Periodic site monitoring | 2400 × 2400 Single beam | 39 | | | SAIC 2002 | 134 |
| 9/2004 | Periodic site monitoring | 2400 × 2400 Multibeam | 45 | | | ENSR 2005 | 162 |
| 8/2007 | Periodic site monitoring | 2100 × 3200 Multibeam | 63 | Grain size, moisture content, and Atterberg limits | Box cores | AECOM 2010 | 181 |
| 9/2012 | Periodic site monitoring | 2000 × 3000 Multibeam | 48 | | | Carey et al. 2013 | 195 |

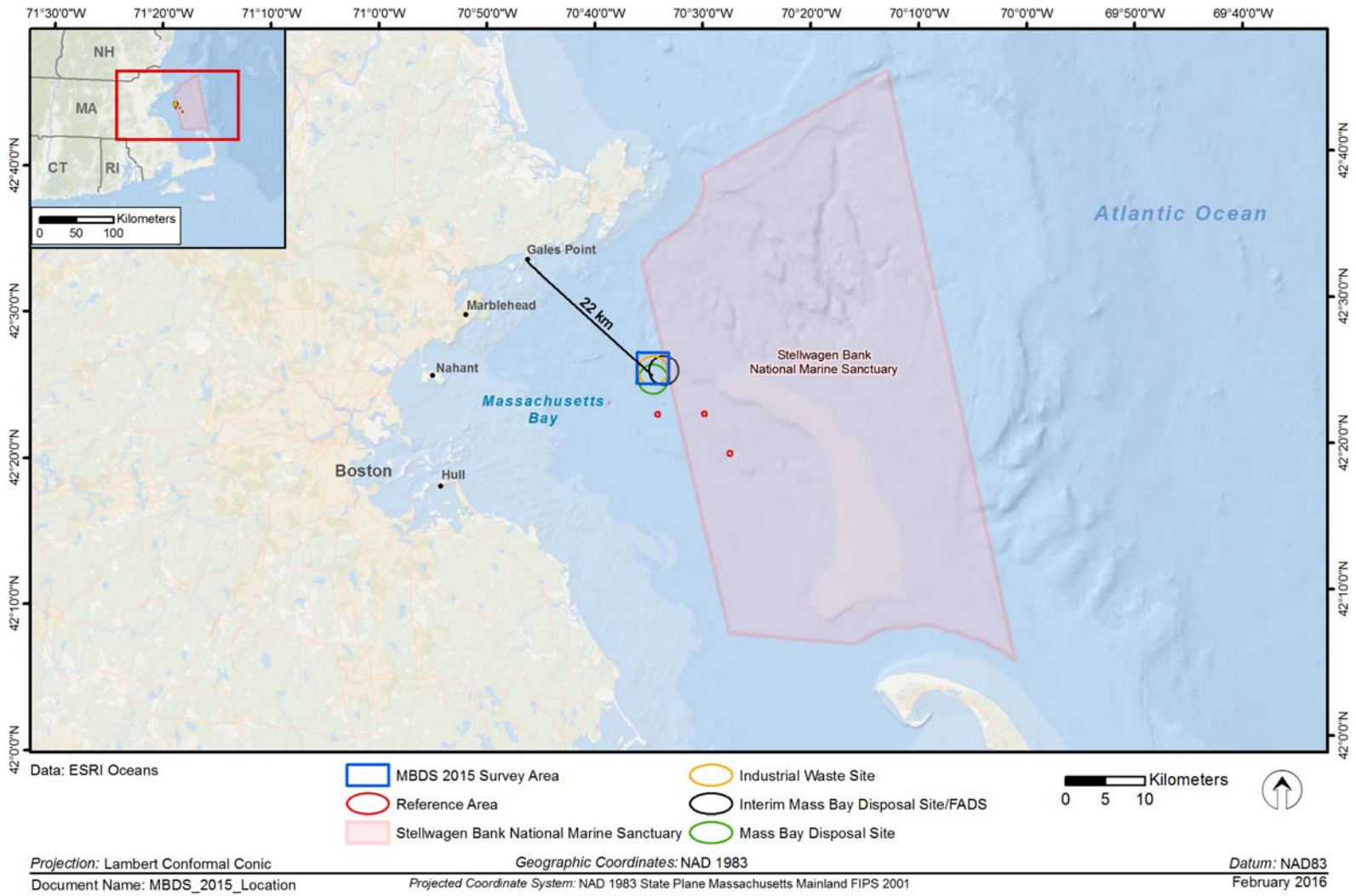



**Figure 1-1**. Location of the Massachusetts Bay Disposal Site (MBDS) and reference areas

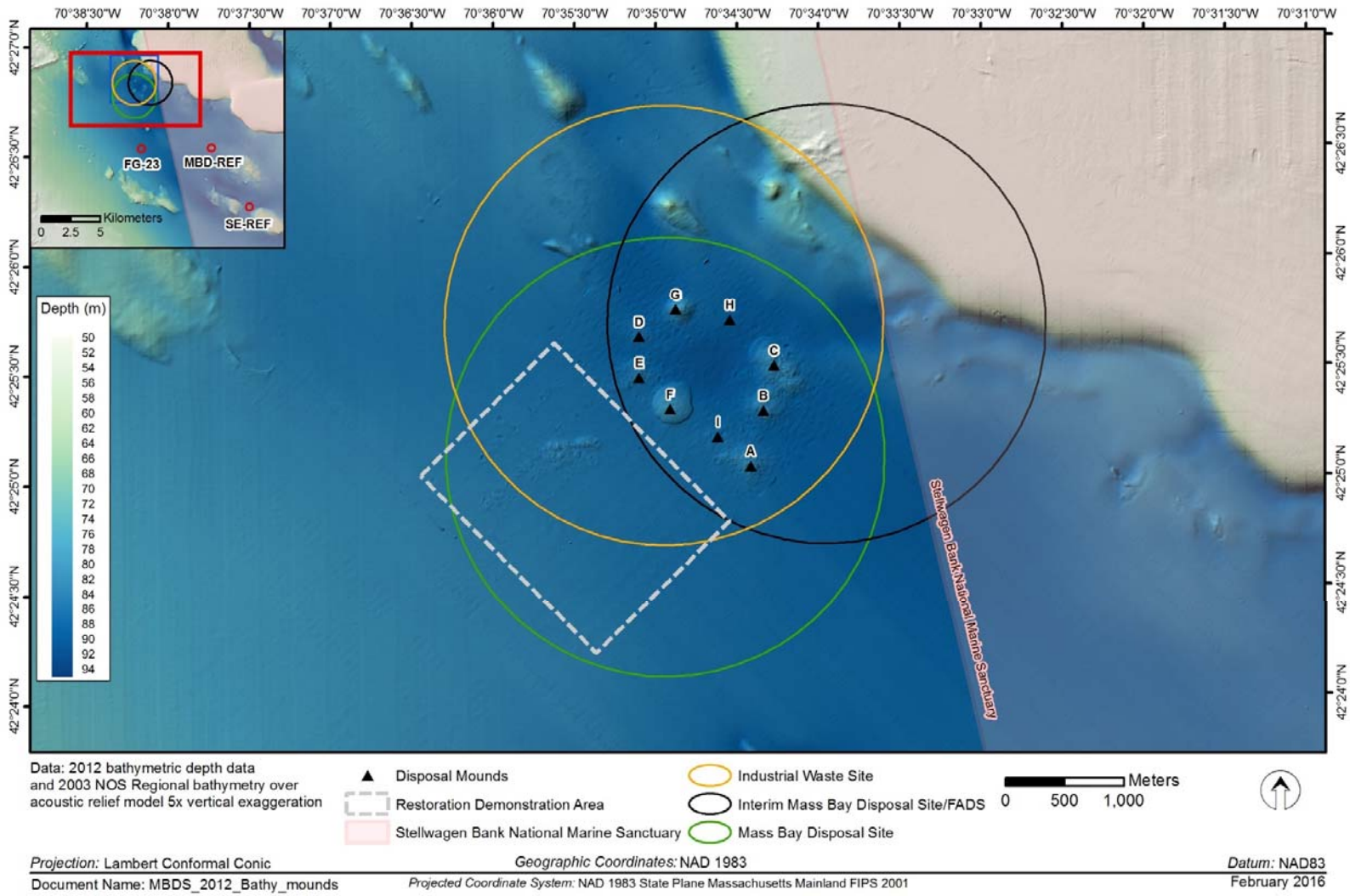



**Figure 1-2.** MBDS with historical site boundaries, dredged material mounds, and Restoration Demonstration Area

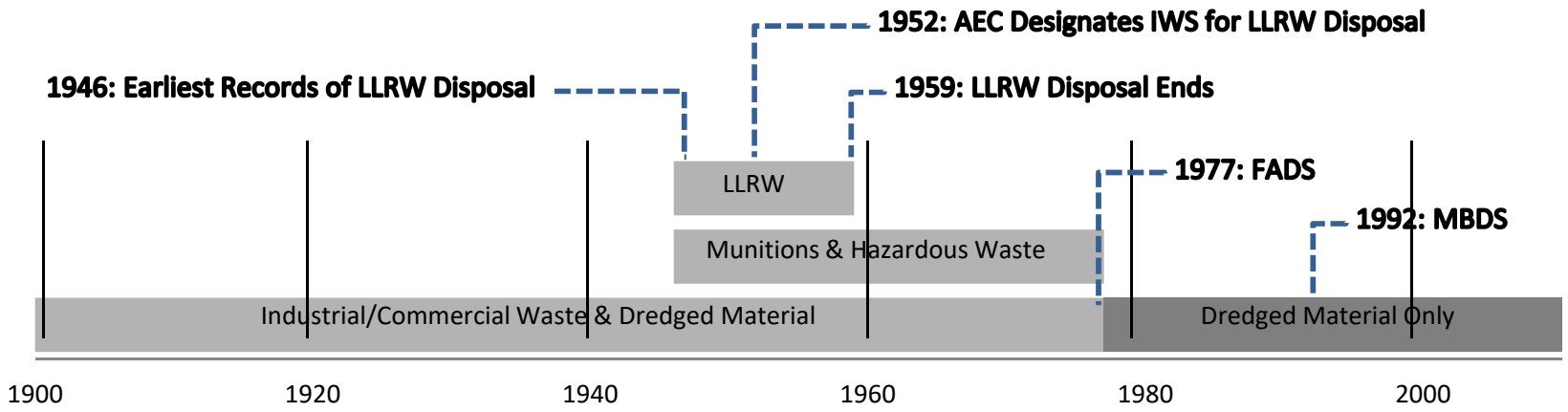



**Figure 1-3.** History of disposal at the Industrial Waste Site (IWS), Interim Massachusetts Bay Disposal Site (FADS), and MBDS

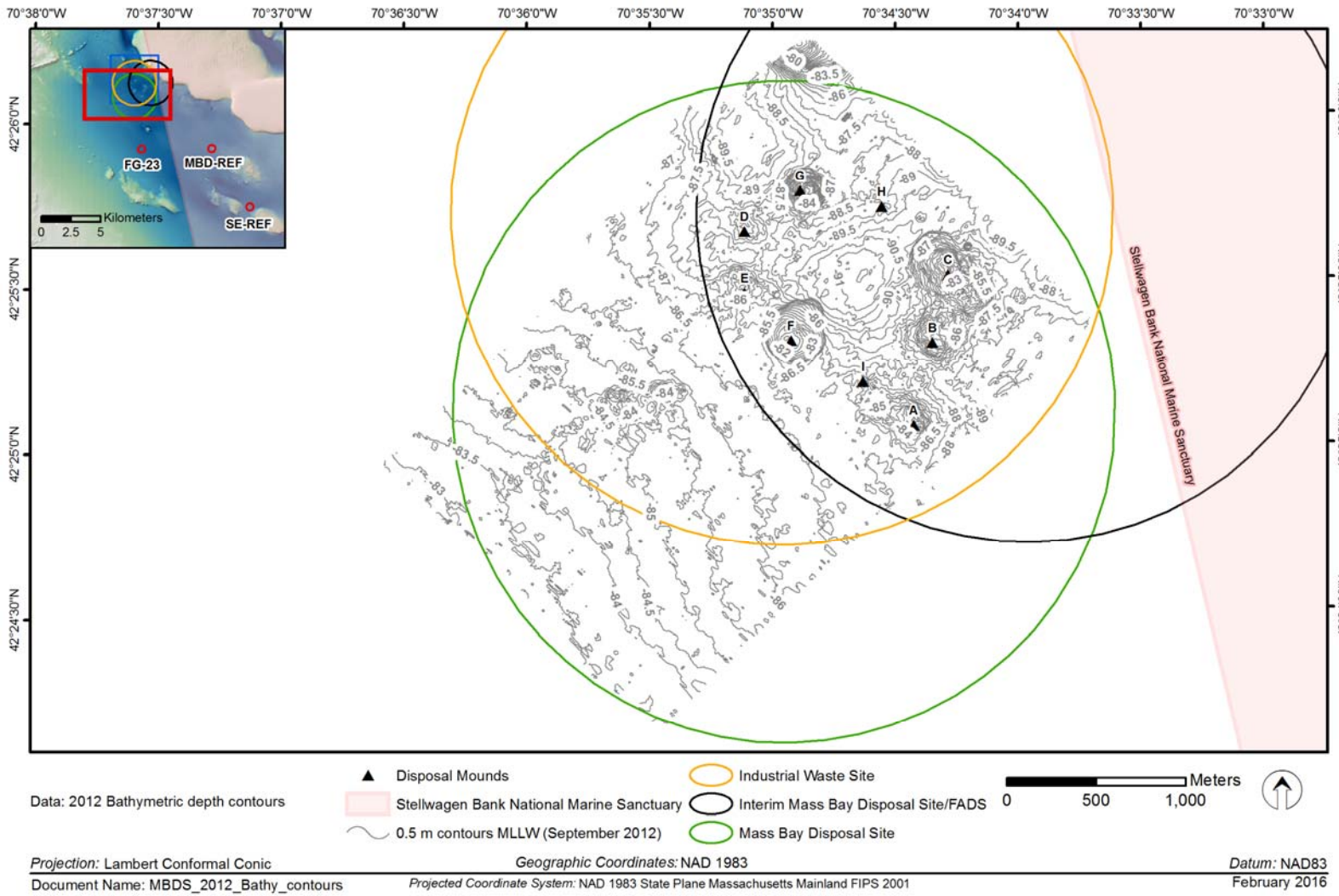



**Figure 1-4.** Bathymetric contour map of MBDS – September 2012

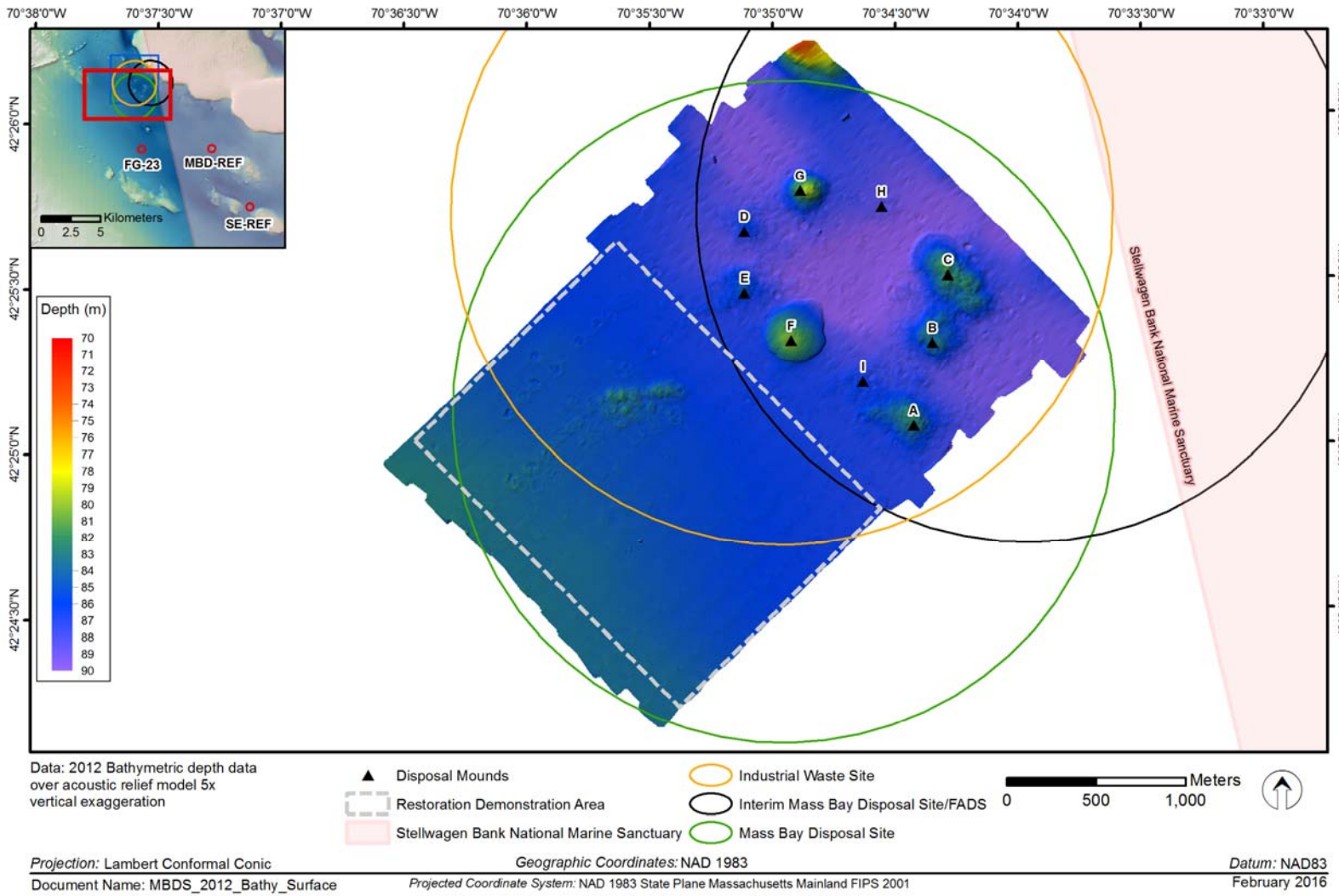



**Figure 1-5**. Bathymetric depth data over acoustic relief model of MBDS – September 2012

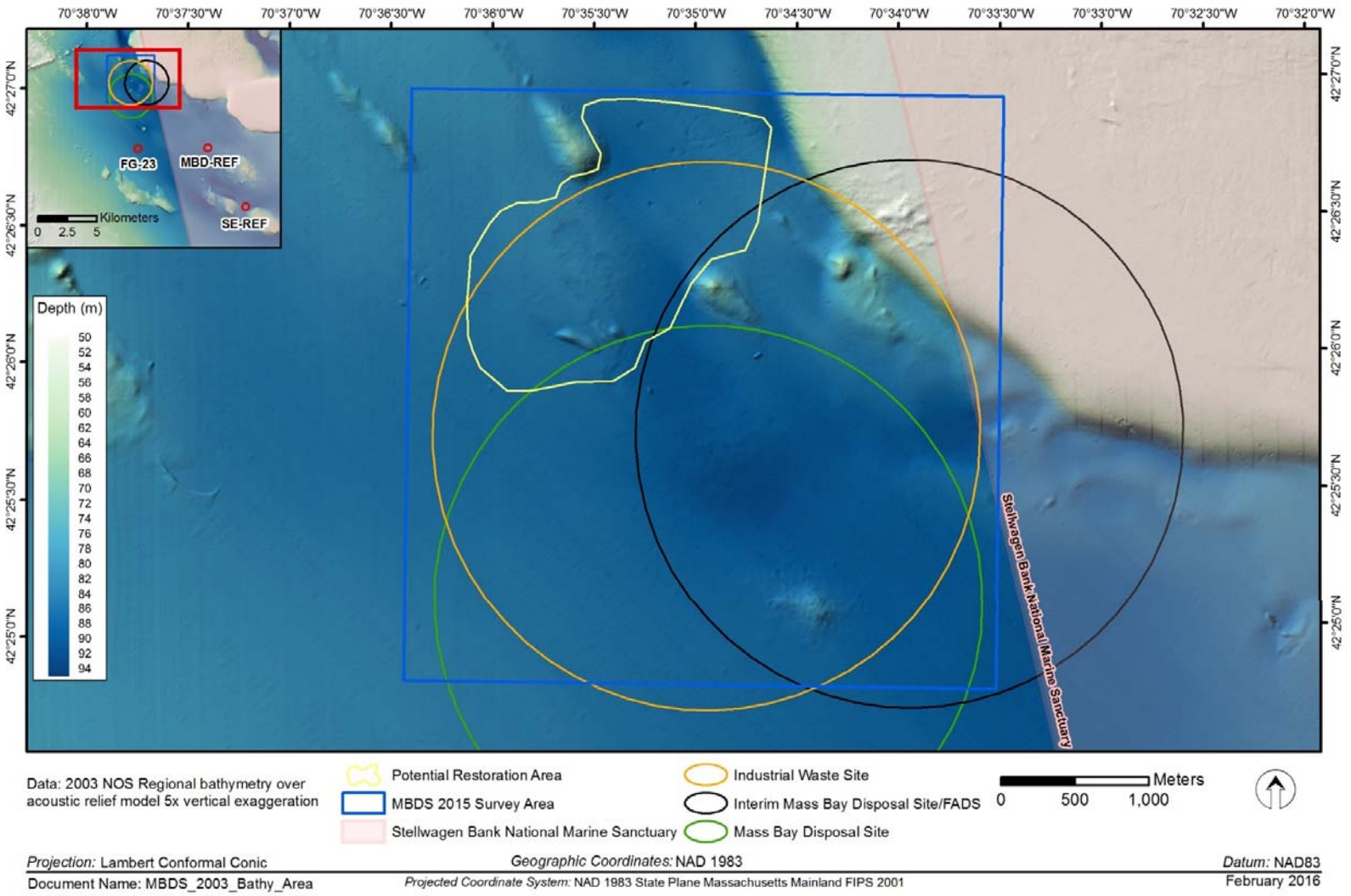



**Figure 1-6**. Location of the potential expansion area of MBDS: the "Potential Restoration Area"

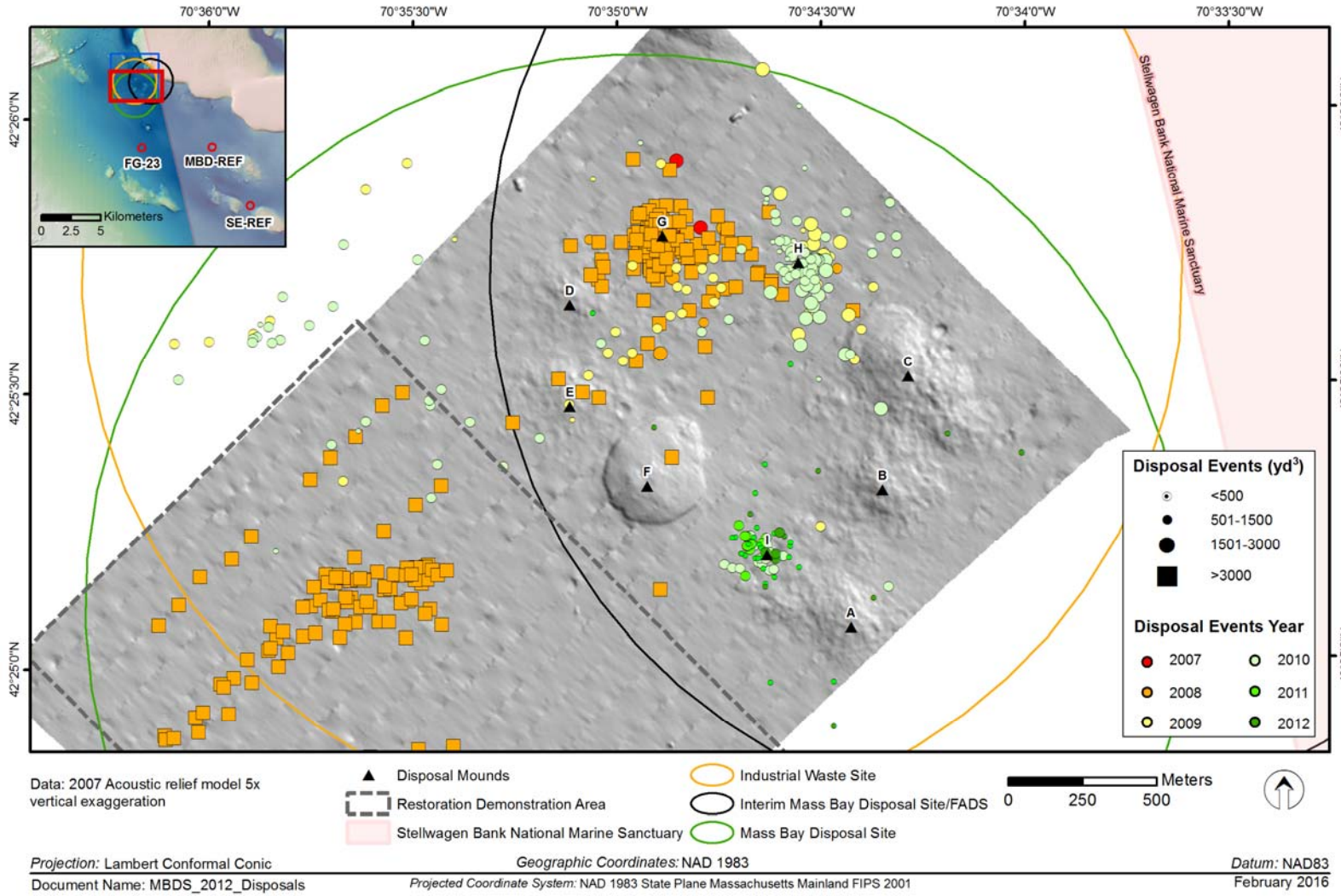



**Figure 1-7.** Location of disposal events at MBDS from November 13, 2007 to September 13, 2012

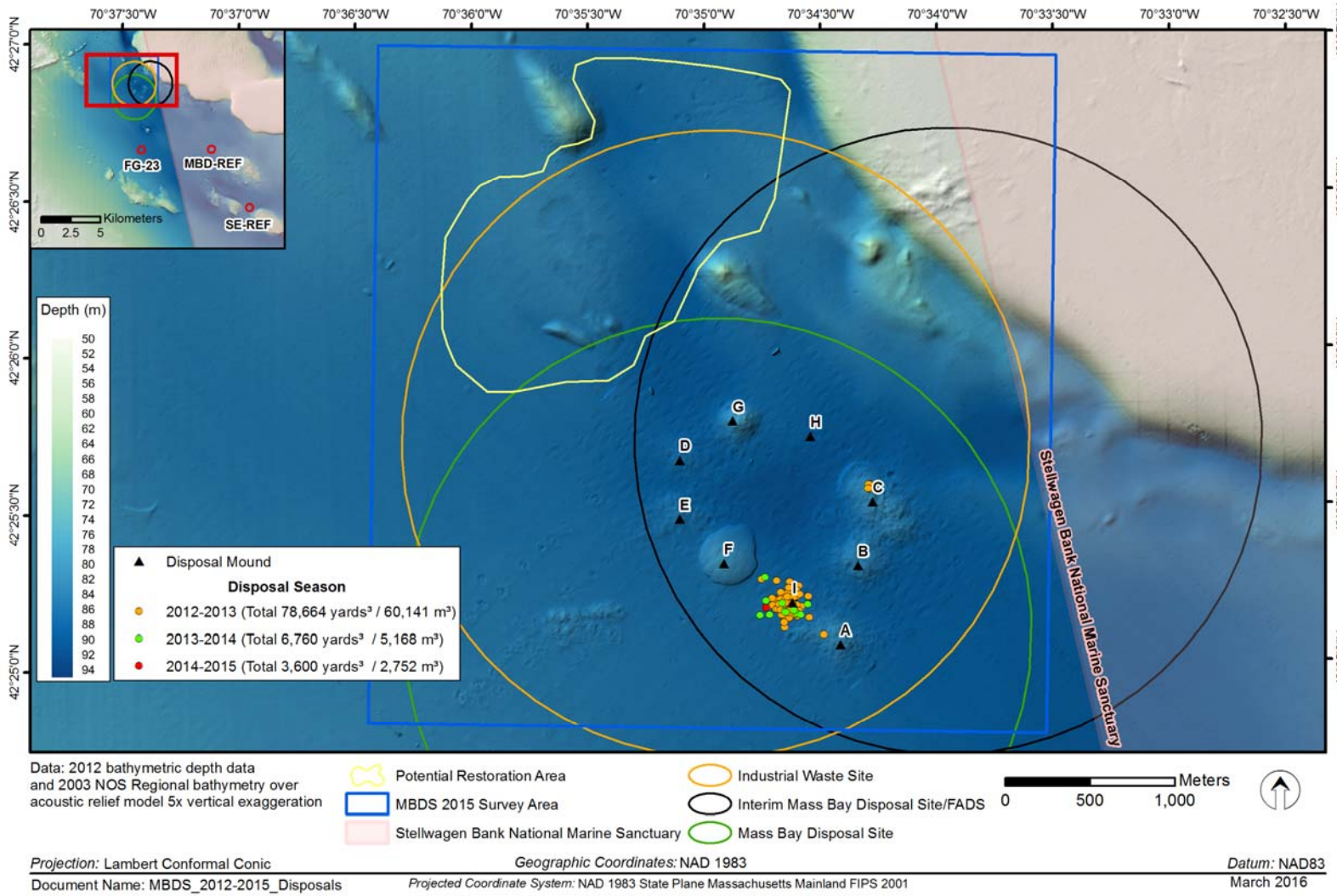



**Figure 1-8.** Location of disposal events at MBDS from September 27, 2012 to January 17, 2015

## 2.0 METHODS

The September/October 2015 baseline survey at MBDS/IWS was conducted by a team of investigators from DAMOSVision (CoastalVision, CR Environmental and Germano & Associates), USACE, and OceanEye aboard the 55-foot *R/V Jamie Hanna*. The acoustic survey was conducted 9-10 September 2015, the SPI/PV survey was conducted 23-24 September 2015, and the ROV survey was conduct 7-8 October 2015. 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 acoustic survey was accomplished using a Hemisphere VS-330 Real time kinematic Global Positioning System (RTK GPS) which received base station correction through the Keynet NTRIP broadcast. Horizontal position accuracy in fixed RTK mode was approximately 2 cm. A dual-antennae Hemisphere VS110 differential GPS was available if necessary as a backup. The GPS system was interfaced to a desktop computer running HYPACK MAX® hydrographic survey software. HYPACK MAX® continually recorded vessel position and GPS 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. Vessel heading measurements were provided by an IxBlue Octans III fiber optic gyrocompass.

Navigation for the SPI survey was accomplished using a Hemisphere R110 differential GPS (DGPS) capable of sub-meter horizontal accuracy. Navigation data were recorded using HYPACK software.

For the ROV survey, and an Applied Acoustics Easy Track Ultra Short Baseline (USBL) tracking system was deployed. The Easy Track hydrophone was mounted on the over-the-side boom of the *R/V Jamie Hanna* and an acoustic transponder was mounted on the ROV. Ship's heading was provided by the internal compass in the Easy Track hydrophone and a dual-antenna Hemisphere VS110 was available as a backup heading source. The Easy Track positioning software provided an output of ship and ROV position to HYPACK that recorded vessel and ROV position and provided a steering display for the vessel captain and ROV operator.

### 2.2 Acoustic Survey

The acoustic survey included bathymetric, backscatter, and side-scan sonar data collection. The bathymetric data provided measurements of water depth that, when processed, were used to map the seafloor topography. Backscatter and side-scan sonar data

provided images that supported characterization of surface sediment texture and roughness. Each of these acoustic data types is useful for assessing dredged material placement and surface sediment features.

### 2.2.1 Acoustic Survey Planning

The acoustic survey featured a high spatial resolution survey over portions of the existing and proposed expanded area of MBDS. DAMOSVision hydrographers coordinated with USACE NAE scientists and reviewed alternative survey designs. For this survey, a 4,000 × 4,000 m area was selected to cover the area of interest. Hydrographers obtained site coordinates, imported them into geographic information system (GIS) software, and created maps to aid design of a survey that would provide greater than 100-percent coverage within the survey area. Base bathymetric data were obtained from the National Ocean Service Hydrographic Data Base to estimate the transect separation required to obtain full bottom coverage using an assumed beam angle limit of 90-degrees (45 degrees to port, 45 degrees to starboard). Transects spaced 150 m apart (70 m apart over the shoal of Stellwagen Bank) and cross-lines spaced 500 m apart were created to meet conservative beam angle constraints (Figure 2-1). The proposed survey area and design were then reviewed and approved by NAE scientists.

### 2.2.2 Acoustic Data Collection

The 2015 multibeam bathymetric survey of MBDS/IWS was conducted 9-10 September 2015. Data layers generated by the survey included bathymetric, acoustic backscatter, and side-scan sonar and were collected using an R2Sonic 2022 broadband multibeam echo sounder (MBES). This 200-400 kHz system forms up to 256 1- to 2-degree beams (frequency dependent) distributed equiangularly or equidistantly across a 10- to 160-degree swath. For this survey a frequency of 290 kHz and pulse length of 0.08 msec was selected to maximize the resolution of bathymetric data without compromising the quality of acoustic backscatter data. The MBES transducer was mounted amidships to the port rail of the survey vessel using a high strength adjustable boom. The primary GPS antenna was mounted atop the transducer boom. The transducer depth below the water surface (draft) and antenna height were checked and recorded at the beginning and end of data acquisition, and draft was confirmed using the “bar check” method.

An IxBlue Octans III motion reference unit (MRU) was interfaced to the MBES topside processor and to the acquisition computer. Precise linear offsets between the MRU and MBES were recorded and applied during acquisition. Depth and backscatter data were synchronized using pulse per second timing and transmitted to the HYPACK MAX® acquisition computer via Ethernet communications. Several patch tests were conducted during the survey to allow computation of angular offsets between the MBES system components.

The system was calibrated for local water mass speed of sound by performing sound velocity profile (SVP) casts at frequent intervals throughout the survey day using a Seabird, Inc. SBE-19 CTD.

### 2.2.3 Bathymetric Data Processing

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

- Adjustment of data for tidal elevation fluctuations
- Correction of ray bending (refraction) due to density variation 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 combination of RTK GPS and tide data obtained from the National Oceanic and Atmospheric Association's (NOAA) Boston Tide Station (#8443970). A site-specific tide zoning model was provided by NOAA and used to adjust range and time offsets. Water surface elevations derived using RTK were adjusted to Mean Lower Low Water (MLLW) elevations using NOAA's VDATUM Model. Processed RTK tide data were successfully ground-truthed against the adjusted NOAA Boson tide records. Tidal amplitudes from RTK data and adjusted NOAA data were similar, with an average deviation of less than 4 cm.

Correction of sounding depth and position (range and azimuth) for refraction due to water column stratification was conducted using a series of nineteen sound-velocity profiles acquired by the survey team. Data artifacts associated with refraction remain in the bathymetric surface model at a relatively fine scale (generally less than 5 to 10 cm) relative to the survey depth.

Bathymetric data were filtered to accept only beams falling within an angular limit of 45° to minimize refraction artifacts. Spurious sounding solutions were rejected based on the careful examination of data on a sweep-specific basis.

The R2Sonics 2022 MBES system was operated at 290 kHz. At this frequency the system has a published beam width of 1.55°. Assuming an average depth of 82 m and a maximum beam angle of 45°, the average diameter of the beam footprint was calculated at approximately 4.4 × 3.1 m (~13.6 $m^2$). Data were reduced to a cell (grid) size of 5.0 × 5.0 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 2013).

Statistical analysis of data as summarized on Table 2-1 showed negligible tide bias and vertical uncertainty substantially lower than values recommended by USACE (2013) or NOAA (2015). Note that the most stringent National Ocean Service (NOS) standard for this project depth (Special Order 1A) would call for a 95th percentile confidence interval (95% CI) of 0.73 m at the maximum site depth (91.6 m) and 0.66 m at the average site depth (81.9 m).

Reduced data were exported in ASCII text format with fields for Easting, Northing, and MLLW Elevation (meters). All data were projected to the Massachusetts State Plane, NAD83 (metric). A variety of data visualizations were generated using a combination of ESRI ArcMap (V.10.1) and Golden Software Surfer (V.13). Visualizations and data products included:

- ASCII data files of all processed soundings including MLLW depths and elevations
- Contours of seabed elevation (25-cm, 50-cm and 1.0-m intervals) in a geospatial data file format suitable for plotting using GIS and 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 tagged image file (TIF) formats, and
- An acoustic relief map of the survey area created using 5× vertical exaggeration, delivered in georeferenced TIF format.

### 2.2.4 Backscatter Data Processing

Backscatter data were extracted from cleaned MBES TruePix formatted files then used to provide an estimation of surface sediment texture based on seabed surface roughness. Mosaics of backscatter data were created using HYPACK's implementation of GeoCoder software developed by scientists at the University of New Hampshire's NOAA Center for Coastal and Ocean Mapping (UNH/NOAA CCOM). A seamless mosaic of unfiltered backscatter data was developed and exported in grayscale TIF format. Backscatter 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 backscatter values on a 2-m grid. The grid was delivered in ESRI binary GRD format to facilitate comparison with other data layers.

### 2.2.5 Side-Scan Sonar Data Processing

Side-scan sonar data were processed using Chesapeake Technology, Inc. Sonar Wiz software to generate a database of images that maximized both textural information and structural detail.

A seamless mosaic of side-scan sonar data was developed using SonarWiz and exported in grayscale TIF format using a resolution of 0.20-m per pixel. Data were adjusted using Empirical Gain Normalization (EGN) methods to minimize nadir artifacts and facilitate visualization of fine seabed structures. Georeferenced TIF files of individual swaths were delivered in raw (no gain adjustment) and EGN versions using a resolution of 0.20 m per pixel.

### 2.2.6 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. The backscatter mosaics and filtered backscatter grid were combined with acoustic relief models in GIS to facilitate visualization of relationships between acoustic datasets. This is done by rendering images and color-coded grids with sufficient transparency to allow three-dimensional acoustic relief model to be visible underneath.

## 2.3 Sediment-Profile and Plan-View Imaging Survey

Sediment-profile imaging (SPI) and plan-view (PV) imaging are monitoring techniques used to provide data on the physical characteristics of the seafloor and the status of the benthic biological community (Germano et al. 2011).

### 2.3.1 SPI and PV Survey Planning

For the MBDS/IWS survey, a total of 45 SPI/PV stations were planned with 30 stations located in the proposed disposal site expansion area, and 5 stations in each of the three reference areas (FG-23, MBD-REF, and SE-REF). SPI station locations in the site expansion area were determined based on the review of existing site data and review of preliminary 2015 bathymetric data (Figure 2-2). A random location generator was used to select the locations of the SPI/PV reference stations (Figure 2-3). SPI/PV station locations are provided in Table 2-2 and actual SPI/PV station replicate locations are provided in Appendix C.

### 2.3.2 Sediment-Profile Imaging

The SPI technique involves deploying an underwater camera system to photograph a cross section of the sediment-water interface. In the 2015 survey at MBDS/IWS, high-resolution SPI images were acquired using a Nikon® D7100 digital single-lens reflex camera mounted inside an Ocean Imaging® Model 3731 pressure housing. The pressure housing sat atop a wedge-shaped steel 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 interface. As 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 2-4).

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 640, shutter speed was 1/250, f-stop was f9, and storage was in compressed raw Nikon Electronic Format (NEF) files (approximately 30 MB each).

Test exposures of the X-Rite Color Checker Classic Color Calibration Target were made on deck at the beginning and end of the 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.

### 2.3.3 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, 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. The field-of-view can be varied by increasing or decreasing the length of the trigger wire and thereby the camera height above the bottom when the picture is taken. 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 2-4). 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 640. The additional camera settings used were as follows: shutter speed 1/20, f14, 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).

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. Water conditions at MBDS/IWS allowed use of a 0.9-m trigger wire, resulting in an area of bottom visualization approximately 0.9 m × 0.6 m in size.

### 2.3.4 SPI and PV Data Collection

The SPI/PV survey was conducted at MBDS/IWS from 23-24 September 2015 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 (Appendix C). The three replicates with the best quality images from each station were chosen for analysis (Appendix D).

The DGPS described above was interfaced to HYPACK® software via laptop serial ports to provide a method to locate and record 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. The system provided a steering display to enable the vessel captain to navigate to the pre-established survey target locations. The navigator electronically recorded the vessel's position when the equipment contacted the seafloor and the winch wire went slack. Each replicate SPI/PV position was recorded and time stamped. Actual SPI/PV sampling locations were recorded using this system.

### 2.3.5 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.

Following completion of the field operations, the raw image files were color calibrated in Adobe Camera Raw® by synchronizing the raw color profiles to an X-Rite Color Checker Classic Color Calibration Target that was photographed on-site with the SPI camera. The raw images were then converted to high-resolution Photoshop Document (PSD) format files, using a lossless conversion file process, maintaining an Adobe RGB (1998) color profile. The PSD images were then calibrated and analyzed in Adobe Photoshop®. Image calibration was achieved by measuring the pixel length of a 5-cm scale bar printed on the X-Rite Color Checker Target, providing a pixel per centimeter calibration. This calibration information was applied to all SPI images analyzed. Linear and area measurements were recorded as the number of pixels and converted to scientific units using the calibration information.

Measured parameters were recorded on a Microsoft Excel© spreadsheet. Germano & Associates' senior scientist Dr. Joseph D. Germano subsequently checked these data as an independent quality assurance/quality control review of the measurements before final interpretation was performed. Spatial distributions of SPI parameters from stations within the study area were mapped using ArcGIS. Detailed results of all SPI and PV image analyses are presented in Appendix D.

#### 2.3.5.1 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 E. The presence and thickness of disposed dredged material were also assessed by inspection of the images.

Thickness of Depositional and Dredged Material Layers–Because of the camera's unique design, SPI can be used to detect the thickness of depositional and dredged material layers. SPI is effective in measuring layers ranging in thickness from 1 mm to 20 cm (the height of the SPI optical window). During image analysis, the thickness of natural and/or anthropogenic depositional layers can be determined by measuring the distance between the pre- and post-disposal sediment-water interface. Recently deposited material is usually

evident because of its unique optical reflectance and/or color relative to the underlying material representing the pre-disposal surface. Also, in most cases, the point of contact between the two layers is clearly visible as a textural change in sediment composition, facilitating measurement of the thickness of the newly deposited layer. Over time, as benthic communities recover and begin to rework and process the sediment, dredged material can visually resemble ambient sediment.

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 substratum) to a maximum of 20 cm (full penetration on very soft substratum).

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 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).

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 visually assessing color and reflectance boundaries within the images, and for each image a mean aRPD was calculated.

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 four 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 (Figure 2-5).

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 were calculated from three replicates from each station and used in statistical analysis.

#### 2.3.5.2 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 allows for 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 D).

### 2.3.6 Statistical Methods

In order to meet the objective of this survey to assess the status of benthic community recolonization of the sediment at disposal areas relative to reference area conditions, statistical analyses were conducted to compare key SPI variables between sampled locations within the disposal site expansion area (MBDS) and reference areas (FG-23, MBD-REF, and SE-REF). The aRPD depth and successional stage measured in each image are the best indicators of infaunal activity measured by SPI and were used in this comparative analysis. Standard boxplots were generated for visual assessment of the central tendency and variation in each of these variables within each disposal area and each reference area. Tests rejecting the inequivalence between the reference and disposal expansion areas were conducted, as described in detail below.

The objective to look for differences has conventionally been addressed using a point null hypothesis of the form, "There is no significant difference in benthic conditions between the reference area and the disposal target areas." However, there is always some difference (perhaps only to a very small decimal place) between groups, but the statistical significance of this difference may or may not be ecologically meaningful. On the other hand, differences may not be detected due to insufficient statistical power. Without a power analysis and specification of what constitutes an ecologically meaningful difference, the results of conventional point null hypothesis testing often provide inadequate information for ecological assessments (Germano 1999). An approach using an inequivalence null hypothesis will identify when groups are statistically similar, within a specified interval, which is more suited to the objectives of the DAMOS monitoring program.

For an inequivalence test, the null hypothesis presumes the difference is great; this is recognized as a "proof of safety" approach because rejection of the inequivalence null hypothesis requires sufficient proof that the difference was actually small (McBride 1999). The null and alternative hypotheses for the inequivalence hypothesis test are:

$$H_0: \ d < -\delta \text{ or } d > \delta \text{ (presumes the difference is great)}$$

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

where d is the difference between a reference mean and a site mean. If the inequivalence null hypothesis is rejected, then it is concluded that the two means are equivalent to one another within ±δ 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 and is therefore not ecologically meaningful. Primarily differences greater than δ are of ecological interest. Previously established δ values of 1 cm for aRPD depth, and 0.5 for successional stage rank (on the 0–3 scale) were used.

The test of this inequivalence (interval) hypothesis can be broken down into two one-sided tests, TOST (McBride 1999, Schuirmann 1987). Assuming a symmetric distribution, the inequivalence hypothesis is rejected at α of 0.05 if the 90% confidence interval for the measured difference (or, equivalently, the 95% upper limit and the 95% lower limit for the difference) is wholly contained within the equivalence interval [-δ, +δ]. The statistics used to test the interval hypotheses shown here are based on the Central Limit Theorem (CLT) and basic statistical properties of random variables. A simplification of the CLT states 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.

In this survey, four distinct locations were sampled, three were categorized as reference areas (FG-23, MBD-REF, and SE-REF) and one was the proposed expansion area (MBDS). The difference equation of interest was the linear contrast of the average of the three reference means minus the disposal expansion area mean, or

$$\hat{d} = [1/3 \times (\text{Mean}_{\text{FG-23}} + \text{Mean}_{\text{MBD-REF}} + \text{Mean}_{\text{SE-REF}}) - (\text{Mean}_{\text{Disposal}})] \quad \text{[Eq. 1]}$$

The three reference areas collectively represented ambient conditions, but if the means were different among these three areas, then pooling them into a single reference group would inflate the variance estimate because it would include the variability between areas, rather than only the variability between stations within each single homogeneous area. The effect of keeping the three reference areas separate has no effect on the grand reference

mean when sample size is equal among these areas, but it ensures that the variance is truly the residual variance within a single population with a constant mean.

The difference equation, $\hat{d}$ , for the comparison of interest was specified in Eq. 1. and the standard error of this difference equation used 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 1/3 for each of the three reference areas, and -1 for the disposal area).

$S_j^2$ = variance for the *j*th area. If equal variances are assumed, the pooled residual variance estimate equal to the mean square error from an ANOVA based on all groups involved, can be used for each $S_j^2$.

$n_j$ = number of stations 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 $H_0$ (the two groups were inequivalent) 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 and Disposal Area.

$t_{\alpha,\upsilon}$ = upper (1-α)*100th percentile of a Student's t-distribution with υ degrees of freedom (α = 0.05)

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

υ = degrees of freedom for the standard error. If a pooled residual variance estimate was used, this was the residual degrees of freedom from an ANOVA on all groups (total number of stations minus the number of groups); if separate

variance estimates were used, degrees of freedom were calculated based on the Welch-Sattherthwaite estimation (Satterthwaite 1946 and Welch 1947, and summarized on the Wikipedia page for "Welch-Satterthwaite equation", retrieved February 24, 2016).

Validity of normality and equal variance assumptions was tested using Shapiro-Wilk's test for normality on the area residuals ($\alpha = 0.05$) and Levene's test for equality of variances among areas ($\alpha = 0.05$). If normality was not rejected but equality of variances was, then normal parametric confidence bounds were calculated, using separate variance estimates for each group. If normality was rejected, then non-parametric bootstrapped estimates of the confidence bounds were calculated.

## 2.4 ROV Survey

A multipart ROV survey was performed at MBDS/IWS which included collection of video footage over portions of the existing and proposed expanded area of MBDS. The objective of this survey was to view the barrel and debris field, and two shipwreck sites within the boundary of MBDS.

### 2.4.1 ROV Survey Planning

The ROV survey featured high resolution color video collection. DAMOSVision managers coordinated with USACE NAE scientists and reviewed alternative survey designs. For this survey, a two-part towed video survey was designed to obtain video footage of (1) (hazardous waste) barrels and construction debris within the proposed restoration area to potentially receive dredged material during a planned restoration project; and (2) two previously identified shipwrecks that lie within the boundary of MBDS adjacent to the proposed restoration area to determine archaeological and historical significance, if any (Figure 2-6).

### 2.4.2 ROV Data Collection

The ROV selected for the study was a SAAB Seaeye Falcon ROV equipped with a high resolution color video camera on a tilt tray with a resolution of 480 TVL at 0.2 LUX. The vehicle was outfitted with an Imagenics Scanning Sonar, battery powered scaling lasers set at 50 cm, and a GoPro 4 HD video camera capable of capturing simultaneous 1080P HD video at 30 frames per second and 12 MP still photos at 10 second intervals. Two additional Fisheye FIX Neo underwater video lights were also installed on the ROV to provide additional lighting for the HD video camera. An Open Frame Benthos Mini-Rover ROV was also available on board as a backup vehicle.

At selected shipwreck or barrel targets, the *Jamie Hanna* would anchor using a taut-line single mooring consisting of 500 feet of ½-in diameter high strength spectra line and a 2000 lb. railroad wheel anchor. The anchor system was deployed using the *Jamie Hanna's* Pullmaster winch and hydraulic A-frame. The anchor embedded in the soft sediments at the barrel and wreck sites, and at those sites negligible vessel swing and movement occurred.

The ROV was deployed and recovered off the A-frame using a specialized stainless steel canister release and recovery system. In most cases, the vessel anchored down-current of the target location. Once deployed the ROV would head about 30 m off the vessel stern before diving. Using guidance from the USBL tracking system, the ROV pilot would then steer a course to the target position. The pilot would operate with 150-200 m of available tether in water depths of approximately 50-90 m. In general, the ROV was no more than 60 m from the vessel. Within 30 m of its target, the scanning sonar on the ROV provided imagery, range, and bearing to the object allowing the operator to steer the final approach to the target.

The Seaeye Falcon video camera data were recorded on DVDs using three portable video recorders. Between dives, DVDs and memory cards were swapped out and the GoPro video and still camera data were downloaded to a portable hard drive.

In addition, at regular intervals, a spare acoustic transponder with recharged batteries was swapped out with the ROV beacon. Batteries for the lasers, video lights, and GoPro were also periodically replaced to ensure they continued to function during water operations.

### 2.4.3 ROV Data Processing and Analysis

HYPACK navigation files were processed to produce tables of locations and ArcView shapefiles. Navigation files included the vessel position, marks of anchoring location and ROV position and processed ROV tracklines (Appendix F). The USBL tracking system was utilized with the sector-scanning sonar to help guide the ROV pilot to targets. However, due to the very strong thermocline at MBDS, it was not expected that the acoustic tracking system would be highly accurate. During live operations, the signal was very noisy but processing was able to eliminate the noise with band pass filters and the resulting tracklines are a much better representation of the ROV position than were available topside.

Seaeye Falcon ROV video was recorded to multiple DVD drives with overlay of time, depth, and heading. GoPro Video did not permit overlay of position but HD video and stills provide additional detail when linked with timecodes to the ROV Video.

Original GoPro video files were captured in MPEG-4 video file format. These files were converted to an H.264 video compression at 1080P using Adobe Media encoder software which allowed a burn-in-timecode to be overlaid on top of original video footage and produced a compressed video file with no discernable decrease in video quality.

Segments of the compressed video files with distinctive imagery were reviewed to check that GoPro video timecodes corresponded to Seaeye Falcon video timecodes.

All video footage and associated navigation files, field notes, and habitat comments were provided to USACE, NAE on 6 November 2015 for analysis by USACE's Archeologist Wendy Weaver, from the Restoration and Resources Section of the Policy and Planning Division of USACE, Jacksonville District.

## Table 2-1.

Accuracy and Uncertainty Analysis of Bathymetric Data

| | | Results (m) | | |
|---|---|---|---|---|
| **Survey Date** | **Quality Control Metric** | **Mean** | **95% Uncertainty** | **Range** |
| 9/9-10/2015 | Cross-Line Swath Comparisons | 0.04 | 0.27 | |
| | Within Cell Uncertainty | 0.12 | 0.33 | 0.00 - 2.97 |
| | Beam Angle Uncertainty (0 - 45d) | 0.07 | 0.36 | 0.29 - 0.48 |

Notes:
1. The mean of cross-line nadir and full swath comparisons are indicators of tide bias.
2. 95% uncertainty values were calculated using the sums of mean differences and standard deviations expressed at the 2-sigma level.
3. Within cell uncertainty values include biases and random errors.
4. Beam angle uncertainty was assessed by comparing cross-line data (45-degree swath limit).
5. Swath and cell based comparisons were conducted using 5 m x 5 m cell averages. These analyses do not exclude sounding variability associated with terrain slopes.

**Table 2-2.**

MBDS/IWS 2015 Survey Target SPI/PV Station Locations

| Station Number | Location | Easting | Northing | Latitude (N) | Longitude (W) |
|---|---|---|---|---|---|
| 1 | Site | 275748.1 | 910773.1 | 42° 26.6282' N | 70° 34.7557' W |
| 2 | Site | 273650.0 | 910931.4 | 42° 26.7258' N | 70° 36.2845' W |
| 3 | Site | 273552.1 | 910635.0 | 42° 26.5662' N | 70° 36.3582' W |
| 4 | Site | 273528.8 | 910341.9 | 42° 26.4080' N | 70° 36.3774' W |
| 5 | Site | 274021.7 | 910788.0 | 42° 26.6462' N | 70° 36.0146' W |
| 6 | Site | 273966.3 | 910466.1 | 42° 26.4727' N | 70° 36.0574' W |
| 7 | Site | 274275.8 | 910888.4 | 42° 26.6990' N | 70° 35.8285' W |
| 8 | Site | 273550.8 | 909757.3 | 42° 26.0922' N | 70° 36.3658' W |
| 9 | Site | 273900.2 | 910039.4 | 42° 26.2425' N | 70° 36.1089' W |
| 10 | Site | 274137.7 | 910170.7 | 42° 26.3121' N | 70° 35.9347' W |
| 11 | Site | 274380.9 | 910286.5 | 42° 26.3733' N | 70° 35.7565' W |
| 12 | Site | 274973.6 | 910881.8 | 42° 26.6914' N | 70° 35.3196' W |
| 13 | Site | 275558.2 | 911224.2 | 42° 26.8730' N | 70° 34.8906' W |
| 14 | Site | 274929.7 | 911129.0 | 42° 26.8252' N | 70° 35.3497' W |
| 15 | Site | 274103.4 | 909748.6 | 42° 26.0843' N | 70° 35.9629' W |
| 16 | Site | 274417.3 | 910061.6 | 42° 26.2516' N | 70° 35.7316' W |
| 17 | Site | 273953.1 | 909215.7 | 42° 25.7974' N | 70° 36.0767' W |
| 18 | Site | 274227.4 | 909248.9 | 42° 25.8137' N | 70° 35.8764' W |
| 19 | Site | 274450.4 | 909572.1 | 42° 25.9870' N | 70° 35.7113' W |
| 20 | Site | 275996.9 | 910233.6 | 42° 26.3353' N | 70° 34.5785' W |
| 21 | Site | 276107.4 | 910018.6 | 42° 26.2186' N | 70° 34.4996' W |
| 22 | Site | 276218.5 | 909780.5 | 42° 26.0893' N | 70° 34.4205' W |
| 23 | Site | 273798.9 | 908880.9 | 42° 25.6174' N | 70° 36.1917' W |
| 24 | Site | 274171.9 | 908900.7 | 42° 25.6260' N | 70° 35.9195' W |
| 25 | Site | 275723.7 | 910615.8 | 42° 26.5434' N | 70° 34.7747' W |
| 26 | Site | 275303.0 | 909608.5 | 42° 26.0018' N | 70° 35.0894' W |
| 27 | Site | 275506.1 | 910822.3 | 42° 26.6562' N | 70° 34.9318' W |
| 28 | Site | 276016.7 | 910660.2 | 42° 26.5657' N | 70° 34.5607' W |
| 29 | Site | 274980.2 | 910266.7 | 42° 26.3591' N | 70° 35.3196' W |
| 30 | Site | 274789.3 | 909904.2 | 42° 26.1644' N | 70° 35.4616' W |
| 1 | FG-23 | 276056.5 | 903639.8 | 42° 22.7735' N | 70° 34.5871' W |
| 2 | FG-23 | 276247.2 | 903578.8 | 42° 22.7394' N | 70° 34.4486' W |
| 3 | FG-23 | 275972.6 | 903494.8 | 42° 22.6957' N | 70° 34.6494' W |
| 4 | FG-23 | 276247.2 | 903334.6 | 42° 22.6075' N | 70° 34.4506' W |
| 5 | FG-23 | 276125.2 | 903449.1 | 42° 22.6700' N | 70° 34.5386' W |

**Table 2-2. (continued)**

MBDS/IWS 2015 Survey Target SPI/PV Station Locations

| Station Number | Location | Easting | Northing | Latitude (N) | Longitude (W) |
|---|---|---|---|---|---|
| 1 | MBD-REF | 281993.0 | 903838.2 | 42° 22.8446' N | 70° 30.2606' W |
| 2 | MBD-REF | 281802.3 | 903670.3 | 42° 22.7551' N | 70° 30.4010' W |
| 3 | MBD-REF | 281985.4 | 903510.1 | 42° 22.6674' N | 70° 30.2689' W |
| 4 | MBD-REF | 282115.1 | 903426.2 | 42° 22.6213' N | 70° 30.1751' W |
| 5 | MBD-REF | 281924.3 | 903433.8 | 42° 22.6266' N | 70° 30.3140' W |
| 1 | SE-REF | 285304.7 | 898794.4 | 42° 20.0990' N | 70° 27.8926' W |
| 2 | SE-REF | 285106.3 | 898779.2 | 42° 20.0921' N | 70° 28.0371' W |
| 3 | SE-REF | 285381.0 | 898611.3 | 42° 19.9996' N | 70° 27.8386' W |
| 4 | SE-REF | 285174.9 | 898458.7 | 42° 19.9185' N | 70° 27.9899' W |
| 5 | SE-REF | 285136.8 | 898618.9 | 42° 20.0053' N | 70° 28.0163' W |

Notes
1. Grid coordinates are MA Mainland FIPS 2001 State Plane (NAD83), metric
2. Geographic coordinates are NAD83 degree decimal minute

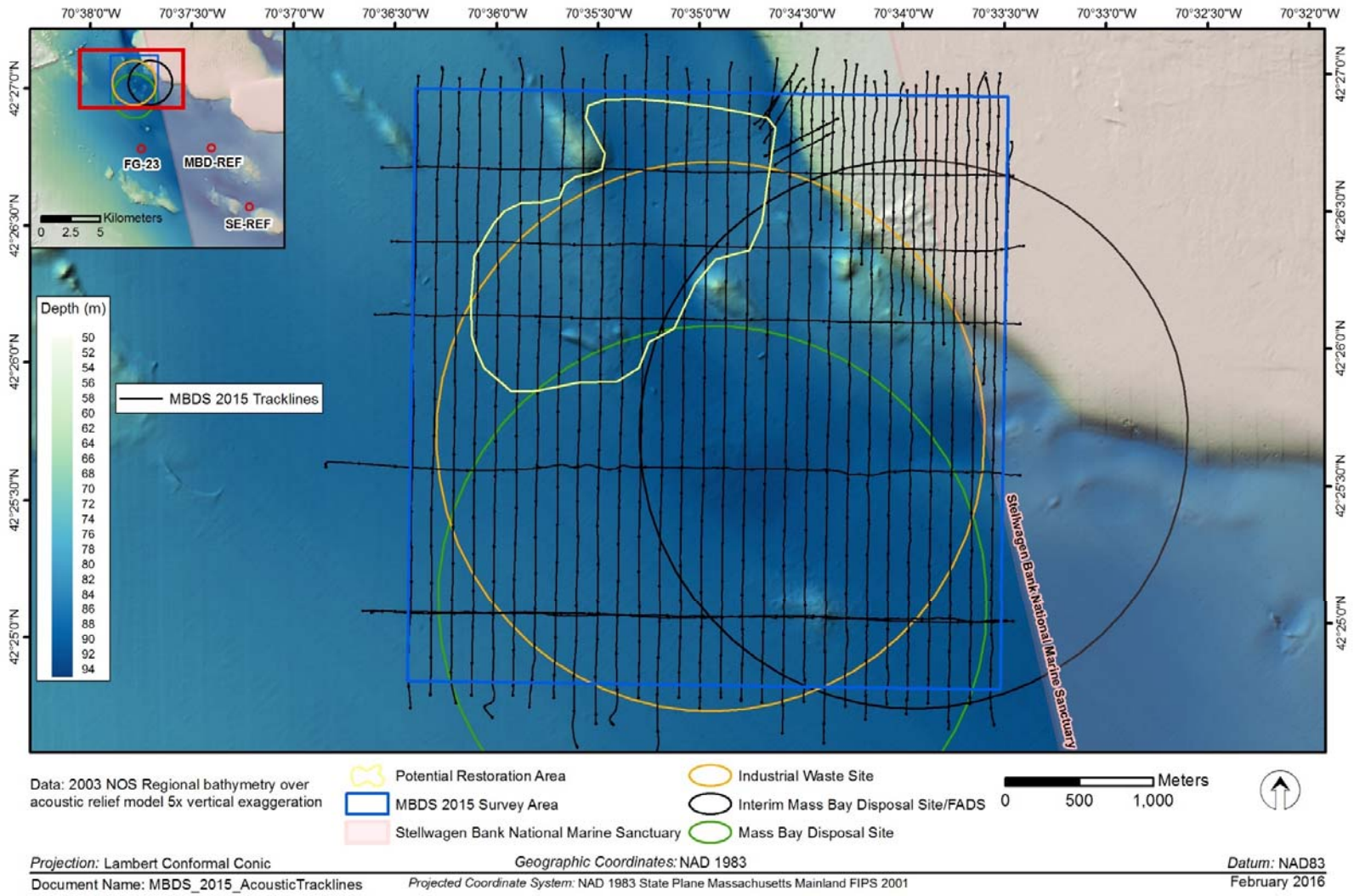



**Figure 2-1.** MBDS bathymetric survey boundary and tracklines

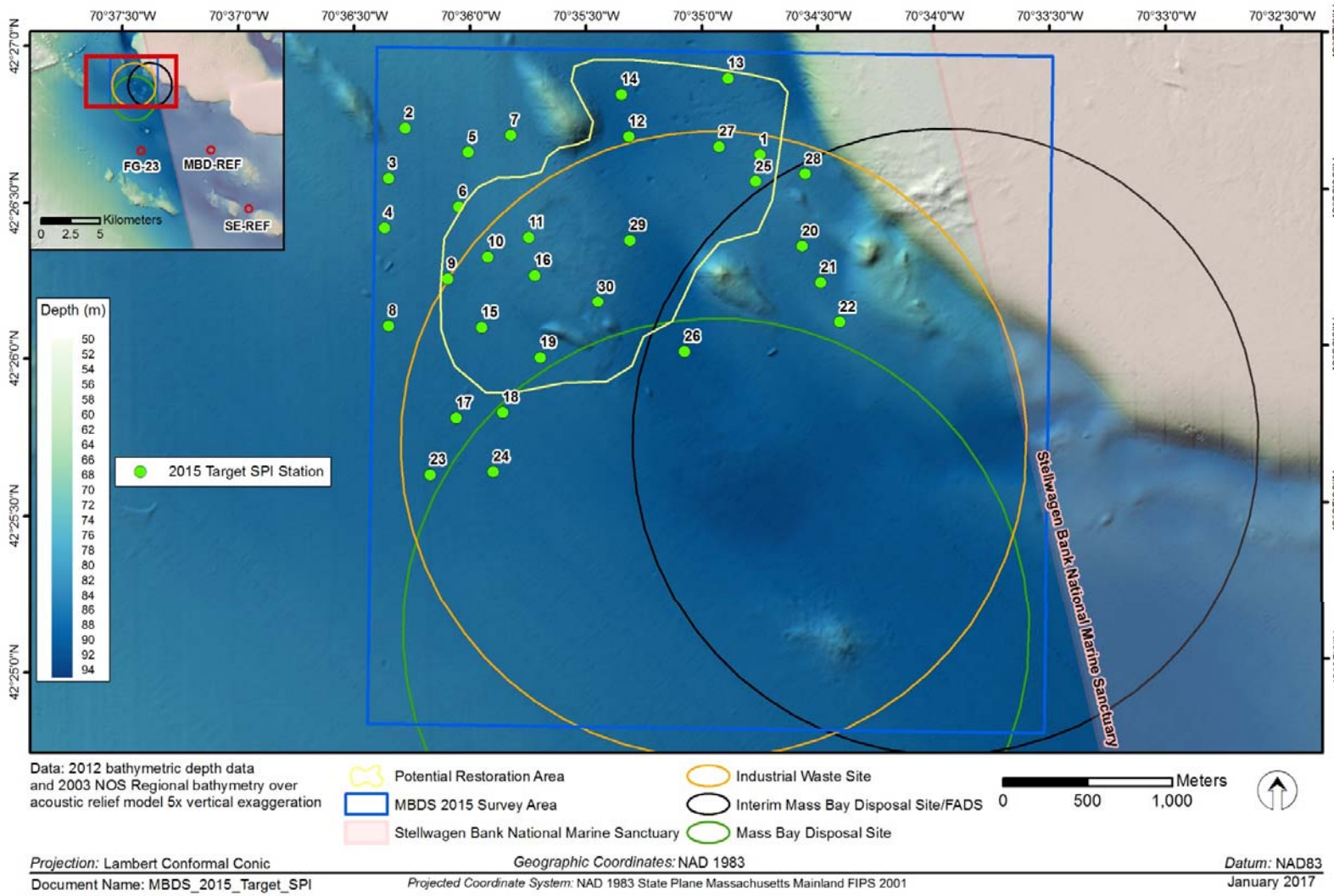



**Figure 2-2.** SPI/PV target locations at the MBDS/IWS potential expansion area

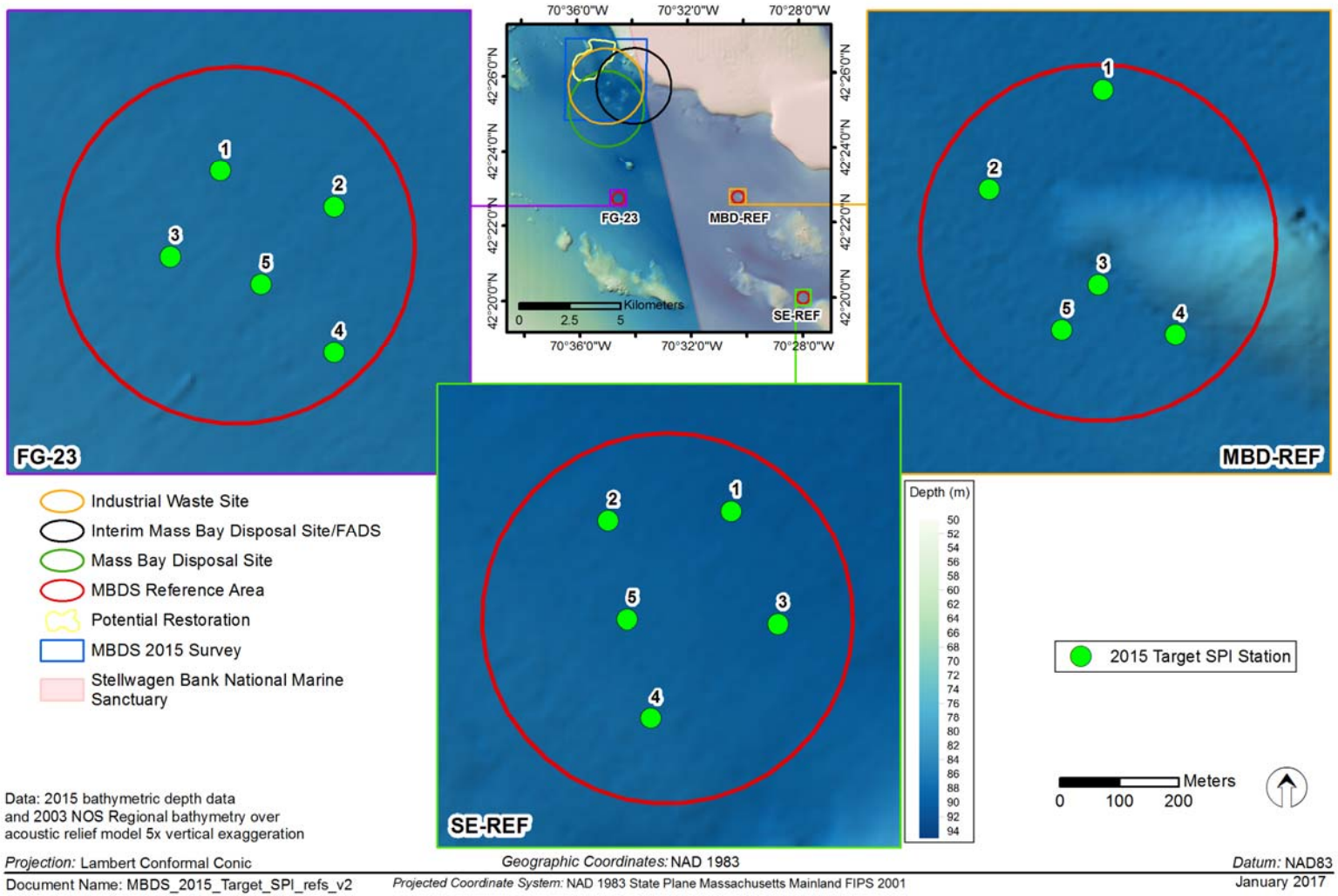



**Figure 2-3.** SPI/PV target locations at MBDS reference areas

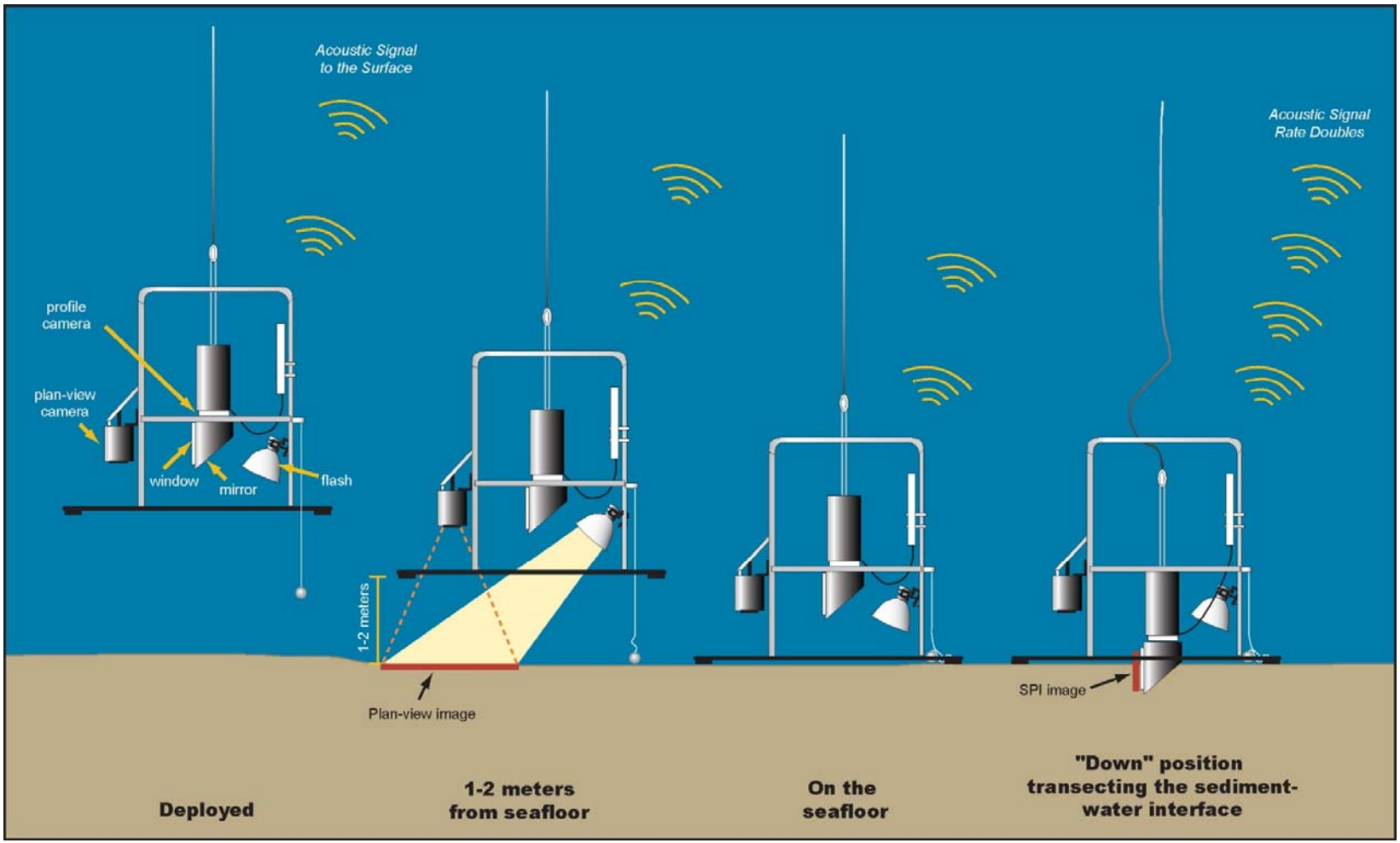



**Figure 2-4.** Schematic diagram of the SPI/PV camera deployment

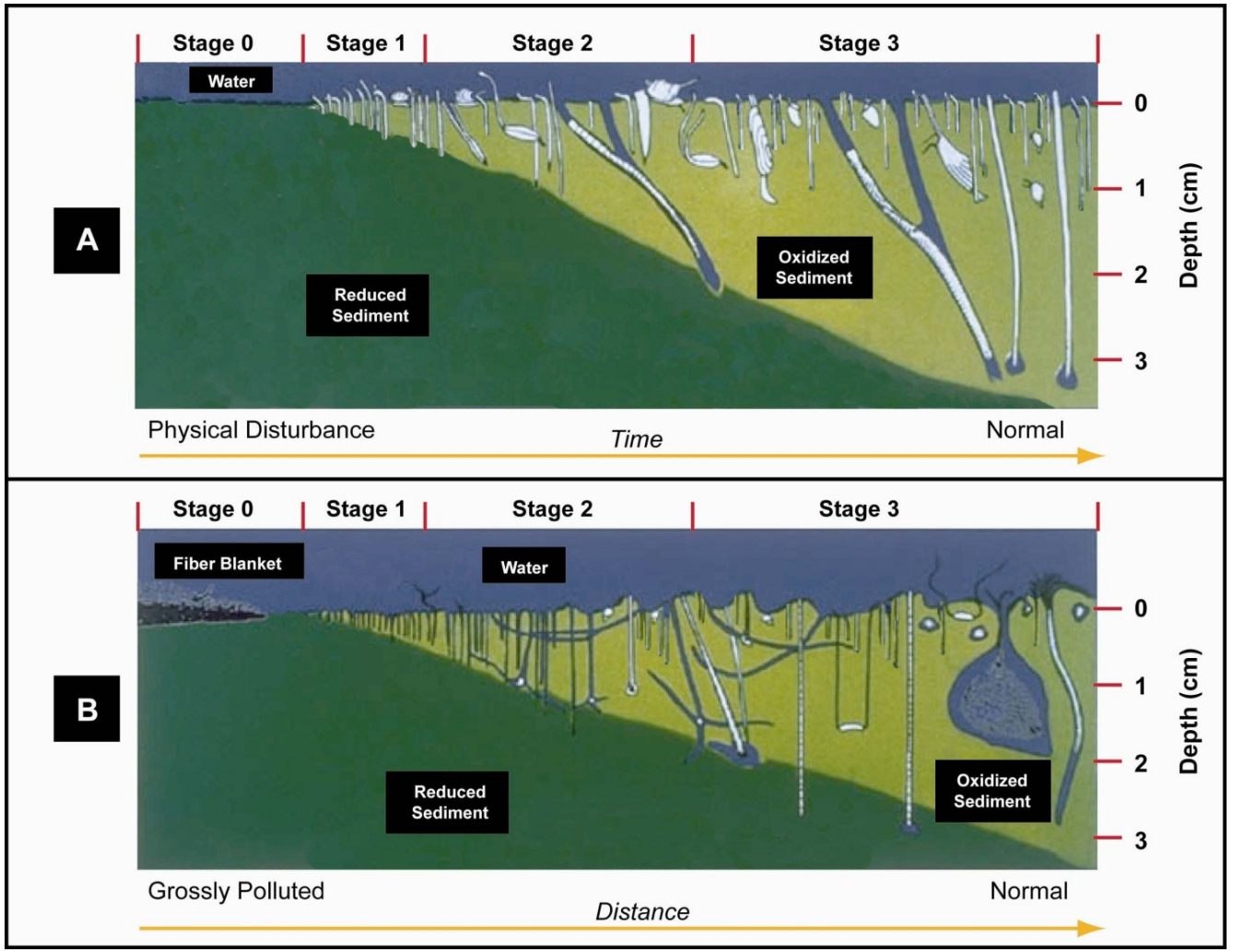



**Figure 2-5.** The stages of infaunal succession as a response of soft-bottom benthic communities to (A) physical disturbance or (B) organic enrichment; from Rhoads and Germano (1982)

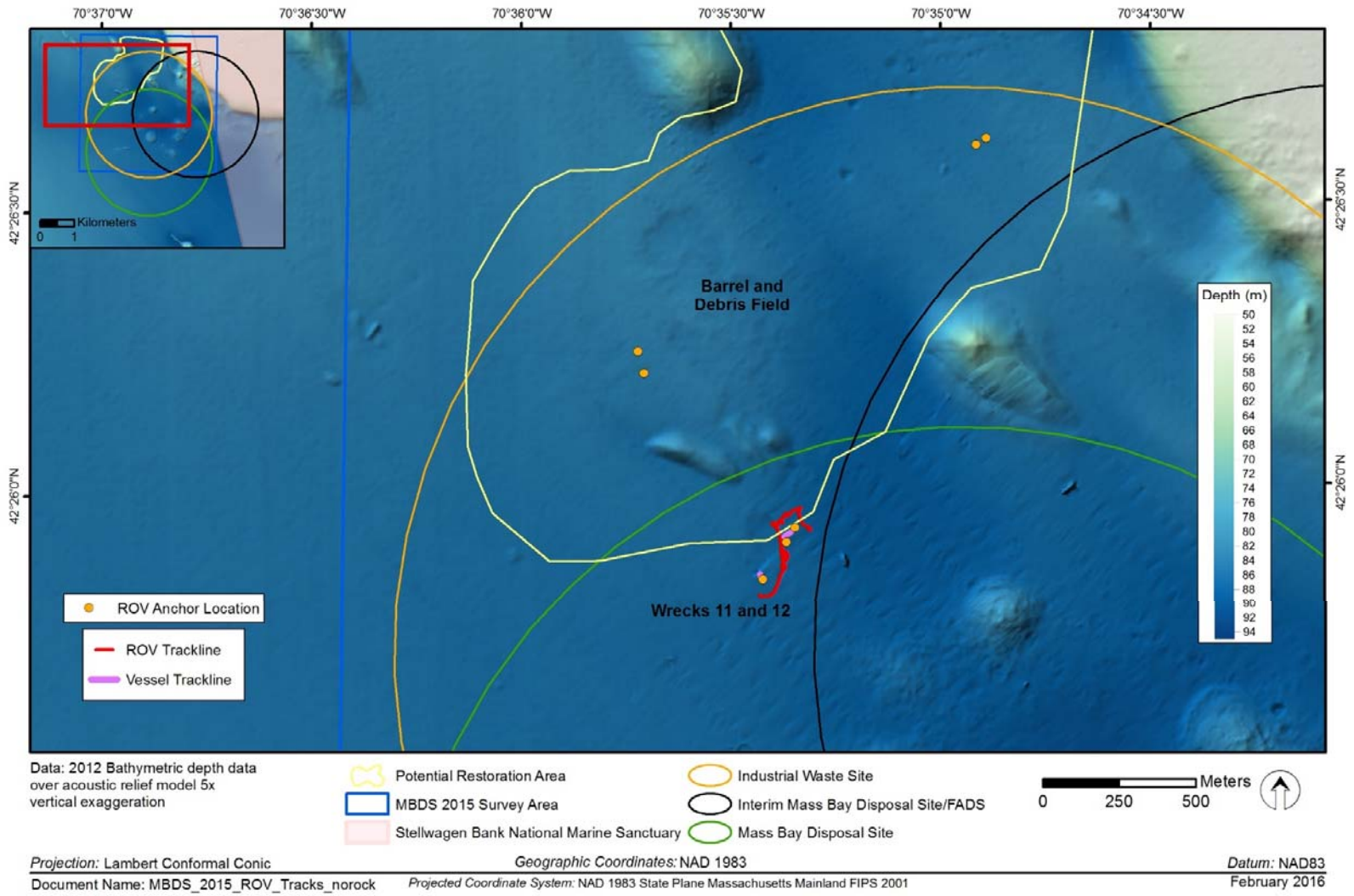



**Figure 2-6.** MBDS ROV survey locations and tracklines

# 3.0 RESULTS

## 3.1 Existing Bathymetry

The overall site bathymetry of the MBDS area surveyed in 2015 was consistent with that of the 2007 and 2012 surveys, with water depths ranging from approximately 91 m in the depression in the center of the MBDS survey area to 50 m in the northeast corner (Figure 3-1). From the center of the MBDS survey area to the boundaries, the seafloor formed an irregular basin with the outer rim composed of historical dredged material mounds (Carey et al. 2013). The proposed restoration area was relatively flat with depths ranging from approximately 74 to 78 m. An irregular mound consistent with a drumline was visible to the south of the proposed restoration area, and a small irregular depression is visible just north of this mound. (Figure 3-1). These seafloor features have been present in the potential restoration area since at least 1999 and were documented in the 2008/2009 and 2012 survey (Oldale et al. 1994, Carey et al. 2013, USACE 2015).

Multibeam bathymetric data rendered as a color scale by depth over an acoustic relief model (grayscale with hillshading) provided a more detailed representation of the surface of the mounds and site (Figure 3-2). The 2015 bathymetric survey confirmed the presence of the historical disposal mounds in the MBDS survey area (Figure 3-2). These mounds had been previously identified (Carey et al. 2013) and were due to the legacy of dredged material placement in this area. In the potential restoration area, color scale presentation of multibeam bathymetric data enhanced the visibility of the irregular depression that was located in the center of this location. A series of small craters consistent with dredged material placement "pock-marked" the seafloor in the northeast of the potential restoration area (Figure 3-2).

### 3.1.1 Acoustic Backscatter and Side-Scan Sonar

Acoustic backscatter results provided a clear representation of several areas with patterns of dredged material disposal activity (Figure 3-3). The mosaic of backscatter intensity displayed light areas (higher backscatter intensity) that corresponded to recent dredged material placement, as well as areas that received dredged material prior to 2007 (compare Figures 1-6 and 3-3). Within the potential restoration area, the mosaic had clear evidence of isolated disposal impact features and curved trails of dredged material that have been observed at other disposal sites (Carey et al. 2012 and Valente et al. 2012). Trails of barge disposal were visible in the northeast and southwest of the potential restoration area (Figure 3-3), and the depression observed in the center of this area in the bathymetric map (Figure 3-2) coincided with a speckled pattern discerned by the backscatter that is indicative of dredged material disposal (Figure 3-3). Given the occurrence of curved trails, from barge

disposal, in the potential restoration area, it is not surprising that stations in this area may contain dredged material in the sediment profiles (discussed below in Section 3.2.2.1).

Filtered backscatter results were processed into a grid file and presented in a quantitative form where backscatter intensity values were assigned a color (Figure 3-4). In this filtered and gridded display, the finer-scale details are less visible, but the relative intensity of backscatter returns are easier to discern. Stellwagen Bank and other shallow outcrops of glacial material in the MBDS 2015 survey area had the strongest return (-9 to -13 dB). Dredged material placed in the area of MBDS-I and the restoration demonstration project area produced irregular areas with moderate return (-18 to - 11 dB; Figure 3-4). Material placed at other mounds in MBDS produced a range in backscatter from a small area of highly elevated return (MBDS-C) to mounds with no apparent return above background (MBDS-D, -E, and -H); Figure 3-4).

Side-scan sonar results also provide a clear representation of disposal activity over the potential restoration area. Side-scan results confirmed observations from the backscatter results, but with additional detail (Figure 3-5). The side-scan sonar results have a higher resolution and are more responsive to minor surface textural features and slope than backscatter results. Some of the disposal impact features and curved marks were clearer in the side-scan sonar data indicating that they retain some surface topographical/textural qualities.

## 3.2 Sediment Profile and Plan-View Imaging

The SPI and PV data from the disposal site stations and the three reference areas were assessed to determine physical and biological benthic characteristics. Three of the four replicate drops of the SPI/PV camera system were selected for analysis at each station. The measurements from three replicates for aRPD depth, prism penetration depth, boundary roughness, and maximum dredged material depth were averaged to get a mean value per station. Successional stage for each station replicate was displayed as a pie chart. A summary of the SPI and PV results for the disposal site and reference area stations is presented in Tables 3-1 and 3-2 as well as in Appendix D.

### 3.2.1 Reference Area Stations

#### 3.2.1.1 Physical Sediment Characteristics

As had been found in previous surveys (AECOM 2010, Carey et al. 2013), the sediments at all three reference areas were a spatially homogenous, well-mixed, uniform light brown silt-clay with a grain size major mode of >4 phi at all stations (Figures 3-6 and 3-7). Two of the three reference areas (MBD-REF and SE-REF) were located inside the boundary of Stellwagen National Marine Sanctuary. There was no evidence of dredged

material at any of the stations sampled in the reference areas, and no evidence of low dissolved oxygen (DO) or sedimentary methane (Figure 3-8).

The stop collar settings and weights were kept constant (stop collar settings of ~33 cm, and one weight per carriage; see Appendix D), so the variation in camera penetration depth was a good measure of relative sediment shear strength among locations within the reference areas. Mean replicate camera prism penetration values among the reference area stations ranged from 16.0 to 20.3 cm with an overall reference station mean of 17.9 cm (SD±1.3) (Table 3-1, Figure 3-9). The spatial distribution in sediment shear strength was relatively the same at all of the reference area stations. The high mean penetration depths suggest low weight bearing strength and supported the observations of fine, less-compact sediment grains observed at the reference area stations (Figure 3-7).

Means of replicate small-scale boundary roughness ranged from 0.7 to 2.6 cm with an overall reference area mean of 1.6 cm (SD±0.5) (Table 3-1, Figures 3-10 and 3-11); the majority of small-scale topography can be attributed to the surface and sub-surface activity of benthic organisms, evidenced by small burrowing openings, pits, mounds, etc. at the sediment-water interface (Figures 3-11 and 3-12). Mean boundary roughness was spatially variable with no discernable trend in the distribution pattern (Figure 3-10). The largest boundary roughness was observed at Station FG-23-05, due to the biogenic creation of a pit at the sediment-water interface (Figure 3-11B). PV images support the SPI findings; in all images that could be classified, the sediment was identified as silt-clay with no bedforms resulting from sediment transport or hydrodynamic forcing (Figure 3-12).

#### 3.2.1.2 Biological Conditions

The means of replicate aRPD depths ranged from 2.2 to 4.7 cm (Table 3-1, Figures 3-13) with an overall mean of 3.7 (SD±0.6) cm across all reference area stations. The mean aRPD depths were shallowest at Station MBD-REF-04 and deepest at Station SE-REF-05 (Figure 3-14). The aRPD depths at the reference area stations were biologically modified by infaunal reworking resulting in relatively deep aRPDs, indicative of a healthy seafloor.

Stage 3 infauna were present across all three reference areas consistent with findings from previous surveys (Carey et al. 2013). All of the reference area images were classified as Stage 1 on 3 (Table 3-1, Figure 3-15). Evidence for the presence of Stage 3 fauna included large-bodied infauna, deep subsurface burrows, and/or deep feeding voids (Figure 3-16); opportunistic Stage 1 taxa were indicated by the presence of small tubes at the sediment water interface (Figure 3-17). Subsurface feeding voids, indicating Stage 3 fauna, were present in at least 1 replicate of each station surveyed. The mean of maximum subsurface feeding void depth (cm) ranged from 7.6 to 17.0 cm, with an overall reference area mean of 13.9 cm (SD±2.6) (Table 3-1; Figures 3-17 and 3-18).

Further indications of subsurface faunal activity from Stage 3 taxa were observed in the PV images as the presence of burrows, ranging from sparse (<10% coverage) to present

(10% to 25% coverage; Figure 3-19). The presence of tubes, indications of Stage 1 taxa, ranged from present at reference area MBD-REF, to dense (>75% coverage) at reference area SE-REF (Figure 3-20). Tracks across the seafloor, often created by epifauna (decapods, gastropods), were seen at all three reference areas (Figure 3-21, Appendix D). The seafloor of the reference areas was free of debris, excluding a replicate at one station (PV_SE-REF-05-B) where small shell fragments were observed in PV images (Figure 3-20). No fish or flora were present in the PV images across reference areas (Appendix D). Due to bottom water turbidity determination of a number of biogenic features (tubes, bedforms, burrows) was not possible in PV images captured at reference area FG-23 (Appendix D).

### 3.2.2 Disposal Site Stations

#### 3.2.2.1 Physical Sediment Characteristics

The sediments at stations in the MBDS survey area were mostly spatially homogenous, consisting of uniform light brown over light gray silt-clay, with a grain size major mode of >4 phi (Figures 3-22 and 3-23). Three stations varied from this description, Station MBDS-11 had light brown silt-clay with a depositional layer of white glacial clay dredged material (Figure 3-24), and Stations MBDS-24 and MBDS-26 had light brown over a darker grayish black silt-clay (Figure 3-25). Grains at the sediment-water interface were generally larger, pelletized silt-clay particles (Figure 3-23), and the sediment column was extensively reworked historical dredged material (addressed in detail in Section 3.2.2.2). Historical dredged material was present at the majority of stations (Figure 3-26) and extended below the penetration maximum of the prism at all stations where it was observed (Figure 3-27A). For these stations the dredged material thickness must be considered a minimum thickness based on prism penetration. The mean of measured dredged material thickness ranged from 7.4 to 21.1 cm, with an overall MBDS station mean of 17.3 cm (SD±2.5). Most stations contained a dredged material layer that was greater than 15 cm in thickness (Table 3-2, Figure 3-28). The one exception, Station MBDS-29, had a smaller documented thickness of dredged material that was largely due to the low prism penetration depth at this site (Figure 3-29). A few stations, 7 of the 30, did not contain dredged material (Figure 3-27B). Most of the stations where dredged material was not present were located in the western portion of the MBDS survey area, except for Station MBDS-25 (Figure 3-26). There was no evidence of low dissolved oxygen (DO) or sedimentary methane at any station.

The stop collar settings and weights were kept virtually constant (stop collar settings of 33 cm except for Station 23 with 33.5 cm, and one weight per carriage; see Appendix D), so the variation in camera penetration depth was a good measure of relative sediment shear strength among locations within the potential restoration area. Mean replicate camera prism penetration values among the MBDS survey area stations ranged from 6.7 to 21.0 cm with an overall MBDS station mean of 17.0 cm (SD±2.4) (Table 3-2, Figure 3-30). The spatial distribution in sediment shear strength was relatively the same at most of the stations in the MBDS survey area. The high mean penetration depths suggest low weight bearing strength

and supported the observations of fine, less-compact sediment grains observed at the MBDS stations (Figure 3-22). Only one station in the MBDS survey area contained high weight bearing strength (MBDS-29), and had relatively low prism penetration depths (Figures 3-29 and 3-30). The physical sediment characteristics at MBDS-29 were similar to the other MBDS survey area stations (predominant silt-clay grain size, pelletized sediment-water interface, presence of dredged material), and the source of higher load bearing strength at this station is unknown.

Means of replicate small-scale boundary roughness ranged from 0.7 to 2.8 cm with an overall MBDS survey area mean of 1.4 cm (SD±0.5) (Table 3-2, Figures 3-31 and 3-32). All of the small-scale topography was attributed to the surface and sub-surface activity of benthic organisms, evidenced by small burrow openings, pits, mounds, tracks, etc. (Figures 3-32 and 3-33). Mean boundary roughness was spatially variable with no discernable trend in the distribution pattern (Figure 3-31). The largest boundary roughness was observed at Station MBDS-23-D, due to the biogenic creation of a pit at the sediment-water interface (Figure 3-32B). PV images support the SPI findings; in all images that could be classified the sediment was identified as silt-clay with no bedforms resulting from sediment transport or hydrodynamic forcing (Figure 3-33).

#### 3.2.2.2 Biological Conditions

The means of replicate aRPD depths ranged from 1.4 to 5.1 cm (Table 3-2, Figures 3-34) with an overall mean of 3.8 cm (SD±0.8) across all MBDS survey area stations. The mean aRPD depths were shallowest at Station MBDS-26 and deepest at Station MBDS-17 (Figure 3-35). The sediment profiles at stations at MBDS were well modified by infaunal reworking with well-developed aRPDs and the presence of feeding voids in the sediment column. Overall, the aRPD depths at the MBDS survey area stations were relatively deep, indicative of a healthy seafloor.

Stage 3 infauna were present across all stations in the MBDS survey area (Figure 3-36). The majority of the survey area stations were classified as Stage 1 on 3 (Table 3-2), though two stations had different classifications. Station MBDS-19 contained Stage 2 on 3 taxa (Figure 3-37), and Station MBDS-26 was classified as simply Stage 3 taxa (Figure 3-35A). Evidence for the presence of Stage 3 fauna included large-bodied infauna, deep subsurface burrows, and/or deep feeding voids; opportunistic Stage 1 taxa were indicated by the presence of tubes at the sediment water interface (Figure 3-38). Subsurface feeding voids, indicating Stage 3 fauna, were present in at least 1 replicate of each station surveyed. The mean of maximum subsurface feeding void depth (cm) ranged from 6.7 to 18.9 (cm), with an overall MBDS survey area mean of 14.3 cm (SD±3.1; Table 3-2; Figures 3-38 and 3-39).

Further indications of subsurface faunal activity from Stage 3 taxa were observed in the PV images as the presence of burrows, ranging from sparse (<10% coverage) to abundant (25% to 75% coverage; Figure 3-40). The presence of tubes, indications of Stage 1 taxa,

ranged from present (10% to 25% coverage) to dense (>75% coverage), with most stations in the MBDS survey area containing abundant tubes on the seafloor (Figure 3-41). Tracks across the seafloor, often created by epifauna (decapods, gastropods), were observed in at least one replicate at all of the MBDS survey area stations (Figure 3-42, Appendix D), excluding Station MBDS-01. Despite no tracks being observed on the seafloor at Station MBDS-01, epifauna were visible on the seafloor in PV images (Figure 3-33A). The presence of epifauna or their tracks at all MBDS stations, indicated their influence on seafloor dynamics was ubiquitous across the MBDS survey area. The seafloor of the MBDS survey areas was free of debris and no fish or flora were present in any of the PV images across the survey area (Appendix D).

### 3.2.3 Comparison to Reference Areas

#### 3.2.3.1 Mean aRPD Variable

Area mean aRPD depth at the MBDS disposal area was 3.8 cm, comparable to the grand mean of the reference areas (3.7 cm, Table 3-3). Area mean aRPD values in the reference areas ranged from 3.2 to 4.0 cm, and were shallowest at MBD-REF. The standard deviation among stations of aRPD depths was 0.6 cm or less at all reference areas (Table 3-3).

A statistical inequivalence test was performed to determine whether or not the difference observed in mean aRPD values between the three reference areas and the disposal area was significantly similar. The station mean aRPD data from all four locations were combined to assess normality and estimate variance. Results for the normality test indicated that the area residuals, i.e., each observation minus the area mean, were significantly different from a normal distribution (Shapiro-Wilk's test p-value = 0.04, with alpha = 0.05). The confidence interval for the difference equation was constructed using a non-parametric bootstrap approach.

The confidence regions for the difference between the mean of the reference areas versus the MBDS disposal area was fully contained within the interval [-1 cm, +1 cm] (Table 3-4). The conclusion was that the aRPD values from the disposal area was significantly equivalent to reference in the 2015 survey. The difference in means between reference and MBDS was -0.1 cm. MBDS had an aRPD mean of 3.8 cm, similar to both FG-23 and SE-REF (3.9 and 4.0 cm, respectively), while MBD-REF area had a shallower aRPD mean value of 3.2 cm (Table 3-4).

#### 3.2.3.2 Successional Stage Rank Variable

Across the reference areas and MBDS, Stage 3 fauna were consistently found at every station. No statistical tests were required to determine that the successional stage conditions at MBDS were equivalent to reference area conditions.

## 3.3 ROV Survey

### 3.3.1 ROV Results

The ROV was navigated into two areas with high density of potential barrels based on side-scan sonar results (Figures 2-6 and 3-43). With poor visibility on the soft mud, the sector-scanning sonar was helpful in acquiring and navigating to potential objects. Two barrel targets were acquired and recorded with the ROV video camera and GoPro (Figure 3-44). Both barrel targets appeared to be concrete formed into barrel shapes with no evidence of metal remaining. The ROV impellers were used to clear some silt from the margin of one barrel to allow assessment of accumulation (Figure 3-44).

The ROV was navigated to shipwreck targets identified on side-scan sonar (Figures 2-6 and 3-45). Poor visibility and bottom currents made it difficult to consistently approach the shipwrecks without risk of entanglement. Shipwreck 12 was imaged very clearly with the ROV video and GoPro and it was possible to make a partial transit on the south side of the wreck (Figure 3-46). Shipwreck 11 was much more difficult to image, it took most of the dive to maneuver close to the wreck with poor visibility and moderate currents. Near Wreck 11 there was debris with a lobster trap (Figure 3-46). The sides and top of the wreck were imaged with the ROV video. Soon after acquiring the wreck the supplemental lights for the GoPro and eventually the GoPro lost battery power after an extended dive trying to find the wreck. The ROV was able to go inside the wreck and collect video footage with details of construction, but concerns over snagging the umbilical cable (visible in the video) and limited sunlight topside led to ending the dive.

### 3.3.2 USACE Cultural Resources ROV Analysis

USACE's Archeologist Wendy Weaver, from the Restoration and Resources Section of the Policy and Planning Division of USACE, Jacksonville District provided a Cultural Resources analysis of the video footage of the shipwreck area. The two shipwrecks, Wrecks 11 and 12, were deemed potentially significant historical resources. They lie about 100 meters south of the proposed IWS Restoration Area boundary, the potential for indirect impacts associated with restoration and future disposal actions necessitated further investigation.

Ms. Weaver reported that side-scan imagery shows that Wreck 11 is approximately 26.7 meters in length and 5.8 meters in width. Wreck 12 is approximately 34.5 meters in length and 6.7 meters in width. The side-scan imagery also shows a possible nearby debris trail that may be associated with Wreck 12.

Due to offshore weather and poor visibility imagery in the surrounding sediment adjacent to either wreck, was insufficient to detect a debris trail or other nearby ship

elements. On the wrecks, soft corals colonized much of the surface obscuring many diagnostic elements of the wrecks.

For Wreck 11, there were no visible diagnostic elements in the ROV footage to determine identification as it was covered in silt and soft coral growth. Ms. Weaver indicated that it is possible that Wreck 11 is an iron hulled vessel.

Based on the ROV footage of Wreck 12, Ms. Weaver indicated that it is a deteriorated wooden hulled vessel. This wreck was also covered in silt and soft coral growth. The only diagnostic elements imaged in the ROV footage is a section of copper sheathing of the stern or stem post and in one place along the hull, what looks to be a fragment of copper sheathing on an outer hull plank. Also, in the footage background there appears to be either a cast or wrought iron anchor without a stock. These features indicate a possible 19th century date for Wreck 12.

## Table 3-1.

Summary of MBDS/IWS Reference Station Sediment-Profile Imaging Results (station means), September 2015

| Station | Water Depth (ft) | Grain Size Major Mode (phi) | Mean Prism Penetration Depth (cm) | Mean Boundary Roughness (cm) | Predominant Type of Boundary Roughness | Mean aRPD (cm) | Dredged Material Present | Mean # of Subsurface Feeding Voids | Mean of Maximum Subsurface Feeding Void Depth (cm) | Predominant Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|
| FG-23-01 | 290 | >4 | 19.4 | 1.1 | Biological | 3.3 | No | 3.0 | 12.2 | 1 on 3 |
| FG-23-02 | 290 | >4 | 17.7 | 1.7 | Biological | 3.3 | No | 1.3 | 14.1 | 1 on 3 |
| FG-23-03 | 290 | >4 | 16.6 | 0.7 | Biological | 3.8 | No | 1.3 | 15.7 | 1 on 3 |
| FG-23-04 | 290 | >4 | 18.0 | 2.2 | Biological | 4.7 | No | 2.7 | 13.8 | 1 on 3 |
| FG-23-05 | 290 | >4 | 16.4 | 2.6 | Biological | 4.3 | No | 1.7 | 13.4 | 1 on 3 |
| MBD-REF-01 | 295 | >4 | 16.0 | 1.6 | Biological | 3.6 | No | 2.3 | 10.3 | 1 on 3 |
| MBD-REF-02 | 295 | >4 | 16.0 | 1.4 | Biological | 3.2 | No | 1.7 | 7.6 | 1 on 3 |
| MBD-REF-03 | 295 | >4 | 16.8 | 1.6 | Biological | 3.9 | No | 1.3 | 12.3 | 1 on 3 |
| MBD-REF-04 | 295 | >4 | 17.6 | 0.8 | Biological | 2.2 | No | 1.3 | 12.5 | 1 on 3 |
| MBD-REF-05 | 295 | >4 | 18.3 | 2.4 | Biological | 3.2 | No | 2.7 | 15.5 | 1 on 3 |
| SE-REF-01 | 298 | >4 | 19.3 | 2.1 | Biological | 4.0 | No | 1.7 | 16.3 | 1 on 3 |
| SE-REF-02 | 300 | >4 | 20.3 | 1.7 | Biological | 3.7 | No | 1.3 | 17.0 | 1 on 3 |
| SE-REF-03 | 297 | >4 | 18.9 | 1.0 | Biological | 4.2 | No | 3.7 | 16.9 | 1 on 3 |
| SE-REF-04 | 290 | >4 | 18.2 | 1.9 | Biological | 3.9 | No | 1.3 | 16.0 | 1 on 3 |
| SE-REF-05 | 293 | >4 | 18.7 | 1.1 | Biological | 4.1 | No | 4.3 | 14.8 | 1 on 3 |
| **Max** | 300 | | 20.3 | 2.6 | | 4.7 | | 4.3 | 17.0 | |
| **Min** | 290 | | 16.0 | 0.7 | | 2.2 | | 1.3 | 7.6 | |
| **Mean** | 294 | | 17.9 | 1.6 | | 3.7 | | 2.1 | 13.9 | |

Ind = Indeterminate

a Grain Size: "/" indicates layer of one phi size range over another (see Appendix E)

b Successional Stage: "on" indicates one Stage is found on top of another Stage (i.e., 1 on 3);"→" indicates one Stage is progressing to another Stage (i.e., 2→3)

**Table 3-2.**

Summary of MBDS/IWS Site Sediment-Profile Imaging Results (station means), September 2015

| Station | Water Depth (ft) | Grain Size Major Mode (phi) | Mean Prism Penetration Depth (cm) | Mean Boundary Roughness (cm) | Predominant Type of Boundary Roughness | Mean aRPD (cm) | Dredged Material Present | Mean of Maximum Dredged Material Depth (cm) | Mean # of Subsurface Feeding Voids | Mean of Maximum Subsurface Feeding Void Depth (cm) | Predominant Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 285 | >4 | 15.1 | 2.0 | Biological | 3.4 | Yes | 16.2 | 1.0 | 14.0 | 1 on 3 |
| 02 | 275 | >4 | 16.9 | 1.2 | Biological | 4.1 | Yes | 17.4 | 1.3 | 15.5 | 1 on 3 |
| 03 | 275 | >4 | 16.4 | 1.3 | Biological | 4.6 | Yes | 17.1 | 3.7 | 15.7 | 1 on 3 |
| 04 | 280 | >4 | 16.2 | 1.1 | Biological | 4.7 | Yes | 16.7 | 1.7 | 12.1 | 1 on 3 |
| 05 | 270 | >4 | 17.7 | 0.8 | Biological | 3.6 | Yes | 18.1 | 1.7 | 15.8 | 1 on 3 |
| 06 | 280 | >4 | 17.3 | 1.6 | Biological | 4.2 | Yes | 18.0 | 2.0 | 17.4 | 1 on 3 |
| 07 | 275 | >4 | 16.0 | 1.4 | Biological | 3.4 | Yes | 16.8 | 1.3 | 12.9 | 1 on 3 |
| 08 | 280 | >4 | 16.7 | 1.1 | Biological | 4.1 | No | | 1.0 | 6.7 | 1 on 3 |
| 09 | 280 | >4 | 16.6 | 1.2 | Biological | 4.7 | No | | 2.3 | 13.8 | 1 on 3 |
| 10 | 280 | >4 | 18.8 | 1.9 | Biological | 4.1 | No | | 1.0 | 13.8 | 1 on 3 |
| 11 | 280 | >4 | 15.6 | 1.0 | Biological | 3.1 | Yes | 16.0 | 1.7 | 11.1 | 1 on 3 |
| 12 | 295 | >4 | 19.3 | 1.8 | Biological | 3.7 | Yes | 18.1 | 1.0 | 15.6 | 1 on 3 |
| 13 | 285 | >4 | 17.3 | 2.3 | Biological | 3.4 | Yes | 18.2 | 0.3 | 17.3 | 1 on 3 |
| 14 | 270 | >4 | 16.9 | 1.7 | Biological | 4.3 | Yes | 18.3 | 3.0 | 15.8 | 1 on 3 |
| 15 | 285 | >4 | 18.2 | 1.2 | Biological | 4.2 | Yes | 18.6 | 3.0 | 12.7 | 1 on 3 |
| 16 | 280 | >4 | 16.0 | 0.8 | Biological | 4.8 | Yes | 15.8 | 2.3 | 13.5 | 1 on 3 |
| 17 | 290 | >4 | 14.4 | 1.1 | Biological | 5.1 | No | | 1.7 | 10.4 | 1 on 3 |
| 18 | 290 | >4 | 19.2 | 1.5 | Biological | 3.9 | No | | 3.3 | 16.9 | 1 on 3 |
| 19 | 290 | >4 | 17.8 | 0.7 | Biological | 3.3 | Yes | 18.0 | 4.0 | 16.6 | 2 on 3 |
| 20 | 285 | >4 | 18.0 | 1.8 | Biological | 4.6 | Yes | 18.8 | 3.3 | 10.5 | 1 on 3 |

## Table 3-2. (continued)

Summary of MBDS/IWS Site Sediment-Profile Imaging Results (station means), September 2015

| Station | Water Depth (ft) | Grain Size Major Mode (phi) | Mean Prism Penetration Depth (cm) | Mean Boundary Roughness (cm) | Predominant Type of Boundary Roughness | Mean aRPD (cm) | Dredged Material Present | Mean of Maximum Dredged Material Depth (cm) | Mean # of Subsurface Feeding Voids | Mean of Maximum Subsurface Feeding Void Depth (cm) | Predominant Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 285 | >4 | 18.0 | 1.7 | Biological | 4.6 | Yes | 18.8 | 3.3 | 17.9 | 1 on 3 |
| 22 | 285 | >4 | 17.8 | 1.1 | Biological | 3.8 | Yes | 18.3 | 3.0 | 16.8 | 1 on 3 |
| 23 | 290 | >4 | 18.5 | 2.8 | Biological | 3.9 | No | | 1.0 | 16.9 | 1 on 3 |
| 24 | 290 | >4 | 18.9 | 0.9 | Biological | 2.2 | Yes | 19.4 | 3.3 | 14.2 | 1 on 3 |
| 25 | 285 | >4 | 18.1 | 1.6 | Biological | 3.5 | No | | 1.7 | 17.4 | 1 on 3 |
| 26 | 301 | >4 | 21.0 | 0.7 | Biological | 1.4 | Yes | 21.1 | 4.7 | 18.9 | 3 |
| 27 | 285 | >4 | 17.7 | 1.0 | Biological | 3.1 | Yes | 18.2 | 2.0 | 17.8 | 1 on 3 |
| 28 | 290 | >4 | 16.3 | 1.1 | Biological | 4.0 | Yes | 16.8 | 2.3 | 11.3 | 1 on 3 |
| 29 | 285 | >4 | 6.7 | 1.4 | Biological | 2.6* | Yes | 7.4 | 0.3 | 7.5 | 1 on 3 |
| 30 | 280 | >4 | 16.4 | 1.6 | Biological | 3.4 | Yes | 17.1 | 2.0 | 12.9 | 1 on 3 |
| **Max** | 301 | | 21.0 | 2.8 | | 5.1 | | 21.1 | 4.7 | 18.9 | |
| **Min** | 270 | | 6.7 | 0.7 | | 1.4 | | 7.4 | 0.3 | 6.7 | |
| **Mean** | 4.8 | | 17.0 | 1.4 | | 3.8 | | 17.3 | 2.1 | 14.3 | |

*This mean includes only replicates with measurable aRPD.
Ind = Indeterminate
a Grain Size: "/" indicates layer of one phi size range over another (see Appendix E)
b Successional Stage: "on" indicates one Stage is found on top of another Stage (i.e., 1 on 3);"→" indicates one Stage is progressing to another Stage (i.e., 2→3)

**Table 3-3.**

Summary of Station Means by Sampling Location

| Site | N | Mean aRPD (cm) | | Successional Stage Rank | | Number of Feeding Voids | |
|---|---|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation | Mean | Standard Deviation |
| Reference Areas | | | | | | | |
| FG-23 | 5 | 3.9 | 0.63 | 3 | 0 | 2.0 | 0.8 |
| MBD-REF | 5 | 3.2 | 0.62 | 3 | 0 | 1.9 | 0.6 |
| SE-REF | 5 | 4.0 | 0.16 | 3 | 0 | 2.5 | 1.4 |
| Mean | | 3.7 | | 3 | | 2.1 | |
| Disposal Area | | | | | | | |
| MBDS | 30 | 3.8 | 0.81 | 3 | 0 | 2.1 | 1.1 |

**Table 3-4.**

Summary Statistics and Results of Inequivalence Hypothesis Testing for aRPD Values

| Difference Equation | Observed Difference (d) | $SE\ (\hat{d})$ | *df* for SE | Confidence Bounds ($D_L$ to $D_U$)[1] | Results[2] |
|---|---|---|---|---|---|
| $Mean_{REF} - Mean_{MBDS}$ | -0.11 | 0.19 | 41 | -0.44 to +0.20 | s |

[1] $D_L$ and $D_U$ as defined in [Eq. 3]
[2] s = Reject the null hypothesis of inequivalence: the two group means are significantly equivalent, within ± 1 cm.
d = Fail to reject the null hypothesis of inequivalence between the two group means, the two group means are different.

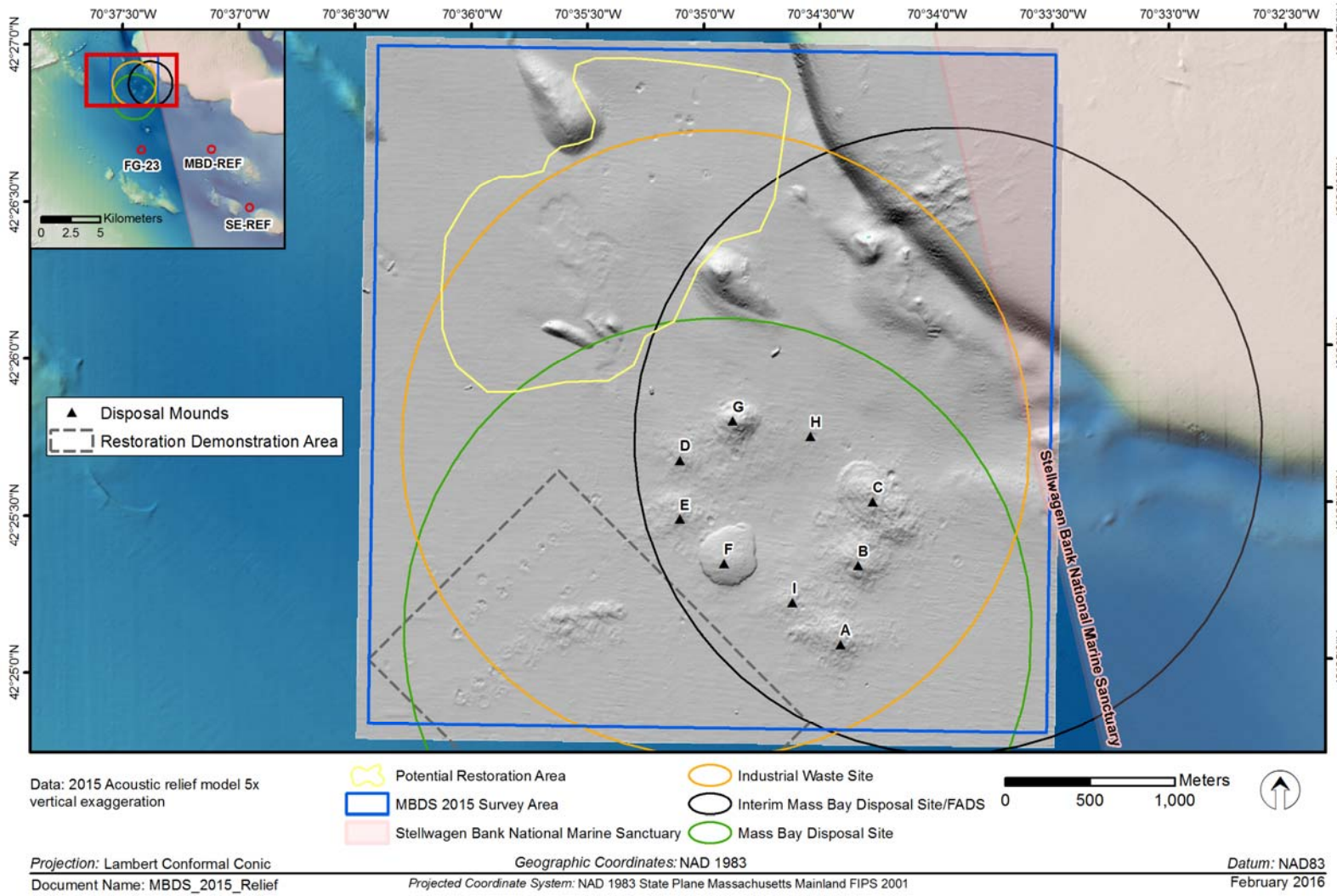



**Figure 3-1.** Acoustic relief model, 5x vertical exaggeration, of MBDS – September 2015

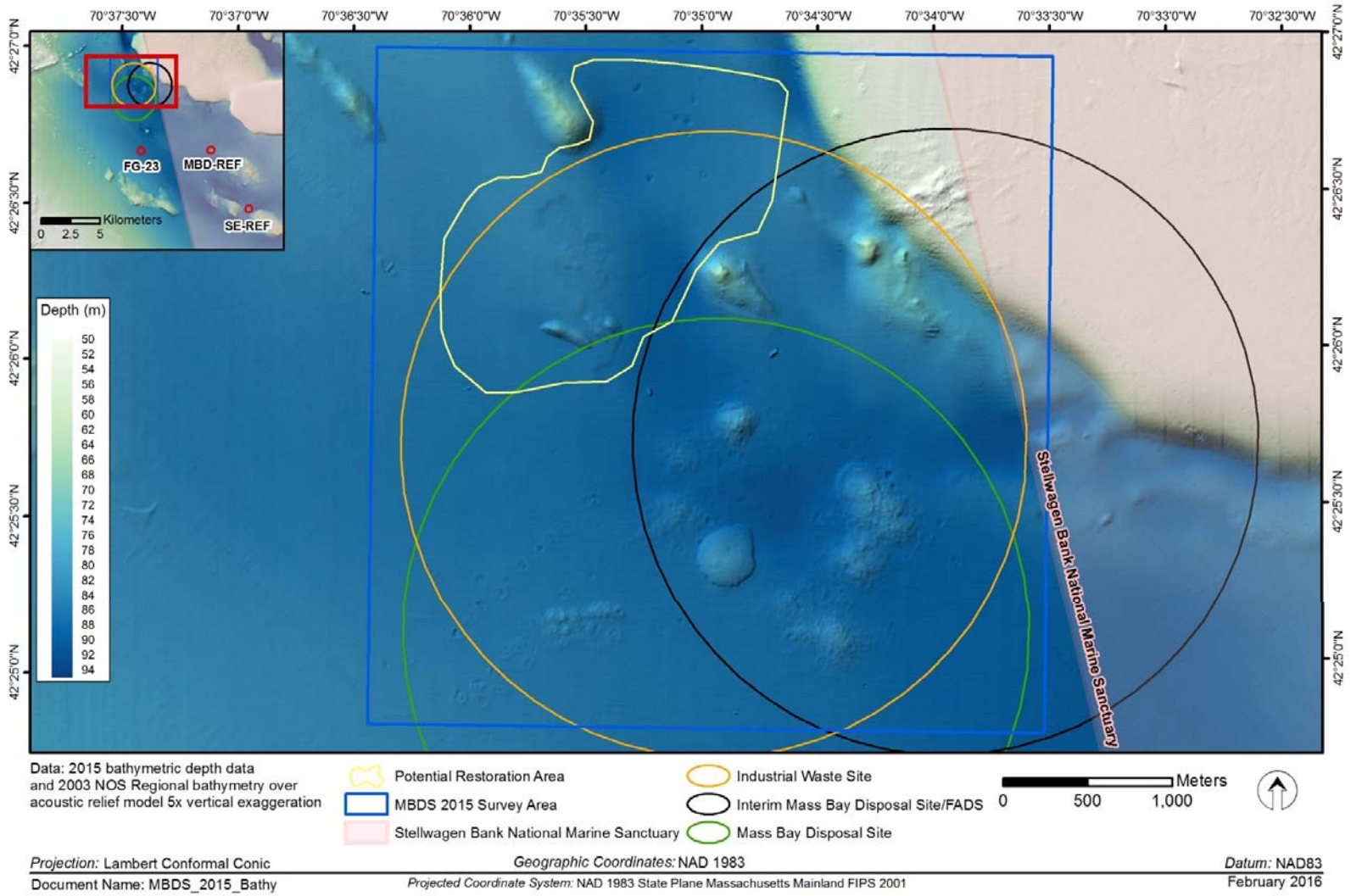



**Figure 3-2.** Bathymetric depth data over acoustic relief model of MBDS – September 2015

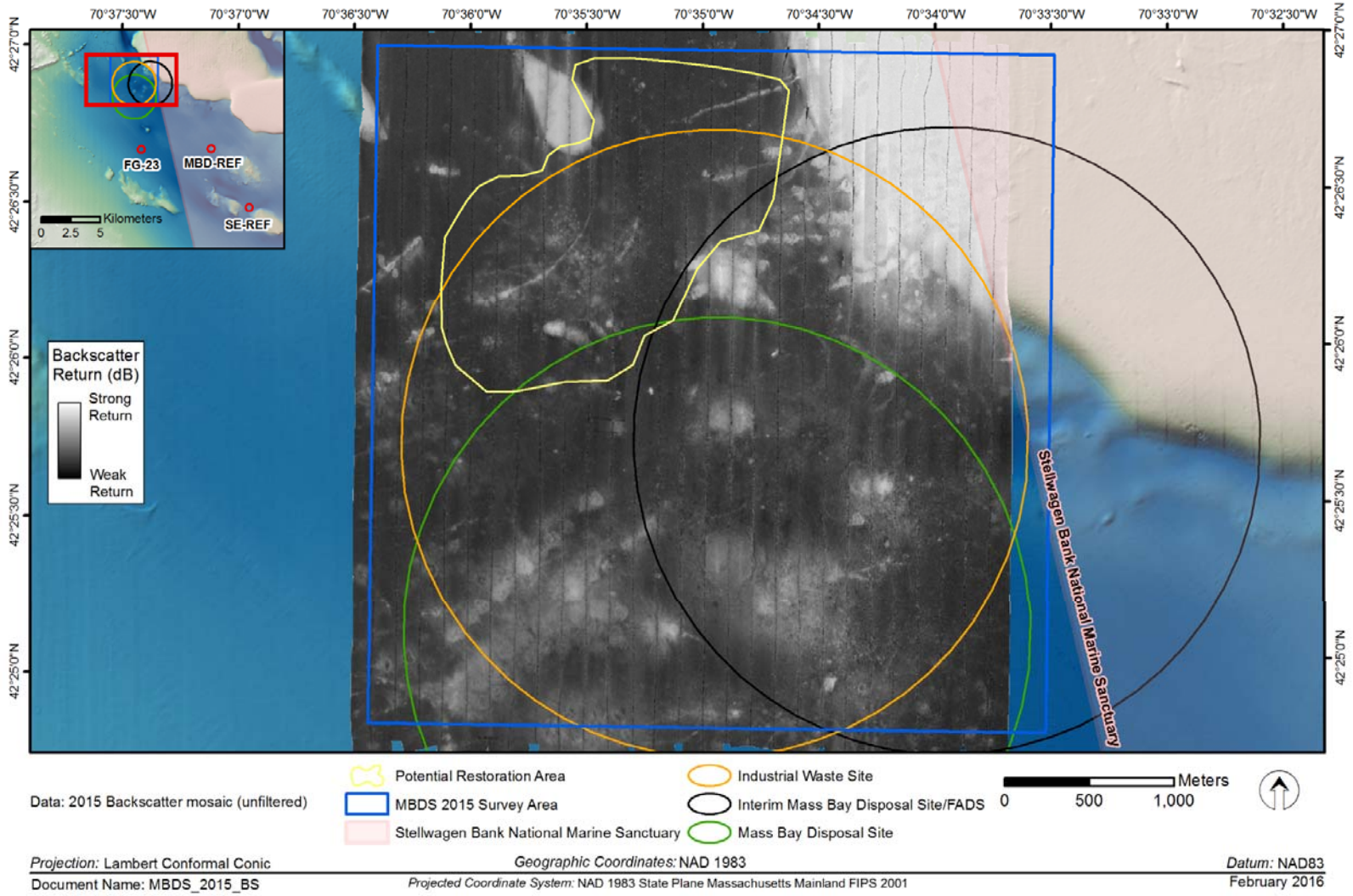



**Figure 3-3.** Mosaic of unfiltered backscatter data of MBDS – September 2015

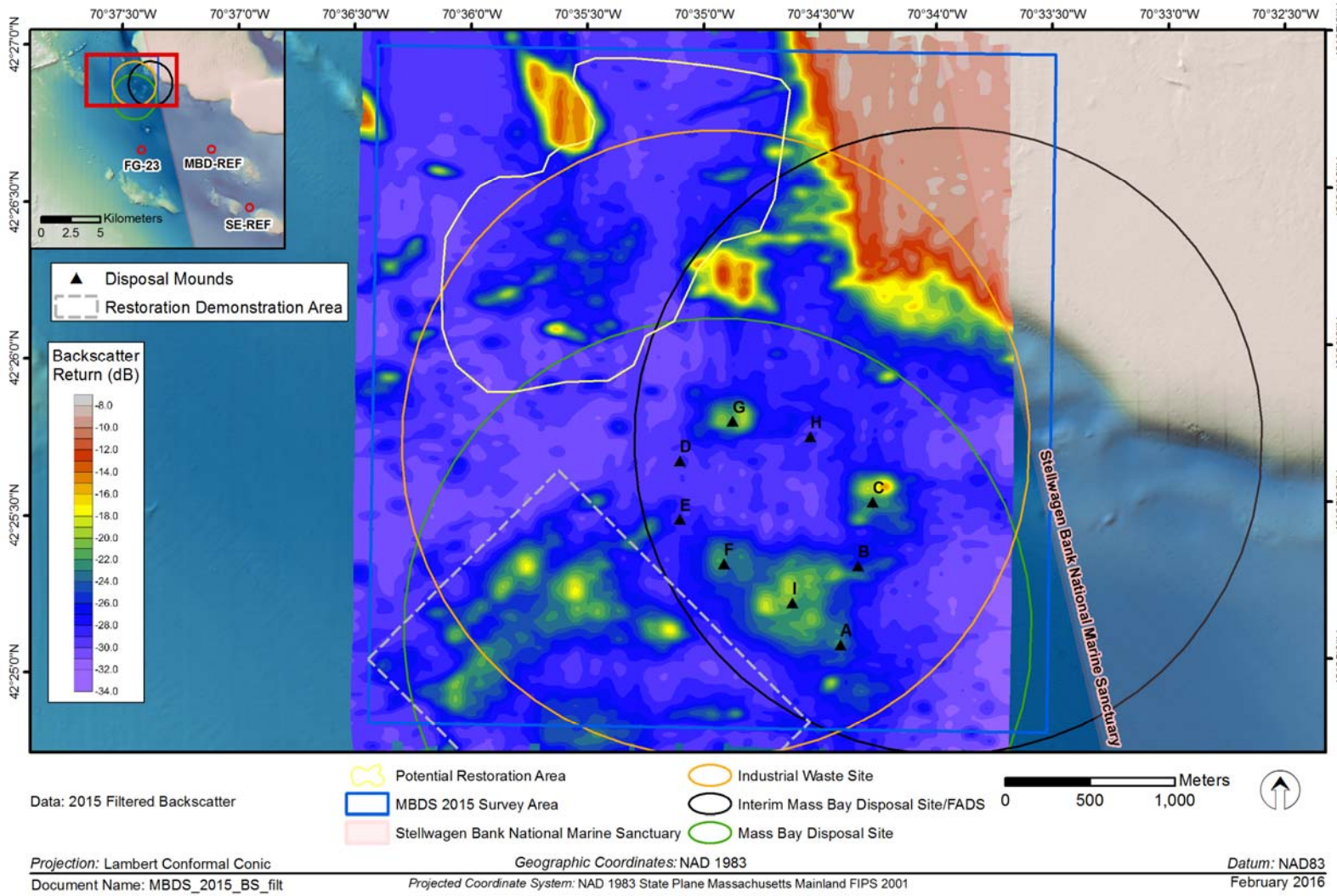



**Figure 3-4.** Filtered backscatter of MBDS – September 2015

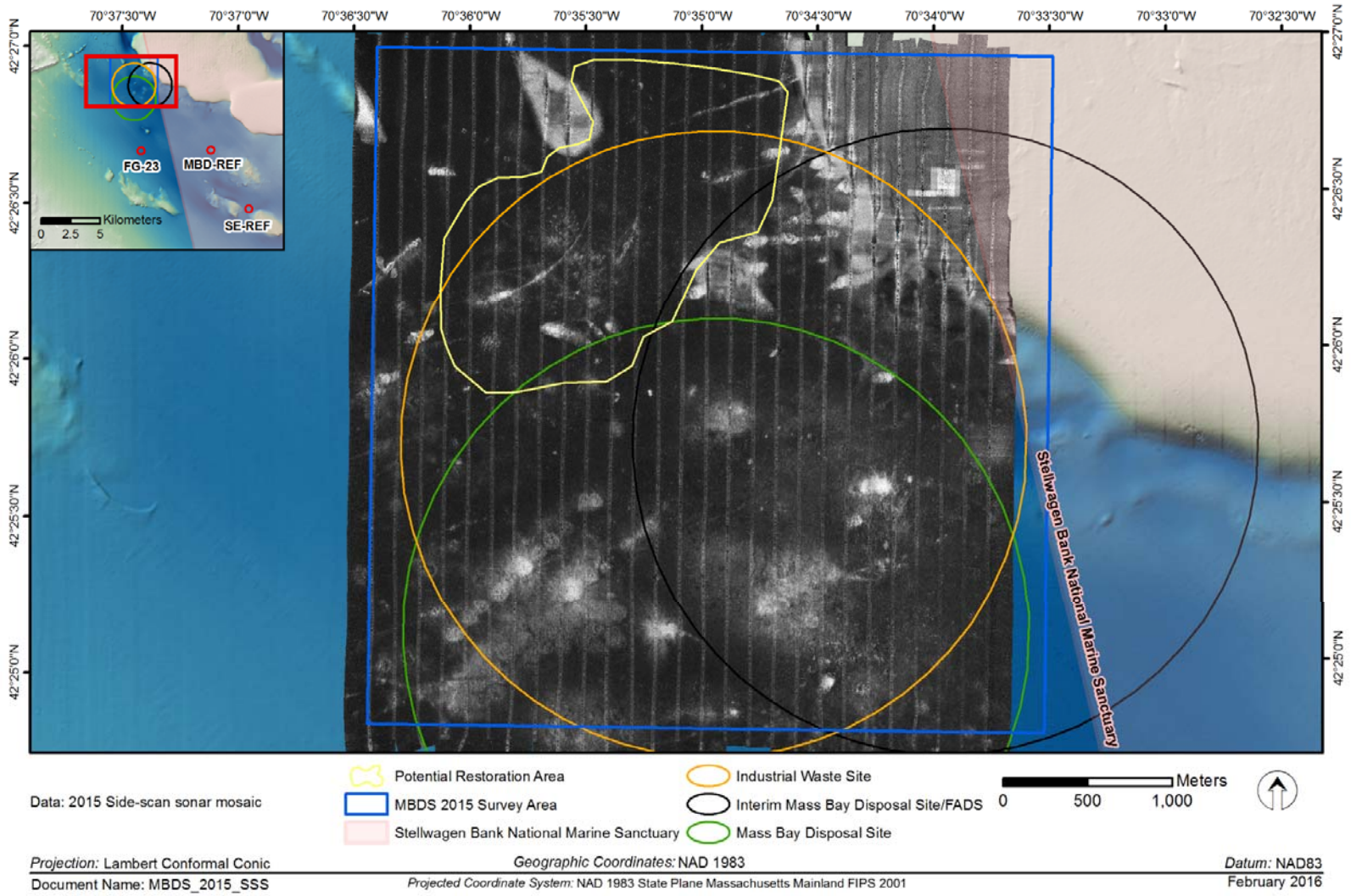



**Figure 3-5.** Side-scan mosaic of MBDS – September 2015

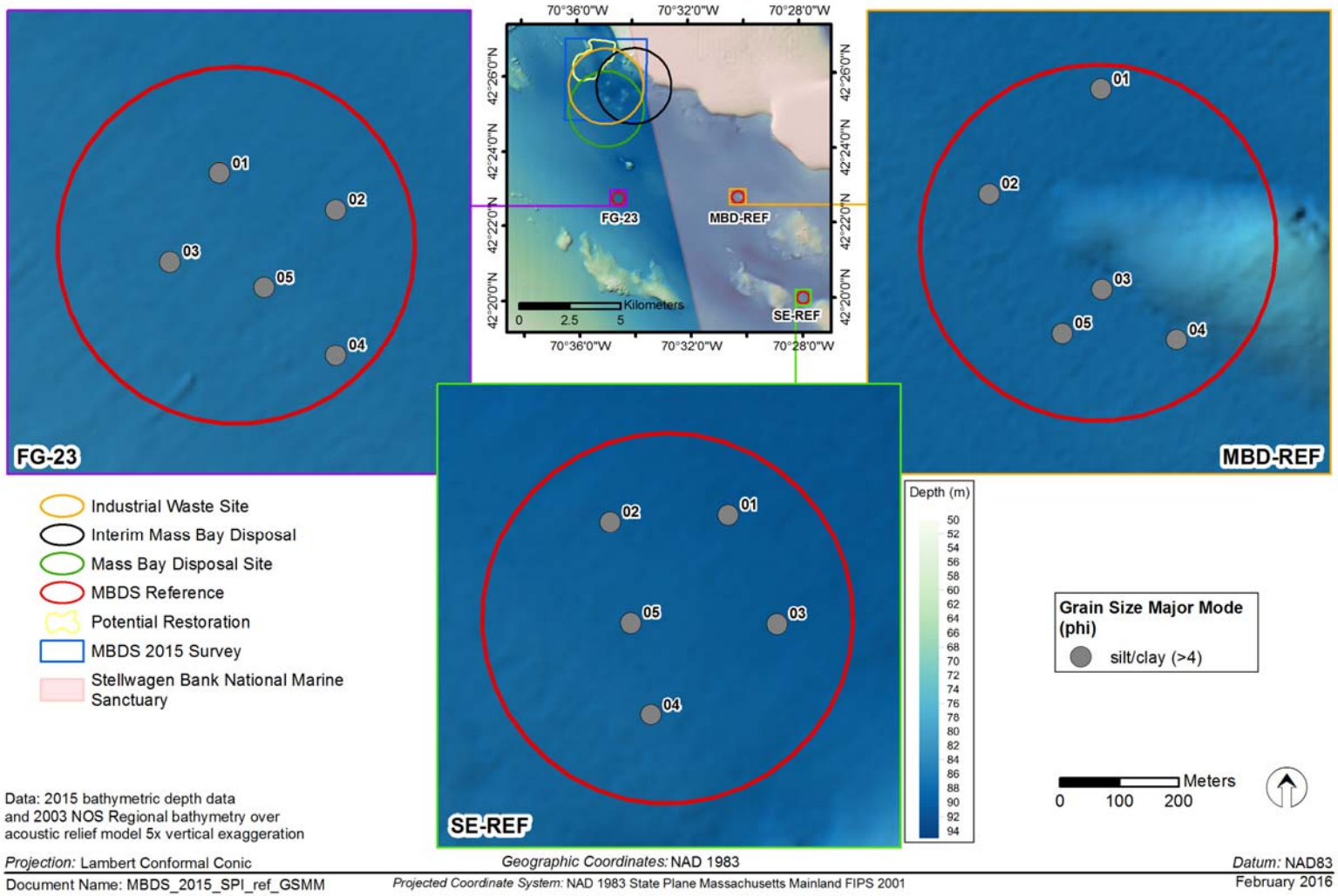
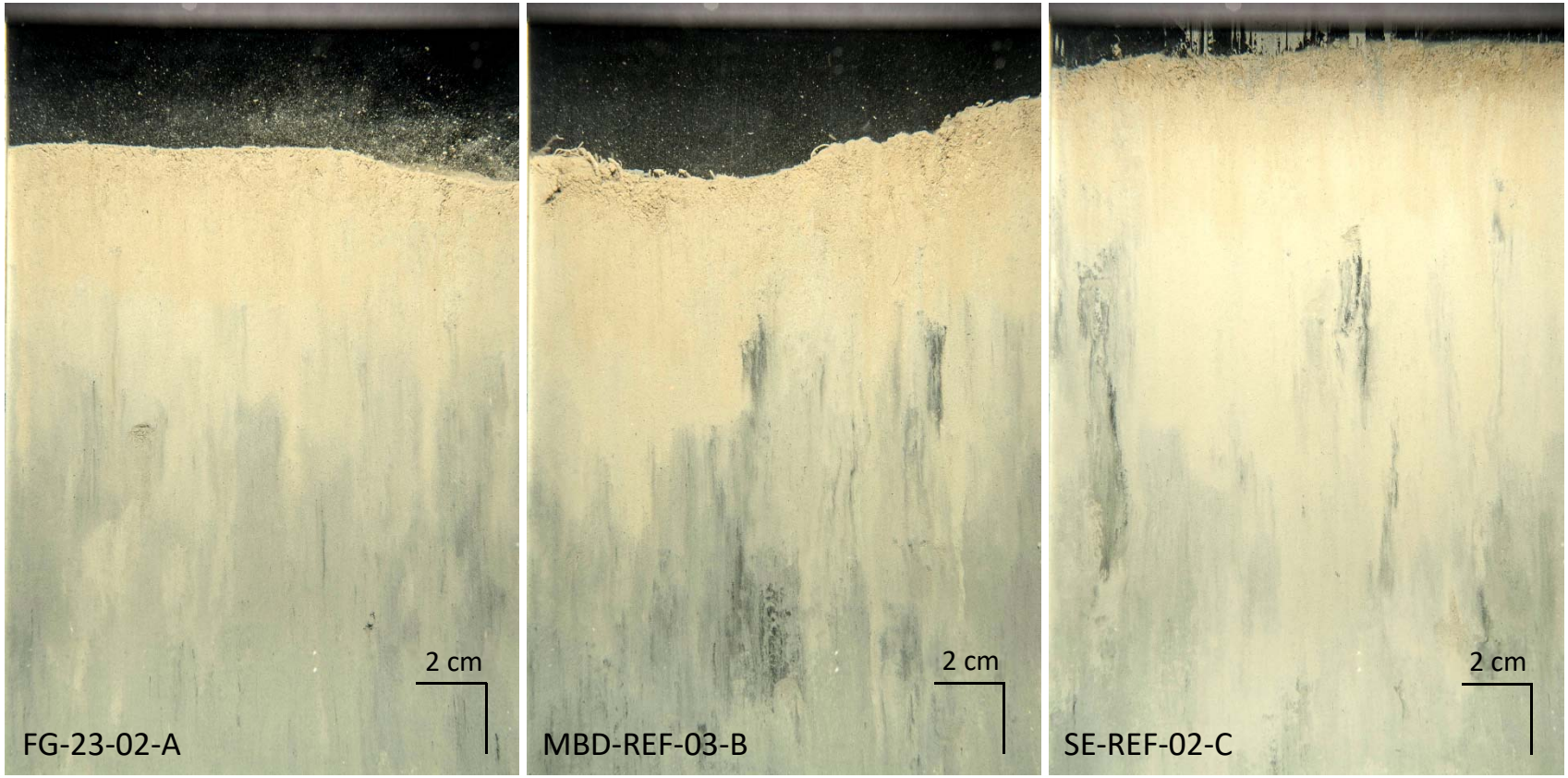



**Figure 3-6.** Spatial distribution of sediment grain size major mode (phi units) at the MBDS reference areas




**(A)** **(B)** **(C)**

**Figure 3-7.** These profile images from Stations (A) FG-23-02, (B) MBD-REF-03, and (C) SE-REF-02 are representative of the >4 phi (silt-clay) grain size major mode and deep prism penetration depths present at all of the reference area stations

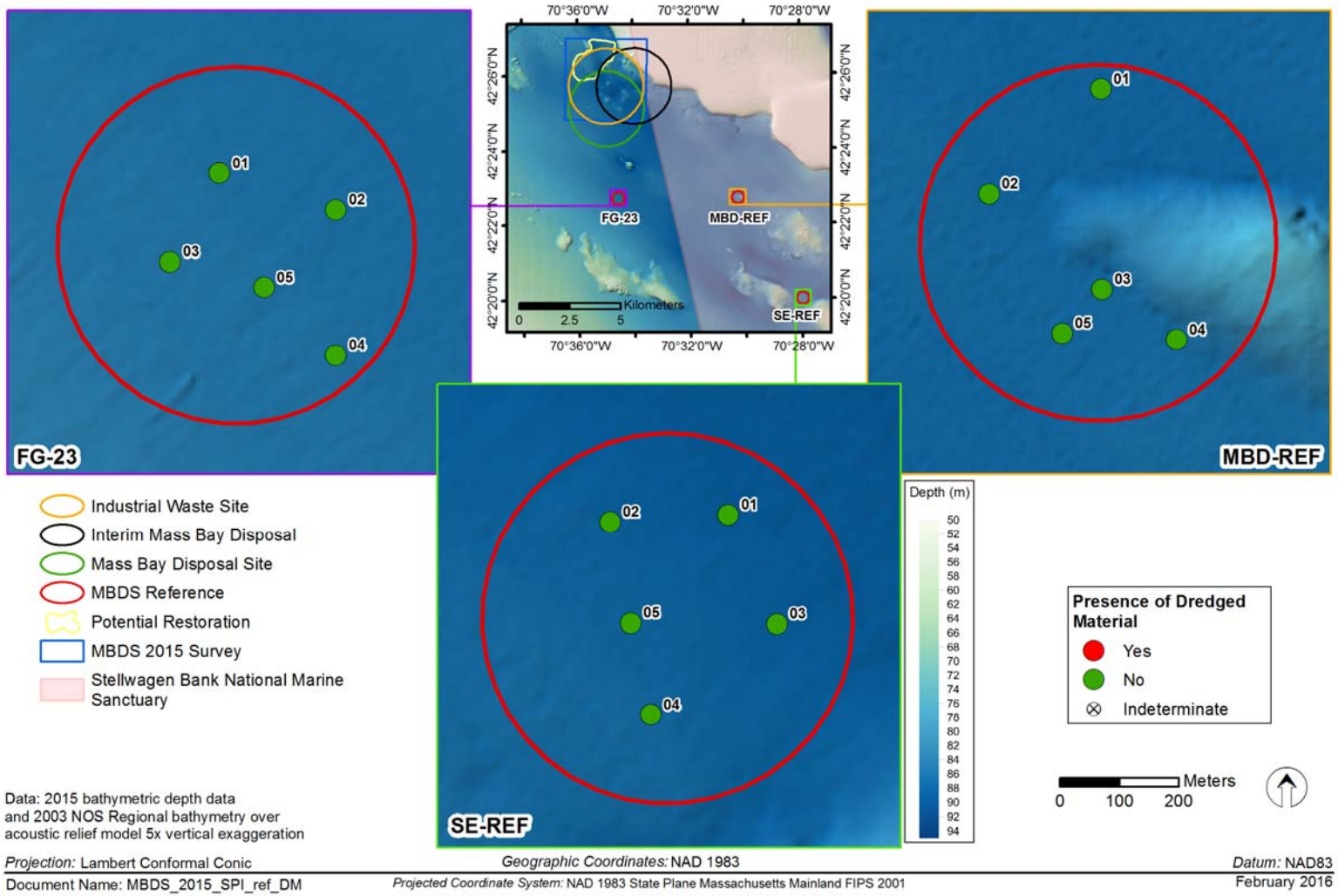



**Figure 3-8.** Spatial distribution of the presence of dredged material at the MBDS reference areas

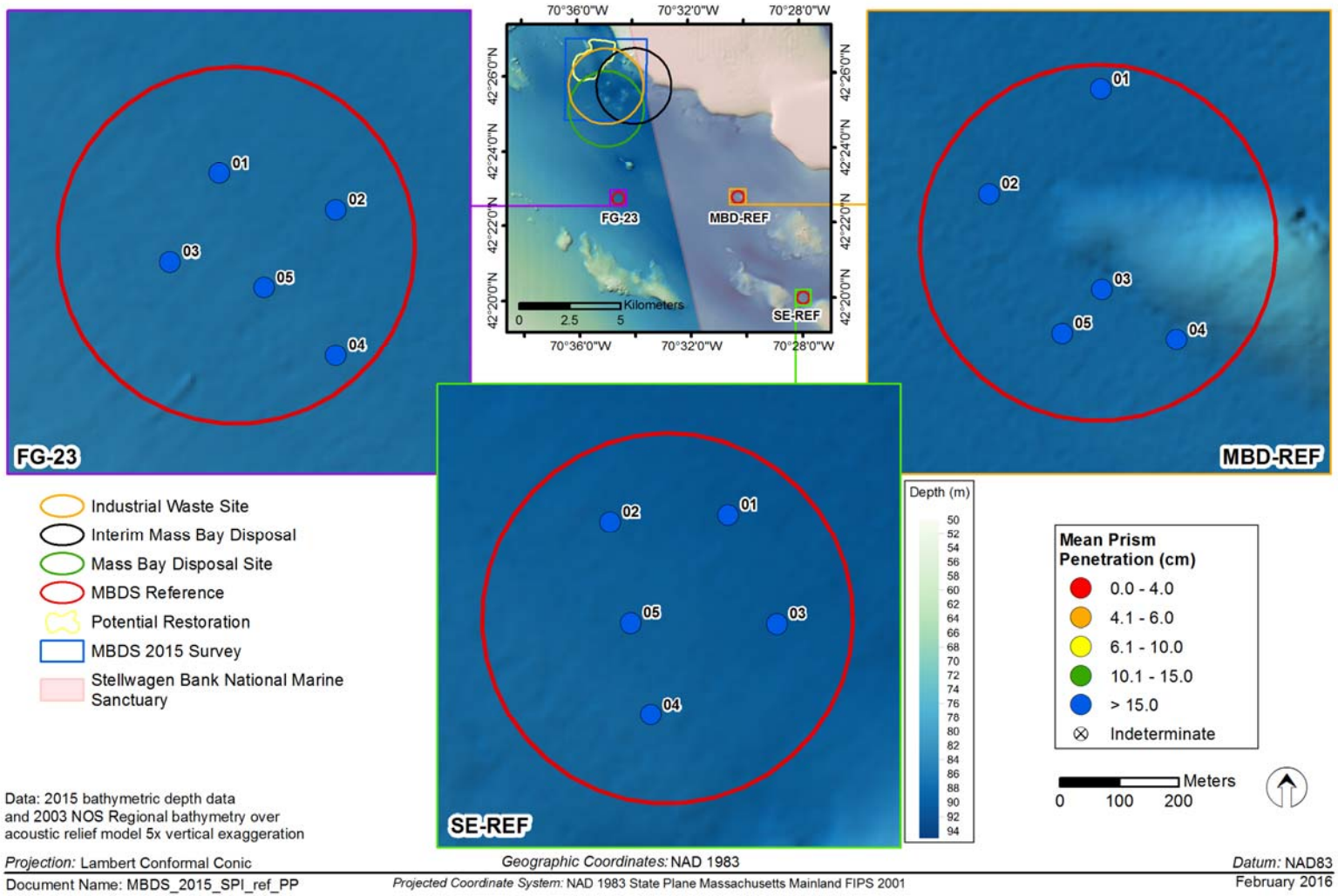



**Figure 3-9.** Spatial distribution of mean station camera prism penetration depths (cm) at the MBDS reference areas

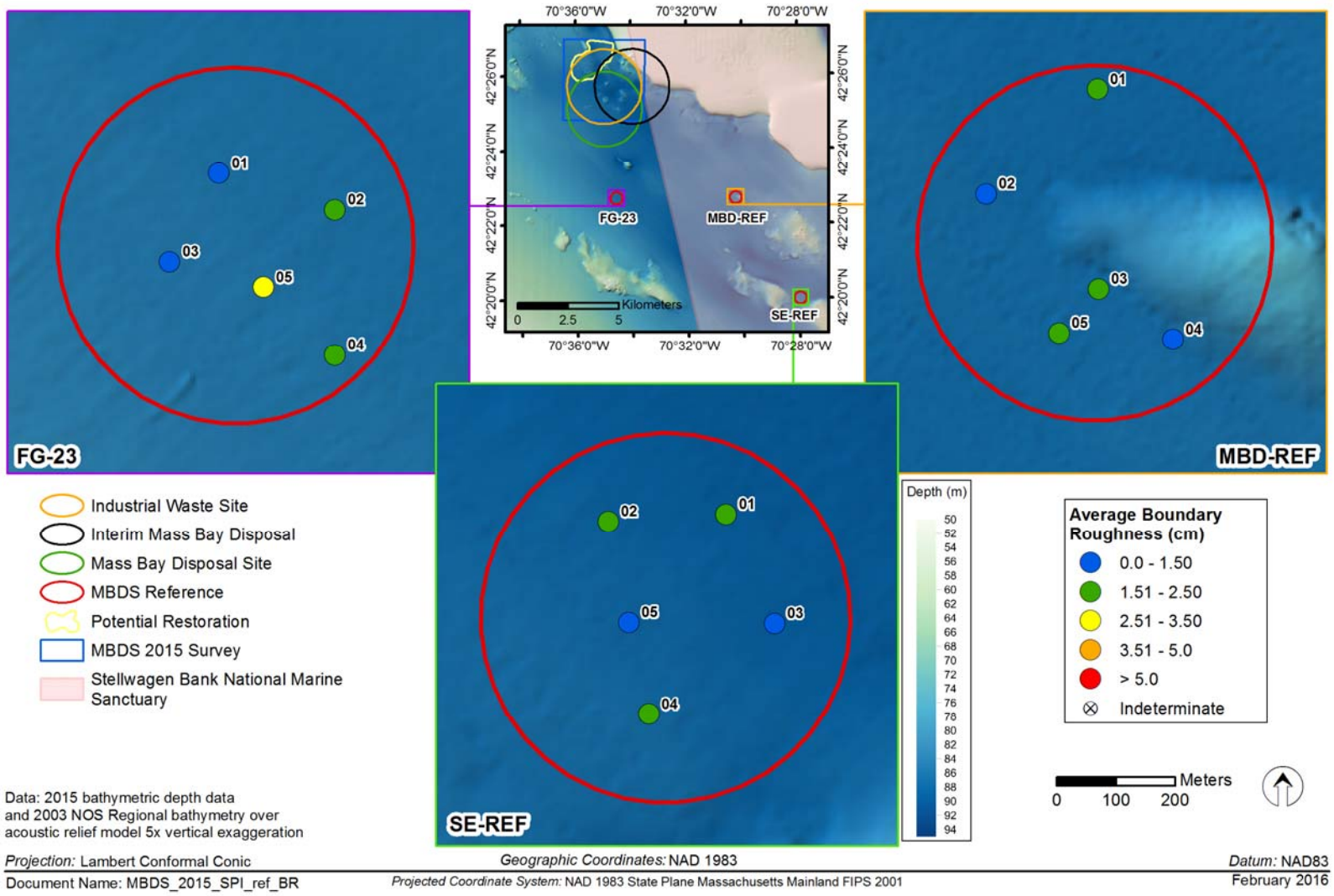



**Figure 3-10.** Spatial distribution of mean station small-scale boundary roughness values (cm) at the MBDS reference areas

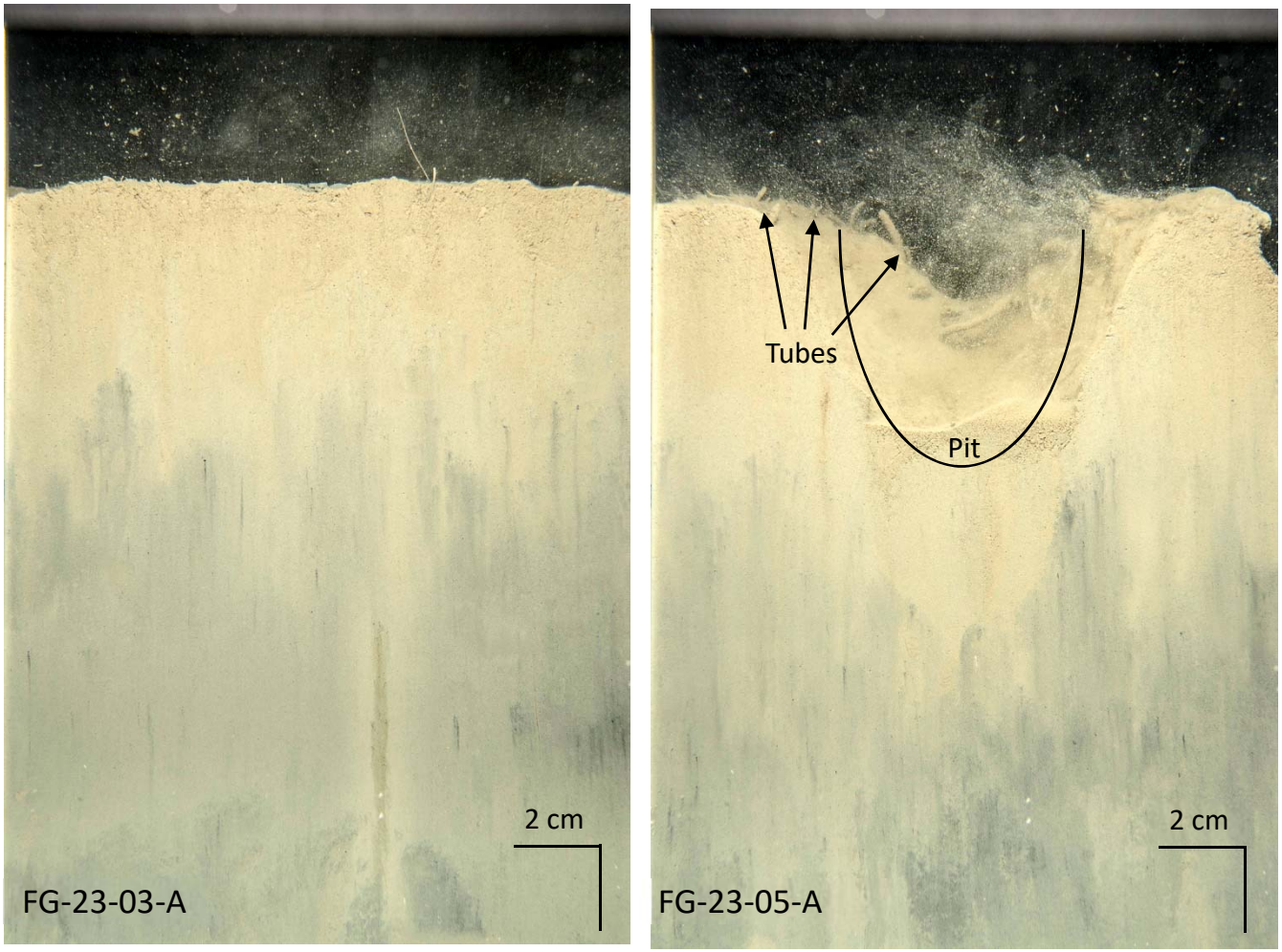
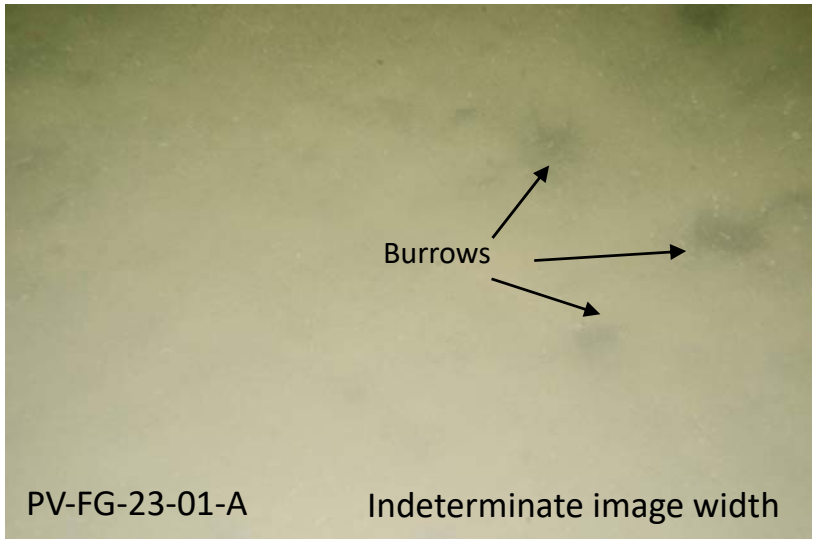
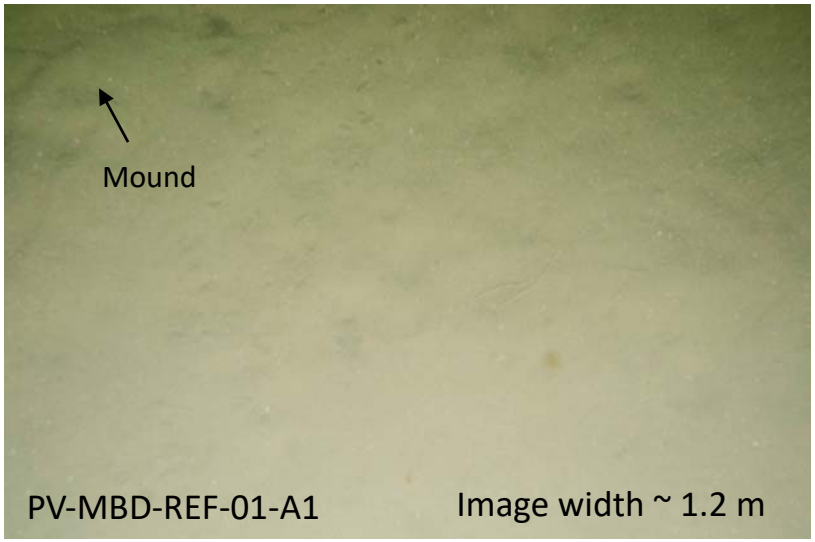


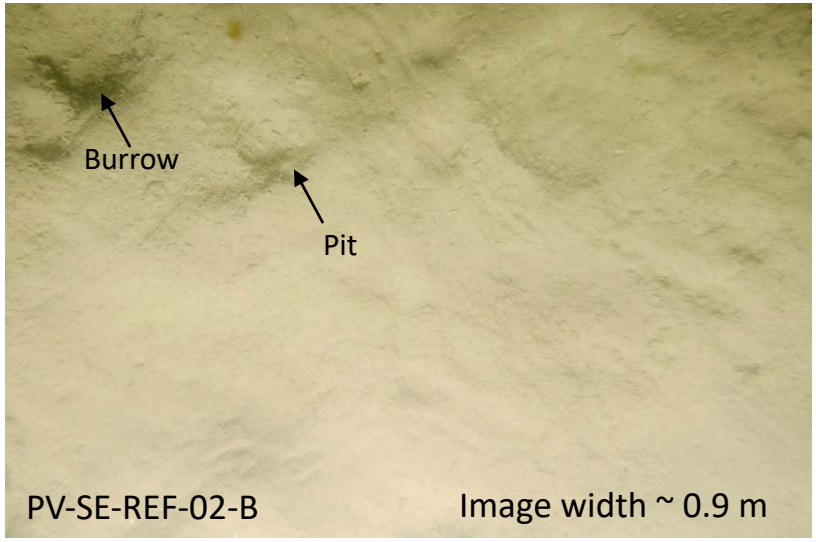

**Figure 3-11.** Sediment-profile images representing (A) reference area minimum small-scale boundary roughness at Station FG-23-03, and (B) reference area maximum small-scale boundary roughness with surface tubes, and biogenic pit at the sediment water interface at Station FG-23 -05




**(A)**




**(B)**




**(C)**

**Figure 3-12.** These plan-view images from Stations (A) FG-23-01, (B) MBD-REF-01, and (C) SE-REF-02 are representative of fine silt-clay and biological surface activity at the reference area stations; evidenced by burrows, pits, and mounds

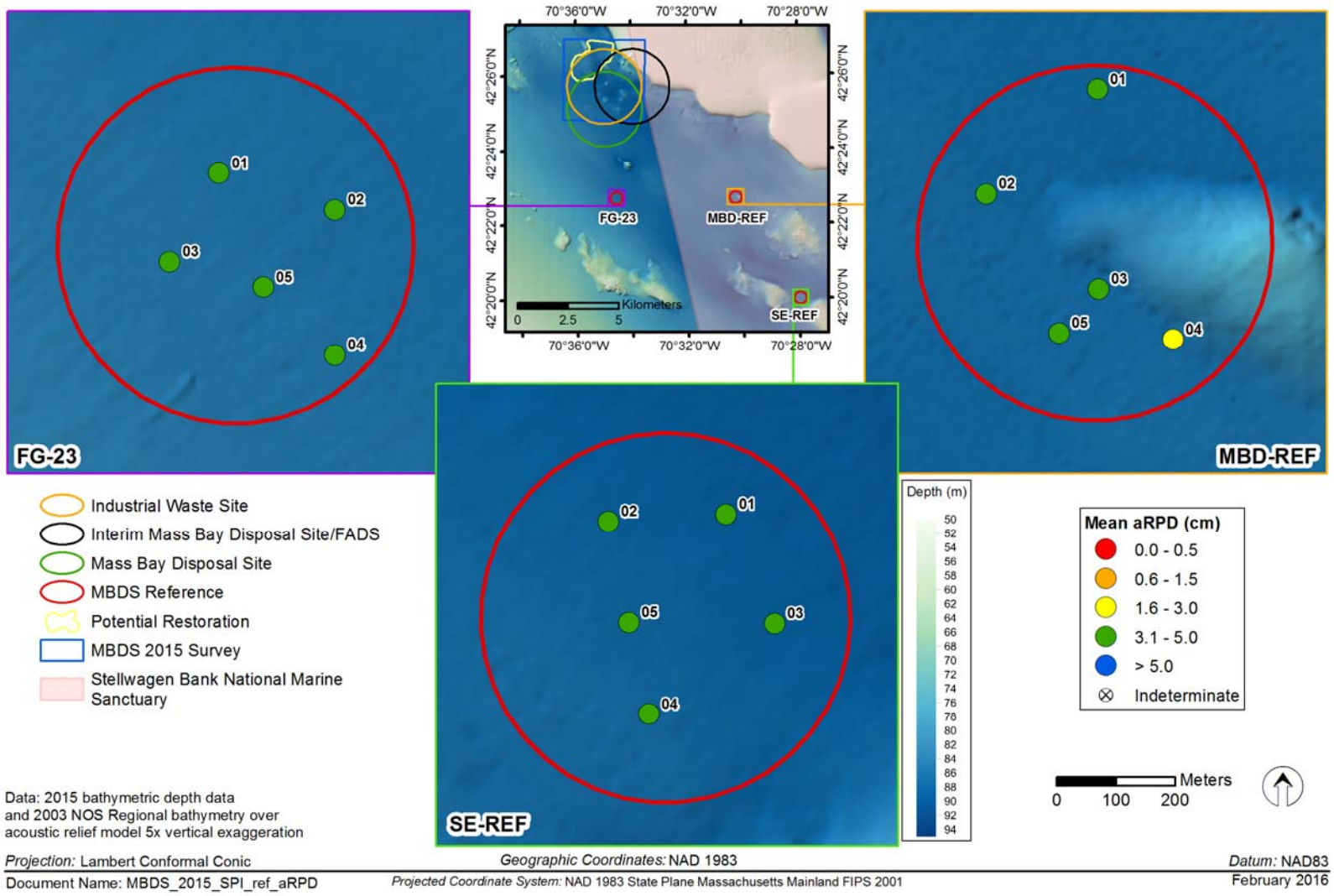



**Figure 3-13.** Spatial distribution of mean aRPD depth (cm) at the MBDS reference areas

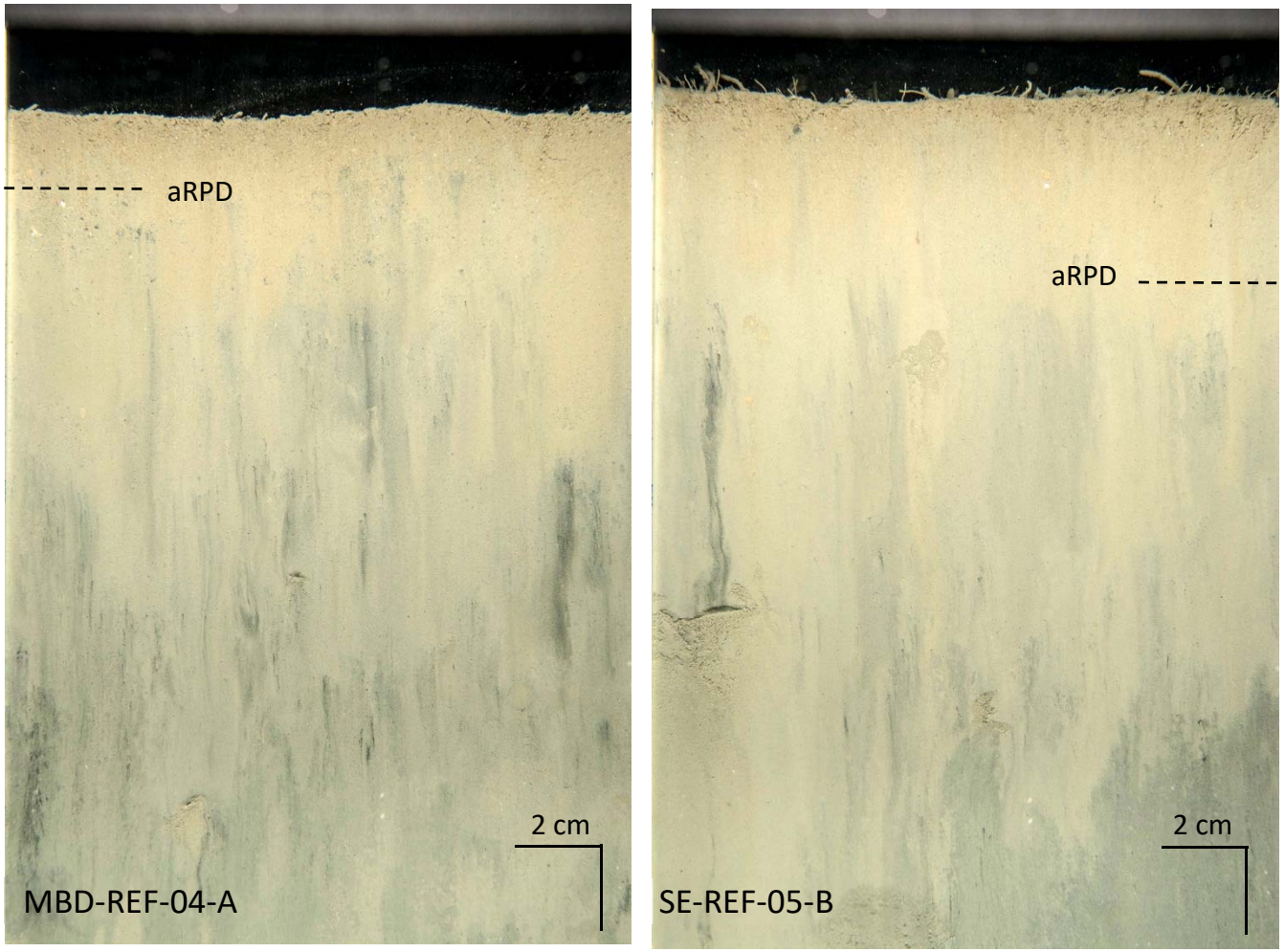



**Figure 3-14.** Sediment-profile images representing (A) reference area minimum aRPD depth at Station MBD-REF-04, and (B) reference area maximum aRPD depth at Station SE-REF-05-B

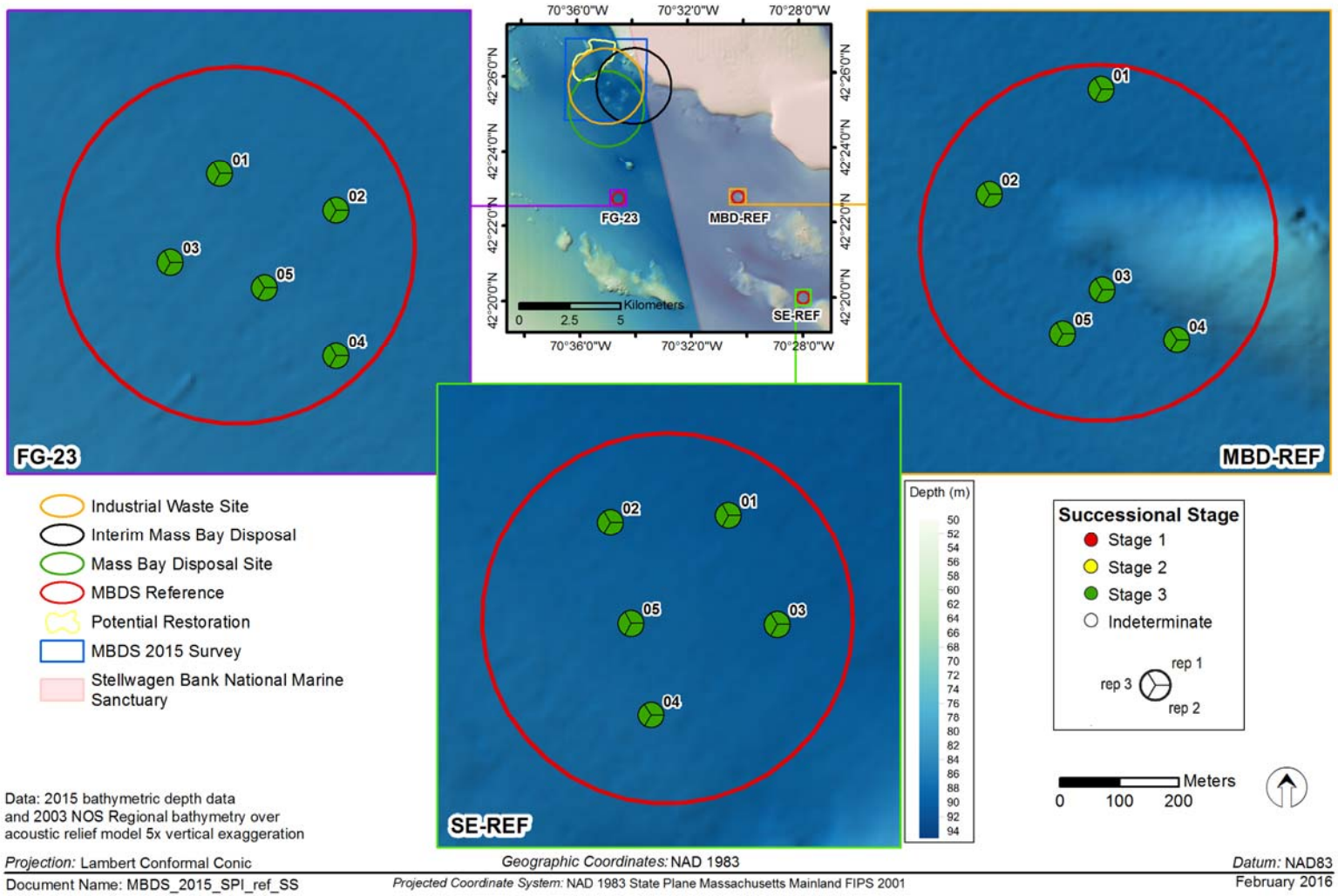



**Figure 3-15.** Spatial distribution of infaunal successional stages found at locations sampled in the three MBDS reference areas

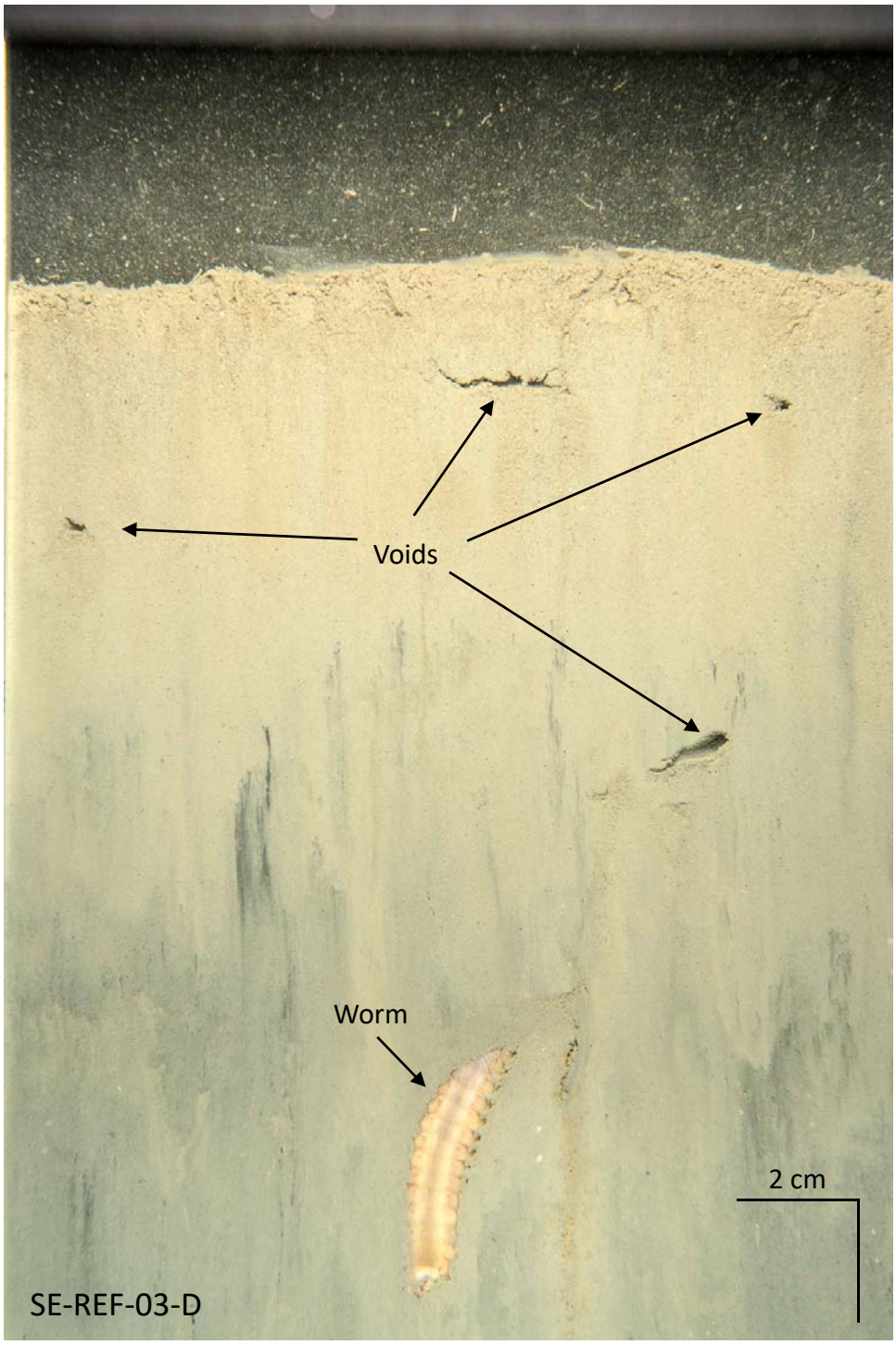



**Figure 3-16.** Sediment-profile image from Station SE-REF-03 is representative of Stage 3 infauna; feeding voids and presence of extra-large worm is visible in the sediment column

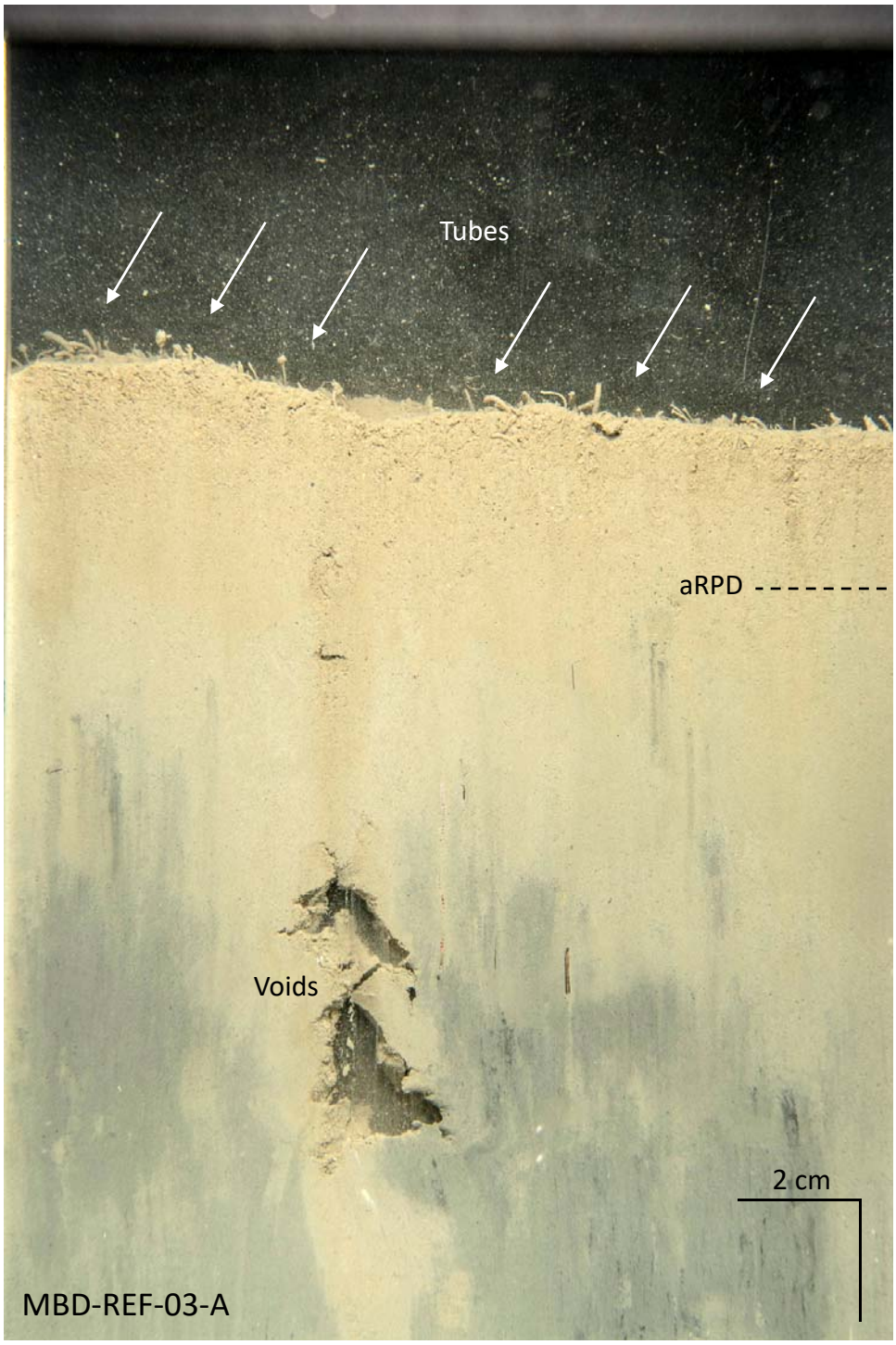



**Figure 3-17.** Sediment-profile image from Station MBD-REF-03 is representative of Stage 1 on 3 infauna; surface tubes at the sediment-water interface (white arrows) with large feeding voids observed in the sediment column below the aRPD

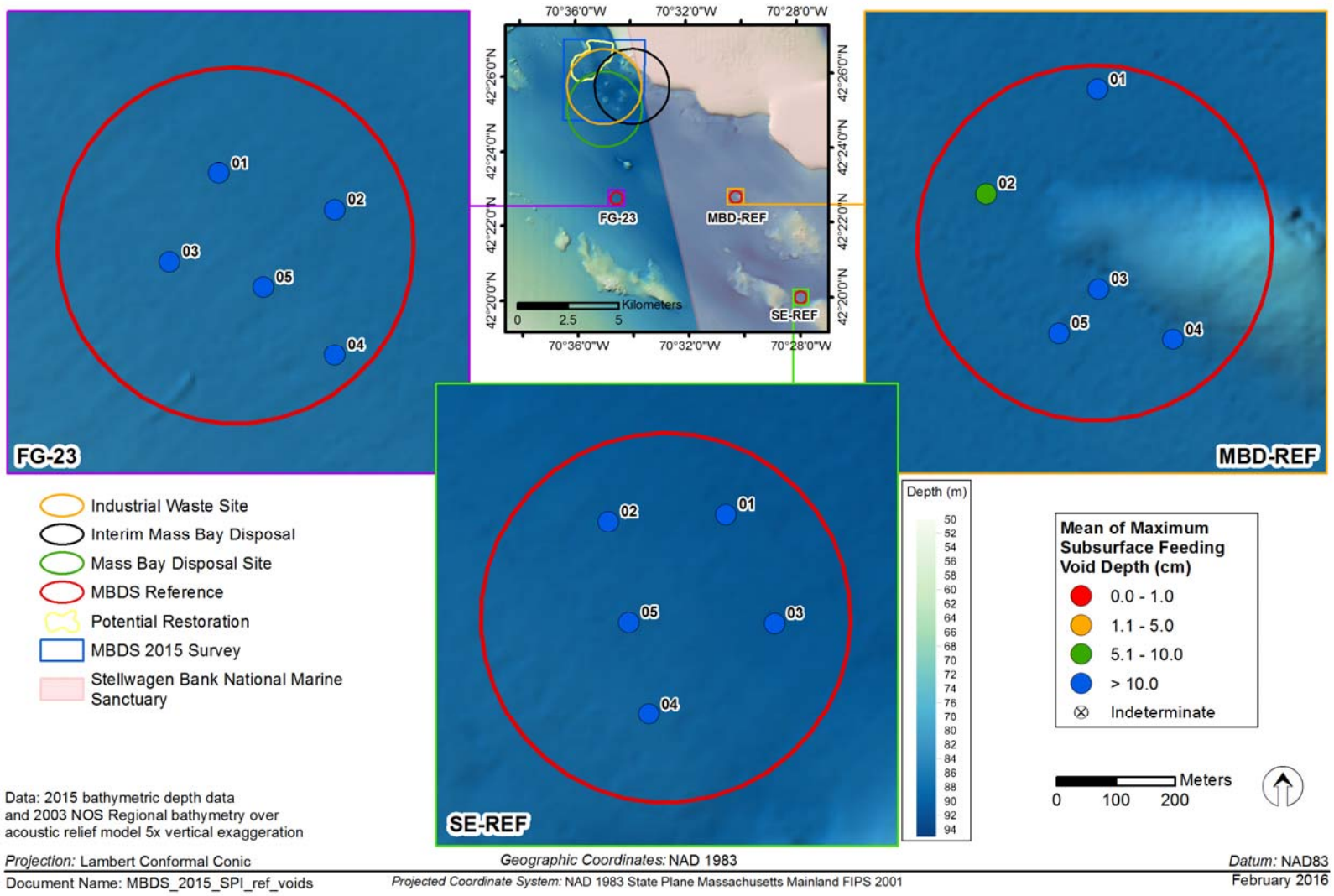
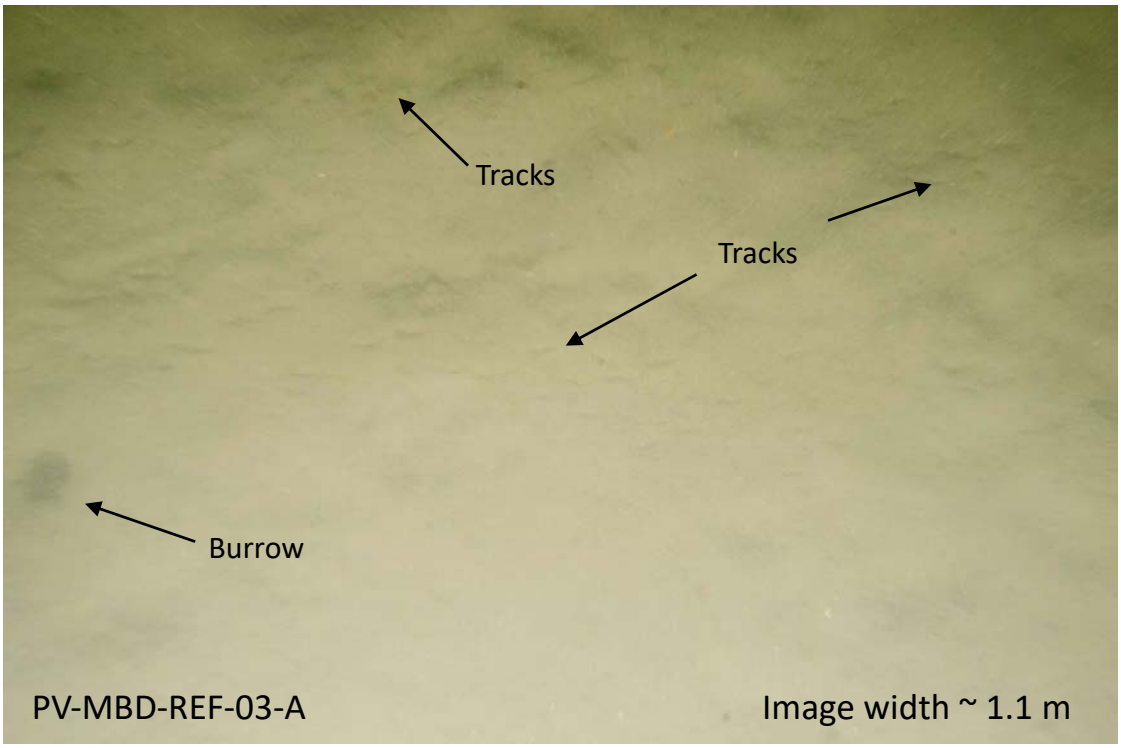
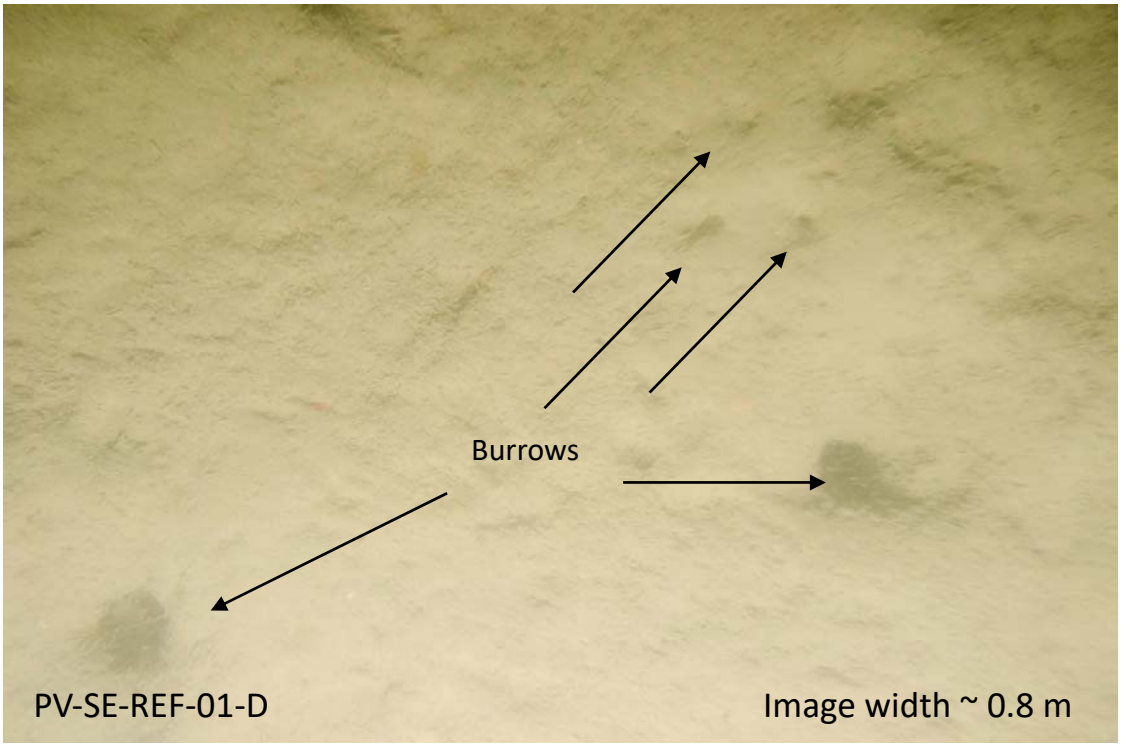



**Figure 3-18.** Spatial distribution of the mean of maximum subsurface feeding void depth (cm) at the MBDS reference areas

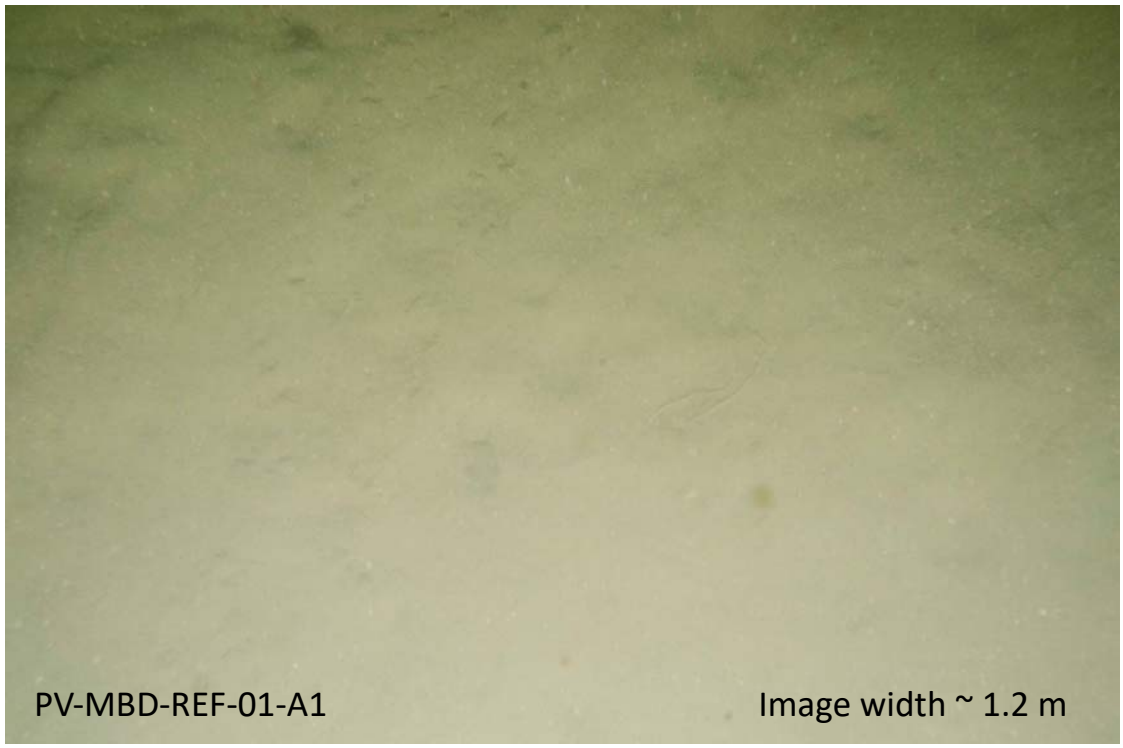



**(A)**

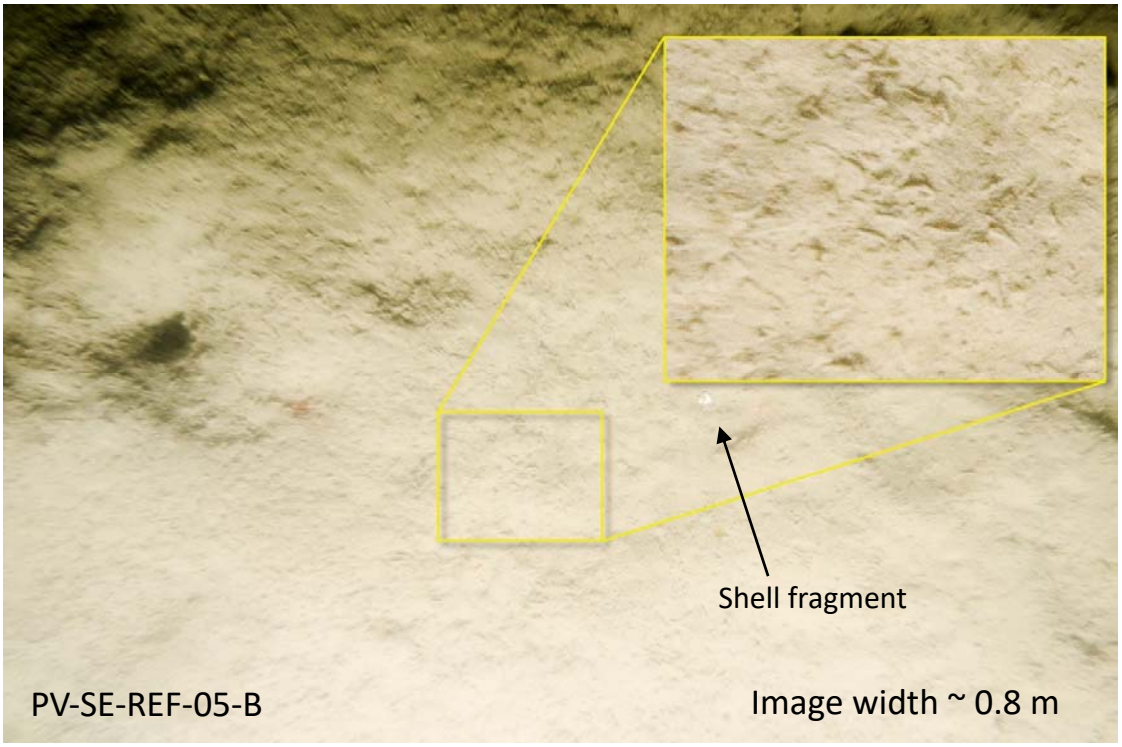



**(B)**

**Figure 3-19.** Plan-view images from (A) Station MBD-REF-03 representative of <10% burrow coverage and presence of tracks on the seafloor, and (B) Station SE-REF-01 representative of 10-25% burrow coverage




**(A)**




**(B)**

**Figure 3-20.** Plan-view images from (A) Station MBD-REF-01 representative of 10-25% coverage of tubes, and (B) Station SE-REF-05 representative of >75% coverage of tubes covering the seafloor with some small shell fragments

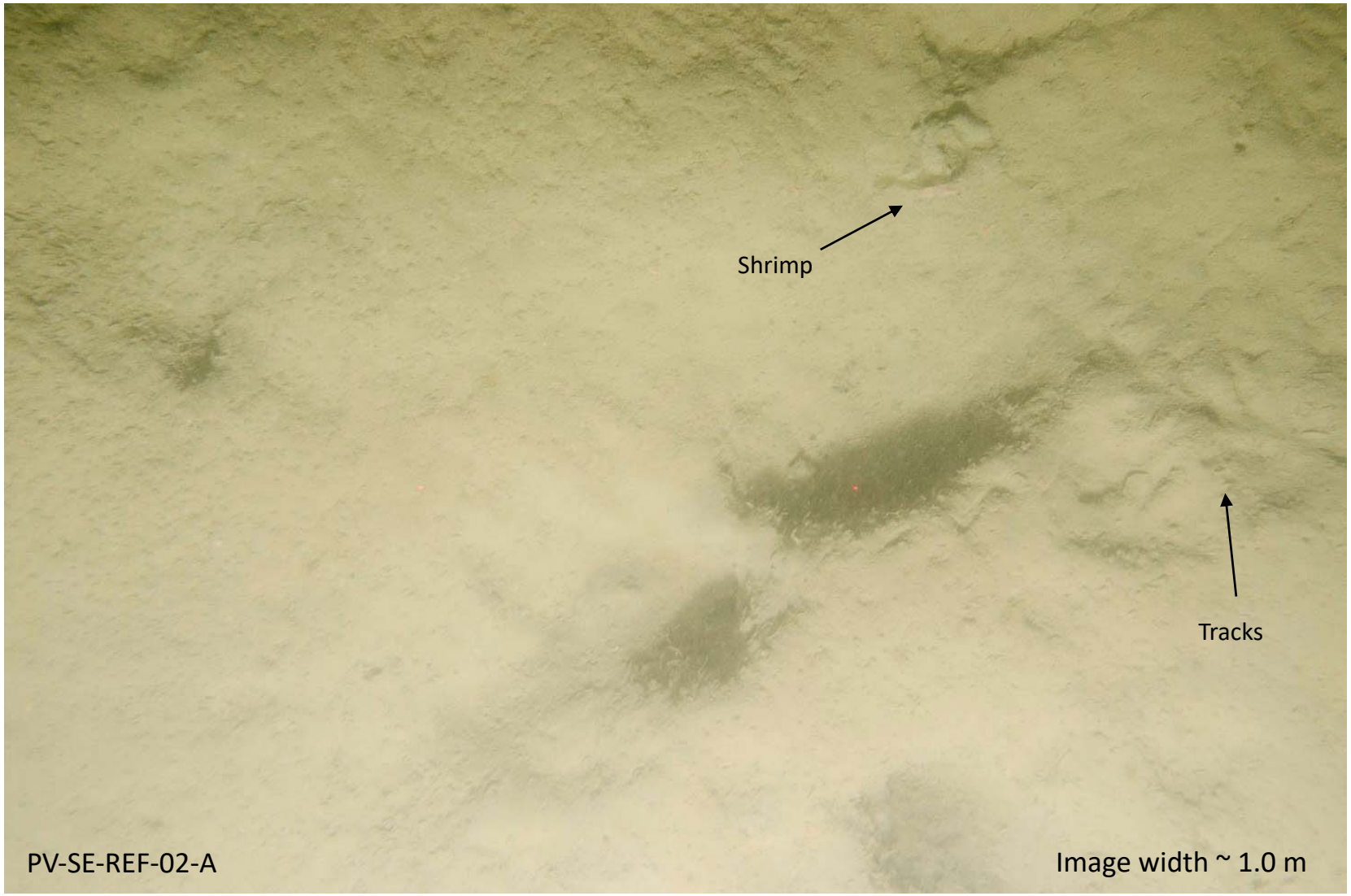



**Figure 3-21.** Plan-view image from Station SE-REF-02 depicting tracks and a shrimp on the seafloor

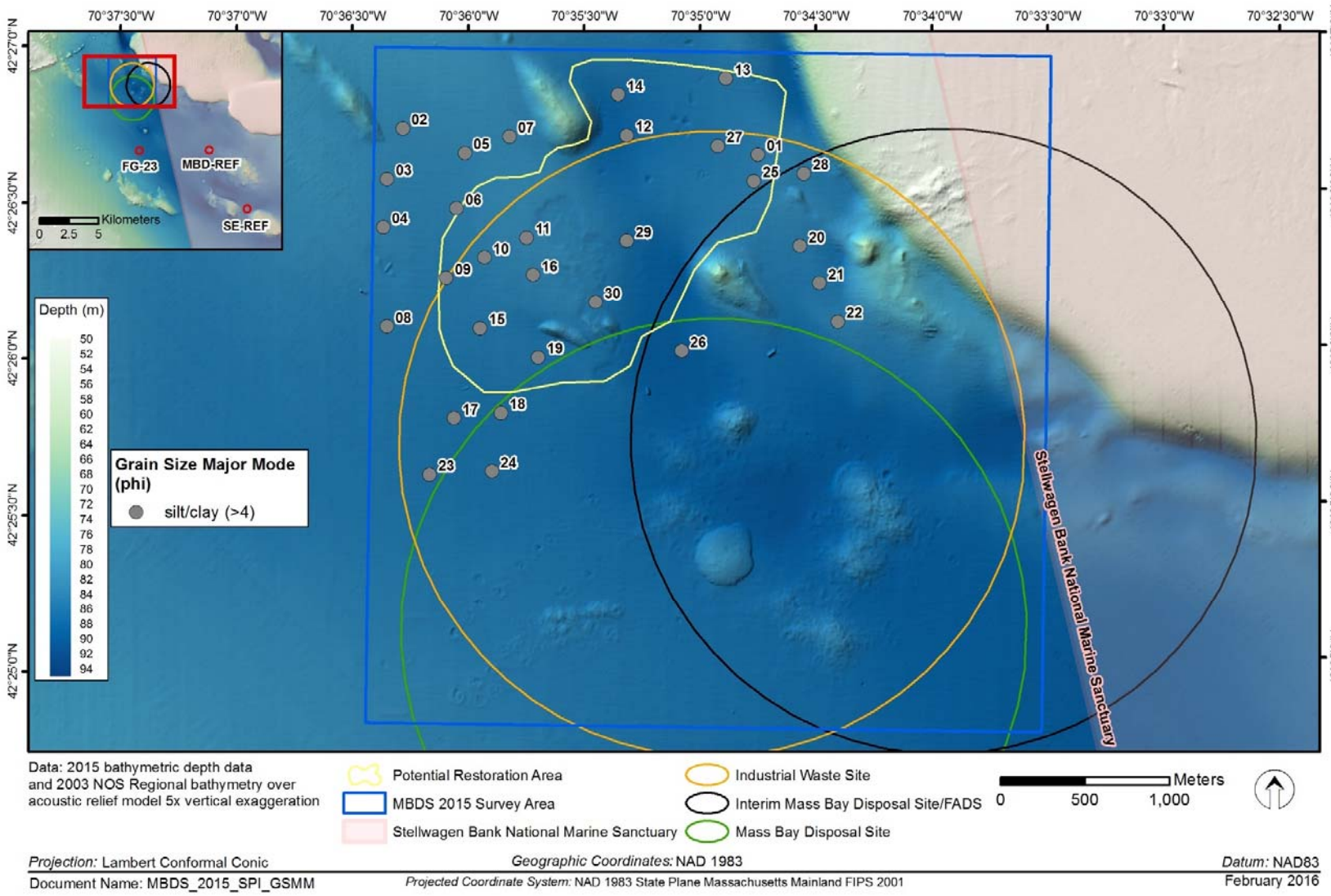



**Figure 3-22.** Spatial distribution of sediment grain size major mode (phi units) at the MBDS survey area


**Figure 3-23.** Sediment-profile image from Station MBDS-08 is representative of the >4 phi (silt-clay) grain size major mode, and pelletized sediment-water interface, present at the majority of stations in the MBDS survey area


**Figure 3-24.** Sediment-profile image from Station MBDS-11 depicting light brown silt-clay with a depositional layer of white glacial clay dredged material


**Figure 3-25.** Sediment-profile image from Station MBDS-24 is representative of a sediment column with light brown silt-clay over a darker silt-clay

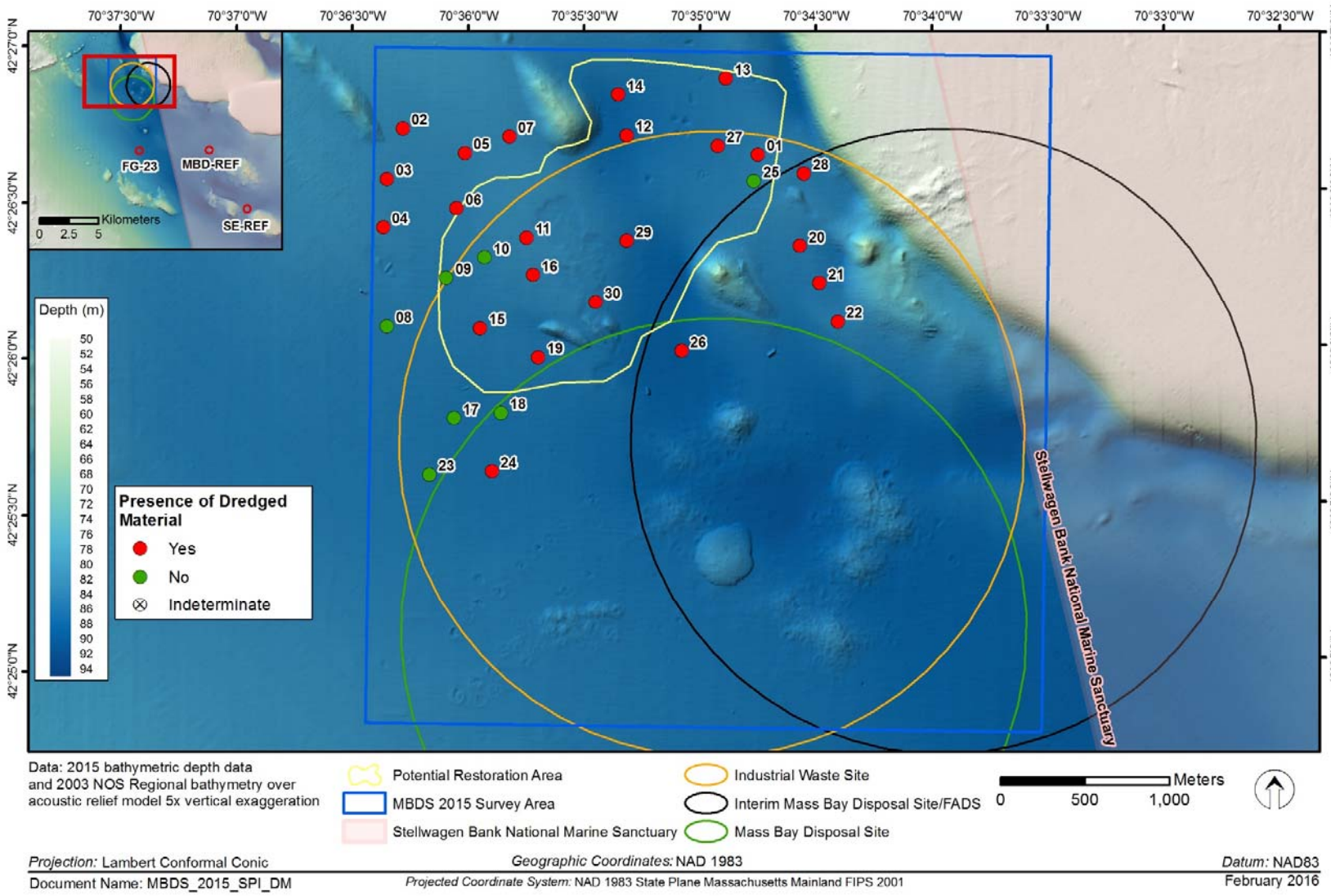



**Figure 3-26.** Spatial distribution of the presence of dredged material at the MBDS survey area

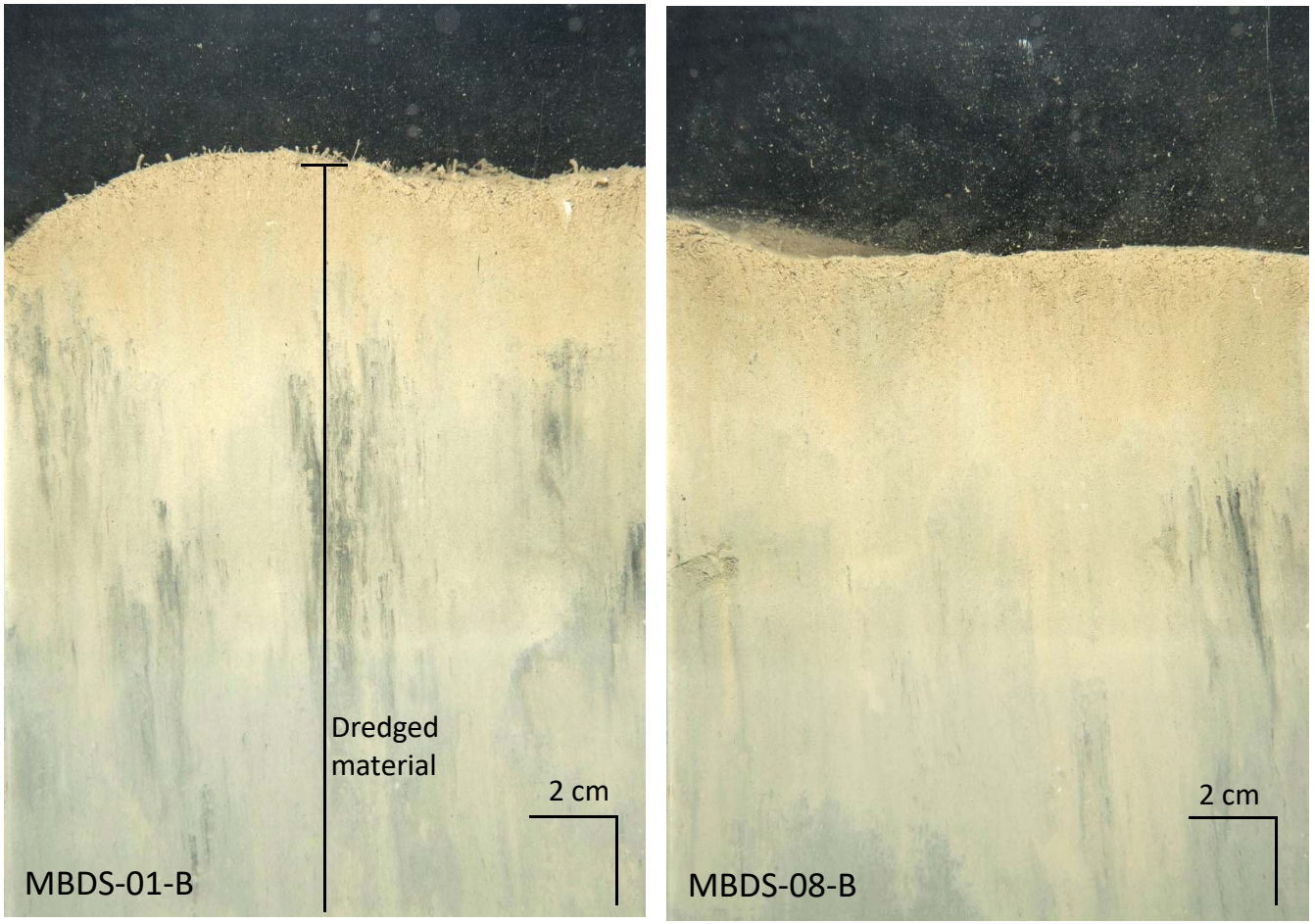



**Figure 3-27.** Representative sediment-profile images from (A) Station MBDS-01 depicting a sediment column with reworked dredged material extending below the prism penetration maximum, and (B) Station MBDS-08 which contains no dredged material

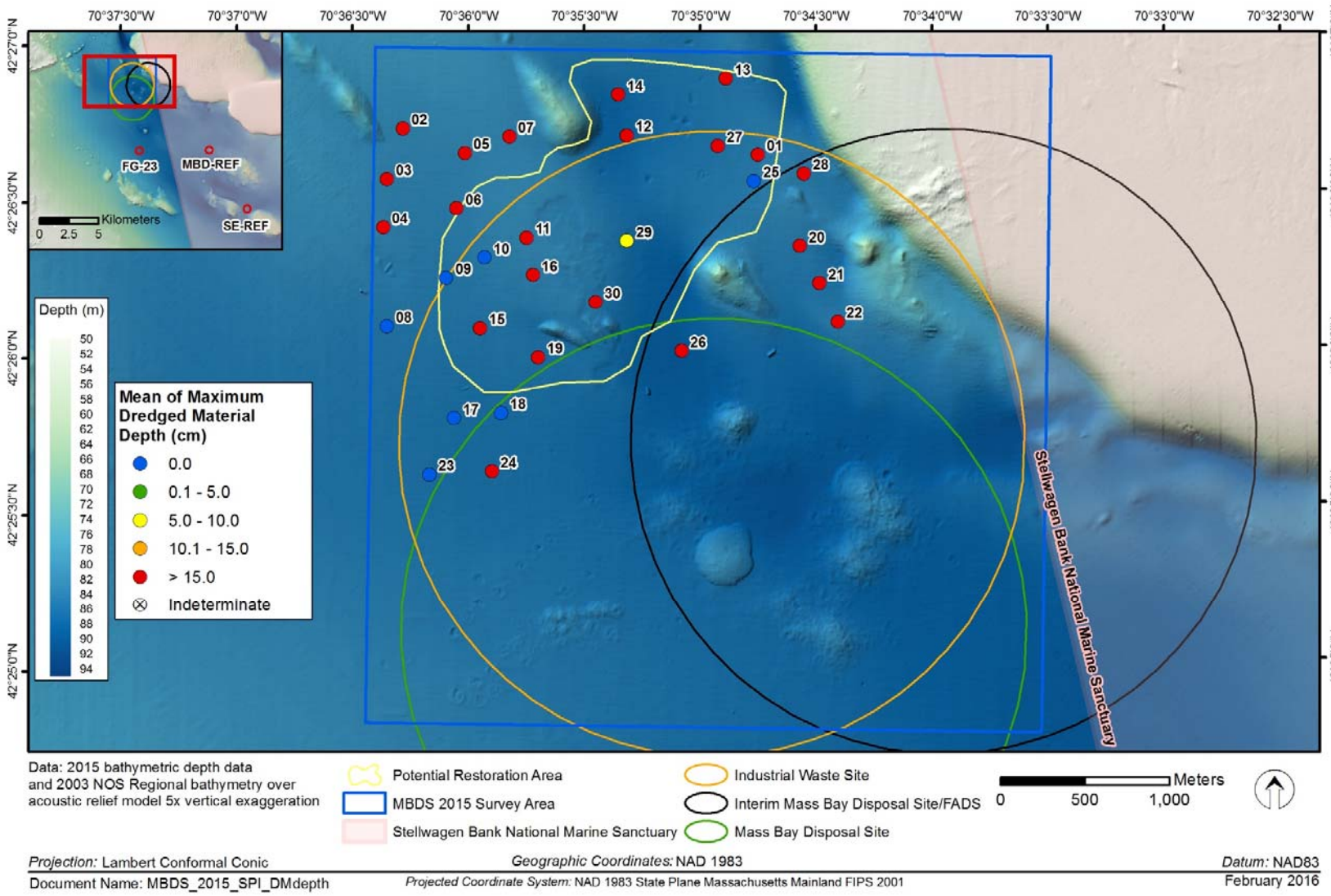



**Figure 3-28.** Spatial distribution of the mean of maximum dredged material depth (cm) at the MBDS survey area

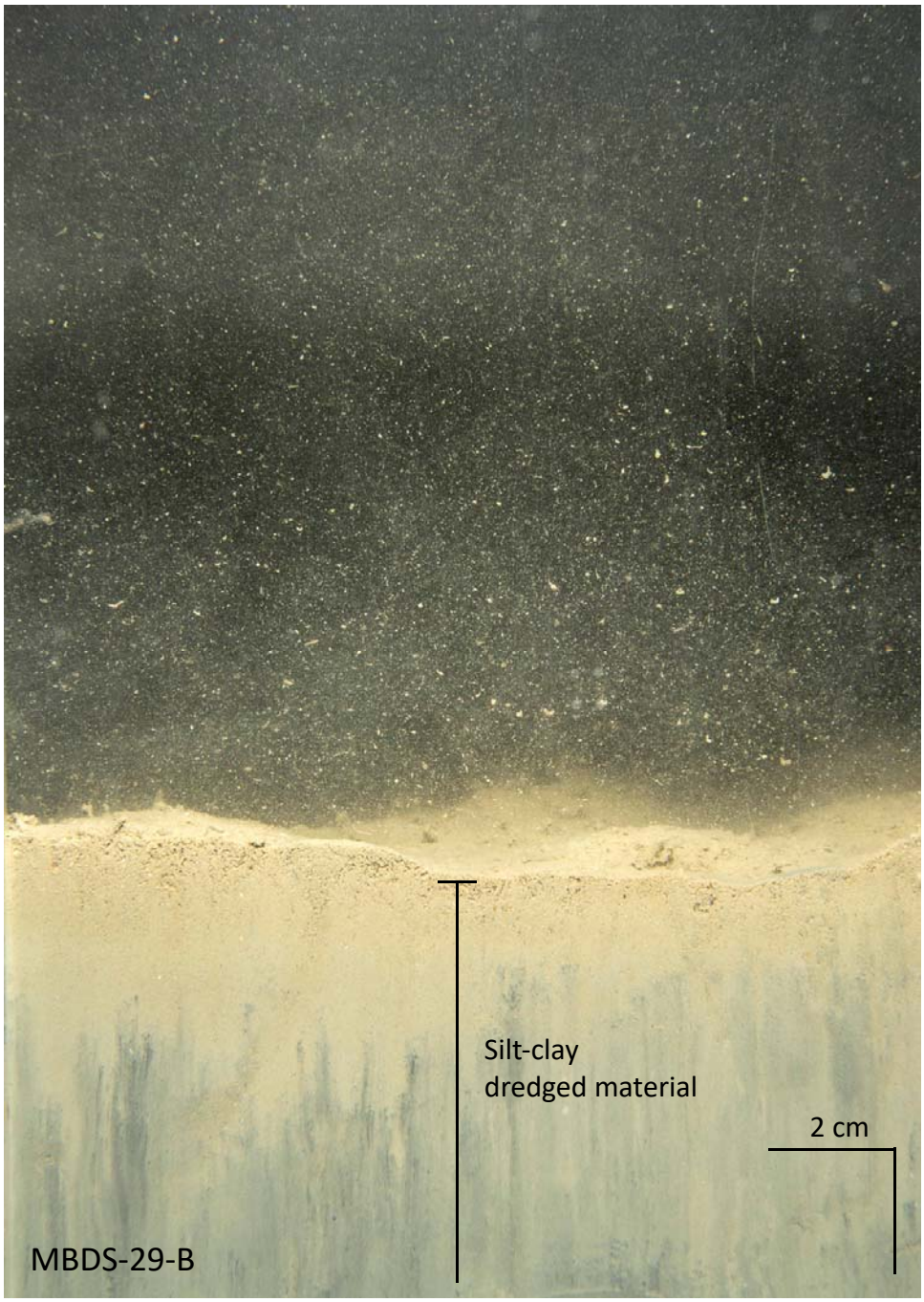



**Figure 3-29.** Sediment-profile image from Station MBDS-29 is representative of the relatively low prism penetration with a sediment column of reworked silt-clay dredged material

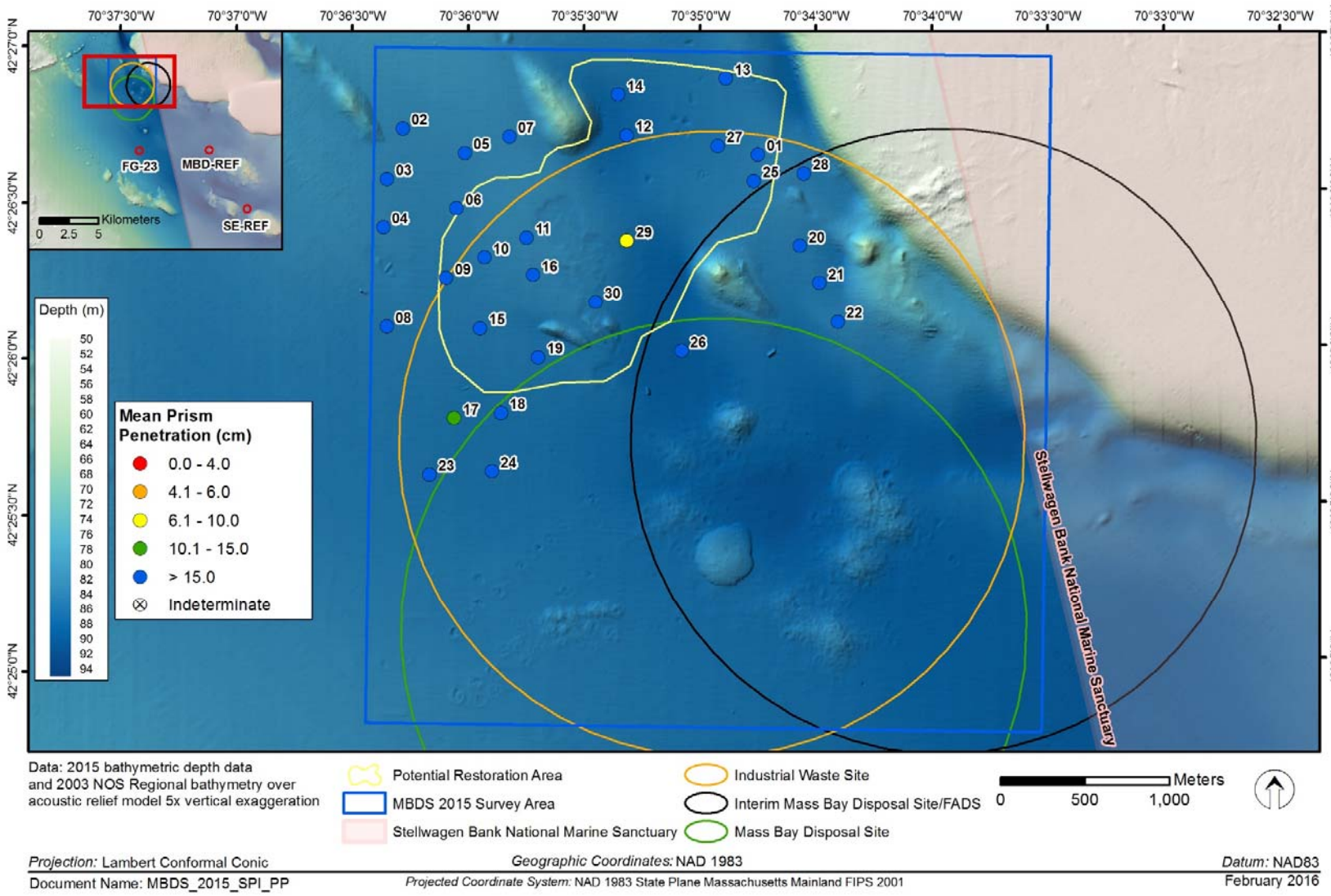



**Figure 3-30.** Spatial distribution of mean station camera prism penetration depths (cm) at the MBDS survey area

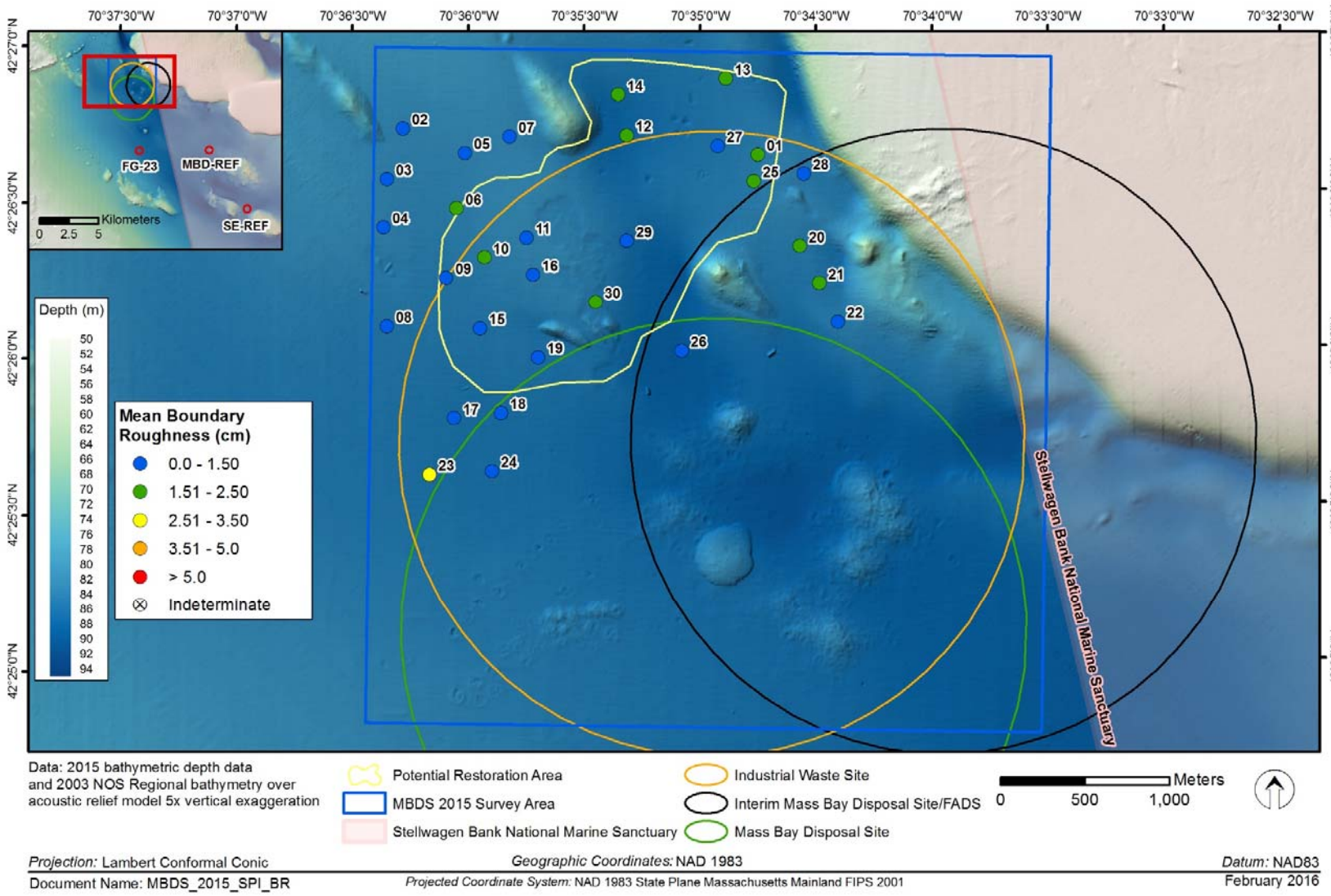



**Figure 3-31.** Spatial distribution of mean station small-scale boundary roughness values (cm) at the MBDS survey area

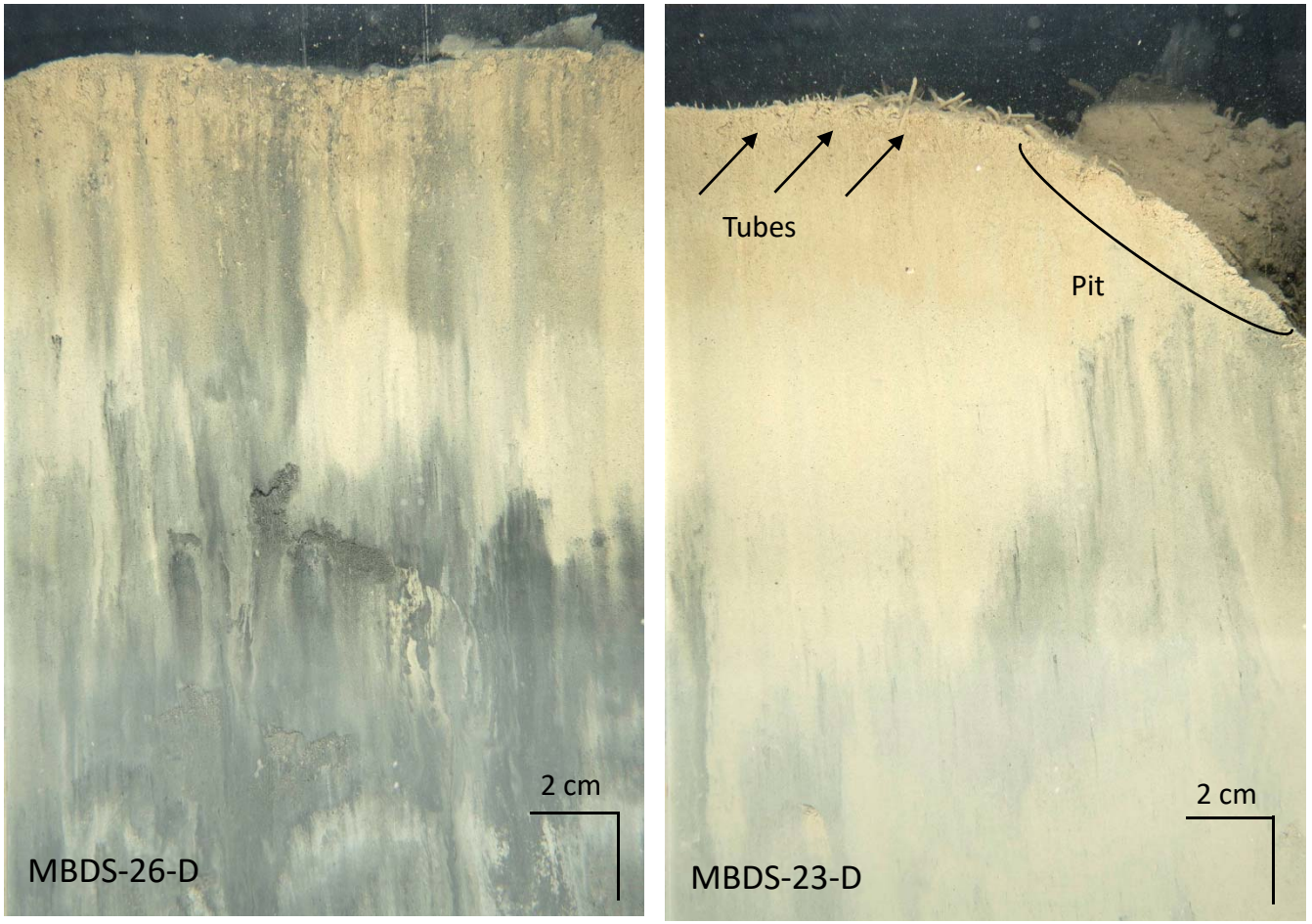
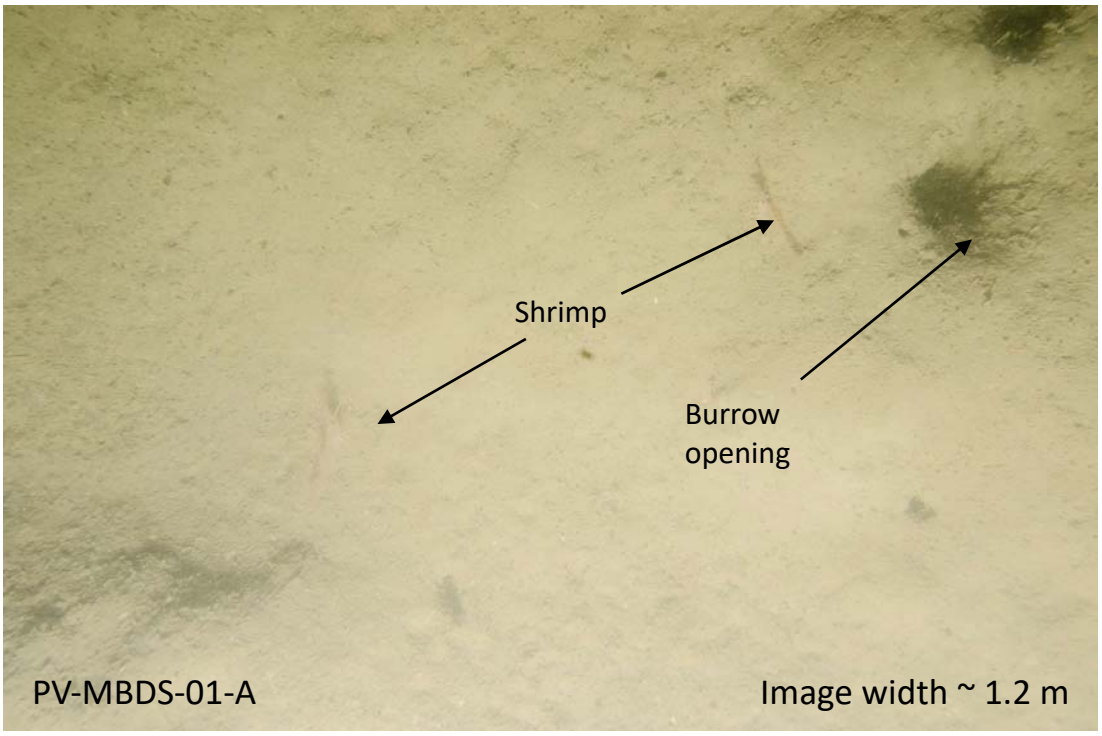
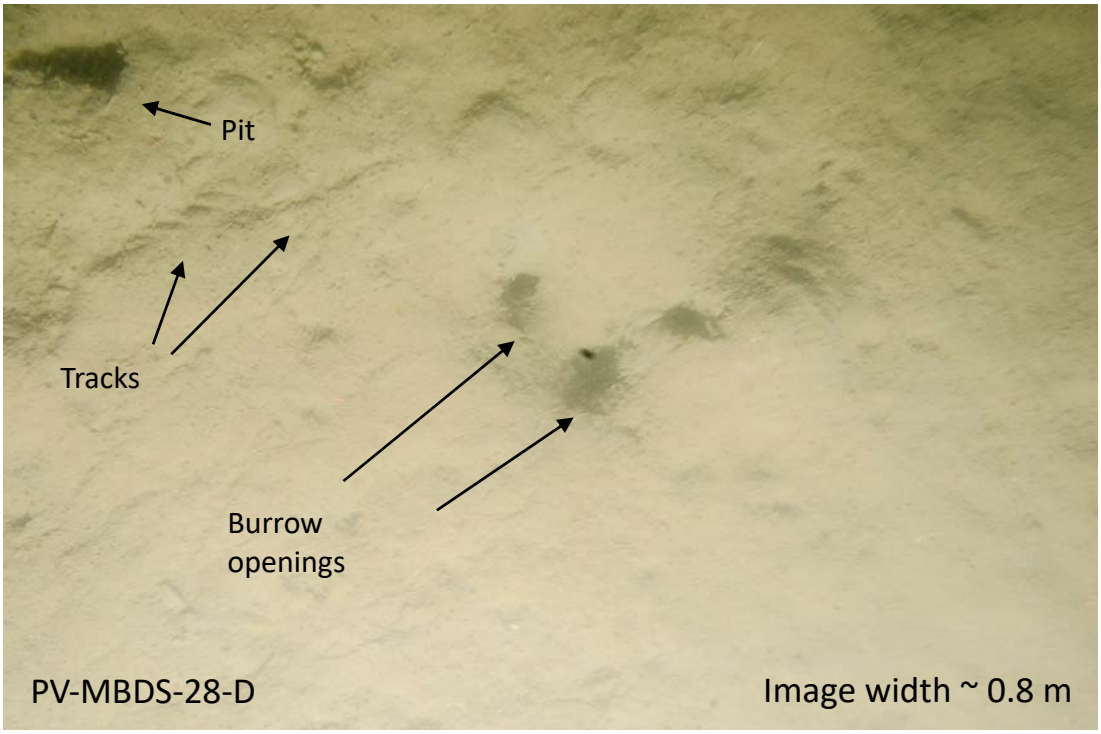



**Figure 3-32.** Sediment-profile images representing (A) minimum small-scale boundary roughness at Station MBDS-26; and (B) maximum small-scale boundary roughness at Station MBDS-23 with surface tubes (arrows), and biogenic pit at the sediment water interface




**(A)**




**(B)**

**Figure 3-33.** These plan-view images from (A) Station MBDS-01 and (B) Station MBDS-28 are representative of fine silt-clay and biological surface activity evidenced by the small burrow openings, pits, mounds, and tracks. Shrimp were observed on the seafloor at MBDS-01.

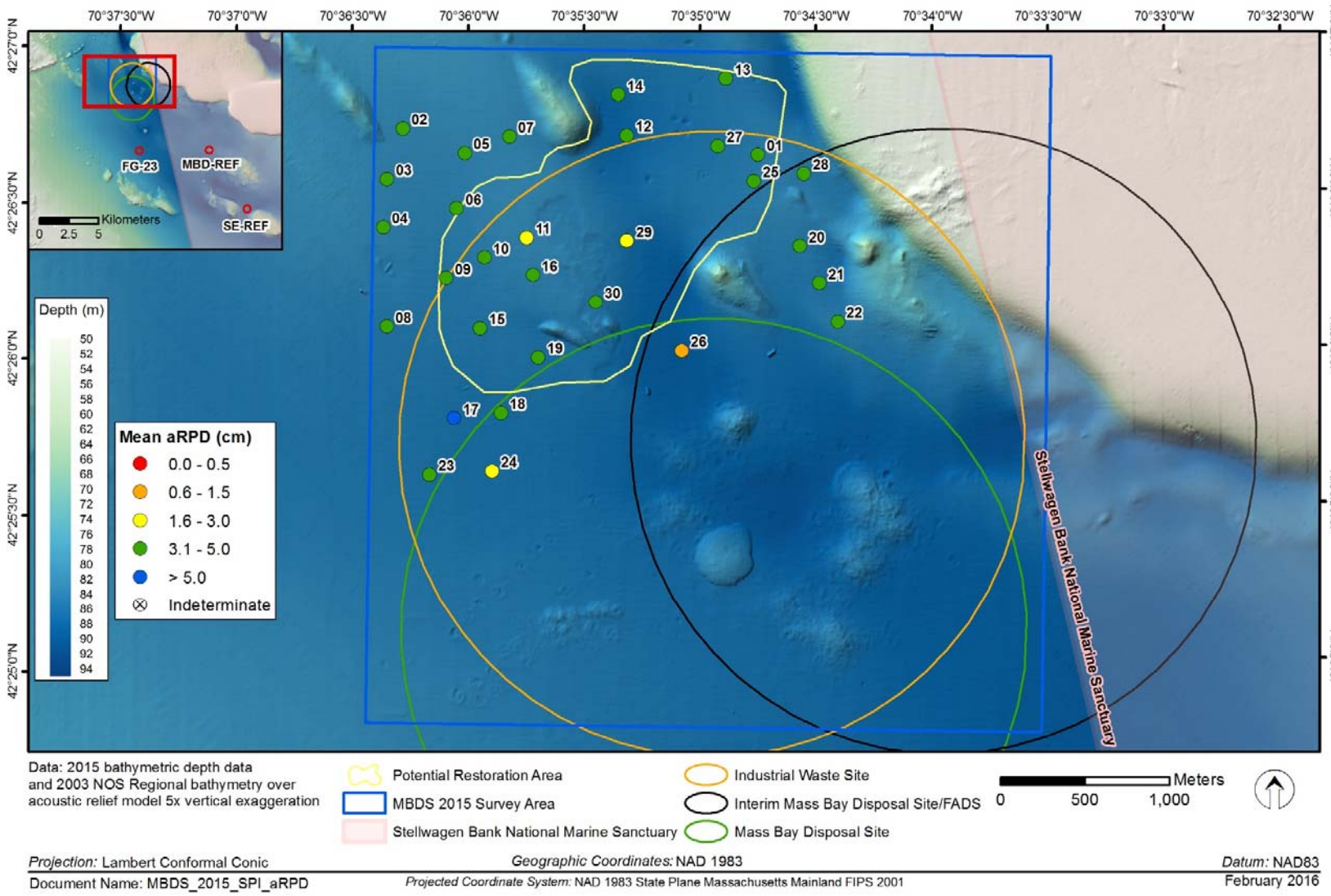



**Figure 3-34.** Spatial distribution of mean aRPD depth (cm) at the MBDS survey area

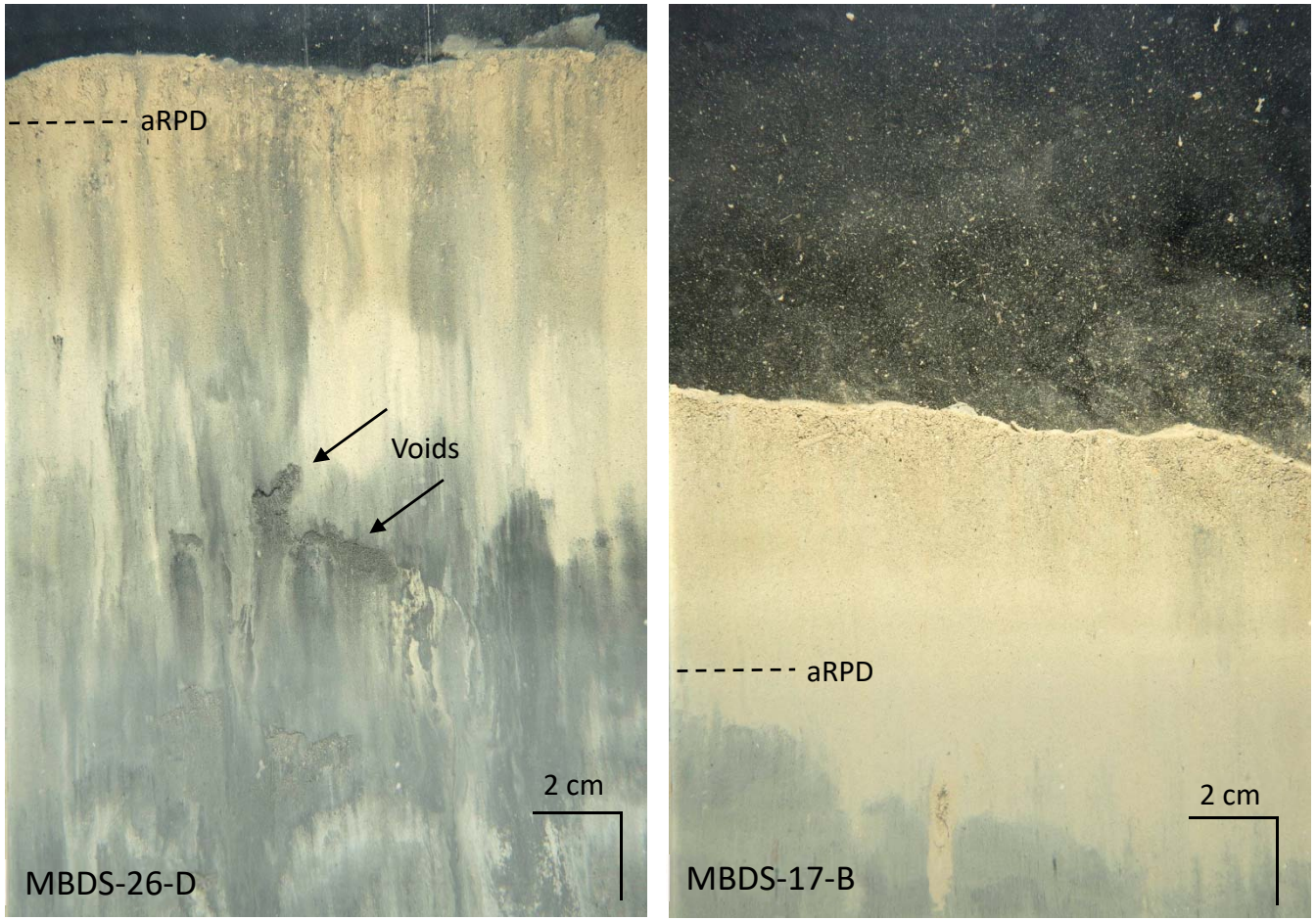



**Figure 3-35.** Sediment-profile images representing (A) minimum aRPD depth observed at Station MBDS-26 with a Stage 3 successional designation; and (B) maximum aRPD depth observed at Station MBDS-17

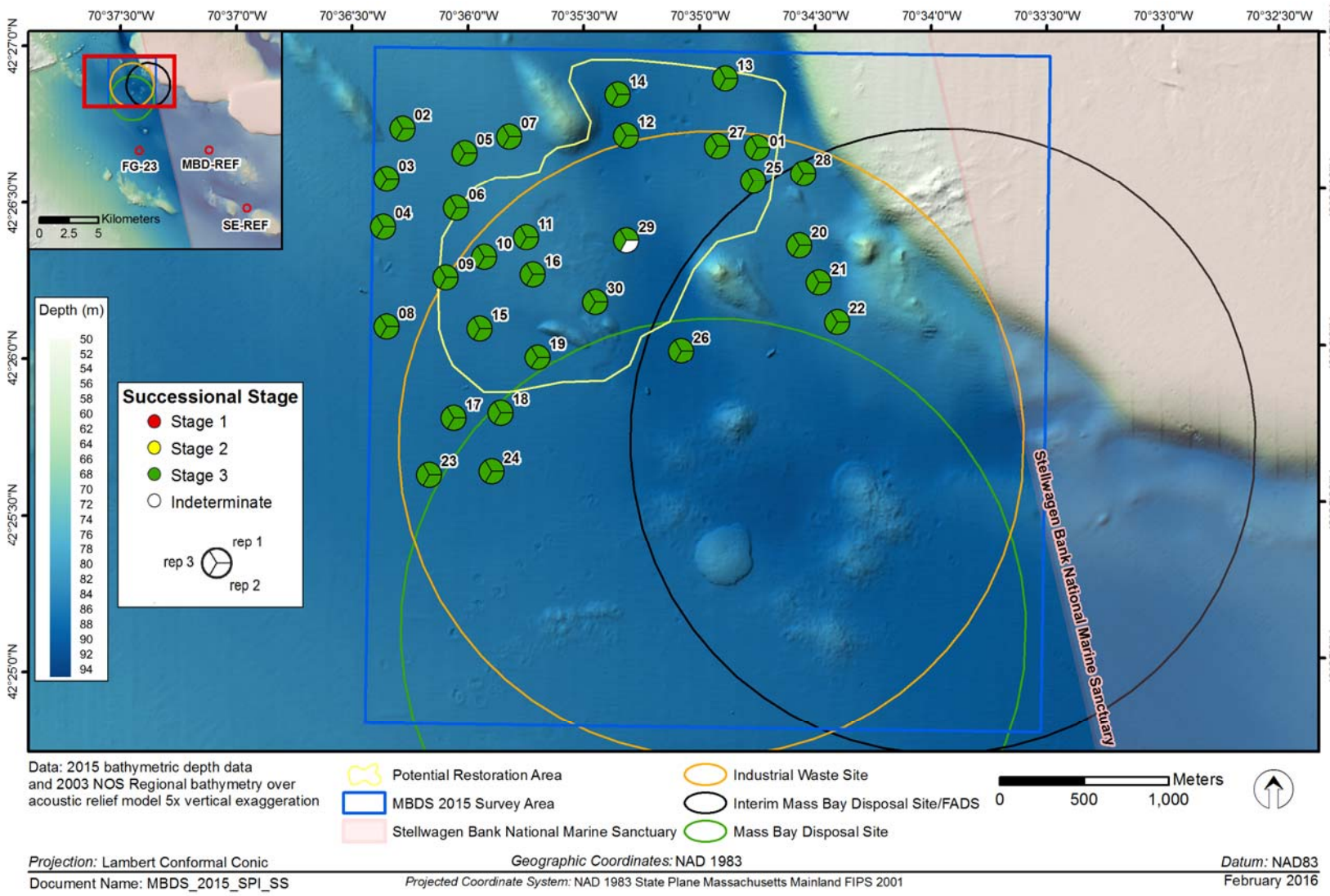



**Figure 3-36.** Spatial distribution of infaunal successional stages found at locations sampled in the MBDS survey area

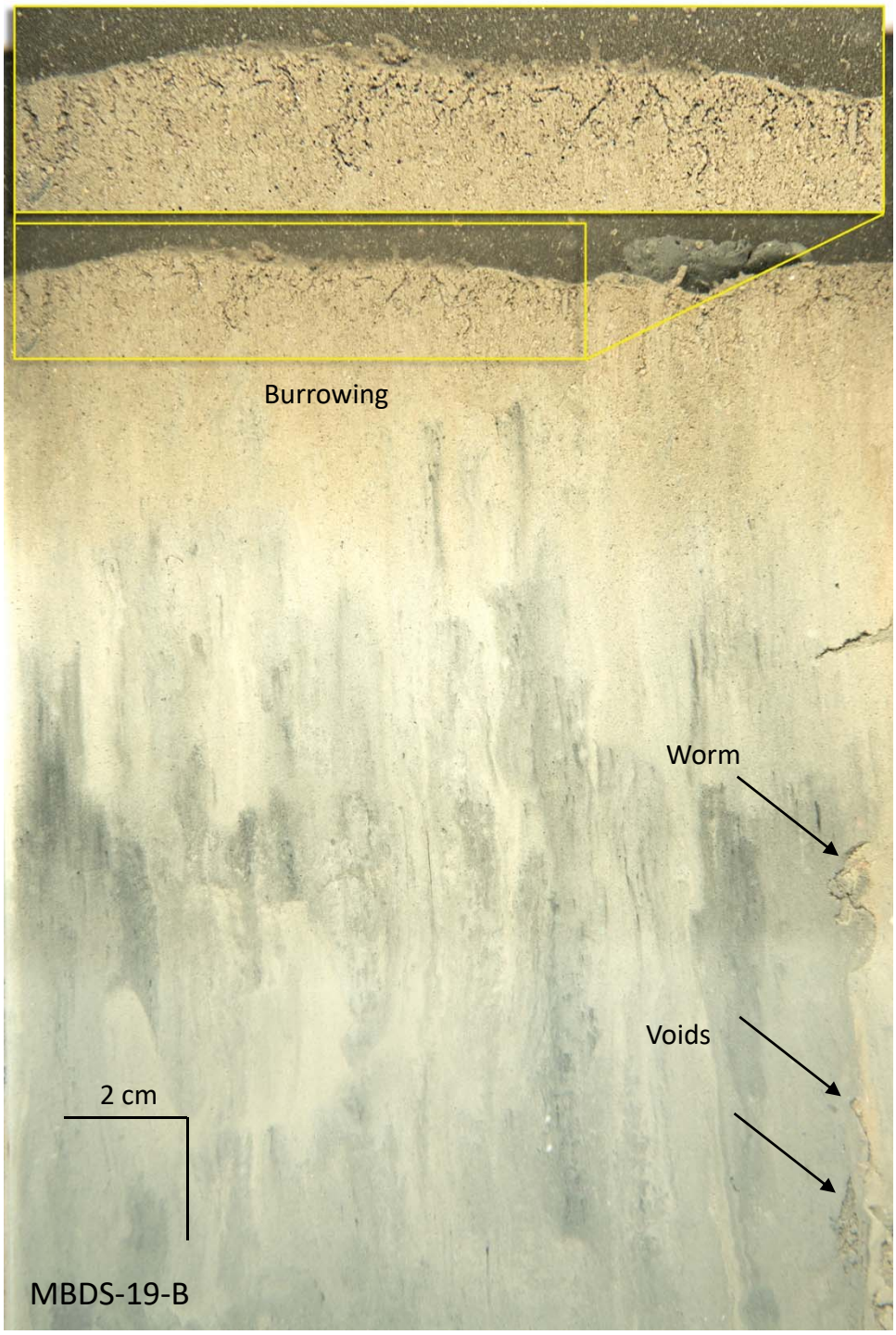



**Figure 3-37.** Sediment-profile image from Station MBDS-19 is representative of Stage 2 on 3 infauna with evidence of burrowing below the sediment-water interface and deep feeding voids and worms visible against the prism faceplate

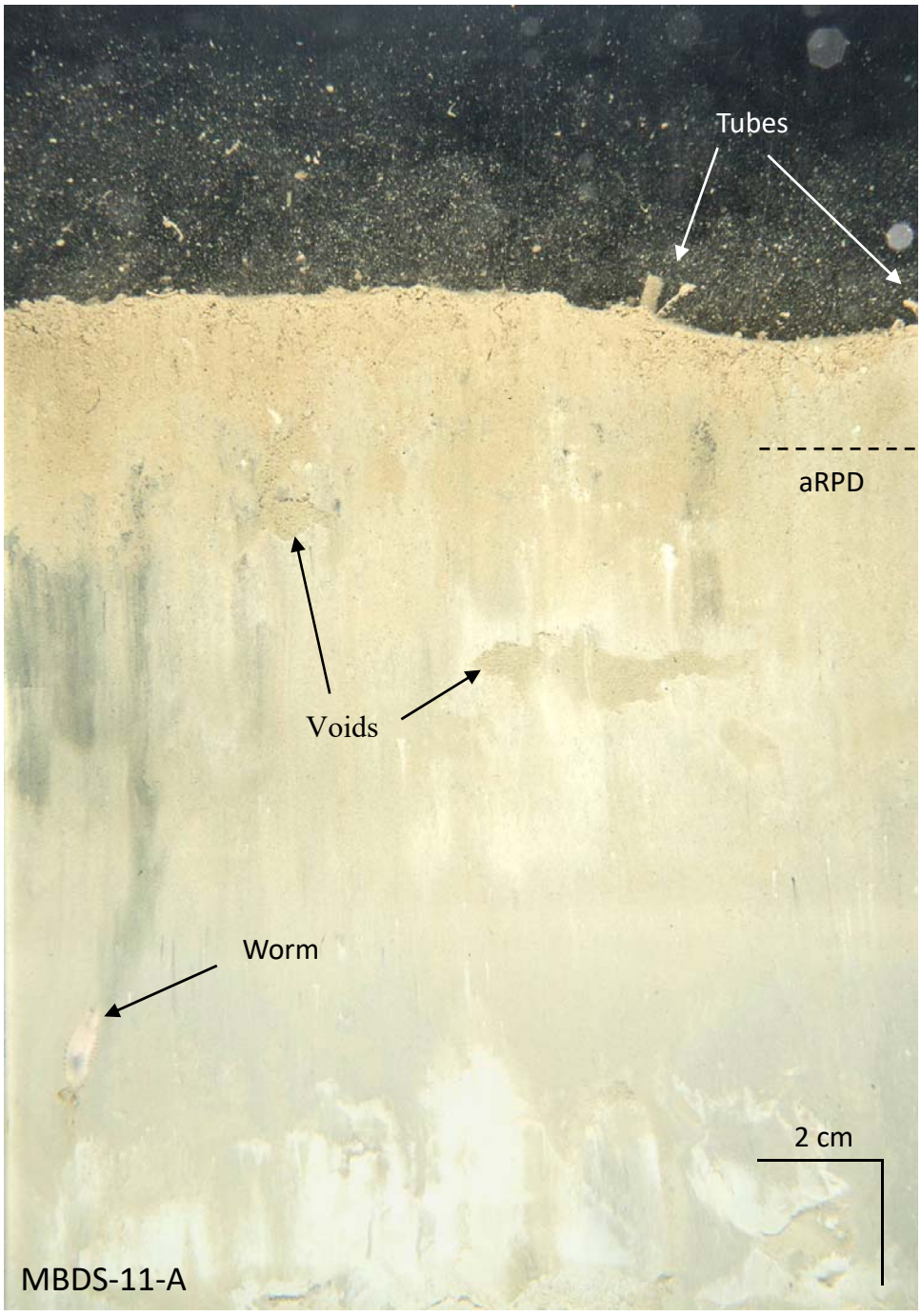



**Figure 3-38.** Sediment-profile image from Station MBDS-11 is representative of Stage 1 on 3 infauna. Surface tubes are visible at the sediment-water interface with large feeding voids observed in the sediment column below the aRPD and a large polychaete (worm) is visible against the faceplate

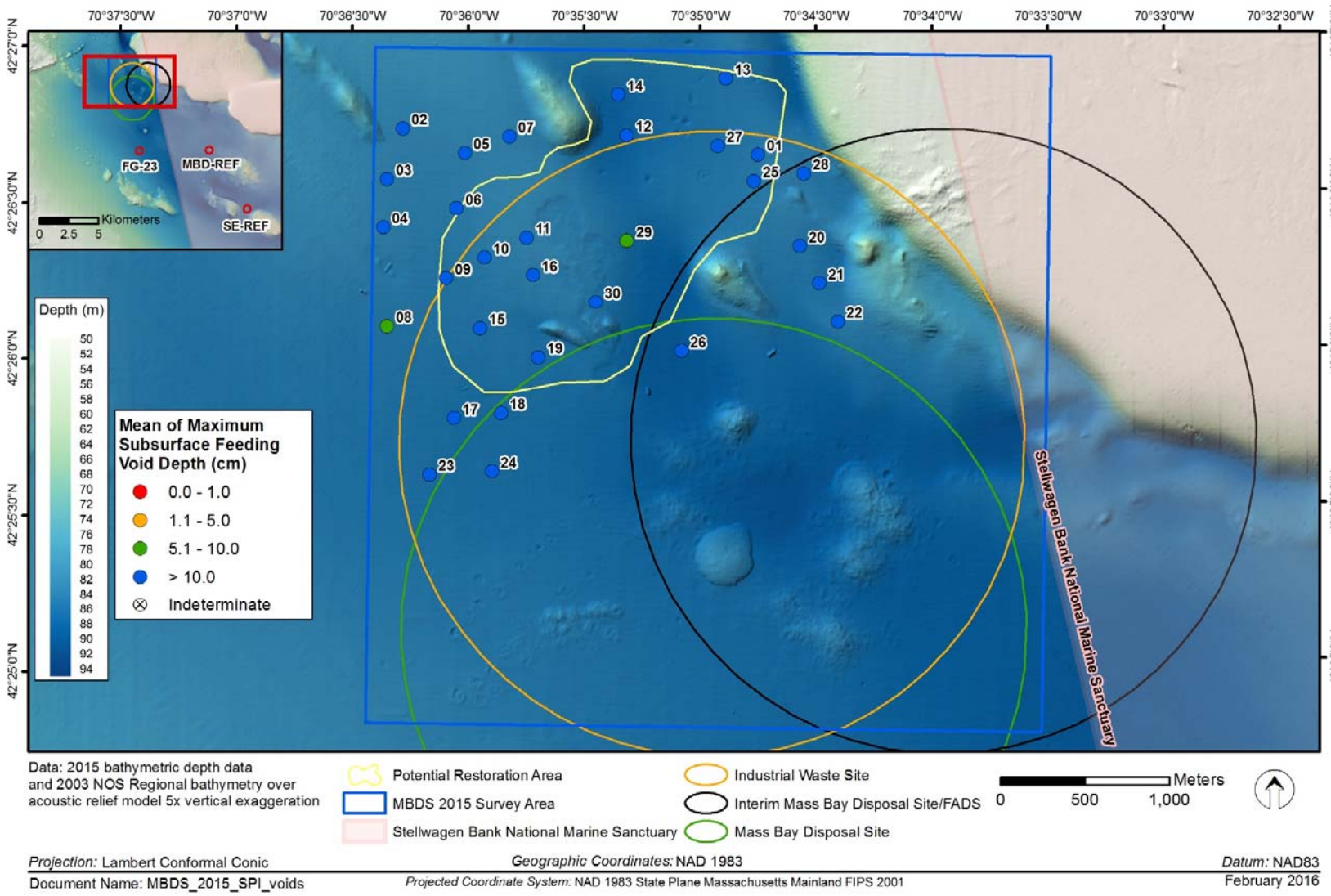
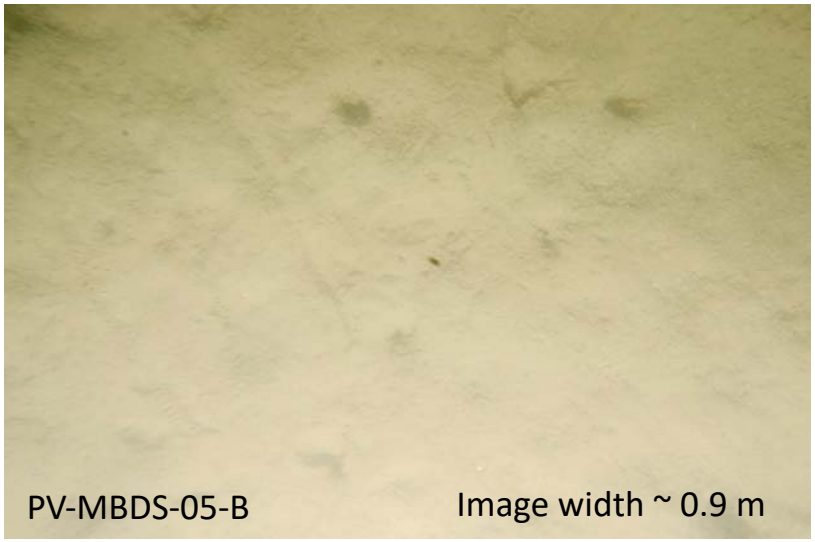
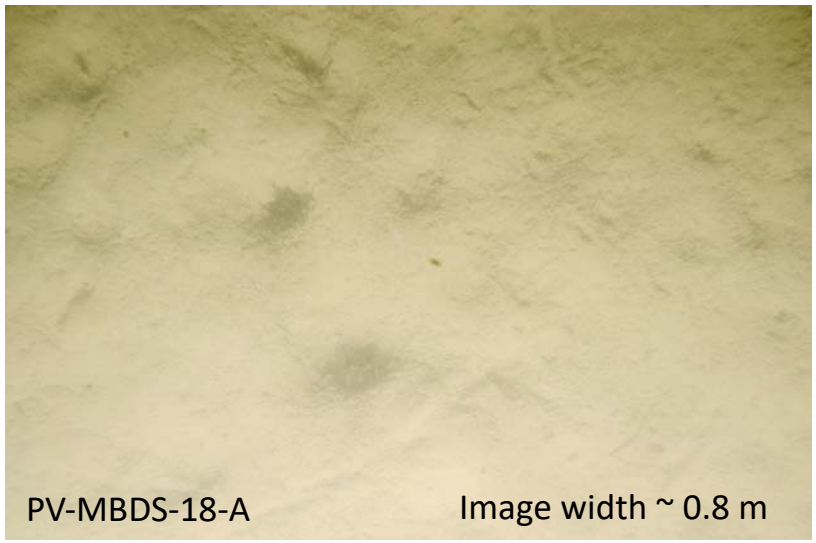



**Figure 3-39.** Spatial distribution of the mean of maximum subsurface feeding void depth (cm) at the MBDS survey area


**(A)**




**(B)**




**(C)**

**Figure 3-40.** Plan-view images from (A) Station MBDS-01 representative of <10% burrow coverage, (B) Station MBDS-05 representative of 10-25% burrow overage, and (C) Station MBDS-18 representative of 25-75% burrow coverage

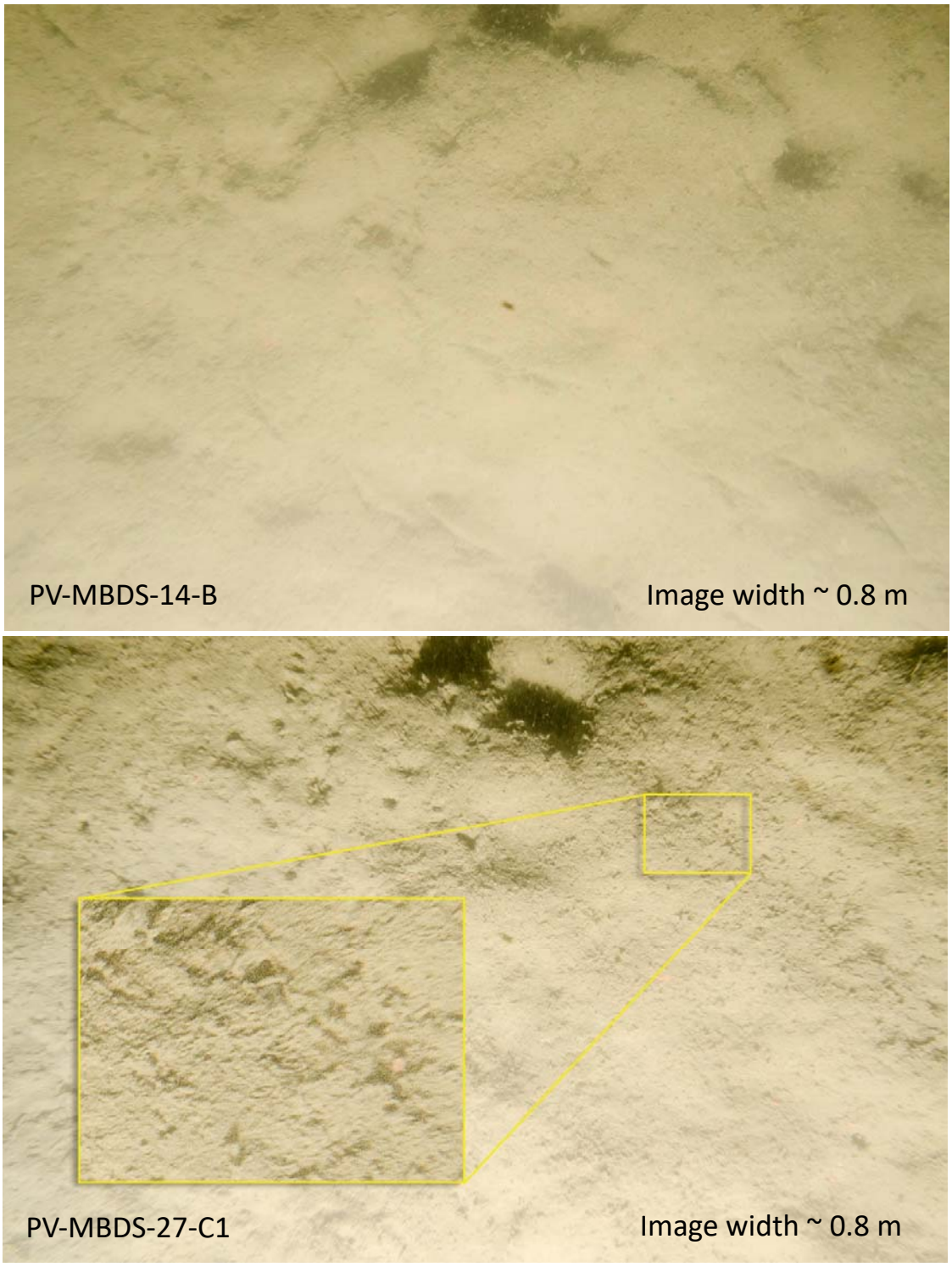



**Figure 3-41.** Plan-view images from (A) Station MBDS-14 representative of 10-25% coverage of tubes, and (B) Station MBDS-27 representative of >75% coverage of tubes on the seafloor

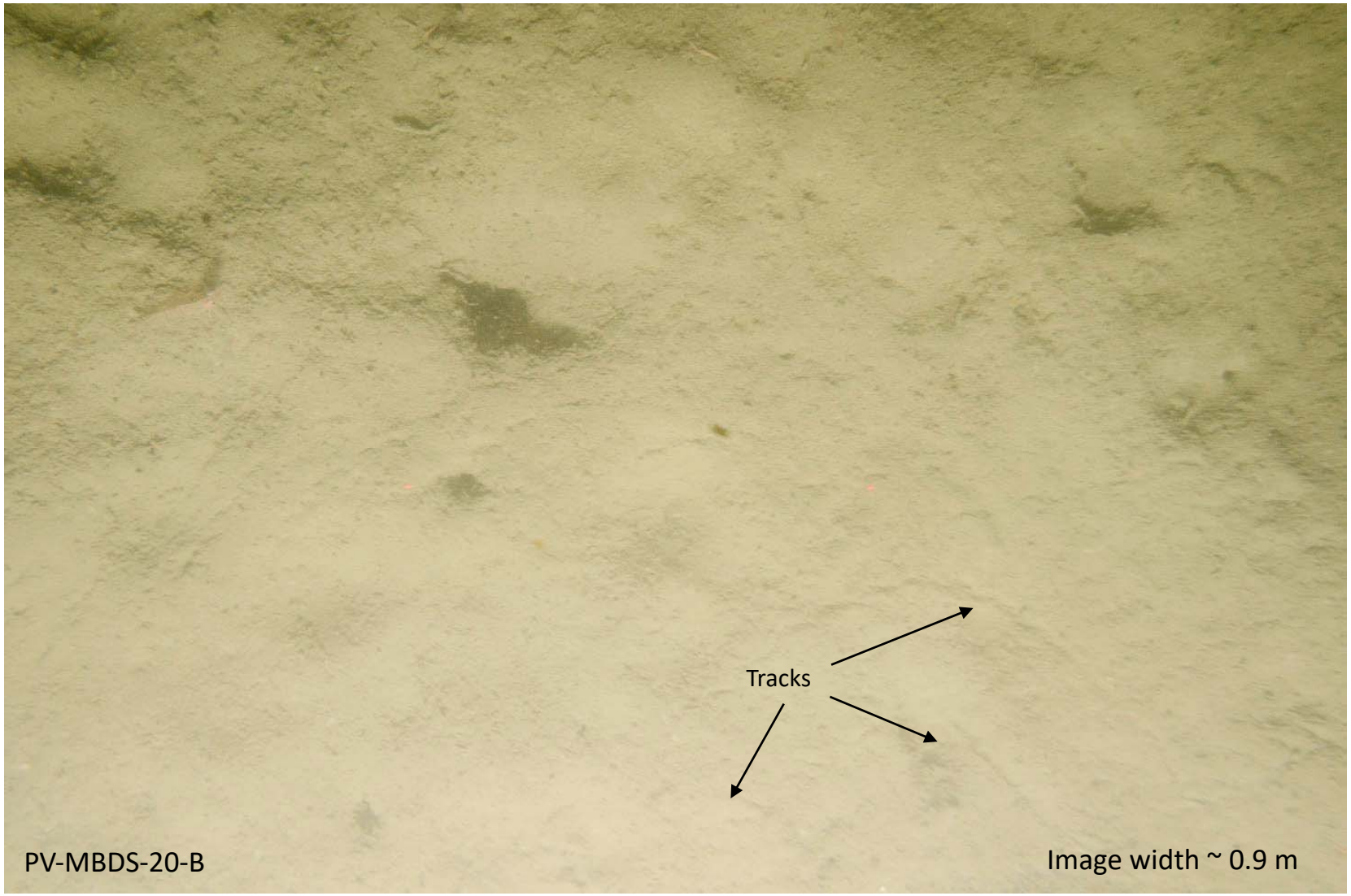



**Figure 3-42.** Plan-view image from Station MBDS-20 depicting tracks on the seafloor

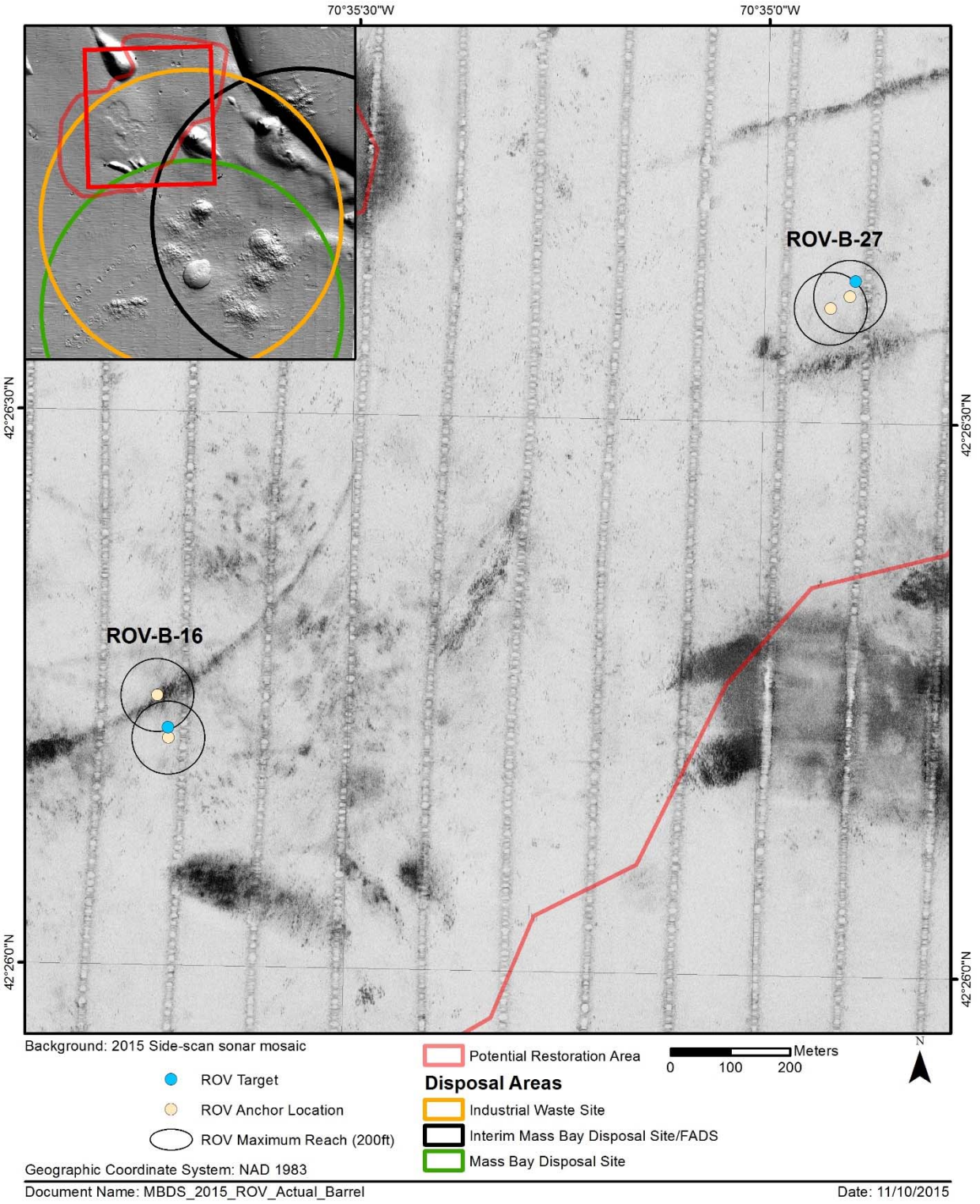



**Figure 3-43.** 2015 MBDS estimated vessel and ROV positioning at the barrel target site

Still Image B-27-1/G0014369
GoPro Video B-27-1/GP014241@11:32

Still Image B-27-1/G0014373
GoPro Video B-27-1/GP014241@11:33

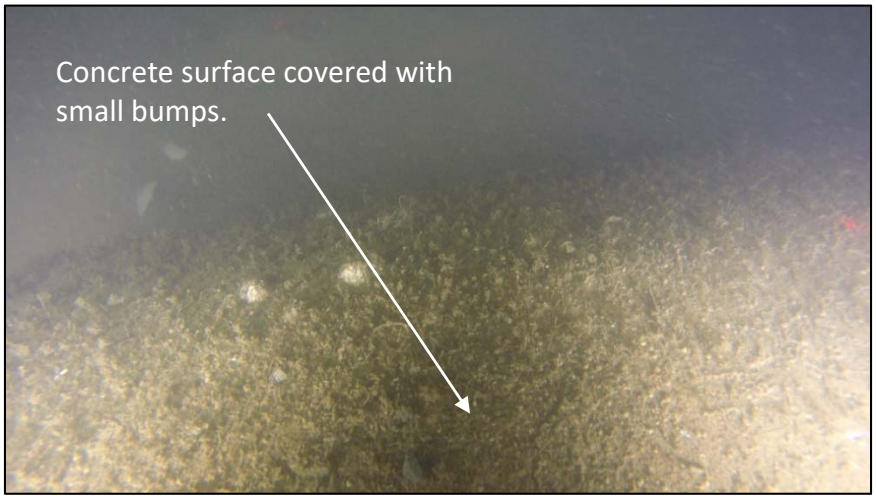



Image B-27-1 G0014375
GoPro Video B-27-1/GP014241

**Figure 3-44.** 2015 MBDS GoPro images from the barrel target site

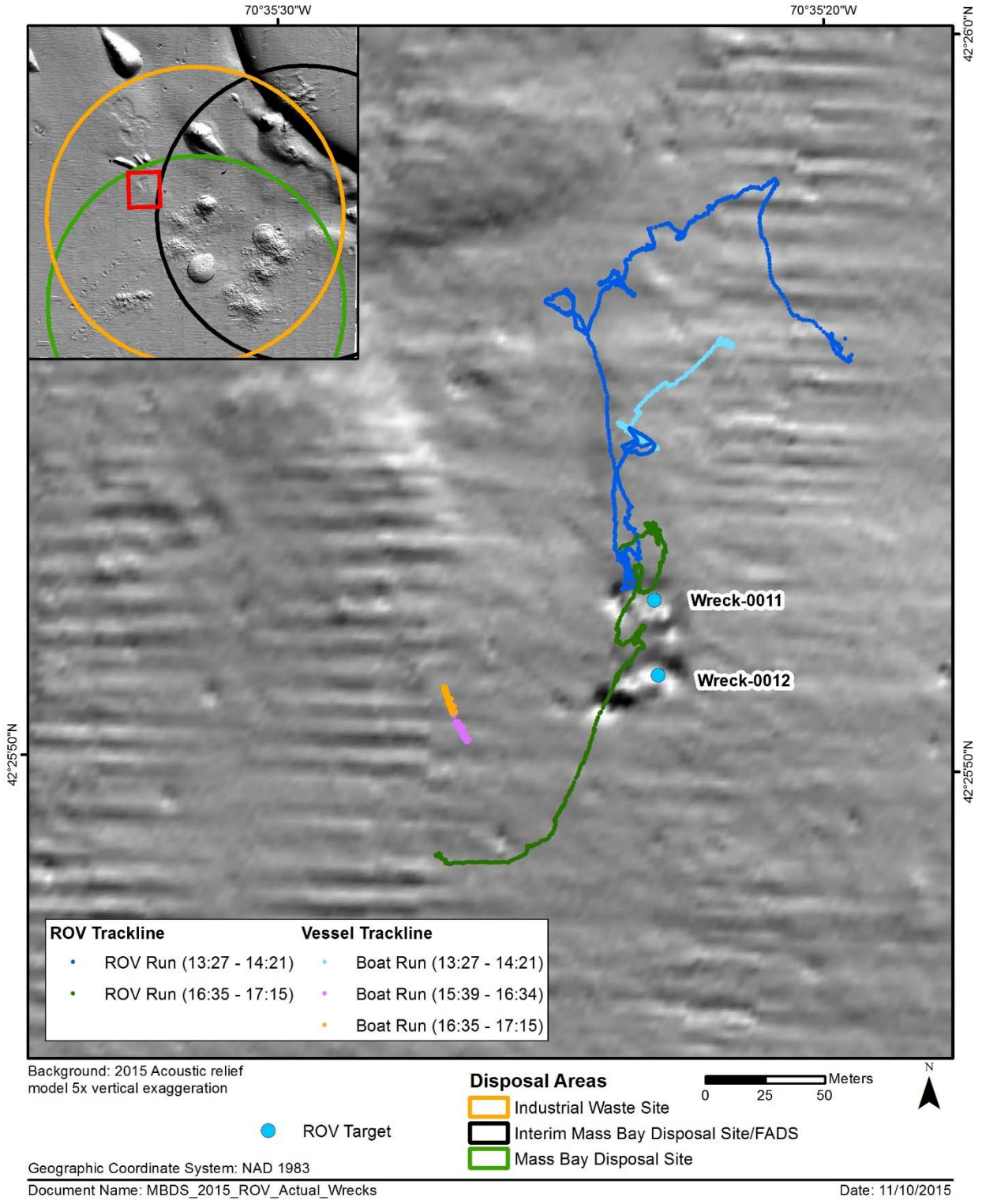



**Figure 3-45.** 2015 MBDS ROV and vessel tracklines at the wreck target site

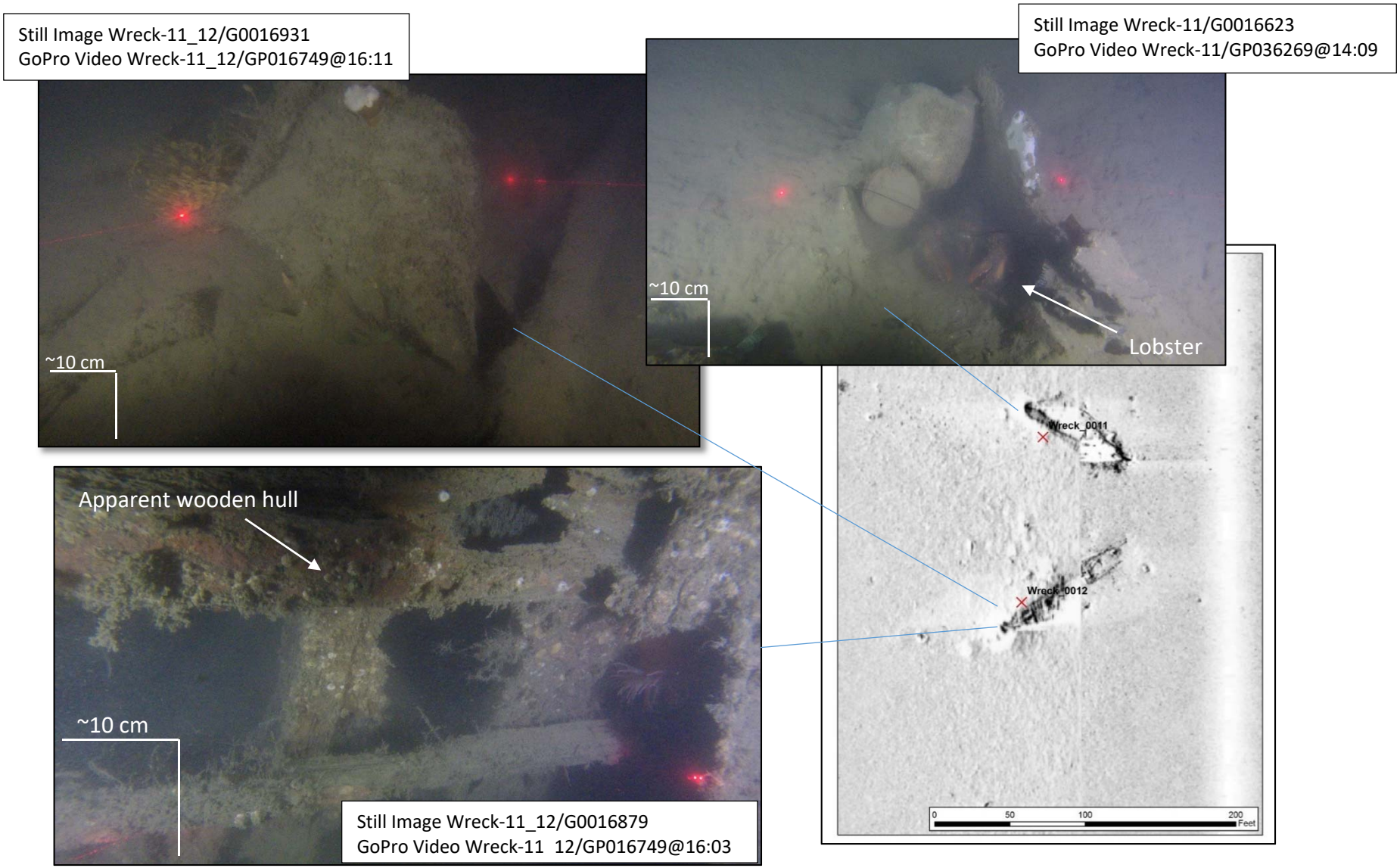



**Figure 3-46.** 2015 MBDS GoPro images from the wreck target site evidence of planking on wooden ship lobster in debris

# 4.0 DISCUSSION

The objectives of the September/October 2015 survey of MBDS/IWS were to characterize the seafloor topography and surficial features, define the physical characteristics of surficial sediment, assess the benthic status over the proposed expanded portion of MBDS and associated reference sites, and provide video footage of specified targets on the seafloor that could be used for identification of artifacts.

## 4.1 Seafloor Topography

The high-resolution acoustic survey revealed disposal mounds, identified in previous surveys, persist on the seafloor at MBDS. These mounds varied in size, rising from 1 to 8 m above the surrounding seafloor. In the proposed restoration area north of MBDS, the seafloor was relatively flat. An irregular mound, consistent with a drumlin, was present in the south of the restoration area, and just north of this mound there was a small depression. These seafloor features have been present since at least 1999 (Carey et al. 2013) indicating the lack of benthic disturbance and persistent nature of bottom topography at MBDS and at the potential restoration area.

Though the proposed restoration area is not inside of MBDS, clear patterns of dredged material disposal activity were visible from the mosaic of acoustic backscatter. Isolated disposal impact features and curved trails provided indications of disposal activity; these features have been observed and employed in the classification of dredged material disposal at other sites (Carey et al. 2012, Valente et al. 2012). The occurrence of curved trails, from barge disposal, in the potential restoration area were supported by the presence of dredged material in the sediment profiles of most stations (addressed in detail below). The lack of a well-defined mound in the potential restoration area indicates that these disposal events occurred at stochastic temporal scales, and were likely not targeted disposal activities. This contrasts with the formation of relatively discrete mounds observed at MBDS.

## 4.2 Distribution of Dredged Material

The history of placement of dredged material at MBDS is complex, but has been managed carefully since the site was designated an ocean dredged material disposal site by the USEPA in 1993 (USEPA 1993). The dredged material deposited outside of MBDS is consistent in texture and distribution with historical dredged material placed prior to the use of taut wire disposal buoys and GPS coordinates.

The mosaic of backscatter intensity provided clear evidence that dredged material placement has previously occurred in the potential restoration area. Throughout the restoration area there was a distinct pattern of curved lines of higher intensity backscatter indicative of scattered disposal events. The distribution pattern of higher backscatter was

interpreted as placement of high water content dredged material that spread approximately linear along the barge travel path. These unique spatial features of the seafloor in the potential restoration area were confirmed by both filtered and side-scan sonar bathymetric mosaics. Because of this activity, the vast majority of SPI/PV stations contained dredged material in the sediment profile images and the thickness of this layer was regularly greater than 15 cm. The stations where dredged material was not present tended to be located in the western portion of the MBDS survey area indicating some spatial trend to disposal activity in the restoration area.

## 4.3 Benthic Characterization

The results of the SPI/PV survey determined that despite the presence of historical dredged material disposal activity, the majority of stations in the potential restoration area did not differ from the reference area stations. Both the restoration and reference areas predominantly contained spatially homogenous, well-mixed, uniform light brown silt-clay with low sediment shear strength and biologically driven small-scale boundary roughness. Mature Stage 3 benthic assemblages were present at all locations sampled; both the aRPD depth and infaunal successional status within the restoration area was equivalent to conditions found on the ambient seafloor.

The bioturbating activity of these infauna contributed to a well-mixed sediment column and a biologically modified aRPD that extended deep into the sediment. The potential restoration area had similar physical and biological benthic characteristics with the ambient seafloor, indicating that with time, and a cessation in persistent disposal activity, benthic communities can recover and mirror undisturbed states. Given the lack of any additional observed anthropogenic disturbance factors, e.g., bottom trawling, it is not surprising that the soft-bottom infaunal community has had sufficient time for complete recovery.

## 4.4 Ship Wreck Observation and Classification

Two ship wrecks (11 and 12) were surveyed by ROV. At this time, a determination of National Register eligibility cannot be made based on the existing information. Further investigation of the two shipwrecks to obtain this information should include a higher resolution, systematic ROV survey of the vessels and outlying areas (debris field) using BOEM's methodology for cultural resources ROV surveys. A higher resolution side scan sonar and/or sector scanning sonar, as well as a magnetometer survey would assist in the identification and determination of significance of these vessels.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

The combined acoustic, SPI/PV, and ROV surveys performed at MBDS in September and October 2015 provided the following findings:

- Acoustic backscatter documented surface features that indicate historical disposal activity of dredged material in the potential restoration area.

- SPI confirms historical dredged material disposal in the potential restoration area. The majority of SPI stations in the potential restoration area contained historical dredged deposits.

- Benthic characteristics of the seafloor in the potential restoration area did not differ from ambient seafloor conditions.

- The disposal site and reference areas displayed a robust benthic community assemblage with relatively uniform sediment characteristics that made mapping and characterizing dredged material distribution and seafloor condition straightforward.

- Given the complete recovery of the benthic infaunal community in the restoration area to previous disposal activity, it is predicted that the effects from any future disposal operations would be transient, and the infaunal community would quickly re-establish itself following completion of disposal operations.

- Two ship wrecks were surveyed by ROV but identification was not possible. Until further investigation is conducted to identify these two vessels, avoidance of any impacts is recommended. A buffer of a minimum 50-meter radius from the outside edge of both vessels is recommended.

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# INDEX

# APPENDIX A

# TABLE OF COMMON CONVERSIONS

APPENDIX A

TABLE OF COMMON CONVERSIONS

| **Metric Unit Conversion to English Unit** | | **English Unit Conversion to Metric Unit** | |
|---|---|---|---|
| 1 meter<br>1 m | 3.2808 ft | 1 foot<br>1 ft | 0.3048 m |
| 1 square meter<br>1 $m^2$ | 10.7639 $ft^2$ | 1 square foot<br>1 $ft^2$ | 0.0929 $m^2$ |
| 1 kilometer<br>1 km | 0.6214 mi | 1 mile<br>1 mi | 1.6093 km |
| 1 cubic meter<br>1 $m^3$ | 1.3080 $yd^3$ | 1 cubic yard<br>1 $yd^3$ | 0.7646 $m^3$ |
| 1 centimeter<br>1 cm | 0.3937 in | 1 inch<br>1 in | 2.54 cm |

# APPENDIX B

# MBDS DISPOSAL LOG DATA FROM SEPT 2012 TO JAN 2015

| Target Site Code | Project name | City/town | State | Placement date/time | Load volume (CY) | Load Volume (CM) | Placement latitude | Placement longitude | Permit number |
|---|---|---|---|---|---|---|---|---|---|
| MBDS-2012 | Boston Rock Removal | Boston | MA | 27-Sep-12 | 150 | 115 | 42.41000 | -70.67680 | W912WJ-12-C-0009 |
| MBDS-2012 | Boston Rock Removal | Boston | MA | 30-Sep-12 | 150 | 115 | 42.42617 | -70.57178 | W912WJ-12-C-0009 |
| MBDS-2012 | Boston Rock Removal | Boston | MA | 30-Sep-12 | 150 | 115 | 42.42618 | -70.57188 | W912WJ-12-C-0009 |
| MBDS-2012 | Boston Rock Removal | Boston | MA | 03-Oct-12 | 150 | 115 | 42.42595 | -70.57185 | W912WJ-12-C-0009 |
| MBDS-2012 | Boston Rock Removal | Boston | MA | 04-Oct-12 | 150 | 115 | 42.42598 | -70.57192 | W912WJ-12-C-0009 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 26-Oct-12 | 673 | 515 | 42.41952 | -70.57790 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 04-Nov-12 | 673 | 515 | 42.41988 | -70.57787 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 05-Nov-12 | 673 | 515 | 42.41993 | -70.57805 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 05-Nov-12 | 673 | 515 | 42.41993 | -70.57805 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 11-Nov-12 | 673 | 515 | 42.42027 | -70.57792 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 13-Nov-12 | 673 | 515 | 42.42118 | -70.57960 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 19-Nov-12 | 673 | 515 | 42.41932 | -70.57820 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 20-Nov-12 | 673 | 515 | 42.42008 | -70.57775 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 21-Nov-12 | 673 | 515 | 42.42082 | -70.57697 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 27-Nov-12 | 771 | 589 | 42.42027 | -70.57710 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 27-Nov-12 | 850 | 650 | 42.42025 | -70.57708 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 29-Nov-12 | 673 | 515 | 42.41962 | -70.57778 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 29-Nov-12 | 673 | 515 | 42.41982 | -70.57783 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 30-Nov-12 | 771 | 589 | 42.41980 | -70.57880 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 30-Nov-12 | 850 | 650 | 42.41980 | -70.57883 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 01-Dec-12 | 771 | 589 | 42.42012 | -70.57843 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 01-Dec-12 | 800 | 612 | 42.42008 | -70.57852 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 01-Dec-12 | 673 | 515 | 42.41905 | -70.57772 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 03-Dec-12 | 771 | 589 | 42.41958 | -70.57858 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 03-Dec-12 | 850 | 650 | 42.41963 | -70.87862 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 03-Dec-12 | 673 | 515 | 42.41958 | -70.57847 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 03-Dec-12 | 673 | 515 | 42.41965 | -70.57715 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 04-Dec-12 | 771 | 589 | 42.42030 | -70.57818 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 04-Dec-12 | 850 | 650 | 42.42030 | -70.57822 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 04-Dec-12 | 771 | 589 | 42.42047 | -70.57823 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 04-Dec-12 | 850 | 650 | 42.42047 | -70.57827 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 05-Dec-12 | 673 | 515 | 42.42007 | -70.57838 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 06-Dec-12 | 771 | 589 | 42.42055 | -70.57735 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 06-Dec-12 | 673 | 515 | 42.41920 | -70.57710 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 07-Dec-12 | 700 | 535 | 42.42063 | -70.57738 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 07-Dec-12 | 771 | 589 | 42.41972 | -70.57683 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 07-Dec-12 | 675 | 516 | 42.41972 | -70.57680 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 07-Dec-12 | 771 | 589 | 42.42055 | -70.57710 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 08-Dec-12 | 725 | 554 | 42.42060 | -70.57715 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 08-Dec-12 | 771 | 589 | 42.41980 | -70.57802 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 08-Dec-12 | 750 | 573 | 42.41985 | -70.57807 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 08-Dec-12 | 771 | 589 | 42.42042 | -70.57740 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 09-Dec-12 | 775 | 593 | 42.42045 | -70.57742 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 09-Dec-12 | 673 | 515 | 42.41947 | -70.57730 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 09-Dec-12 | 771 | 589 | 42.41965 | -70.57818 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 09-Dec-12 | 700 | 535 | 42.41965 | -70.57818 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 09-Dec-12 | 673 | 515 | 42.41978 | -70.57765 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 11-Dec-12 | 673 | 515 | 42.41947 | -70.57748 | NAE-2009-00209 |

| Target Site Code | Project name | City/town | State | Placement date/time | Load volume (CY) | Load Volume (CM) | Placement latitude | Placement longitude | Permit number |
|---|---|---|---|---|---|---|---|---|---|
| MBDS-2012 | Allen Harbor | Harwich | MA | 12-Dec-12 | 673 | 515 | 42.41990 | -70.57815 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 12-Dec-12 | 771 | 589 | 42.41948 | -70.57777 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 12-Dec-12 | 625 | 478 | 42.41950 | -70.57792 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 13-Dec-12 | 771 | 589 | 42.41993 | -70.57788 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 13-Dec-12 | 650 | 497 | 42.42007 | -70.57805 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 13-Dec-12 | 771 | 589 | 42.42007 | -70.57802 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 13-Dec-12 | 673 | 515 | 42.41980 | -70.57712 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 13-Dec-12 | 650 | 497 | 42.42010 | -70.57813 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 14-Dec-12 | 771 | 589 | 42.41912 | -70.57767 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 14-Dec-12 | 673 | 515 | 42.41912 | -70.57622 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 14-Dec-12 | 675 | 516 | 42.41912 | -70.57767 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 14-Dec-12 | 771 | 589 | 42.41923 | -70.57812 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 14-Dec-12 | 700 | 535 | 42.41927 | -70.57819 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 15-Dec-12 | 673 | 515 | 42.41935 | -70.57722 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 16-Dec-12 | 673 | 515 | 42.41945 | -70.57733 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 31-Dec-12 | 673 | 515 | 42.42032 | -70.57738 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 03-Jan-13 | 673 | 515 | 42.42003 | -70.57763 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 03-Jan-13 | 600 | 459 | 42.41965 | -70.57827 | NAE200501095 |
| MBDS-2012 | Salem Wharf | Salem | MA | 04-Jan-13 | 771 | 589 | 42.41960 | -70.57818 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 04-Jan-13 | 625 | 478 | 42.41960 | -70.57810 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 04-Jan-13 | 673 | 515 | 42.41987 | -70.57747 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 05-Jan-13 | 771 | 589 | 42.42037 | -70.57763 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 06-Jan-13 | 675 | 516 | 42.42043 | -70.57767 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 06-Jan-13 | 673 | 515 | 42.41985 | -70.57792 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 06-Jan-13 | 771 | 589 | 42.41980 | -70.57805 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 06-Jan-13 | 600 | 459 | 42.41988 | -70.57818 | NAE200501095 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 07-Jan-13 | 673 | 515 | 42.42108 | -70.57853 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 07-Jan-13 | 771 | 589 | 42.42005 | -70.57815 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 07-Jan-13 | 771 | 589 | 42.42013 | -70.57810 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 08-Jan-13 | 673 | 515 | 42.42003 | -70.57818 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 08-Jan-13 | 673 | 515 | 42.42015 | -70.57887 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 08-Jan-13 | 771 | 589 | 42.41993 | -70.57832 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 09-Jan-13 | 771 | 589 | 42.42015 | -70.57803 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 11-Jan-13 | 673 | 515 | 42.41862 | -70.57800 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 11-Jan-13 | 673 | 515 | 42.42010 | -70.57825 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 11-Jan-13 | 771 | 589 | 42.42013 | -70.57743 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 12-Jan-13 | 673 | 515 | 42.42102 | -70.57760 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 12-Jan-13 | 673 | 515 | 42.42003 | -70.57750 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 12-Jan-13 | 771 | 589 | 42.42035 | -70.57717 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 14-Jan-13 | 673 | 515 | 42.41950 | -70.57718 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 14-Jan-13 | 673 | 515 | 42.41990 | -70.57748 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 14-Jan-13 | 771 | 589 | 42.42010 | -70.57757 | NAE-2005-010995 |
| MBDS-2012 | Salem Wharf | Salem | MA | 14-Jan-13 | 771 | 589 | 42.42008 | -70.57795 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 15-Jan-13 | 673 | 515 | 42.41982 | -70.57762 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 16-Jan-13 | 673 | 515 | 42.42043 | -70.57775 | NAE-2009-00209 |
| MBDS-2012 | Salem Wharf | Salem | MA | 16-Jan-13 | 771 | 589 | 42.42013 | -70.57745 | NAE-2005-010995 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 17-Jan-13 | 673 | 515 | 42.41937 | -70.57717 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 26-Jan-13 | 673 | 515 | 42.42025 | -70.57740 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 28-Jan-13 | 673 | 515 | 42.41983 | -70.57838 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 28-Jan-13 | 673 | 515 | 42.41975 | -70.57795 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 30-Jan-13 | 673 | 515 | 42.41953 | -70.57828 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 30-Jan-13 | 673 | 515 | 42.42070 | -70.57768 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 03-Feb-13 | 673 | 515 | 42.41992 | -70.57783 | NAE-2009-00209 |

| Target Site Code | Project name | City/town | State | Placement date/time | Load volume (CY) | Load Volume (CM) | Placement latitude | Placement longitude | Permit number |
|---|---|---|---|---|---|---|---|---|---|
| MBDS-2012 | Allen Harbor | Harwich | MA | 05-Feb-13 | 673 | 515 | 42.41945 | -70.57743 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 05-Feb-13 | 673 | 515 | 42.42070 | -70.57767 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 07-Feb-13 | 673 | 515 | 42.41947 | -70.57695 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 12-Feb-13 | 673 | 515 | 42.42022 | -70.57780 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 12-Feb-13 | 673 | 515 | 42.42020 | -70.57733 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 14-Feb-13 | 673 | 515 | 42.41820 | -70.57520 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 14-Feb-13 | 673 | 515 | 42.41887 | -70.57802 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 15-Feb-13 | 673 | 515 | 42.42035 | -70.57690 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 16-Feb-13 | 673 | 515 | 42.41930 | -70.57723 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 20-Feb-13 | 673 | 515 | 42.41937 | -70.57768 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 20-Feb-13 | 673 | 515 | 42.42025 | -70.57628 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 01-Mar-13 | 673 | 515 | 42.41955 | -70.57733 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 02-Mar-13 | 673 | 515 | 42.41988 | -70.57745 | NAE-2009-00209 |
| MBDS-2012 | Allen Harbor | Harwich | MA | 04-Mar-13 | 673 | 515 | 42.41950 | -70.57775 | NAE-2009-00209 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 20-Nov-13 | 600 | 459 | 42.41932 | -70.57710 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 21-Nov-13 | 600 | 459 | 42.41983 | -70.57633 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 22-Nov-13 | 600 | 459 | 42.41952 | -70.57735 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 30-Nov-13 | 600 | 459 | 42.41927 | -70.57975 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 02-Dec-13 | 600 | 459 | 42.41927 | -70.57683 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 03-Dec-13 | 600 | 459 | 42.41927 | -70.57907 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 04-Dec-13 | 600 | 459 | 42.41945 | -70.57797 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 05-Dec-13 | 600 | 459 | 42.42128 | -70.57938 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 06-Dec-13 | 701 | 536 | 42.42002 | -70.57932 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 07-Dec-13 | 659 | 504 | 42.41940 | -70.57793 | NAE-2007-2344 |
| MBDS-2012 | Hull Harbor - Nantasket Pier | Hull | MA | 20-Dec-13 | 600 | 459 | 42.41990 | -70.57815 | NAE-2007-2344 |
| MBDS-2012 | Citgo Petroleum | Braintree | MA | 17-Jan-15 | 3600 | 2752 | 42.41965 | -70.57931 | NAE-2008-2721 |

# APPENDIX C

# MBDS ACTUAL SPI/PV REPLICATE LOCATIONS

September 2015

| MBDS September 2015 SPI/PV Replicate Locations | | | | | |
|---|---|---|---|---|---|
| **Replicate** | **Latitude (N)** | **Longitude (W)** | **Replicate** | **Latitude (N)** | **Longitude (W)** |
| MBDS-01-A | 42° 26.624' | 70° 34.757' | MBDS-09-A | 42° 26.245' | 70° 36.107' |
| MBDS-01-B | 42° 26.629' | 70° 34.756' | MBDS-09-B | 42° 26.241' | 70° 36.109' |
| MBDS-01-C | 42° 26.628' | 70° 34.758' | MBDS-09-C | 42° 26.239' | 70° 36.114' |
| MBDS-01-D | 42° 26.631' | 70° 34.756' | MBDS-09-D | 42° 26.245' | 70° 36.111' |
| MBDS-02-A | 42° 26.724' | 70° 36.288' | MBDS-10-A | 42° 26.310' | 70° 35.942' |
| MBDS-02-B | 42° 26.726' | 70° 36.281' | MBDS-10-B | 42° 26.313' | 70° 35.935' |
| MBDS-02-C | 42° 26.729' | 70° 36.281' | MBDS-10-C | 42° 26.311' | 70° 35.934' |
| MBDS-02-D | 42° 26.723' | 70° 36.286' | MBDS-10-D | 42° 26.312' | 70° 35.937' |
| MBDS-03-A | 42° 26.563' | 70° 36.359' | MBDS-11-A | 42° 26.371' | 70° 35.758' |
| MBDS-03-B | 42° 26.564' | 70° 36.362' | MBDS-11-B | 42° 26.372' | 70° 35.761' |
| MBDS-03-C | 42° 26.567' | 70° 36.358' | MBDS-11-C | 42° 26.373' | 70° 35.761' |
| MBDS-03-D | 42° 26.564' | 70° 36.363' | MBDS-11-D | 42° 26.372' | 70° 35.757' |
| MBDS-04-A | 42° 26.410' | 70° 36.376' | MBDS-12-A | 42° 26.694' | 70° 35.322' |
| MBDS-04-B | 42° 26.407' | 70° 36.381' | MBDS-12-B | 42° 26.695' | 70° 35.318' |
| MBDS-04-C | 42° 26.409' | 70° 36.378' | MBDS-12-C | 42° 26.693' | 70° 35.329' |
| MBDS-04-D | 42° 26.411' | 70° 36.375' | MBDS-12-D | 42° 26.696' | 70° 35.321' |
| MBDS-05-A | 42° 26.644' | 70° 36.021' | MBDS-13-A | 42° 26.873' | 70° 34.891' |
| MBDS-05-B | 42° 26.646' | 70° 36.018' | MBDS-13-B | 42° 26.873' | 70° 34.891' |
| MBDS-05-C | 42° 26.650' | 70° 36.012' | MBDS-13-C | 42° 26.875' | 70° 34.894' |
| MBDS-05-D | 42° 26.651' | 70° 36.016' | MBDS-13-D | 42° 26.875' | 70° 34.897' |
| MBDS-06-A | 42° 26.467' | 70° 36.059' | MBDS-14-A | 42° 26.825' | 70° 35.356' |
| MBDS-06-B | 42° 26.472' | 70° 36.057' | MBDS-14-B | 42° 26.824' | 70° 35.348' |
| MBDS-06-C | 42° 26.472' | 70° 36.057' | MBDS-14-C | 42° 26.823' | 70° 35.347' |
| MBDS-06-D | 42° 26.473' | 70° 36.060' | MBDS-14-D | 42° 26.825' | 70° 35.354' |
| MBDS-07-A | 42° 26.695' | 70° 35.828' | MBDS-15-A | 42° 26.082' | 70° 35.963' |
| MBDS-07-B | 42° 26.697' | 70° 35.830' | MBDS-15-B | 42° 26.083' | 70° 35.960' |
| MBDS-07-C | 42° 26.700' | 70° 35.830' | MBDS-15-C | 42° 26.083' | 70° 35.960' |
| MBDS-07-D | 42° 26.701' | 70° 35.834' | MBDS-15-D | 42° 26.082' | 70° 35.961' |
| MBDS-08-A | 42° 26.090' | 70° 36.366' | MBDS-16-A | 42° 26.252' | 70° 35.733' |
| MBDS-08-B | 42° 26.091' | 70° 36.367' | MBDS-16-B | 42° 26.253' | 70° 35.737' |
| MBDS-08-C | 42° 26.094' | 70° 36.369' | MBDS-16-C | 42° 26.255' | 70° 35.733' |
| MBDS-08-D | 42° 26.090' | 70° 36.368' | MBDS-16-D | 42° 26.253' | 70° 35.729' |

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

| MBDS September 2015 SPI/PV Replicate Locations | | | | | |
|---|---|---|---|---|---|
| **Replicate** | **Latitude (N)** | **Longitude (W)** | **Replicate** | **Latitude (N)** | **Longitude (W)** |
| MBDS-17-A | 42° 25.796' | 70° 36.081' | MBDS-25-A | 42° 26.545' | 70° 34.775' |
| MBDS-17-B | 42° 25.800' | 70° 36.079' | MBDS-25-B | 42° 26.547' | 70° 34.772' |
| MBDS-17-C | 42° 25.799' | 70° 36.083' | MBDS-25-C | 42° 26.543' | 70° 34.778' |
| MBDS-17-D | 42° 25.799' | 70° 36.079' | MBDS-25-D | 42° 26.543' | 70° 34.770' |
| MBDS-18-A | 42° 25.811' | 70° 35.878' | MBDS-26-A | 42° 26.003' | 70° 35.095' |
| MBDS-18-B | 42° 25.813' | 70° 35.879' | MBDS-26-B | 42° 26.001' | 70° 35.087' |
| MBDS-18-C | 42° 25.811' | 70° 35.882' | MBDS-26-C | 42° 26.001' | 70° 35.092' |
| MBDS-18-D | 42° 25.811' | 70° 35.882' | MBDS-26-D | 42° 25.998' | 70° 35.093' |
| MBDS-19-A | 42° 25.987' | 70° 35.715' | MBDS-27-A | 42° 26.658' | 70° 34.930' |
| MBDS-19-B | 42° 25.988' | 70° 35.713' | MBDS-27-B | 42° 26.659' | 70° 34.933' |
| MBDS-19-C | 42° 25.986' | 70° 35.713' | MBDS-27-C | 42° 26.656' | 70° 34.932' |
| MBDS-19-D | 42° 25.985' | 70° 35.716' | MBDS-27-D | 42° 26.656' | 70° 34.935' |
| MBDS-20-A | 42° 26.335' | 70° 34.574' | MBDS-28-A | 42° 26.567' | 70° 34.559' |
| MBDS-20-B | 42° 26.336' | 70° 34.580' | MBDS-28-B | 42° 26.569' | 70° 34.563' |
| MBDS-20-C | 42° 26.335' | 70° 34.576' | MBDS-28-C | 42° 26.568' | 70° 34.557' |
| MBDS-20-D | 42° 26.333' | 70° 34.582' | MBDS-28-D | 42° 26.566' | 70° 34.564' |
| MBDS-21-A | 42° 26.217' | 70° 34.497' | MBDS-29-A | 42° 26.358' | 70° 35.326' |
| MBDS-21-B | 42° 26.221' | 70° 34.497' | MBDS-29-B | 42° 26.362' | 70° 35.321' |
| MBDS-21-C | 42° 26.219' | 70° 34.496' | MBDS-29-C | 42° 26.359' | 70° 35.316' |
| MBDS-21-D | 42° 26.221' | 70° 34.499' | MBDS-29-D | 42° 26.357' | 70° 35.320' |
| MBDS-22-A | 42° 26.091' | 70° 34.420' | MBDS-30-A | 42° 26.163' | 70° 35.464' |
| MBDS-22-B | 42° 26.090' | 70° 34.420' | MBDS-30-B | 42° 26.165' | 70° 35.467' |
| MBDS-22-C | 42° 26.089' | 70° 34.422' | MBDS-30-C | 42° 26.168' | 70° 35.464' |
| MBDS-22-D | 42° 26.091' | 70° 34.423' | MBDS-30-D | 42° 26.164' | 70° 35.465' |
| MBDS-23-A | 42° 25.617' | 70° 36.188' | | | |
| MBDS-23-B | 42° 25.613' | 70° 36.192' | | | |
| MBDS-23-C | 42° 25.614' | 70° 36.188' | | | |
| MBDS-23-D | 42° 25.614' | 70° 36.189' | | | |
| MBDS-24-A | 42° 25.626' | 70° 35.919' | | | |
| MBDS-24-B | 42° 25.625' | 70° 35.924' | | | |
| MBDS-24-C | 42° 25.625' | 70° 35.920' | | | |
| MBDS-24-D | 42° 25.624' | 70° 35.920' | | | |

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

| MBDS September 2015 SPI/PV Reference Replicate Locations | | | | | |
|---|---|---|---|---|---|
| **Replicate** | **Latitude (N)** | **Longitude (W)** | **Replicate** | **Latitude (N)** | **Longitude (W)** |
| FG-23-01-A | 42° 22.771' | 70° 34.588' | MBD-REF-03-C | 42° 22.664' | 70° 30.274' |
| FG-23-01-B | 42° 22.770' | 70° 34.590' | MBD-REF-03-D | 42° 22.662' | 70° 30.267' |
| FG-23-01-C | 42° 22.770' | 70° 34.590' | MBD-REF-04-A | 42° 22.616' | 70° 30.174' |
| FG-23-01-D | 42° 22.769' | 70° 34.588' | MBD-REF-04-B | 42° 22.620' | 70° 30.174' |
| FG-23-02-A | 42° 22.737' | 70° 34.446' | MBD-REF-04-C | 42° 22.618' | 70° 30.176' |
| FG-23-02-B | 42° 22.739' | 70° 34.449' | MBD-REF-04-D | 42° 22.619' | 70° 30.177' |
| FG-23-02-C | 42° 22.737' | 70° 34.449' | MBD-REF-05-A | 42° 22.624' | 70° 30.314' |
| FG-23-02-D | 42° 22.735' | 70° 34.449' | MBD-REF-05-B | 42° 22.626' | 70° 30.314' |
| FG-23-03-A | 42° 22.691' | 70° 34.650' | MBD-REF-05-C | 42° 22.623' | 70° 30.314' |
| FG-23-03-B | 42° 22.696' | 70° 34.646' | MBD-REF-05-D | 42° 22.623' | 70° 30.311' |
| FG-23-03-C | 42° 22.694' | 70° 34.651' | SE-REF-01-A | 42° 20.096' | 70° 27.896' |
| FG-23-03-D | 42° 22.692' | 70° 34.646' | SE-REF-01-B | 42° 20.100' | 70° 27.892' |
| FG-23-04-A | 42° 22.605' | 70° 34.448' | SE-REF-01-C | 42° 20.101' | 70° 27.892' |
| FG-23-04-B | 42° 22.607' | 70° 34.452' | SE-REF-01-D | 42° 20.100' | 70° 27.893' |
| FG-23-04-C | 42° 22.608' | 70° 34.450' | SE-REF-02-A | 42° 20.091' | 70° 28.035' |
| FG-23-04-D | 42° 22.608' | 70° 34.450' | SE-REF-02-B | 42° 20.093' | 70° 28.040' |
| FG-23-05-A | 42° 22.667' | 70° 34.535' | SE-REF-02-C | 42° 20.091' | 70° 28.037' |
| FG-23-05-B | 42° 22.668' | 70° 34.545' | SE-REF-02-D | 42° 20.091' | 70° 28.036' |
| FG-23-05-C | 42° 22.669' | 70° 34.540' | SE-REF-03-A | 42° 19.996' | 70° 27.837' |
| FG-23-05-D | 42° 22.667' | 70° 34.539' | SE-REF-03-B | 42° 20.000' | 70° 27.840' |
| MBD-REF-01-A | 42° 22.845' | 70° 30.263' | SE-REF-03-C | 42° 20.000' | 70° 27.839' |
| MBD-REF-01-B | 42° 22.842' | 70° 30.262' | SE-REF-03-D | 42° 20.000' | 70° 27.841' |
| MBD-REF-01-C | 42° 22.843' | 70° 30.266' | SE-REF-04-A | 42° 19.921' | 70° 27.990' |
| MBD-REF-01-D | 42° 22.841' | 70° 30.263' | SE-REF-04-B | 42° 19.916' | 70° 27.994' |
| MBD-REF-02-A | 42° 22.751' | 70° 30.401' | SE-REF-04-C | 42° 19.919' | 70° 27.988' |
| MBD-REF-02-B | 42° 22.755' | 70° 30.400' | SE-REF-04-D | 42° 19.916' | 70° 27.993' |
| MBD-REF-02-C | 42° 22.751' | 70° 30.402' | SE-REF-05-A | 42° 20.002' | 70° 28.012' |
| MBD-REF-02-D | 42° 22.753' | 70° 30.399' | SE-REF-05-B | 42° 20.008' | 70° 28.020' |
| MBD-REF-03-A | 42° 22.663' | 70° 30.264' | SE-REF-05-C | 42° 20.003' | 70° 28.013' |
| MBD-REF-03-B | 42° 22.665' | 70° 30.268' | SE-REF-05-D | 42° 20.002' | 70° 28.012' |

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

# APPENDIX D

# SEDIMENT-PROFILE AND PLAN-VIEW IMAGE ANALYSIS RESULTS FOR MBDS SURVEY, SEPTEMBER 2015

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | Date | Time | Stop Collar Setting (in) | # of Weights (per side) | Water Depth (ft) | Grain Size Major Mode (phi) | Grain Size Minimum (phi) | Grain Size Maximum (phi) | Grain Size Range | Penetration Area (sq cm) | Penetration Mean (cm) | Penetration Minimum (cm) | Penetration Maximum (cm) | Boundary Roughness (cm) | Boundary Roughness Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 01 | B | 09/23/15 | 16:10:06 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 242.2 | 16.7 | 16.4 | 17.3 | 0.9 | Biological |
| MBDS | 01 | C | 09/23/15 | 16:10:57 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 259.7 | 17.9 | 17.1 | 18.3 | 1.2 | Biological |
| MBDS | 01 | D | 09/23/15 | 16:11:53 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 157.1 | 10.8 | 9.1 | 12.9 | 3.8 | Biological |
| MBDS | 02 | A | 09/23/15 | 14:28:08 | 13 | 1 | 275 | >4 | >4 | 1 | >4 to 1 | 256.9 | 17.7 | 17.4 | 18.0 | 0.6 | Biological |
| MBDS | 02 | B | 09/23/15 | 14:28:52 | 13 | 1 | 275 | >4 | >4 | 2 | >4 to 2 | 234.7 | 16.2 | 15.0 | 16.4 | 1.4 | Biological |
| MBDS | 02 | C | 09/23/15 | 14:29:32 | 13 | 1 | 275 | >4 | >4 | 2 | >4 to 2 | 245.6 | 16.9 | 16.2 | 17.7 | 1.5 | Biological |
| MBDS | 03 | A | 09/23/15 | 14:19:22 | 13 | 1 | 275 | >4 | >4 | 2 | >4 to 2 | 239.0 | 16.5 | 16.1 | 17.2 | 1.1 | Biological |
| MBDS | 03 | C | 09/23/15 | 14:21:14 | 13 | 1 | 275 | >4 | >4 | 2 | >4 to 2 | 242.9 | 16.7 | 16.3 | 17.5 | 1.2 | Biological |
| MBDS | 03 | D | 09/23/15 | 14:22:06 | 13 | 1 | 275 | >4 | >4 | 2 | >4 to 2 | 230.7 | 15.9 | 15.0 | 16.6 | 1.5 | Biological |
| MBDS | 04 | A | 09/23/15 | 14:11:33 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 251.6 | 17.3 | 16.8 | 17.6 | 0.8 | Biological |
| MBDS | 04 | C | 09/23/15 | 14:13:00 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 231.0 | 15.9 | 15.2 | 16.6 | 1.4 | Biological |
| MBDS | 04 | D | 09/23/15 | 14:13:46 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 223.8 | 15.4 | 14.8 | 15.9 | 1.1 | Biological |
| MBDS | 05 | A | 09/23/15 | 14:35:47 | 13 | 1 | 270 | >4 | >4 | 1 | >4 to 1 | 262.1 | 18.1 | 17.6 | 18.3 | 0.7 | Biological |
| MBDS | 05 | B | 09/23/15 | 14:37:22 | 13 | 1 | 270 | >4 | >4 | 2 | >4 to 2 | 243.1 | 16.8 | 16.4 | 17.3 | 0.8 | Biological |
| MBDS | 05 | C | 09/23/15 | 14:38:07 | 13 | 1 | 270 | >4 | >4 | 2 | >4 to 2 | 266.4 | 18.4 | 18.0 | 18.8 | 0.8 | Biological |
| MBDS | 06 | A | 09/23/15 | 14:03:38 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 299.3 | 20.6 | 19.2 | 21.7 | 2.5 | Biological |
| MBDS | 06 | B | 09/23/15 | 14:04:20 | 13 | 1 | 280 | >4 | >4 | 1 | >4 to 1 | 232.3 | 16.0 | 15.5 | 16.5 | 1.0 | Biological |
| MBDS | 06 | C | 09/23/15 | 14:05:05 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 220.7 | 15.2 | 14.5 | 15.7 | 1.2 | Biological |
| MBDS | 07 | A | 09/23/15 | 14:45:07 | 13 | 1 | 275 | >4 | >4 | 2 | >4 to 2 | 242.6 | 16.7 | 16.4 | 17.0 | 0.7 | Biological |
| MBDS | 07 | B | 09/23/15 | 14:45:49 | 13 | 1 | 275 | >4 | >4 | 2 | >4 to 2 | 218.0 | 15.0 | 14.3 | 15.9 | 1.6 | Biological |
| MBDS | 07 | C | 09/23/15 | 14:46:35 | 13 | 1 | 275 | >4 | >4 | 1 | >4 to 1 | 237.1 | 16.3 | 15.6 | 17.5 | 2.0 | Biological |
| MBDS | 08 | A | 09/23/15 | 12:48:45 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 244.7 | 16.9 | 16.4 | 17.2 | 0.8 | Biological |
| MBDS | 08 | B | 09/23/15 | 12:49:31 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 219.5 | 15.1 | 14.9 | 15.8 | 0.9 | Biological |
| MBDS | 08 | C | 09/23/15 | 12:50:23 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 261.0 | 18.0 | 17.0 | 18.5 | 1.5 | Biological |
| MBDS | 09 | A | 09/23/15 | 12:59:04 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 233.0 | 16.1 | 15.1 | 16.6 | 1.6 | Biological |
| MBDS | 09 | B | 09/23/15 | 12:59:53 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 250.0 | 17.2 | 16.9 | 17.6 | 0.6 | Biological |
| MBDS | 09 | C | 09/23/15 | 13:00:43 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 241.3 | 16.6 | 15.8 | 17.2 | 1.4 | Biological |
| MBDS | 10 | A | 09/23/15 | 13:07:44 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 270.7 | 18.7 | 18.0 | 18.9 | 0.8 | Biological |
| MBDS | 10 | B | 09/23/15 | 13:08:32 | 13 | 1 | 280 | >4 | >4 | 1 | >4 to 1 | 283.5 | 19.5 | 18.4 | 20.6 | 2.2 | Biological |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | Date | Time | Stop Collar Setting (in) | # of Weights (per side) | Water Depth (ft) | Grain Size Major Mode (phi) | Grain Size Minimum (phi) | Grain Size Maximum (phi) | Grain Size Range | Penetration Area (sq cm) | Penetration Mean (cm) | Penetration Minimum (cm) | Penetration Maximum (cm) | Boundary Roughness (cm) | Boundary Roughness Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 10 | C | 09/23/15 | 13:09:21 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 263.6 | 18.2 | 17.3 | 19.8 | 2.6 | Biological |
| MBDS | 11 | A | 09/23/15 | 13:55:18 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 229.3 | 15.8 | 15.3 | 16.1 | 0.8 | Biological |
| MBDS | 11 | C | 09/23/15 | 13:56:49 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 210.0 | 14.5 | 13.9 | 15.0 | 1.1 | Biological |
| MBDS | 11 | D | 09/23/15 | 13:57:32 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 240.7 | 16.6 | 15.9 | 16.8 | 1.0 | Biological |
| MBDS | 12 | A | 09/23/15 | 14:58:08 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 256.2 | 17.7 | 17.2 | 18.1 | 0.9 | Biological |
| MBDS | 12 | B | 09/23/15 | 14:58:49 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 286.4 | 19.7 | 18.0 | 21.5 | 3.6 | Biological |
| MBDS | 12 | D | 09/23/15 | 15:00:36 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 295.2 | 20.3 | 19.9 | 21.0 | 1.1 | Biological |
| MBDS | 13 | A | 09/23/15 | 15:48:31 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 251.3 | 17.3 | 16.7 | 18.2 | 1.5 | Biological |
| MBDS | 13 | B | 09/23/15 | 15:49:20 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 266.0 | 18.3 | 16.9 | 18.9 | 2.1 | Biological |
| MBDS | 13 | C | 09/23/15 | 15:50:22 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 235.9 | 16.3 | 14.1 | 17.5 | 3.5 | Biological |
| MBDS | 14 | A | 09/23/15 | 15:34:23 | 13 | 1 | 270 | >4 | >4 | 2 | >4 to 2 | 224.2 | 15.5 | 14.5 | 16.5 | 2.0 | Biological |
| MBDS | 14 | B | 09/23/15 | 15:35:06 | 13 | 1 | 270 | >4 | >4 | 2 | >4 to 2 | 249.9 | 17.2 | 16.4 | 17.9 | 1.5 | Biological |
| MBDS | 14 | C | 09/23/15 | 15:36:21 | 13 | 1 | 270 | >4 | >4 | 2 | >4 to 2 | 259.5 | 17.9 | 17.0 | 18.6 | 1.6 | Biological |
| MBDS | 15 | A | 09/23/15 | 12:00:22 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 269.2 | 18.6 | 18.1 | 19.2 | 1.0 | Biological |
| MBDS | 15 | B | 09/23/15 | 12:01:16 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 262.6 | 18.1 | 17.3 | 18.5 | 1.2 | Biological |
| MBDS | 15 | C | 09/23/15 | 12:02:05 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 258.5 | 17.8 | 16.9 | 18.2 | 1.3 | Biological |
| MBDS | 16 | A | 09/23/15 | 13:15:23 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 253.7 | 17.5 | 17.2 | 17.7 | 0.5 | Biological |
| MBDS | 16 | B | 09/23/15 | 13:16:22 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 197.0 | 13.6 | 12.7 | 14.3 | 1.6 | Physical |
| MBDS | 16 | C | 09/23/15 | 13:17:11 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 246.7 | 17.0 | 16.8 | 17.2 | 0.4 | Biological |
| MBDS | 17 | A | 09/23/15 | 11:29:46 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 234.8 | 16.2 | 15.8 | 16.4 | 0.7 | Biological |
| MBDS | 17 | B | 09/23/15 | 11:30:54 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 162.4 | 11.2 | 10.1 | 12.0 | 1.9 | Biological |
| MBDS | 17 | C | 09/23/15 | 11:31:41 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 227.8 | 15.7 | 15.4 | 16.1 | 0.7 | Biological |
| MBDS | 18 | A | 09/23/15 | 11:39:00 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 243.7 | 16.8 | 16.3 | 17.5 | 1.1 | Biological |
| MBDS | 18 | B | 09/23/15 | 11:39:55 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 287.5 | 19.8 | 18.9 | 20.5 | 1.6 | Biological |
| MBDS | 18 | D | 09/23/15 | 11:41:54 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 306.4 | 21.1 | 20.1 | 21.8 | 1.6 | Biological |
| MBDS | 19 | A | 09/23/15 | 11:49:39 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 260.0 | 17.9 | 17.6 | 18.3 | 0.7 | Biological |
| MBDS | 19 | B | 09/23/15 | 11:50:25 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 250.6 | 17.3 | 16.9 | 17.5 | 0.7 | Biological |
| MBDS | 19 | C | 09/23/15 | 11:51:20 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 263.3 | 18.2 | 17.8 | 18.4 | 0.7 | Biological |
| MBDS | 20 | B | 09/23/15 | 16:36:48 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 284.5 | 19.6 | 18.5 | 20.4 | 1.9 | Biological |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | Date | Time | Stop Collar Setting (in) | # of Weights (per side) | Water Depth (ft) | Grain Size Major Mode (phi) | Grain Size Minimum (phi) | Grain Size Maximum (phi) | Grain Size Range | Penetration Area (sq cm) | Penetration Mean (cm) | Penetration Minimum (cm) | Penetration Maximum (cm) | Boundary Roughness (cm) | Boundary Roughness Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 20 | C | 09/23/15 | 16:37:41 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 253.9 | 17.5 | 16.1 | 18.1 | 2.0 | Biological |
| MBDS | 20 | D | 09/23/15 | 16:38:31 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 245.5 | 16.9 | 16.2 | 17.7 | 1.5 | Biological |
| MBDS | 21 | A | 09/23/15 | 16:43:34 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 268.7 | 18.5 | 17.4 | 19.1 | 1.7 | Biological |
| MBDS | 21 | B | 09/23/15 | 16:44:27 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 263.9 | 18.2 | 17.3 | 19.2 | 1.9 | Biological |
| MBDS | 21 | C | 09/23/15 | 16:45:26 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 252.5 | 17.4 | 16.8 | 18.2 | 1.4 | Biological |
| MBDS | 22 | A | 09/23/15 | 16:52:44 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 279.2 | 19.2 | 18.7 | 19.7 | 1.0 | Biological |
| MBDS | 22 | C | 09/23/15 | 16:54:17 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 260.0 | 17.9 | 17.6 | 18.4 | 0.9 | Biological |
| MBDS | 22 | D | 09/23/15 | 16:55:04 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 237.0 | 16.3 | 15.5 | 16.8 | 1.3 | Biological |
| MBDS | 23 | A | 09/23/15 | 10:50:25 | 13.5 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 282.8 | 19.5 | 18.2 | 20.2 | 2.0 | Biological |
| MBDS | 23 | C | 09/23/15 | 10:52:27 | 13.5 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 273.1 | 18.8 | 18.0 | 19.3 | 1.3 | Biological |
| MBDS | 23 | D | 09/23/15 | 10:53:30 | 13.5 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 250.4 | 17.3 | 13.3 | 18.5 | 5.2 | Biological |
| MBDS | 24 | A | 09/23/15 | 11:19:14 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 274.3 | 18.9 | 18.5 | 19.4 | 0.8 | Biological |
| MBDS | 24 | B | 09/23/15 | 11:20:03 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 266.0 | 18.3 | 17.7 | 18.9 | 1.2 | Biological |
| MBDS | 24 | C | 09/23/15 | 11:20:49 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 281.2 | 19.4 | 19.1 | 19.9 | 0.8 | Biological |
| MBDS | 25 | A | 09/23/15 | 16:16:47 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 268.1 | 18.5 | 17.9 | 19.1 | 1.2 | Biological |
| MBDS | 25 | C | 09/23/15 | 16:18:35 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 260.6 | 18.0 | 16.6 | 19.1 | 2.5 | Biological |
| MBDS | 25 | D | 09/23/15 | 16:20:09 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 260.5 | 18.0 | 17.4 | 18.4 | 1.0 | Biological |
| MBDS | 26 | A | 09/23/15 | 17:06:05 | 13 | 1 | 301 | >4 | >4 | 2 | >4 to 2 | 315.7 | 21.8 | 21.8 | 21.8 | Ind | Ind |
| MBDS | 26 | B | 09/23/15 | 17:06:53 | 13 | 1 | 301 | >4 | >4 | 2 | >4 to 2 | 315.7 | 21.8 | 21.8 | 21.8 | Ind | Ind |
| MBDS | 26 | D | 09/23/15 | 17:08:44 | 13 | 1 | 301 | >4 | >4 | 2 | >4 to 2 | 281.0 | 19.4 | 18.9 | 19.7 | 0.7 | Biological |
| MBDS | 27 | A | 09/23/15 | 15:58:42 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 277.1 | 19.1 | 18.5 | 19.6 | 1.1 | Biological |
| MBDS | 27 | B | 09/23/15 | 15:59:31 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 234.0 | 16.1 | 15.8 | 16.5 | 0.7 | Biological |
| MBDS | 27 | C | 09/23/15 | 16:00:21 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 259.1 | 17.9 | 17.1 | 18.2 | 1.1 | Biological |
| MBDS | 28 | A | 09/23/15 | 16:26:10 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 225.9 | 15.6 | 15.1 | 15.9 | 0.9 | Biological |
| MBDS | 28 | B | 09/23/15 | 16:26:56 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 255.2 | 17.6 | 17.0 | 18.1 | 1.1 | Biological |
| MBDS | 28 | C | 09/23/15 | 16:27:58 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 227.9 | 15.7 | 15.0 | 16.2 | 1.1 | Biological |
| MBDS | 29 | A | 09/23/15 | 13:37:36 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 157.3 | 10.8 | 10.2 | 11.7 | 1.6 | Biological |
| MBDS | 29 | B | 09/23/15 | 13:38:51 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 100.8 | 7.0 | 6.5 | 7.4 | 0.9 | Biological |
| MBDS | 29 | D | 09/23/15 | 13:40:41 | 13 | 1 | 285 | >4 | >4 | 2 | >4 to 2 | 31.8 | 2.2 | 1.0 | 2.9 | 1.9 | Biological |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | Date | Time | Stop Collar Setting (in) | # of Weights (per side) | Water Depth (ft) | Grain Size Major Mode (phi) | Grain Size Minimum (phi) | Grain Size Maximum (phi) | Grain Size Range | Penetration Area (sq cm) | Penetration Mean (cm) | Penetration Minimum (cm) | Penetration Maximum (cm) | Boundary Roughness (cm) | Boundary Roughness Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 30 | A | 09/23/15 | 13:25:25 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 238.2 | 16.4 | 16.1 | 17.0 | 0.9 | Biological |
| MBDS | 30 | B | 09/23/15 | 13:26:10 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 235.1 | 16.2 | 14.7 | 17.1 | 2.4 | Biological |
| MBDS | 30 | D | 09/23/15 | 13:27:52 | 13 | 1 | 280 | >4 | >4 | 2 | >4 to 2 | 238.8 | 16.5 | 15.8 | 17.2 | 1.4 | Biological |
| FG-23 | FG-23-01 | A | 09/24/15 | 8:58:21 | 13 | 1 | 290 | >4 | >4 | 3 | >4 to 3 | 296.6 | 20.4 | 20.0 | 20.8 | 0.8 | Biological |
| FG-23 | FG-23-01 | B | 09/24/15 | 8:59:21 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 276.3 | 19.0 | 18.5 | 19.6 | 1.1 | Biological |
| FG-23 | FG-23-01 | C | 09/24/15 | 9:00:24 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 273.4 | 18.8 | 18.1 | 19.4 | 1.3 | Biological |
| FG-23 | FG-23-02 | A | 09/24/15 | 9:24:17 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 253.0 | 17.4 | 16.4 | 17.8 | 1.4 | Biological |
| FG-23 | FG-23-02 | C | 09/24/15 | 9:26:02 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 245.6 | 16.9 | 16.1 | 17.9 | 1.8 | Biological |
| FG-23 | FG-23-02 | D | 09/24/15 | 9:26:57 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 269.9 | 18.6 | 17.6 | 19.4 | 1.8 | Biological |
| FG-23 | FG-23-03 | A | 09/24/15 | 9:05:21 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 254.7 | 17.6 | 17.1 | 17.7 | 0.6 | Biological |
| FG-23 | FG-23-03 | B | 09/24/15 | 9:06:10 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 238.9 | 16.5 | 16.2 | 16.6 | 0.4 | Biological |
| FG-23 | FG-23-03 | C | 09/24/15 | 9:07:09 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 227.9 | 15.7 | 15.0 | 16.2 | 1.2 | Biological |
| FG-23 | FG-23-04 | A | 09/24/15 | 9:32:04 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 245.1 | 16.9 | 16.4 | 17.7 | 1.3 | Biological |
| FG-23 | FG-23-04 | B | 09/24/15 | 9:33:09 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 293.7 | 20.2 | 19.0 | 21.2 | 2.2 | Biological |
| FG-23 | FG-23-04 | C | 09/24/15 | 9:34:10 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 244.9 | 16.9 | 15.8 | 19.1 | 3.3 | Physical |
| FG-23 | FG-23-05 | A | 09/24/15 | 9:14:00 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 214.6 | 14.8 | 12.0 | 17.4 | 5.5 | Physical |
| FG-23 | FG-23-05 | B | 09/24/15 | 9:15:26 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 248.3 | 17.1 | 16.4 | 17.7 | 1.3 | Biological |
| FG-23 | FG-23-05 | C | 09/24/15 | 9:16:43 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 250.8 | 17.3 | 17.0 | 18.0 | 1.0 | Biological |
| MBD-REF | MBD-REF-01 | A | 09/24/15 | 10:22:42 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 243.8 | 16.8 | 16.1 | 18.0 | 1.8 | Biological |
| MBD-REF | MBD-REF-01 | B | 09/24/15 | 10:23:41 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 227.6 | 15.7 | 14.1 | 16.5 | 2.4 | Biological |
| MBD-REF | MBD-REF-01 | C | 09/24/15 | 10:24:54 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 225.1 | 15.5 | 15.2 | 15.8 | 0.6 | Biological |
| MBD-REF | MBD-REF-02 | A | 09/24/15 | 10:30:21 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 251.6 | 17.3 | 16.6 | 17.9 | 1.3 | Biological |
| MBD-REF | MBD-REF-02 | B | 09/24/15 | 10:31:28 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 272.1 | 18.8 | 18.1 | 19.2 | 1.1 | Biological |
| MBD-REF | MBD-REF-02 | C | 09/24/15 | 10:32:25 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 171.1 | 11.8 | 10.8 | 12.7 | 1.9 | Biological |
| MBD-REF | MBD-REF-03 | A | 09/24/15 | 10:38:59 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 222.1 | 15.3 | 14.7 | 16.1 | 1.3 | Biological |
| MBD-REF | MBD-REF-03 | B | 09/24/15 | 10:39:53 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 255.2 | 17.6 | 16.7 | 19.1 | 2.4 | Biological |
| MBD-REF | MBD-REF-03 | C | 09/24/15 | 10:40:49 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 255.7 | 17.6 | 17.1 | 18.1 | 1.0 | Biological |
| MBD-REF | MBD-REF-04 | A | 09/24/15 | 10:53:59 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 278.8 | 19.2 | 19.0 | 19.4 | 0.4 | Biological |
| MBD-REF | MBD-REF-04 | B | 09/24/15 | 10:54:53 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 242.0 | 16.7 | 15.9 | 17.3 | 1.4 | Biological |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | Date | Time | Stop Collar Setting (in) | # of Weights (per side) | Water Depth (ft) | Grain Size Major Mode (phi) | Grain Size Minimum (phi) | Grain Size Maximum (phi) | Grain Size Range | Penetration Area (sq cm) | Penetration Mean (cm) | Penetration Minimum (cm) | Penetration Maximum (cm) | Boundary Roughness (cm) | Boundary Roughness Type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBD-REF | MBD-REF-04 | D | 09/24/15 | 10:56:46 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 243.3 | 16.8 | 16.5 | 17.3 | 0.7 | Biological |
| MBD-REF | MBD-REF-05 | A | 09/24/15 | 10:45:37 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 289.5 | 20.0 | 15.2 | 21.0 | 5.8 | Biological |
| MBD-REF | MBD-REF-05 | B | 09/24/15 | 10:46:41 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 244.6 | 16.9 | 16.4 | 17.2 | 0.8 | Biological |
| MBD-REF | MBD-REF-05 | C | 09/24/15 | 10:47:39 | 13 | 1 | 295 | >4 | >4 | 2 | >4 to 2 | 264.5 | 18.2 | 17.9 | 18.6 | 0.7 | Biological |
| SE-REF | SE-REF-01 | A | 09/24/15 | 11:50:25 | 13 | 1 | 298 | >4 | >4 | 2 | >4 to 2 | 304.3 | 21.0 | 18.5 | 21.8 | 3.2 | Biological |
| SE-REF | SE-REF-01 | B | 09/24/15 | 11:51:28 | 13 | 1 | 298 | >4 | >4 | 2 | >4 to 2 | 267.8 | 18.5 | 17.8 | 19.2 | 1.5 | Biological |
| SE-REF | SE-REF-01 | C | 09/24/15 | 11:52:34 | 13 | 1 | 298 | >4 | >4 | 2 | >4 to 2 | 269.4 | 18.6 | 17.7 | 19.2 | 1.6 | Biological |
| SE-REF | SE-REF-02 | A | 09/24/15 | 11:41:10 | 13 | 1 | 300 | >4 | >4 | 2 | >4 to 2 | 301.2 | 20.8 | 20.3 | 21.0 | 0.7 | Biological |
| SE-REF | SE-REF-02 | B | 09/24/15 | 11:42:15 | 13 | 1 | 300 | >4 | >4 | 2 | >4 to 2 | 288.4 | 19.9 | 18.0 | 21.8 | 3.8 | Biological |
| SE-REF | SE-REF-02 | C | 09/24/15 | 11:43:17 | 13 | 1 | 300 | >4 | >4 | 2 | >4 to 2 | 295.1 | 20.3 | 19.9 | 20.6 | 0.8 | Biological |
| SE-REF | SE-REF-03 | B | 09/24/15 | 12:00:49 | 13 | 1 | 297 | >4 | >4 | 2 | >4 to 2 | 286.7 | 19.8 | 19.0 | 20.6 | 1.6 | Biological |
| SE-REF | SE-REF-03 | C | 09/24/15 | 12:01:45 | 13 | 1 | 297 | >4 | >4 | 2 | >4 to 2 | 284.7 | 19.6 | 18.7 | 19.3 | 0.7 | Biological |
| SE-REF | SE-REF-03 | D | 09/24/15 | 12:03:18 | 13 | 1 | 297 | >4 | >4 | 2 | >4 to 2 | 253.2 | 17.5 | 17.1 | 17.8 | 0.7 | Biological |
| SE-REF | SE-REF-04 | A | 09/24/15 | 12:15:34 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 273.1 | 18.8 | 18.0 | 19.2 | 1.1 | Biological |
| SE-REF | SE-REF-04 | B | 09/24/15 | 12:16:30 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 247.0 | 17.0 | 16.2 | 17.6 | 1.5 | Biological |
| SE-REF | SE-REF-04 | C | 09/24/15 | 12:17:29 | 13 | 1 | 290 | >4 | >4 | 2 | >4 to 2 | 271.2 | 18.7 | 17.7 | 20.8 | 3.1 | Physical |
| SE-REF | SE-REF-05 | A | 09/24/15 | 12:08:08 | 13 | 1 | 293 | >4 | >4 | 2 | >4 to 2 | 260.2 | 17.9 | 17.4 | 18.4 | 1.0 | Biological |
| SE-REF | SE-REF-05 | B | 09/24/15 | 12:09:11 | 13 | 1 | 293 | >4 | >4 | 2 | >4 to 2 | 285.9 | 19.7 | 19.4 | 20.0 | 0.6 | Biological |
| SE-REF | SE-REF-05 | D | 09/24/15 | 12:11:10 | 13 | 1 | 293 | >4 | >4 | 2 | >4 to 2 | 266.3 | 18.4 | 17.3 | 18.9 | 1.6 | Biological |

Note: 1) "Ind" indicates that the sample result was indeterminate
2) "mean" indicates the mean value across a single sediment profile image

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | aRPD Area (sq cm) | Mean aRPD (cm) | Dredged Material | Max Dredged Material Depth cm | Dredged Material Comments | Mud Clast Number | Mud Clast State | Methane? | Low DO? | # of Feeding Voids | Void Minimum Depth (cm) | Void Maximum Depth (cm) | Void Average Depth (cm) | Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 01 | B | 33.3 | 2.3 | Yes | 17.3 | | 0 | - | No | No | 1 | 16.9 | 17.3 | 17.1 | 1 on 3 |
| MBDS | 01 | C | 42.4 | 2.9 | Yes | 18.3 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 01 | D | 74.0 | 5.1 | Yes | 12.9 | | 0 | - | No | No | 2 | 8.3 | 10.7 | 9.5 | 1 on 3 |
| MBDS | 02 | A | 50.3 | 3.5 | Yes | 18.0 | | 0 | - | No | No | 3 | 8.4 | 13.8 | 11.1 | 1 on 3 |
| MBDS | 02 | B | 56.2 | 3.9 | Yes | 16.4 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 02 | C | 73.1 | 5.0 | Yes | 17.7 | | 0 | - | No | No | 1 | 16.4 | 17.3 | 16.9 | 1 on 3 |
| MBDS | 03 | A | 55.0 | 3.8 | Yes | 17.2 | | 0 | - | No | No | 2 | 13.5 | 16.9 | 15.2 | 1 on 3 |
| MBDS | 03 | C | 76.1 | 5.2 | Yes | 17.5 | | 0 | - | No | No | 6 | 7.1 | 14.1 | 10.6 | 1 on 3 |
| MBDS | 03 | D | 67.6 | 4.7 | Yes | 16.6 | | 1 | Ox | No | No | 3 | 7.9 | 16.1 | 12.0 | 2 on 3 |
| MBDS | 04 | A | 61.4 | 4.2 | Yes | 17.6 | | 0 | | No | No | 1 | 8.1 | 8.6 | 8.4 | 1 on 3 |
| MBDS | 04 | C | 68.1 | 4.7 | No | | | 0 | - | No | No | 2 | 7.8 | 16.6 | 12.2 | 1 on 3 |
| MBDS | 04 | D | 73.4 | 5.1 | Yes | 15.9 | | 0 | - | No | No | 2 | 7.3 | 10.9 | 9.1 | 1 on 3 |
| MBDS | 05 | A | 39.0 | 2.7 | Yes | 18.3 | | 0 | - | No | No | 2 | 9.2 | 13.0 | 11.1 | 1 on 3 |
| MBDS | 05 | B | 63.3 | 4.4 | Yes | 17.3 | | 0 | - | No | No | 1 | 15.4 | 16.1 | 15.7 | 1 on 3 |
| MBDS | 05 | C | 55.9 | 3.9 | Yes | 18.8 | | 0 | - | No | No | 2 | 5.3 | 18.4 | 11.9 | 1 on 3 |
| MBDS | 06 | A | 73.0 | 5.0 | Yes | 21.7 | White clay in sediment column. | 0 | - | No | No | 3 | 9.3 | 20.8 | 15.0 | 1 on 3 |
| MBDS | 06 | B | 69.9 | 4.8 | Yes | 16.5 | | 0 | - | No | No | 2 | 2.7 | 16.4 | 9.5 | 1 on 3 |
| MBDS | 06 | C | 41.4 | 2.9 | Yes | 15.7 | | 0 | - | No | No | 1 | 14.8 | 14.9 | 14.8 | 1 on 3 |
| MBDS | 07 | A | 48.8 | 3.4 | Yes | 17.0 | | 0 | - | No | No | 1 | 16.9 | 17.0 | 17.0 | 1 on 3 |
| MBDS | 07 | B | 39.7 | 2.7 | Yes | 15.9 | | 0 | - | No | No | 1 | 8.5 | 9.1 | 8.8 | 1 on 3 |
| MBDS | 07 | C | 59.8 | 4.1 | Yes | 17.5 | | 0 | - | No | No | 2 | 8.9 | 12.5 | 10.7 | 1 on 3 |
| MBDS | 08 | A | 58.5 | 4.0 | No | | | 0 | - | No | No | 1 | 5.8 | 6.6 | 6.2 | 1 on 3 |
| MBDS | 08 | B | 60.4 | 4.2 | No | | | 0 | - | No | No | 1 | 6.8 | 8.1 | 7.5 | 2 on 3 |
| MBDS | 08 | C | 59.4 | 4.1 | No | | | 0 | - | No | No | 1 | 4.9 | 5.3 | 5.1 | 1 on 3 |
| MBDS | 09 | A | 70.9 | 4.9 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 09 | B | 68.4 | 4.7 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | aRPD Area (sq cm) | Mean aRPD (cm) | Dredged Material | Max Dredged Material Depth cm | Dredged Material Comments | Mud Clast Number | Mud Clast State | Methane? | Low DO? | # of Feeding Voids | Void Minimum Depth (cm) | Void Maximum Depth (cm) | Void Average Depth (cm) | Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 09 | C | 63.5 | 4.4 | No | | | 0 | - | No | No | 7 | 4.7 | 13.8 | 9.2 | 1 on 3 |
| MBDS | 10 | A | 47.4 | 3.3 | No | | | 8 | Ox | No | No | 2 | 7.1 | 16.9 | 12.0 | 1 on 3 |
| MBDS | 10 | B | 63.6 | 4.4 | No | | | 0 | - | No | No | 1 | 9.5 | 10.7 | 10.1 | 1 on 3 |
| MBDS | 10 | C | 65.2 | 4.5 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 11 | A | 39.5 | 2.7 | Yes | 16.1 | White clay forms layer deep in sediment. | 0 | - | No | No | 4 | 3.1 | 14.8 | 9.0 | 1 on 3 |
| MBDS | 11 | C | 35.3 | 2.4 | Yes | 15.0 | White clay forms layer deep in sediment. | 0 | - | No | No | 1 | 6.3 | 7.3 | 6.8 | 1 on 3 |
| MBDS | 11 | D | 58.7 | 4.0 | Yes | 16.8 | White clay forms layer deep in sediment. | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 12 | A | 60.0 | 4.1 | Yes | 18.1 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 12 | B | 55.5 | 3.8 | Yes | 21.5 | | 0 | - | No | No | 3 | 5.9 | 15.6 | 10.7 | 1 on 3 |
| MBDS | 12 | D | 44.8 | 3.1 | Yes | 14.7 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 13 | A | 62.2 | 4.3 | No | | | 0 | - | No | No | 1 | 16.4 | 17.3 | 16.8 | 1 on 3 |
| MBDS | 13 | B | 54.4 | 3.7 | Yes | 18.9 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 13 | C | 30.3 | 2.1 | Yes | 17.5 | | 2 | Ox | No | No | 0 | | | | 1 on 3 |
| MBDS | 14 | A | 58.5 | 4.0 | No | | | 0 | - | No | No | 3 | 4.2 | 12.1 | 8.1 | 1 on 3 |
| MBDS | 14 | B | 68.9 | 4.7 | Yes | 17.9 | | 0 | - | No | No | 3 | 5.2 | 17.9 | 11.6 | 1 on 3 |
| MBDS | 14 | C | 59.4 | 4.1 | Yes | 18.6 | | 0 | - | No | No | 3 | 7.6 | 17.3 | 12.4 | 1 on 3 |
| MBDS | 15 | A | 62.0 | 4.3 | Yes | 19.2 | | 0 | - | No | No | 5 | 8.4 | 15.6 | 12.0 | 1 on 3 |
| MBDS | 15 | B | 59.3 | 4.1 | Yes | 18.5 | | 0 | - | No | No | 2 | 3.9 | 15.0 | 9.5 | 1 on 3 |
| MBDS | 15 | C | 62.5 | 4.3 | Yes | 18.2 | | 1 | Ox | No | No | 2 | 3.6 | 7.5 | 5.6 | 1 on 3 |
| MBDS | 16 | A | 86.9 | 6.0 | No | | | 0 | - | No | No | 3 | 6.1 | 10.4 | 8.2 | 1 on 3 |
| MBDS | 16 | B | Ind | Ind | Yes | 14.3 | | 0 | - | No | No | 1 | 11.9 | 13.9 | 12.9 | 3 |
| MBDS | 16 | C | 51.6 | 3.6 | Yes | 17.2 | | 0 | - | No | No | 3 | 2.7 | 16.3 | 9.5 | 1 on 3 |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | aRPD Area (sq cm) | Mean aRPD (cm) | Dredged Material | Max Dredged Material Depth cm | Dredged Material Comments | Mud Clast Number | Mud Clast State | Methane? | Low DO? | # of Feeding Voids | Void Minimum Depth (cm) | Void Maximum Depth (cm) | Void Average Depth (cm) | Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 17 | A | 78.9 | 5.4 | No | | | 0 | - | No | No | 2 | 8.4 | 13.5 | 11.0 | 1 on 3 |
| MBDS | 17 | B | 75.0 | 5.2 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 17 | C | 68.6 | 4.7 | No | | | 0 | - | No | No | 3 | 4.3 | 7.3 | 5.8 | 1 on 3 |
| MBDS | 18 | A | 50.1 | 3.5 | No | | | 0 | - | No | No | 4 | 2.3 | 16.0 | 9.1 | 1 on 3 |
| MBDS | 18 | B | 46.7 | 3.2 | No | | | 0 | - | No | No | 2 | 12.7 | 15.3 | 14.0 | 1 on 3 |
| MBDS | 18 | D | 73.2 | 5.0 | No | | | 0 | - | No | No | 4 | 9.9 | 19.4 | 14.7 | 1 on 3 |
| MBDS | 19 | A | 53.8 | 3.7 | No | | | 0 | - | No | No | 3 | 14.2 | 17.3 | 15.8 | 2 on 3 |
| MBDS | 19 | B | 45.7 | 3.1 | Yes | 17.5 | | 0 | - | No | No | 3 | 5.7 | 17.3 | 11.5 | 2 on 3 |
| MBDS | 19 | C | 45.3 | 3.1 | Yes | 18.4 | | 0 | - | No | No | 6 | 6.3 | 15.1 | 10.7 | 1 on 3 |
| MBDS | 20 | B | 63.5 | 4.4 | Yes | 20.4 | | 0 | - | No | No | 1 | 6.7 | 6.8 | 6.8 | 1 on 3 |
| MBDS | 20 | C | 66.9 | 4.6 | Yes | 18.1 | | 0 | - | No | No | 4 | 4.5 | 6.9 | 5.7 | 1 on 3 |
| MBDS | 20 | D | 70.1 | 4.8 | Yes | 17.7 | | 5 | Red | No | No | 5 | 9.2 | 17.6 | 13.4 | 1 on 3 |
| MBDS | 21 | A | 68.5 | 4.7 | Yes | 19.1 | | 0 | - | No | No | 1 | 17.6 | 18.9 | 18.3 | 1 on 3 |
| MBDS | 21 | B | 79.5 | 5.5 | Yes | 19.2 | | 1 | Ox | No | No | 5 | 3.3 | 17.6 | 10.5 | 1 on 3 |
| MBDS | 21 | C | 53.3 | 3.7 | Yes | 18.2 | | 0 | - | No | No | 4 | 3.4 | 17.2 | 10.3 | 1 on 3 |
| MBDS | 22 | A | 46.6 | 3.2 | Yes | 19.7 | | 1 | Ox | No | No | 4 | 2.8 | 17.1 | 9.9 | 1 on 3 |
| MBDS | 22 | C | 57.4 | 4.0 | Yes | 18.4 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 22 | D | 62.9 | 4.3 | Yes | 16.8 | | 0 | - | No | No | 5 | 4.1 | 16.4 | 10.3 | 1 on 3 |
| MBDS | 23 | A | 54.2 | 3.7 | No | | | 0 | - | No | No | 2 | 2.7 | 17.5 | 10.1 | 1 on 3 |
| MBDS | 23 | C | 55.0 | 3.8 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 23 | D | 60.2 | 4.2 | No | | | 0 | - | No | No | 1 | 15.8 | 16.3 | 16.1 | 1 on 3 |
| MBDS | 24 | A | 56.1 | 3.9 | Yes | 19.4 | Dark gray material under aRPD, mottled with tan and white at penetration maximum. | 0 | - | No | No | 4 | 5.3 | 11.0 | 8.1 | 1 on 3 |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | aRPD Area (sq cm) | Mean aRPD (cm) | Dredged Material | Max Dredged Material Depth cm | Dredged Material Comments | Mud Clast Number | Mud Clast State | Methane? | Low DO? | # of Feeding Voids | Void Minimum Depth (cm) | Void Maximum Depth (cm) | Void Average Depth (cm) | Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 24 | B | 16.6 | 1.1 | Yes | 18.9 | Dark gray material under aRPD, mottled with tan and white at penetration maximum. | 0 | - | No | No | 2 | 9.4 | 13.6 | 11.5 | 1 on 3 |
| MBDS | 24 | C | 21.0 | 1.4 | Yes | 19.9 | Dark gray material under aRPD, mottled with tan and white at penetration maximum. | 1 | Ox | No | No | 4 | 6.8 | 18.0 | 12.4 | 1 on 3 |
| MBDS | 25 | A | 48.5 | 3.3 | No | | | 0 | - | No | No | 3 | 8.9 | 18.3 | 13.6 | 1 on 3 |
| MBDS | 25 | C | 40.4 | 2.8 | No | | | 0 | - | No | No | 1 | 11.5 | 15.7 | 13.6 | 1 on 3 |
| MBDS | 25 | D | 61.1 | 4.2 | No | | | 0 | - | No | No | 1 | 17.2 | 18.2 | 17.7 | 1 on 3 |
| MBDS | 26 | A | Ind | Ind | Yes | 21.8 | Dark gray material under aRPD, mottled with tan and white at penetration maximum. | 0 | - | No | No | 5 | Ind | Ind | Ind | 3 |
| MBDS | 26 | B | Ind | Ind | Yes | 21.8 | Dark gray material under aRPD, mottled with tan and white at penetration maximum. | 0 | - | No | No | 3 | Ind | Ind | Ind | 3 |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | aRPD Area (sq cm) | Mean aRPD (cm) | Dredged Material | Max Dredged Material Depth cm | Dredged Material Comments | Mud Clast Number | Mud Clast State | Methane? | Low DO? | # of Feeding Voids | Void Minimum Depth (cm) | Void Maximum Depth (cm) | Void Average Depth (cm) | Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 26 | D | 20.3 | 1.4 | Yes | 19.7 | Dark gray material under aRPD, mottled with tan and white at penetration maximum. | 0 | - | No | No | 6 | 9.0 | 18.9 | 14.0 | 1 on 3 |
| MBDS | 27 | A | 53.4 | 3.7 | No | | | 0 | - | No | No | 3 | 8.6 | 19.5 | 14.1 | 1 on 3 |
| MBDS | 27 | B | 43.3 | 3.0 | No | | | 0 | - | No | No | 3 | 6.1 | 16.0 | 11.0 | 1 on 3 |
| MBDS | 27 | C | 40.2 | 2.8 | Yes | 18.2 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 28 | A | 52.7 | 3.6 | Yes | 15.9 | Small white streak in lower left corner of image. | 0 | - | No | No | 1 | 2.7 | 7.0 | 4.8 | 1 on 3 |
| MBDS | 28 | B | 64.1 | 4.4 | Yes | 18.1 | | 0 | - | No | No | 1 | 9.7 | 11.4 | 10.6 | 1 on 3 |
| MBDS | 28 | C | 58.1 | 4.0 | Yes | 16.2 | | 0 | - | No | No | 5 | 6.3 | 15.5 | 10.9 | 1 on 3 |
| MBDS | 29 | A | 47.7 | 3.3 | No | | | 0 | - | No | No | 1 | 7.4 | 7.5 | 7.5 | 1 on 3 |
| MBDS | 29 | B | 27.0 | 1.9 | Yes | 7.4 | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBDS | 29 | D | 31.8 | 2.2 | No | | | 0 | - | No | No | 0 | | | | Ind |
| MBDS | 30 | A | 41.4 | 2.9 | Yes | 17.0 | | 0 | - | No | No | 1 | 9.9 | 11.9 | 10.9 | 1 on 3 |
| MBDS | 30 | B | 51.6 | 3.6 | Yes | 17.1 | | 0 | - | No | No | 2 | 6.1 | 15.1 | 10.6 | 1 on 3 |
| MBDS | 30 | D | 52.8 | 3.6 | Yes | 17.2 | | 0 | - | No | No | 3 | 6.1 | 11.8 | 9.0 | 1 on 3 |
| FG-23 | FG-23-01 | A | 47.4 | 3.3 | No | | | 1 | Ox | No | No | 4 | 0.0 | 10.2 | 5.1 | 1 on 3 |
| FG-23 | FG-23-01 | B | 57.3 | 4.0 | No | | | 0 | - | No | No | 1 | 7.4 | 8.3 | 7.8 | 1 on 3 |
| FG-23 | FG-23-01 | C | 40.7 | 2.8 | No | | | 0 | - | No | No | 4 | 3.8 | 18.1 | 11.0 | 1 on 3 |
| FG-23 | FG-23-02 | A | 50.6 | 3.5 | No | | | 0 | - | No | No | 2 | 7.8 | 13.4 | 10.6 | 1 on 3 |
| FG-23 | FG-23-02 | C | 39.0 | 2.7 | No | | | 0 | - | No | No | 1 | 8.7 | 10.5 | 9.6 | 1 on 3 |
| FG-23 | FG-23-02 | D | 51.9 | 3.6 | No | | | 0 | - | No | No | 1 | 17.8 | 18.3 | 18.1 | 1 on 3 |
| FG-23 | FG-23-03 | A | 57.4 | 4.0 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| FG-23 | FG-23-03 | B | 60.3 | 4.2 | No | | | 0 | - | No | No | 4 | 4.0 | 15.7 | 9.9 | 1 on 3 |

| Location | Station | Replicate | aRPD Area (sq cm) | Mean aRPD (cm) | Dredged Material | Max Dredged Material Depth cm | Dredged Material Comments | Mud Clast Number | Mud Clast State | Methane? | Low DO? | # of Feeding Voids | Void Minimum Depth (cm) | Void Maximum Depth (cm) | Void Average Depth (cm) | Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FG-23 | FG-23-03 | C | 46.7 | 3.2 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| FG-23 | FG-23-04 | A | 63.1 | 4.3 | No | | | 0 | - | No | No | 1 | 6.0 | 7.1 | 6.5 | 1 on 3 |
| FG-23 | FG-23-04 | B | 84.2 | 5.8 | No | | | 0 | - | No | No | 4 | 0.9 | 19.4 | 10.1 | 1 on 3 |
| FG-23 | FG-23-04 | C | 58.6 | 4.0 | No | | | 0 | - | No | No | 3 | 10.5 | 15.0 | 12.7 | 1 on 3 |
| FG-23 | FG-23-05 | A | Ind | Ind | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| FG-23 | FG-23-05 | B | 67.8 | 4.7 | No | | | 0 | - | No | No | 3 | 7.5 | 9.9 | 8.7 | 1 on 3 |
| FG-23 | FG-23-05 | C | 56.7 | 3.9 | No | | | 0 | - | No | No | 2 | 7.4 | 17.0 | 12.2 | 1 on 3 |
| MBD-REF | MBD-REF-01 | A | 52.1 | 3.6 | No | | | 0 | - | No | No | 1 | 7.8 | 9.2 | 8.5 | 1 on 3 |
| MBD-REF | MBD-REF-01 | B | 55.2 | 3.8 | No | | | 0 | - | No | No | 3 | 7.8 | 13.9 | 10.8 | 1 on 3 |
| MBD-REF | MBD-REF-01 | C | 47.6 | 3.3 | No | | | 0 | - | No | No | 3 | 4.1 | 7.9 | 6.0 | 1 on 3 |
| MBD-REF | MBD-REF-02 | A | 49.4 | 3.4 | No | | | 0 | - | No | No | 1 | 5.4 | 6.5 | 6.0 | 1 on 3 |
| MBD-REF | MBD-REF-02 | B | 48.1 | 3.3 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBD-REF | MBD-REF-02 | C | 43.5 | 3.0 | No | | | 0 | - | No | No | 4 | 5.3 | 8.8 | 7.1 | 1 on 3 |
| MBD-REF | MBD-REF-03 | A | 56.6 | 3.9 | No | | | 0 | - | No | No | 3 | 2.3 | 12.5 | 7.4 | 1 on 3 |
| MBD-REF | MBD-REF-03 | B | 51.4 | 3.5 | No | | | 0 | - | No | No | 1 | 11.4 | 12.0 | 11.7 | 1 on 3 |
| MBD-REF | MBD-REF-03 | C | 60.9 | 4.2 | No | | | 10 | Ox | No | No | 0 | | | | 1 on 3 |
| MBD-REF | MBD-REF-04 | A | 20.4 | 1.4 | No | | | 0 | - | No | No | 2 | 10.5 | 17.0 | 13.7 | 1 on 3 |
| MBD-REF | MBD-REF-04 | B | 36.5 | 2.5 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| MBD-REF | MBD-REF-04 | D | 40.5 | 2.8 | No | | | 0 | - | No | No | 2 | 3.7 | 8.0 | 5.9 | 1 on 3 |
| MBD-REF | MBD-REF-05 | A | 33.7 | 2.3 | No | | | 0 | - | Yes | No | 3 | 5.5 | 16.6 | 11.0 | 1 on 3 |
| MBD-REF | MBD-REF-05 | B | 51.1 | 3.5 | No | | | 0 | - | No | No | 3 | 5.2 | 16.3 | 10.8 | 1 on 3 |
| MBD-REF | MBD-REF-05 | C | 52.7 | 3.6 | No | | | 0 | - | No | No | 2 | 10.7 | 13.8 | 12.3 | 1 on 3 |
| SE-REF | SE-REF-01 | A | 65.9 | 4.5 | No | | | 0 | - | No | No | 3 | 12.7 | 20.6 | 16.7 | 1 on 3 |
| SE-REF | SE-REF-01 | B | 57.1 | 3.9 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| SE-REF | SE-REF-01 | C | 50.1 | 3.5 | No | | | 0 | - | No | No | 2 | 4.7 | 12.0 | 8.3 | 1 on 3 |
| SE-REF | SE-REF-02 | A | 61.7 | 4.3 | No | | | 0 | - | No | No | 2 | 13.3 | 17.3 | 15.3 | 1 on 3 |
| SE-REF | SE-REF-02 | B | 53.2 | 3.7 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |

Sediment-Profile Image Analysis Results

| Location | Station | Replicate | aRPD Area (sq cm) | Mean aRPD (cm) | Dredged Material | Max Dredged Material Depth cm | Dredged Material Comments | Mud Clast Number | Mud Clast State | Methane? | Low DO? | # of Feeding Voids | Void Minimum Depth (cm) | Void Maximum Depth (cm) | Void Average Depth (cm) | Successional Stage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE-REF | SE-REF-02 | C | 48.0 | 3.3 | No | | | 0 | - | No | No | 2 | 5.0 | 16.8 | 10.9 | 1 on 3 |
| SE-REF | SE-REF-03 | B | 62.8 | 4.3 | No | | | 0 | - | No | No | 2 | 13.4 | 16.1 | 14.8 | 1 on 3 |
| SE-REF | SE-REF-03 | C | 54.0 | 3.7 | No | | | 0 | - | No | No | 4 | 2.5 | 17.6 | 10.1 | 1 on 3 |
| SE-REF | SE-REF-03 | D | 63.9 | 4.4 | No | | | 0 | - | No | No | 5 | 1.6 | 17.1 | 9.3 | 1 on 3 |
| SE-REF | SE-REF-04 | A | 47.8 | 3.3 | No | | | 0 | - | No | No | 4 | 4.3 | 16.0 | 10.1 | 1 on 3 |
| SE-REF | SE-REF-04 | B | 60.5 | 4.2 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| SE-REF | SE-REF-04 | C | 59.6 | 4.1 | No | | | 0 | - | No | No | 0 | | | | 1 on 3 |
| SE-REF | SE-REF-05 | A | 39.3 | 2.7 | No | | | 0 | - | No | No | 2 | 3.5 | 13.7 | 8.6 | 1 on 3 |
| SE-REF | SE-REF-05 | B | 62.0 | 4.3 | No | | | 0 | - | No | No | 4 | 5.0 | 14.8 | 9.9 | 1 on 3 |
| SE-REF | SE-REF-05 | D | 75.7 | 5.2 | No | | | 0 | - | No | No | 7 | 1.7 | 15.9 | 8.8 | 1 on 3 |

Note: 1) "Ind" indicates that the sample result was indeterminate
2) "mean" indicates the mean value across a single sediment profile image

| Location | Station | Replicate | Comment |
|---|---|---|---|
| MBDS | 01 | B | Recolonized historical DM deposit; transected burrows at depth. SWI is pelleted. Abundant stage 1 tubes at SWI. |
| MBDS | 01 | C | Recolonized historical DM deposit; transected burrows at depth. SWI is pelleted. Stage 1 tubes at SWI. Small polychaetes visible in sediment column. Large burrow halo extends from SWI. |
| MBDS | 01 | D | Well sorted silt-clay with thick surface oxidized layer; SWI is pelleted. Few stage 1 tubes at SWI. Several small voids in sediment column. |
| MBDS | 02 | A | Historical recolonized DM with thick pelletal layer along with Stage 1 and 2 tubes at SWI. Large burrow openings in SWI. Large voids in sediment column as deep as 13 cm. |
| MBDS | 02 | B | Historical recolonized DM with thick surface oxidized layer and pelletized surface. Reduced wiper blade artifacts on SWI. Polychaetes visible deep into sediment. Transected burrows at depth |
| MBDS | 02 | C | Historical recolonized DM with thick surface oxidized layer and pelletized surface. Stage 1 and 2 tubes at SWI. Large burrow opening in SWI, transected burrows at depth |
| MBDS | 03 | A | Historical recolonized DM with well-developed aRPD and Stage 1 - 2 tubes at SWI. Small void near penetration maximum. Long halo indicating burrow in center of image. Several polychaetes visible in sediment column. |
| MBDS | 03 | C | Historical recolonized silt-clay DM with Stage 1 tubes at SWI. Scant amount of reduced pellets at SWI from bioturbation Debris at SWI. Many voids deep in sediment column, bioturbation >prism penetration |
| MBDS | 03 | D | Silt-clay that is historical DM but has been recolonized with thick oxidized surface layer. Stage 1 and 2 tubes are abundant at SWI. Voids deep in sediment column. Large clump of cohesive sediment at SWI is colonized by larger worm tubes. |
| MBDS | 04 | A | Historical recolonized DM that is primarily silt-clay with small fraction of very fine to fine sand with extensively pelletized surface layer and thick aRPD; Stage 1 and 2 tubes are present at SWI. Transected burrows at depth |
| MBDS | 04 | C | Silt-clay that has been extensively re-worked by infauna with thick pelletal layer and well developed aRPD. Stage 1 and 2 tubes are present at SWI. Transected burrows at depth and edge of void transected in lower right corner. |
| MBDS | 04 | D | Historical DM of silt clay that has been recolonized and extensively reworked to depth; SWI is pelleted. Stage 1 and 2 tubes are present at SWI. Two small voids deep in sediment column. |
| MBDS | 05 | A | Silt clay, historical DM that has been extensively recolonized and re-worked; SWI is pelleted. Stage 1 and 2 tubes are present at SWI. Extensive void and burrow structures deep in sediment. |
| MBDS | 05 | B | Silt-clay historical DM with Stage 1 and 2 tubes at SWI along with 1-2 cm pelletal layer. Reduced material deposited by camera. Sediment is mottled with large patches of light sediment in reduced layer. |
| MBDS | 05 | C | Silt clay (historical DM) with thick aRPD, small tubes at SWI, and bioturbation exceeding prism penetration depth. SWI is pelleted. Extensive void and burrow structures deep in sediment. |
| MBDS | 06 | A | Historical DM that has been recolonized and extensively reworked; traces of white clay inclusions at depth, with bioturbation exceeding prism penetration. Red polychaete visible to far right of image. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| MBDS | 06 | B | Recolonized, historical DM (silt-clay) with active reworking to depth of profile with mound of reduced fecal pellets at right edge of image at SWI. Stage 1 tubes at SWI. Burrow opening visible at SWI with voids underneath. Large clump of reduced sediment deposited by camera at SWI. |
| MBDS | 06 | C | Silt-clay historical DM that has been recolonized with surface pellet layer. Tubes have been dragged into sediment column, transected burrows at depth. |
| MBDS | 07 | A | Recolonized historical DM; silt-clay with minor fraction of very fine sand, small tubes & pellet layer at SWI. Transected burrows at depth, bioturbation > prism penetration |
| MBDS | 07 | B | Primarily silt-clay with minor very fine sand fraction; historical DM that has been recolonized. Burrowing textures and voids apparent in sediment column. Large mass of reduced sediment deposited at SWI (camera artifact). |
| MBDS | 07 | C | Small tubes & pellet at SWI; silt-clay (historical DM) that has been extensively re-worked. Several voids and deep burrowing structures deep in sediment column. |
| MBDS | 08 | A | Silt-clay with dense assemblage of small tubes and fecal pellets at SWI; if there was historical DM here, the optical signature has been erased from extensive bioturbation |
| MBDS | 08 | B | Silt-clay with dense assemblage of small tubes and fecal pellets at SWI; if there was historical DM here, the optical signature has been erased from extensive bioturbation. |
| MBDS | 08 | C | Silt-clay with dense assemblage of small tubes and fecal pellets at SWI; if there was historical DM here, the optical signature has been erased from extensive bioturbation. Large tubes in depression at SWI. Burrowing structures visible in sediment. |
| MBDS | 09 | A | Silt-clay with dense assemblage of small tubes and fecal pellets at SWI; evidence of transected burrows at depth. |
| MBDS | 09 | B | Silt-clay with dense assemblage of small tubes and fecal pellets at SWI; evidence of transected burrows at depth. |
| MBDS | 09 | C | Silt clay with fecal pellets and tubes abundant at SWI. Many voids in sediment column, some are very large. Large infauna visible at max penetration depth. |
| MBDS | 10 | A | Silt clay with extensive biogenic reworking; SWI is pelleted and Stage 1 tubes present. Long burrow with orange hued oxidized lining transected. |
| MBDS | 10 | B | Silt-clay with multiple tubes @ SWI. Reduced clay deposited by camera on sediment surface. Intense burrowing evident in sediment column. |
| MBDS | 10 | C | Silt-clay with multiple tubes at SWI. Reduced clay deposited by camera on sediment surface. Deep oxidized halos in sediment from transected burrows; bioturbation > prism penetration depth. |
| MBDS | 11 | A | Silt clay, historical DM that is completely recolonized & re-worked to depth of penetration & beyond. Large polychaete in lower left of image. Many voids and burrow structures in sediment. Large tubes and abundant pellets at SWI. |
| MBDS | 11 | C | Silt-clay, historical DM that has been reworked with white clay inclusions at depth. Pellets and tubes at SWI. Prism appears to have pulled back slightly from sediment allowing fines to fall between prism and sediment matrix. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| MBDS | 11 | D | Silt-clay historical, recolonized DM with white clay inclusions at depth. Pellets and tubes at SWI. Several large polychaetes in sediment column. Smearing clay adhered to prism above SWI. |
| MBDS | 12 | A | Historical DM (silt-clay) with some inclusions of black clay at depth. SWI is pelleted with small tubes. Deep burrowing infauna visible deep in sediment; burrow openings visible in corresponding PV image. |
| MBDS | 12 | B | Silt-clay, historical DM with a few mottled inclusions of black clay. SWI is pelleted with small tubes. Voids in sediment column. |
| MBDS | 12 | D | Silt-clay (historical DM) with thick pellet layer and small tubes at SWI. Infauna visible in sediment. Very large burrow transected to far left. Reduced material deposited by prism at SWI. |
| MBDS | 13 | A | Silt-clay, could be historical DM layer that has been recolonized. Infauna visible in sediment. Very large burrow transected. Stage 1 tubes at SWI. Infilled void in lower right corner. Well developed aRPD. |
| MBDS | 13 | B | Historical DM (silt-clay) that has been recolonized; SWI is pelleted with large tubes. Infauna visible up to penetration maximum. Reduced material deposited at SWI by prism. |
| MBDS | 13 | C | Silt-clay (historical DM) with infauna and transected burrows in sediment. Large burrow depression at SWI. Stage 1 tubes at SWI. |
| MBDS | 14 | A | Silt-clay (appears to be historical DM that has been recolonized); SWI is heavily pelleted. Abundant stage 1 and 2 tubes at SWI. Small polychaete visible at SWI. Voids and burrow textures in sediment column. |
| MBDS | 14 | B | Historical DM (silt clay) with abundant fecal pellets & small tubes at SWI. Infauna visible in sediment column. Very large voids in sediment. Long burrow has been transected. |
| MBDS | 14 | C | Historical DM (silt-clay) that has been recolonized with thick pellet aggregations and small tubes at SWI. Clumps of reduced sediment deposited by SPI camera at SWI. Burrow opening at SWI with worm body visible inside pelleted material. Very large voids in sediment. Long burrow has been transected. |
| MBDS | 15 | A | Silt-clay (historical DM deposit) that has been recolonized; SWI is heavily pelleted. Small tubes at SWI. Abundant voids in sediment. |
| MBDS | 15 | B | Historical DM that has been recolonized; silt-clay with small tubes & pellets at SWI. Very large tube at SWI. White clay in lower corner of image. Several small voids. |
| MBDS | 15 | C | Historical DM that has been recolonized; silt-clay with small tubes & pellets at SWI. White clay inclusions in image; transected burrows at depth |
| MBDS | 16 | A | Primarily silt clay with minor very fine sand fraction, most likely historical DM but signature largely erased from extensive bioturbation; Pellets and small tubes at SWI. Very deep aRPD. |
| MBDS | 16 | B | Silt-clay (historical DM deposit) with disturbed surface; looks like prism inserted in sled footprint of previous replicate; Very large void deep in sediment. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| MBDS | 16 | C | Historical DM deposit; primarily silt-clay with intense re-working of upper 3 cm, SWI is fluffy and pelleted. Several small voids in sediment. Infauna visible in sediment column. |
| MBDS | 17 | A | Silt-clay with dilated and pelleted surface layer; extremely deep surface oxidized layer. Two small voids transected. |
| MBDS | 17 | B | Silt-clay with dilated and pelleted surface layer; extremely deep surface oxidized layer. Transected burrows at depth, bioturbation exceeds prism penetration depth. |
| MBDS | 17 | C | Silt clay with minor fraction of very fine sand; three small voids transected. Abundant tubes at SWI. |
| MBDS | 18 | A | Recolonized historical DM deposit, highly reworked silt-clay; SWI has a large burrow opening that has been transected with vertically transported reduced sediment near surface. Several small voids in sediment. |
| MBDS | 18 | B | Recolonized historical DM deposit, highly reworked silt-clay. Pelleted SWI. Many stage 1 tubes. Two small voids in sediment column. |
| MBDS | 18 | D | Over penetration in right half of image. Substantial burrowing visible in sediment column. Very thick aRPD with oxidized halo extending from left side of image. Historical DM, primarily silt-clay with minor fine sand fraction |
| MBDS | 19 | A | Recolonized historical DM, primarily silt-clay with small tubes & pellets at SWI. Reduced material visible at far left edge of SWI. Small voids deep in right corner of image. |
| MBDS | 19 | B | Silt-clay, historical DM deposit that has been recolonized with pelleted SWI. Small tubes & wiper blade artifact clast at SWI. Large burrow extending down right side of image. |
| MBDS | 19 | C | Recolonized historical DM deposit, silt clay with reduced pellets vertically transported by burrowing infauna to SWI. Abundant burrows in sediment column. Many small voids. |
| MBDS | 20 | B | Historical DM deposit, silt-clay with pellet layer & small tubes at SWI. aRPD layer is uneven, very deep to left side of image. Deep burrowing evident in sediment. Single small void. |
| MBDS | 20 | C | Silt-clay, historical DM deposit that has been recolonized with pellet layer & tubes at SWI. Cluster of small voids under burrow depression. |
| MBDS | 20 | D | Silt-clay, historical DM deposit that is extensively reworked with pellet layer & small tubes at SWI. Many burrows in sediment. Polychaete visible at 9 cm below SWI. |
| MBDS | 21 | A | Silt-clay, most likely historical DM deposit that has been recolonized. Pelleted SWI. Stage 1 and 2 tubes at SWI. Large burrow near pen maximum. Small shell fragment at SWI. |
| MBDS | 21 | B | Silt-clay, historical DM deposit with dense tubes & pellet layer at SWI. Abundant burrowing with large voids in sediment. SWI is depressed by two transected burrow openings |
| MBDS | 21 | C | Historical DM deposit, silt-clay with wiper blade mud clast artifact at SWI. Pellets & small tubes at SWI. Large voids in sediment column. Reworking of sediment clearly evident to penetration maximum. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| MBDS | 22 | A | Silt-clay with pellet layer & small tubes at SWI. Voids and deep transected burrows visible ins sediment column. Nereid polychaete near bottom of image. |
| MBDS | 22 | C | Historical DM deposit that has been recolonized with pellets & Stage 1 tubes at SWI. Long thin burrows and polychaete visible in sediment column. |
| MBDS | 22 | D | Silt-clay, historical DM deposit; very large burrow through center of image. Smaller voids surrounding large burrow. Polychaete visible to low left of image. SWI is fluffy and pelleted with stage 1 tubes. |
| MBDS | 23 | A | Silt-clay, historical DM that is thoroughly recolonized; small burrow and void transected. Polychaete visible in sediment. SWI is pelleted and fluffy with stage 1 tubes. Reduced pellets deposited at SWI. |
| MBDS | 23 | C | Well-sorted silt-clay with wiper blade mud clast artifacts @ SWI along with pellets & small tubes. Bioturbation exceeds prism penetration depth |
| MBDS | 23 | D | Historical DM, silt-clay with dense tube assemblage @ SWI and mud clast artifact from camera. Small void near penetration maximum. SWI curves downwards towards large burrow (see corresponding PV image). |
| MBDS | 24 | A | Silt clay, DM > penetration & mottled with patches of white clay. Many small voids. SWI is fluffy with pellets and stage 1 and 2 tubes. |
| MBDS | 24 | B | Silt-clay, DM > penetration & 8s mottled with patches of white clay. Two small voids in sediment. SWI is fluffy and pelleted with stage 1 tubes. DM disposal looks fairly recent (within last 12 months) |
| MBDS | 24 | C | Silt-clay, recent DM > penetration with many voids in sediment column. SWI is fluffy and pelleted with stage 1 tubes. |
| MBDS | 25 | A | Silt-clay, historical, recolonized DM deposit; SWI is pelleted and fluffy with stage 1 tubes. Several large voids in sediment. Bioturbation > prism penetration. |
| MBDS | 25 | C | Silt-clay, historical DM with dense tube assemblage @ SWI along with some wiper blade mud clast artifacts. Large void in lower portion of image. Burrow opening transected at SWI. |
| MBDS | 25 | D | Silt-clay, historical, recolonized DM; SWI is pelleted and fluffy with stage 1 and 2 tubes. Single very large tube at SWI. Infilled void near penetration max. Bioturbation > penetration |
| MBDS | 26 | A | Over penetration. Tan fines over dark gray dredged material. Many voids and burrowing textures in sediment column. Large polychaete visible in image. |
| MBDS | 26 | B | Over penetration. Tan fines over dark gray dredged material. Many voids and burrowing textures in sediment column. |
| MBDS | 26 | D | Silt-clay, fairly recent DM deposit; aRPD somewhat obscured by reduced mud smeared by camera prism. Abundant voids and transected burrows. Small tubes at SWI. Reduced material deposited at SWI by camera. |
| MBDS | 27 | A | Silt-clay, historical DM deposit; SWI is pelleted and fluffy with stage 1 tubes. Long burrows with oxidized halos deep into sediment column. Large voids at penetration maximum. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| MBDS | 27 | B | Silt-clay, historical DM deposit. SWI is pelleted and fluffy with stage 1 tubes. Small voids and polychaetes are visible in sediment column. Reduced material deposited at SWI by prism/ Large burrow transected. |
| MBDS | 27 | C | Silt-clay, historical DM deposit; SWI is pelleted and fluffy with stage 1 tubes. Small burrows and polychaetes are visible in sediment column. Reduced material deposited at SWI by prism. |
| MBDS | 28 | A | Silt-clay, historical DM deposit; SWI is pelleted and fluffy with stage 1 tubes. Burrow transected at SWI, void underneath is large and complex. |
| MBDS | 28 | B | Silt-clay, historical DM deposit; SWI is pelleted and fluffy with stage 1 and 2 tubes. Large void at 10 cm below SWI. Reduced material deposited by prism at SWI. |
| MBDS | 28 | C | Silt-clay, historical DM deposit that is thoroughly recolonized; SWI is pelleted and fluffy with stage 1 tubes. Burrow opening transected at SWI. Large burrows in sediment column. |
| MBDS | 29 | A | Silt-clay with dense small tubes and 1+ cm pellet layer. Transected burrows in sediment column. Bioturbation > penetration |
| MBDS | 29 | B | Silt clay, historical DM deposit with bioturbation > penetration; small tubes & pellets at SWI. Transected infilled burrows present in sediment. Burrow mound transected at SWI. SWI is hummocky in far field. |
| MBDS | 29 | D | Limited penetration. aRPD > Penetration. Small shell fragments at SWI. SWI is slightly hummocky. Stage 1 tubes at SWI. Pellets at SWI. |
| MBDS | 30 | A | Historical DM that is thoroughly recolonized; silt clay with dense tube assemblage & pellets at SWI. Large void visible in sediment. Infauna visible below aRPD. |
| MBDS | 30 | B | Historical DM deposit that is recolonized & reworked to depth, both pellets & small tubes @ SWI. Burrow opening transected at SWI. Large void is infilled in sediment column. Deepest void contains white threads, may be ambient Beggiatoa. |
| MBDS | 30 | D | Historical, recolonized DM deposit, silt-clay withy tubes & pellets @ SWI. Several large voids in sediment column. Chaotic texture diagnostic of DM with white and dark gray streaks in lower layers of sediment. |
| FG-23 | FG-23-01 | A | Silt-clay that looks like historical DM; SWI is pelleted and covered with loose sediment transported from burrow. Small tubes at SWI. Transected burrow extends to 10 cm below SWI with void structures surrounding. |
| FG-23 | FG-23-01 | B | Silt-clay with appearance of historical DM deposit; SWI is pelleted and covered with thin patches of reduced material that have been dragged over aRPD. Small tubes at SWI. |
| FG-23 | FG-23-01 | C | Silt-clay with pellet layer & many small and few very large tubes at SWI. Reduced material deposited by prism at SWI. Small burrows transected. Larger voids transected in sediment column up to pen max. |
| FG-23 | FG-23-02 | A | Ambient silt-clay with pellets & small stage 1 tubes at SWI. Voids in sediment column. |
| FG-23 | FG-23-02 | C | Silt-clay with pellets and mottled subsurface texture. Stage 1 tubes dragged into upper cm of sediment column. Large void. |
| FG-23 | FG-23-02 | D | Well-sorted silt-clay with pellets and small tubes @ SWI. Sediment deep in column is slightly mottled with black and tan streaks. Transected burrows @ depth. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| FG-23 | FG-23-03 | A | Well-sorted silt-clay with Stage 1 tubes & pellets at SWI. Long burrow transected deep in sediment column. |
| FG-23 | FG-23-03 | B | Well-sorted silt-clay with Stage 1 tubes & pellets at SWI. Large network of voids transected at 15 cm below SWI. Reduced material deposited by prism at SWI. |
| FG-23 | FG-23-03 | C | Well-sorted silt- clay with 1-2 cm layer of pellets & stage 1 tubes at SWI. Transected burrows throughout sediment column. |
| FG-23 | FG-23-04 | A | Orange-tan fines at aRPD transition to pale gray underlying layer. SWI is fluffy and pelleted. Stage 1 tubes at SWI. Voids and burrowing textures in sediment. Few black streaks in sediment. |
| FG-23 | FG-23-04 | B | Orange-tan fines at aRPD transition to pale gray underlying layer. Very thick aRPD. SWI is fluffy and pelleted. Stage 1 tubes at SWI. Several voids in sediment column. Infauna visible in sediment. |
| FG-23 | FG-23-04 | C | SWI is disturbed. Bright orange-tan fines near SWI transition to pale gray-tan. Large voids in sediment column. Stage 1 and 2 tubes on disturbed SWI. aRPD done by linear measurement due to disturbance. |
| FG-23 | FG-23-05 | A | SWI is very disturbed. Bright orange-tan fines near SWI transition to pale gray-tan. Large & small tubes at SWI. |
| FG-23 | FG-23-05 | B | Well-sorted silt-clay with slight mottling under aRPD. Few small voids in sediment column. |
| FG-23 | FG-23-05 | C | Silt-clay with abundant tubes at SWI. Reduced material deposited by prism. Infilled voids visible in sediment column. Bioturbation > penetration |
| MBD-REF | MBD-REF-01 | A | Well-sorted silt-clay, ambient sediment; slight mottling under aRPD. Stage 1 tubes at SWI. Evidence of subsurface burrowing |
| MBD-REF | MBD-REF-01 | B | Silt-clay, ambient sediment. Slight mottling under aRPD. Stage 1 and tubes at SWI. Slight depression to left of sediment surface. Large void at 8 cm below SWI. |
| MBD-REF | MBD-REF-01 | C | Orange-tan fines at aRPD transition to pale gray underlying layer. Slight mottling under aRPD. Stage 1 tubes at SWI. Small voids in sediment. |
| MBD-REF | MBD-REF-02 | A | Ambient silt-clay with dense tube assemblage at SWI. Infauna visible in sediment column. Small void to far right. |
| MBD-REF | MBD-REF-02 | B | Well-sorted silt clay with Stage 1 and 2 tubes at SWI. Polychaete in sediment column. Sediment is much darker in bottom left corner of image. |
| MBD-REF | MBD-REF-02 | C | Orange-tan fines at aRPD transition to pale gray underlying layer. Slight mottling under aRPD. Stage 1 tubes at SWI.. SWI undulates in far field. Few small voids in sediment column. |
| MBD-REF | MBD-REF-03 | A | Silt-clay with extensive bioturbation throughout profile. Dense cover of tubes at SWI. Polychaetes visible in sediment column. Large burrow and void network transected. |
| MBD-REF | MBD-REF-03 | B | Ambient silt-clay with pellet layer @ SWI. Mottling and black streaks/patches under aRPD. Stage 1 and 2 tubes at SWI. Small void at 12 cm below SWI. |
| MBD-REF | MBD-REF-03 | C | Thick tan aRPD, well-sorted silt-clay. Burrowing evident in sediment column. Many polychaetes visible in sediment. SWI appears uneven with clasts deposited in midfield. Dense tubes at SWI. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| MBD-REF | MBD-REF-04 | A | Silt clay with thin aRPD over a darker tan material with streaks of dark gray. Two small voids in sediment column. Stage 1 tubes at SWI. SWI is fluffy and pelleted. |
| MBD-REF | MBD-REF-04 | B | Silt-clay with some wiper blade artifact mud clasts @ SWI. Polychaetes visible in sediment column. Stage 1 tubes at SWI. SWI is fluffy and pelleted. |
| MBD-REF | MBD-REF-04 | D | Orange-tan fines over a darker tan material with streaks of dark gray. Polychaetes visible in sediment column. Stage 1 tubes at SWI. SWI is fluffy and pelleted. Two voids in sediment. |
| MBD-REF | MBD-REF-05 | A | Silt clay with thick pellet layer and dense tube assemblage at SWI; SWI is mounded to left and right. Polychaetes visible in sediment. Distinct void in upper 6 cm of sediment. Unusual for methane to appear in sediments with such low organics. |
| MBD-REF | MBD-REF-05 | B | Ambient silt-clay with dense assemblage of Stage 1 and 2 tubes at SWI. Polychaetes visible in sediment. Long burrow transected. Large void in lower left corner of image. |
| MBD-REF | MBD-REF-05 | C | Orange-tan fines over a darker tan material with streaks of dark gray. Stage 1 and 2 tubes at SWI. Few stage 2 tubes at SWI. Mottled deep sediment. Small voids. |
| SE-REF | SE-REF-01 | A | Overpenetrated. Left half of SWI is out of frame. Heavily bioturbated silt-clay with Stage 1 and 2 tubes at SWI. Deep aRPD, based on linear measurement from right half of image. Voids in sediment. |
| SE-REF | SE-REF-01 | B | Well-sorted silt-clay; Stage 1 and 2 tubes are abundant at SWI. SWI is uneven, undulating into distance. Oxidized halos deep in sediment surrounding burrows. |
| SE-REF | SE-REF-01 | C | Well-sorted silt clay that is extensively bioturbated. Stage 1 and 2 tubes are dense at SWI. Polychaete visible in sediment column. Very large void is primary feature in sediment column. |
| SE-REF | SE-REF-02 | A | Heavily bioturbated silt-clay with Stage 1 tubes at SWI. SWI is fluffy and pelleted. Large voids and polychaete visible in sediment column. |
| SE-REF | SE-REF-02 | B | Silt-clay with thick oxidized surface layer & pellets @ SWI. Oxidized halos deep in sediment column. Polychaetes visible in sediment. Stage 1 tubes at SWI. Slight Over penetration. |
| SE-REF | SE-REF-02 | C | Silt-clay with heavily reworked, oxidized surface layer; SWI is fluffy and pelleted. Stage 1 and 2 tubes at SWI. Oxidized voids in sediment column. |
| SE-REF | SE-REF-03 | B | Orange-tan fines over a darker tan material with streaks of dark gray. SWI is fluffy and pelleted. Dense tube assemblage at SWI. Transected burrow opening at SWI is very large and ends in void. Long oxidized halos in sediment. |
| SE-REF | SE-REF-03 | C | Silt-clay with 1-2 cm pellet layer & abundant tubes at SWI. Many small voids in sediment. Orange patch at depth appears to be infauna against faceplate. |
| SE-REF | SE-REF-03 | D | Silt-clay with extensive re-working from infauna. SWI is fluffy and pelleted. Stage 1 tubes at SWI. Many large voids in sediment. Very large polychaete (Nereididae) in sediment column. |
| SE-REF | SE-REF-04 | A | Well-sorted silt-clay; SWI is fluffy and pelleted. Stage 1 tubes at SWI. Many voids in sediment. |

| Location | Station | Replicate | Comment |
|---|---|---|---|
| SE-REF | SE-REF-04 | B | Silt-clay with well-developed surface oxidized layer and dense assemblage of Stage 1 and 2 tubes at SWI. Long burrow halos present in sediment. Evidence of reworking at depth |
| SE-REF | SE-REF-04 | C | Silt-clay with extensively reworked profile, thick surface oxidized layer & dense tube assemblage. Evidence of reworking & transected burrows at depth, large burrow openings in corresponding PV image.' |
| SE-REF | SE-REF-05 | A | Silt-clay with dense tube assemblage @ SWI; surface is fluffy and pelleted. Two infilled oxidized voids in sediment, both quite large. |
| SE-REF | SE-REF-05 | B | Extensively bioturbated silt-clay with dense tube assemblage @ SWI. Several oxidized voids in sediment column. |
| SE-REF | SE-REF-05 | D | Extensively bioturbated silt-clay with small tubes @ SWI. Loose fluidized material and pellets in depression. Many voids in sediment, few are quite large. |

Note: 1) "Ind" indicates that the sample result was indeterminate
2) "mean" indicates the mean value across a single sediment profile image

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 1 | A | 98.36 | 65.57 | 0.64 | Silt/Clay | Ox | None | None | Present | Present | None | Shrimp | None | 0 | Fine sediment surface is pale tan with low relief. Large burrow openings in SWI. Small tubes are present in low density throughout image. Two shrimp. |
| MBDS | 1 | B | 86.43 | 57.62 | 0.50 | Silt/Clay | Ox | None | None | Present | Present | None | None | None | 0 | Fine sediment surface is pale tan with low relief. Large burrow openings in SWI. Small tubes are present in low density throughout image. |
| MBDS | 2 | A | 85.06 | 56.71 | 0.48 | Silt/Clay | Ox | None | None | Present | Present | None | Shrimp | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes are present in low density throughout image. Single shrimp. |
| MBDS | 2 | B | 96.59 | 64.40 | 0.62 | Silt/Clay | Ox | None | None | Present | Sparse | None | Shrimp | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes are present in low density throughout image. Single shrimp. Sediment in water column prevents clear view of SWI. Large empty tube on surface. |
| MBDS | 3 | A | 93.75 | 62.50 | 0.59 | Silt/Clay | Ox | None | None | Present | Sparse | Sparse | None | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes are present in low density throughout image. Sediment in water column prevents clear view of SWI. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 3 | B | 96.95 | 64.64 | 0.63 | Silt/Clay | Ox | None | None | Present | Present | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes are present in low density throughout image. Single shrimp. Sediment in water column prevents clear view of SWI. Thin tracks visible in soft sediment. |
| MBDS | 3 | C | 95.12 | 63.41 | 0.60 | Silt/Clay | Ox | None | None | Present | Sparse | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes are present in low density throughout image. Single shrimp. Sediment in water column prevents clear view of SWI. Thin tracks visible in soft sediment. |
| MBDS | 4 | A | 93.69 | 62.46 | 0.59 | Silt/Clay | Ox | None | None | Present | Sparse | Sparse | None | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes are present in low density throughout image with some larger tubes visible against sediment.. Sediment in water column prevents clear view of SWI. |
| MBDS | 5 | A | 92.91 | 61.94 | 0.58 | Silt/Clay | Ox | None | None | Present | Sparse | Sparse | None | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes throughout image. Sediment in water column prevents clear view of SWI. Small side by side tracks in sediment. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 5 | B | 88.39 | 58.92 | 0.52 | Silt/Clay | Ox | None | None | Present | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan with low relief. Burrow openings in SWI. Small tubes throughout image. Sediment in water column prevents clear view of SWI. Small tracks similar to a tire tread mark in sediment. |
| MBDS | 5 | C | 85.43 | 56.96 | 0.49 | Silt/Clay | Ox | None | None | Present | Present | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Very large and very small burrow openings in SWI. Small tubes throughout image. Sediment in water column prevents clear view of SWI. Thin tracks in sediment. |
| MBDS | 6 | A | 89.97 | 59.98 | 0.54 | Silt/Clay | Ox | None | None | Present | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan with low relief. Very large openings in SWI. Small tubes throughout image. Sediment in water column prevents clear view of SWI. Thin tracks in sediment. Dimples in sediment surface. |
| MBDS | 7 | A | 88.84 | 59.23 | 0.53 | Silt/Clay | Ox | None | None | Present | Present | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Very large burrow openings in SWI. Small tubes throughout image. Tracks visible in SWI. Some fecal castings on sediment surface. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 7 | B | 91.50 | 61.00 | 0.56 | Silt/Clay | Ox | None | None | Abundant | Sparse | Present | Shrimp | None | 0 | Fine sediment surface is pale tan with low relief. Very large burrow openings in SWI. Small tubes in high density throughout image. Sediment in water column prevents clear view of SWI. Tracks visible in SWI. Sediment falling from SPI camera rig. Shrimp visible at SWI. |
| MBDS | 8 | A | 87.54 | 58.36 | 0.51 | Silt/Clay | Ox | None | None | Abundant | Sparse | Present | Shrimp | None | 0 | Fine sediment surface is pale tan with low relief. Very large burrow openings in SWI. Small tubes in high density throughout image. Sediment in water column prevents clear view of SWI. Shrimp visible at SWI. |
| MBDS | 8 | B | Ind | Ind | Ind | Silt/Clay | Ox | None | None | Present | Sparse | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Very large burrow openings in SWI. Small tubes in high density throughout image. Large plume of dense sediment |
| MBDS | 9 | A | 84.92 | 56.61 | 0.48 | Silt/Clay | Ox | None | None | Abundant | Sparse | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Very large burrow openings in SWI. Small tubes in high density with few larger tubes. Water column is cloudy and turbid. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 9 | B | Ind | Ind | Ind | Silt/Clay | Ox | None | None | Present | Sparse | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Few burrow openings in SWI. Small tubes with few larger tubes. Water column is cloudy and turbid. |
| MBDS | 9 | C | 87.10 | 58.07 | 0.51 | Silt/Clay | Ox | None | None | Present | Sparse | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Few burrow openings in SWI. Small tubes with few larger tubes. Water column is cloudy and turbid. |
| MBDS | 10 | A | 98.86 | 65.91 | 0.65 | Silt/Clay | Ox | None | None | Present | Sparse | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Few burrow openings in SWI. Small tubes with few larger tubes. Water column is cloudy and turbid. Long thin tracks, as well as larger short pairs of tracks at SWI. |
| MBDS | 10 | B | 82.80 | 55.20 | 0.46 | Silt/Clay | Ox | None | None | Abundant | Sparse | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Few burrow openings in SWI. Small tubes in high density with few larger tubes. Water column is cloudy and turbid. Long thin tracks, as well as larger short pairs of tracks at SWI. |
| MBDS | 11 | A | 98.48 | 65.66 | 0.65 | Silt/Clay | Ox | None | None | Present | Sparse | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Few burrow openings in SWI. Small tubes on surface; water column is cloudy and turbid. Few tracks in upper right corner of image. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 11 | D | 86.43 | 57.62 | 0.50 | Silt/Clay | Ox | None | None | Present | Present | None | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Two large burrow openings. Small tubes throughout image. Water column is cloudy and turbid. |
| MBDS | 12 | A | 83.20 | 55.47 | 0.46 | Silt/Clay | Ox | None | None | Present | Present | Present | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Small tubes throughout image. Water column is cloudy and turbid. Long thin tracks throughout SWI. |
| MBDS | 13 | A | 85.34 | 56.89 | 0.49 | Silt/Clay | Ox | None | None | Abundant | Sparse | None | Burrowing Anemone | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Small tubes throughout image. Water column is cloudy and turbid. Burrowing anemone visible. |
| MBDS | 13 | C | 94.43 | 62.95 | 0.59 | Silt/Clay | Ox | None | None | Abundant | Sparse | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Small tubes throughout image. Water column is cloudy and turbid. Small pieces of cohesive white clay are falling from camera as it descends. |
| MBDS | 14 | A | 80.70 | 53.80 | 0.43 | Silt/Clay | Ox | None | None | Present | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky.. Small tubes at SWI. Large burrow opening. Few long thin tracks. |
| MBDS | 14 | B | 79.80 | 53.20 | 0.42 | Silt/Clay | Ox | None | None | Present | Abundant | Abundant | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Small tubes at SWI. Several large burrow openings in upper half of image. Many small paired tracks. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 14 | C | 77.96 | 51.97 | 0.41 | Silt/Clay | Ox | None | None | Abundant | Present | None | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Small tubes at SWI. Turbid water column. Image taken very close to SWI. Few burrow openings. |
| MBDS | 15 | A | 94.78 | 63.18 | 0.60 | Silt/Clay | Ox | None | None | Present | Sparse | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Few burrow openings. Small tubes at SWI. Turbid water column. |
| MBDS | 15 | B | 84.69 | 56.46 | 0.48 | Silt/Clay | Ox | None | None | Abundant | None | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Abundant small tubes at SWI. Clay falling from camera. Turbid water column. |
| MBDS | 15 | C | 87.64 | 58.43 | 0.51 | Silt/Clay | Ox | None | None | Present | Sparse | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Few small burrows. Tubes barely visible through water column. Turbid water column. |
| MBDS | 16 | A | 99.30 | 66.20 | 0.66 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Few burrows, two are very large. Tubes barely visible through water column. Turbid water column. Shrimp visible in image. |
| MBDS | 16 | C | 74.96 | 49.98 | 0.37 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Few burrows.. Turbid water column; large plume of resuspended sediment. Shrimp visible in image. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 16 | D | 90.38 | 60.25 | 0.54 | Silt/Clay | Ox | None | None | Abundant | Sparse | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Few burrows, one is large. Turbid water column. Shrimp visible in image. |
| MBDS | 17 | A | 89.97 | 59.98 | 0.54 | Silt/Clay | Ox | None | None | Abundant | Present | Present | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Small burrows in sediment surface as well as few larger openings. Long thin tracks along sediment surface. Many small tubes. |
| MBDS | 17 | B | 95.88 | 63.92 | 0.61 | Silt/Clay | Ox | None | None | Abundant | Present | Present | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky. Single very large burrow opening. Long thin tracks along sediment surface. Very turbid water, only top of image has discernible details. |
| MBDS | 18 | A | 84.42 | 56.28 | 0.48 | Silt/Clay | Ox | None | None | Dense | Abundant | Present | Gastropods | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Large burrows in sediment surface. SWI is covered with small tubes. Long thin tracks cross sediment surface. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 18 | B | Ind | Ind | Ind | Silt/Clay | Ox | None | None | Dense | Present | Sparse | Gastropods, Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Large plume of sediment covers most of image. Large burrows in sediment surface. SWI is covered with small tubes. Long thin tracks cross sediment surface. |
| MBDS | 18 | C | 96.00 | 64.00 | 0.61 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Turbid water column. Small tubes visible through cloudy water. Several large burrow openings. Sediment appears soft with long thin tracks. |
| MBDS | 19 | A | 90.91 | 60.61 | 0.55 | Silt/Clay | Ox | None | None | Abundant | Sparse | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Turbid water column. Small tubes visible through cloudy water. Sediment is soft at SWI. Large plume of sediment in water column. |
| MBDS | 19 | D | 88.99 | 59.33 | 0.53 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Small burrows. Shrimp visible. Turbid water column. Small tubes visible through cloudy water. Sediment is soft at SWI. Large plume of sediment in water column. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 20 | A | 78.59 | 52.39 | 0.41 | Silt/Clay | Ox | None | None | Abundant | Present | Present | Ind | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Several large burrows. Many tubes, large and small. Sediment is soft at SWI. |
| MBDS | 20 | B | 91.87 | 61.25 | 0.56 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Small burrows. Shrimp visible. Turbid water column. Small tubes visible through cloudy water. Sediment is soft at SWI. Long thin tracks present. |
| MBDS | 21 | A | 98.42 | 65.62 | 0.65 | Silt/Clay | Ox | None | None | Abundant | Present | Present | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Small fauna and shrimp visible in image. Large burrow opening in upper left corner of image. |
| MBDS | 21 | B | Ind | Ind | Ind | Silt/Clay | Ox | None | None | Abundant | Present | Present | Shrimp | None | 0 | Shot taken very close to SWI, right laser diffuse in plume and unmeasurable. Long tracks, small burrow openings, abundant small tubes. |
| MBDS | 21 | C | 93.53 | 62.35 | 0.58 | Silt/Clay | Ox | None | None | Present | Abundant | Present | None | None | 0 | Fine sediment surface is pale tan, with low relief. Fluffy drape over SWI. Small fauna at SWI. Many small burrow openings. Small tubes present at SWI. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 22 | A | 89.66 | 59.77 | 0.54 | Silt/Clay | Ox | None | None | Abundant | Present | None | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. |
| MBDS | 22 | B | 84.19 | 56.13 | 0.47 | Silt/Clay | Ox | None | None | Abundant | Abundant | Present | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Abundant small tubes at SWI. Shrimp visible in image. |
| MBDS | 23 | A | 80.58 | 53.72 | 0.43 | Silt/Clay | Ox | None | None | Abundant | Abundant | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Small tubes at SWI. |
| MBDS | 23 | B | 88.99 | 59.33 | 0.53 | Silt/Clay | Ox | None | None | Present | Abundant | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Small tubes at SWI. Water column is very turbid. Several shrimp visible. |
| MBDS | 23 | C | 85.86 | 57.24 | 0.49 | Silt/Clay | Ox | None | None | Present | Abundant | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Small tubes at SWI. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 24 | A | 84.64 | 56.43 | 0.48 | Silt/Clay | Ox | None | None | Present | Abundant | Abundant | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Small tubes at SWI. Water column is very turbid. Several shrimp visible. |
| MBDS | 24 | B | 81.50 | 54.34 | 0.44 | Silt/Clay | Ox | None | None | Present | Abundant | Abundant | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Small tubes at SWI. |
| MBDS | 25 | A | 92.14 | 61.43 | 0.57 | Silt/Clay | Ox | None | None | Dense | Abundant | Present | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Dense assemblage of small tubes. Red organisms at SWI. (really??) |
| MBDS | 25 | B | 89.86 | 59.91 | 0.54 | Silt/Clay | Ox | None | None | Abundant | Abundant | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation. Fluffy drape over SWI. Large burrows in sediment. Dense assemblage of small tubes. Red organisms at SWI. Shrimp visible in image. |
| MBDS | 25 | C | Ind | Ind | Ind | Silt/Clay | Ox | None | None | Abundant | Ind | Ind | Ind | None | 0 | Most of image is clouded by large plume of resuspended sediment. Silt/clay with mud drape and dense tubes visible. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 26 | A | Ind | Ind | Ind | Silt/Clay | Ox | None | None | Present | Present | Ind | Ind | None | 0 | Most of image is clouded by large plume of resuspended sediment. Burrows visible. |
| MBDS | 26 | B | Ind | Ind | Ind | Silt/Clay | Ox | Rope | None | Present | Present | None | None | None | 0 | Most of image is clouded by large plume of resuspended sediment. Tubes visible in portion of image. A rope/line is draped over SWI. Few large burrows visible. |
| MBDS | 26 | C | 85.57 | 57.05 | 0.49 | Silt/Clay | Ox | None | None | Present | Sparse | Present | None | None | 0 | Fine sediment surface is pale tan with low relief. Fluffy drape over SWI. Burrowing depressions visible. Small tubes on SWI. Two long tracks are side by side in sediment. |
| MBDS | 27 | A | 88.24 | 58.82 | 0.52 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan with low relief. Fluffy drape over SWI. Dense small tubes throughout visible area. Many small burrow openings. |
| MBDS | 27 | B | 83.83 | 55.88 | 0.47 | Silt/Clay | Ox | None | None | Abundant | Abundant | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Fluffy drape over SWI. Dense small tubes throughout visible area. Many small burrow openings. Single large opening in center of image. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 27 | C | 71.63 | 47.75 | 0.34 | Silt/Clay | Ox | None | None | Dense | Abundant | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Fluffy drape over SWI. Dense small tubes throughout visible area. Many small burrow openings. Small red organisms at SWI. Image taken very close to sediment. |
| MBDS | 28 | A | 85.43 | 56.96 | 0.49 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | Shrimp | None | 0 | Fine sediment surface is pale tan and with low relief. Fluffy drape over SWI. Dense small tubes throughout visible area. Two large burrow openings. Small shrimp and organisms at SWI, |
| MBDS | 28 | B | 86.24 | 57.49 | 0.50 | Silt/Clay | Ox | None | None | Present | Present | Present | Shrimp | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Fluffy drape over SWI. Small tubes throughout visible area. Large burrow openings. Several shrimp at SWI. |
| MBDS | 28 | D | 95.76 | 63.84 | 0.61 | Silt/Clay | Ox | None | None | Present | Present | Present | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Fluffy drape over SWI. Small tubes throughout visible area. Few burrow openings in sediment surface. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBDS | 29 | A | 100.13 | 66.75 | 0.67 | Silt/Clay | Ox | None | None | Present | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Water column is very turbid. Small tubes and burrows visible through cloudy water. |
| MBDS | 29 | B | 90.75 | 60.50 | 0.55 | Silt/Clay | Ox | None | None | Present | Sparse | Abundant | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Water column is very turbid. Small tubes and burrows visible through cloudy water. Abundant tracks, side by side small pairs, as well as long thin lines. |
| MBDS | 29 | D | 87.44 | 58.30 | 0.51 | Silt/Clay | Ox | None | None | Abundant | Present | Abundant | Burrowing Anemone | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Water column is very turbid. Small tubes and burrows visible through cloudy water. Burrowing anemone at SWI. |
| MBDS | 30 | A | 93.30 | 62.20 | 0.58 | Silt/Clay | Ox | None | None | Abundant | Abundant | Present | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Water column is very turbid. Small tubes. Many burrows. Few tracks. |
| MBDS | 30 | D | 94.60 | 63.07 | 0.60 | Silt/Clay | Ox | None | None | Present | Abundant | Present | None | None | 0 | Fine sediment surface is pale tan and slightly hummocky from bioturbation.. Water column is very turbid. Small tubes. Many burrows. Few tracks. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FG-23 | 1 | A | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Present | Ind | Ind | Ind | 0 | Very turbid. Few large burrows identifiable. Lasers not visible. |
| FG-23 | 1 | B | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Ind | Ind | Ind | 0 | Very turbid. No features identifiable. Lasers not visible. |
| FG-23 | 1 | D | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Ind | Ind | Ind | 0 | Very turbid. No features identifiable. Lasers not visible. |
| FG-23 | 2 | A | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Present | Ind | Ind | Ind | 0 | Very turbid. Few large burrows identifiable. Lasers not visible. |
| FG-23 | 2 | B | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Present | Ind | Ind | Ind | 0 | Very turbid. Few large burrows identifiable. Lasers not visible. |
| FG-23 | 2 | C | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Present | Ind | Ind | Ind | 0 | Very turbid. Few large burrows identifiable. Lasers not visible. |
| FG-23 | 3 | A | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Sparse | Ind | Ind | 0 | Very turbid. Large undulating crest at SWI, likely a track mark made by fish. Lasers not visible. |
| FG-23 | 3 | B | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Ind | Ind | Ind | 0 | Very turbid. No features identifiable. Lasers not visible. Bottom appears hummocky. |
| FG-23 | 3 | C | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Sparse | Ind | Ind | 0 | Very turbid. Lasers not visible. Bottom appears hummocky. Thin tracks barely visible in sediment surface. |
| FG-23 | 4 | A | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Ind | Ind | Ind | 0 | Very turbid. No features identifiable. Lasers not visible. |
| FG-23 | 5 | A | 112.47 | 74.98 | 0.84 | Silt/Clay | Ox | Ind | Ind | Ind | Present | Present | None | None | 0 | Very turbid. Lasers barely visible. Bottom appears hummocky. Thin tracks barely visible in sediment surface. Burrow openings visible against sediment. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FG-23 | 5 | B | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Ind | Ind | Ind | 0 | Very turbid. No features identifiable. Lasers not visible. |
| FG-23 | 5 | C | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Sparse | Ind | Ind | 0 | Very turbid. Lasers not visible. Bottom appears hummocky. Thin tracks barely visible in sediment surface. |
| MBD-REF | 1 | A | 121.68 | 81.12 | 0.99 | Silt/Clay | Ox | None | None | Present | Present | Present | None | None | 0 | Very turbid water column. Silt/clay is tan with burrow openings visible. Tubes visible through cloudy water. Two parallel rows of small tracks. |
| MBD-REF | 1 | C | 115.81 | 77.21 | 0.89 | Silt/Clay | Ox | None | None | Ind | Present | Present | None | None | 0 | Very turbid water column. Silt/clay is tan with burrow openings visible. Water column is too cloudy to see tubes. |
| MBD-REF | 1 | D | 109.40 | 72.93 | 0.80 | Silt/Clay | Ox | None | None | Present | Present | Present | None | None | 0 | Very turbid water column. Silt/clay is tan with burrow openings visible. Few tubes visible through cloudy water. |
| MBD-REF | 2 | A | 124.11 | 82.74 | 1.03 | Silt/Clay | Ox | None | None | Ind | Present | Sparse | None | None | 0 | Very turbid water column. Silt/clay is tan with burrow openings visible. No tubes visible through clouded water. Small tracks apparent in sediment, |
| MBD-REF | 2 | B | 118.99 | 79.33 | 0.94 | Silt/Clay | Ox | None | None | Ind | Present | Sparse | None | None | 0 | Very turbid water column. Silt/clay is tan with burrow openings visible. No tubes visible through clouded water. Small tracks apparent in sediment, |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MBD-REF | 2 | C | Ind | Ind | Ind | Silt/Clay | Ox | Ind | Ind | Ind | Ind | Ind | Ind | Ind | 0 | Very turbid. Lasers not visible. |
| MBD-REF | 3 | A | 107.29 | 71.53 | 0.77 | Silt/Clay | Ox | None | None | Ind | Sparse | Present | None | None | 0 | Very turbid. Lasers barely visible. Side by side small tracks in sediment. Few burrows visible. Tubes are not visible through cloudy water column. SWI appears slightly hummocky. |
| MBD-REF | 3 | C | 118.18 | 78.79 | 0.93 | Silt/Clay | Ox | None | None | Ind | Sparse | Ind | None | None | 0 | Very turbid. Lasers barely visible. Few burrows visible. Tubes are not visible through cloudy water column. SWI appears slightly hummocky. |
| SE-REF | 1 | A | 85.53 | 57.02 | 0.49 | Silt/Clay | Ox | None | None | Dense | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan with shallow hummocks. Dense cover of short tubes. Few larger burrows. |
| SE-REF | 1 | B | 80.83 | 53.89 | 0.44 | Silt/Clay | Ox | None | None | Dense | Present | Sparse | None | None | 0 | Fine sediment surface is pale tan with shallow hummocks. Dense cover of short tubes. Few larger burrows. Long shallow tracks cross image. |
| SE-REF | 1 | D | 83.11 | 55.41 | 0.46 | Silt/Clay | Ox | None | None | Dense | Abundant | Present | None | None | 0 | Fine sediment surface is pale tan with shallow hummocks. Dense cover of short tubes. Many burrows. Long shallow tracks cross image. |
| SE-REF | 2 | A | 97.26 | 64.84 | 0.63 | Silt/Clay | Ox | None | None | Abundant | Present | Present | Shrimp | None | 0 | Fine sediment surface is pale tan with low ridge towards lower right quadrant of image. Cover of short tubes. Few larger burrows. Shrimp at SWI. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE-REF | 2 | B | 89.40 | 59.60 | 0.53 | Silt/Clay | Ox | None | None | Abundant | Sparse | Present | None | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Few distinct burrows visible. Long thin tracks visible in soft sediment. |
| SE-REF | 2 | D | 79.55 | 53.03 | 0.42 | Silt/Clay | Ox | None | None | Abundant | Sparse | None | Shrimp | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Few distinct burrows visible. Shrimp visible in image. |
| SE-REF | 3 | A | 92.58 | 61.72 | 0.57 | Silt/Clay | Ox | None | None | Abundant | Sparse | Sparse | Shrimp | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Few distinct burrows visible. Shrimp is barely visible in upper portion of image. |
| SE-REF | 3 | B | 90.75 | 60.50 | 0.55 | Silt/Clay | Ox | None | None | Abundant | Sparse | Abundant | None | None | 0 | Fine loose sediment surface is heavily disturbed with track marks. Abundant tubes at SWI. Few small burrows present. |
| SE-REF | 3 | D | 81.12 | 54.08 | 0.44 | Silt/Clay | Ox | None | None | Abundant | Present | Present | None | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Few distinct burrows visible. Small organisms on sediment surface. |
| SE-REF | 4 | A | 82.71 | 55.14 | 0.46 | Silt/Clay | Ox | None | None | Dense | Present | Sparse | None | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Few distinct burrows visible. |

Plan-View Image Analysis Results

| Location | Station | Replicate | ImageWidth (cm) | Image Height (cm) | Field of View Imaged ($m^2$) | Sediment Type | Surface Ox | Debris | Bedforms | Tubes | Burrows | Tracks | Epifauna | Flora | Number of Fish | Other Salient Features/Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SE-REF | 4 | B | 95.12 | 63.41 | 0.60 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | None | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Few distinct burrows visible. Parallel set of tracks in upper right corner of image. |
| SE-REF | 4 | C | 87.59 | 58.39 | 0.51 | Silt/Clay | Ox | Ind | None | Abundant | Sparse | None | Shrimp | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Few distinct burrows visible. Debris, appears similar to a broadleaf, in lower half of image. Very small shrimp in top right corner of image. |
| SE-REF | 5 | A | 95.01 | 63.34 | 0.60 | Silt/Clay | Ox | None | None | Dense | Ind | None | None | None | 0 | Large plume of resuspended sediment clouds most of image. Dense tubes visible. |
| SE-REF | 5 | B | 77.08 | 51.38 | 0.40 | Silt/Clay | Ox | Small Shell Fragment | None | Dense | Present | None | None | None | 0 | Fine loose sediment surface is pale tan, slightly hummocky . Carpet of short tubes. Large and small burrows in sediment surface. Small red organisms. |
| SE-REF | 5 | C | 83.47 | 55.64 | 0.46 | Silt/Clay | Ox | None | None | Abundant | Present | Sparse | None | None | 0 | Very turbid water column. Lasers barely visible. Sediment appears carpeted in short tubes. Long thin tracks mark SWI. |

Note: 1) "Ind" indicates that the sample result was indeterminate

# APPENDIX E

# GRAIN SIZE SCALE FOR SEDIMENTS

APPENDIX E

GRAIN SIZE SCALE FOR SEDIMENTS

| **Phi (Φ) 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 F

# ROV NAVIGATION FILES: MARKS OF ANCHORING LOCATION FOR WRECKS AND BARREL SITES AND VESSEL POSITION FOR WRECKS SITE

# MARKS OF ANCHORING LOCATION FOR WRECKS AND BARREL SITES

| Target | X | Y | Lat | Long | Date | Time | Depth |
|---|---|---|---|---|---|---|---|
| Anchor for ROV-B-27 | 369897.65 | 4700219.37 | 42.443389 | -70.581961 | 10/7/2015 | 8:36:10 | 290 |
| Anchor for ROV B-27-1 | 369930.17 | 4700238.64 | 42.443568 | -70.581571 | 10/7/2015 | 11:01:45 | 284 |
| Anchor for ROV-B-16 | 368788.84 | 4699502.66 | 42.436750 | -70.595275 | 10/7/2015 | 13:06:21 | 275 |
| Anchor for B-16-1 | 368771.01 | 4699574.01 | 42.437389 | -70.595508 | 10/7/2015 | 14:56:46 | 275 |
| Anchor for Rock-1 | 371211.27 | 4700108.94 | 42.442614 | -70.565970 | 10/8/2015 | 9:01:22 | 160 |
| Initial anchor for Wreck-11 | 369268.94 | 4698986.75 | 42.432186 | -70.589323 | 10/8/2015 | 12:57:16 | 290 |
| "Anchor" for wreck-11 (let anchor line out) | 369239.77 | 4698939.66 | 42.431758 | -70.589667 | 10/8/2015 | 13:54:30 | |
| Anchor for Wreck-11/12 | 369158.52 | 4698820.18 | 42.430668 | -70.590627 | 10/8/2015 | 15:40:58 | 286 |
| Wreck-11 actual site | 369236.57 | 4698911.18 | 42.431501 | -70.589699 | 10/8/2015 | 17:08:03 | |

**Note: Datum is UTM North Zone 19, meter**

| File | X | y | Date | Time |
|---|---|---|---|---|
| Wreck11.ROV_smooth | 369319.1 | 4698984.9 | 10/8/2015 | 1:26:51 PM |
| Wreck11.ROV_smooth | 369321.85 | 4698978.05 | 10/8/2015 | 1:26:53 PM |
| Wreck11.ROV_smooth | 369321.05 | 4698975.78 | 10/8/2015 | 1:26:55 PM |
| Wreck11.ROV_smooth | 369320.98 | 4698977.13 | 10/8/2015 | 1:26:57 PM |
| Wreck11.ROV_smooth | 369320.72 | 4698977.09 | 10/8/2015 | 1:26:59 PM |
| Wreck11.ROV_smooth | 369321.26 | 4698975.73 | 10/8/2015 | 1:27:01 PM |
| Wreck11.ROV_smooth | 369320.79 | 4698976.07 | 10/8/2015 | 1:27:03 PM |
| Wreck11.ROV_smooth | 369320.56 | 4698976.03 | 10/8/2015 | 1:27:05 PM |
| Wreck11.ROV_smooth | 369320.61 | 4698975.13 | 10/8/2015 | 1:27:07 PM |
| Wreck11.ROV_smooth | 369320.4 | 4698975.35 | 10/8/2015 | 1:27:09 PM |
| Wreck11.ROV_smooth | 369319.46 | 4698975.8 | 10/8/2015 | 1:27:11 PM |
| Wreck11.ROV_smooth | 369318.77 | 4698976.57 | 10/8/2015 | 1:27:13 PM |
| Wreck11.ROV_smooth | 369318.46 | 4698976.97 | 10/8/2015 | 1:27:15 PM |
| Wreck11.ROV_smooth | 369318.1 | 4698976.57 | 10/8/2015 | 1:27:17 PM |
| Wreck11.ROV_smooth | 369317.73 | 4698977.39 | 10/8/2015 | 1:27:19 PM |
| Wreck11.ROV_smooth | 369317.11 | 4698977.62 | 10/8/2015 | 1:27:21 PM |
| Wreck11.ROV_smooth | 369316.7 | 4698978.5 | 10/8/2015 | 1:27:23 PM |
| Wreck11.ROV_smooth | 369316.4 | 4698978.28 | 10/8/2015 | 1:27:25 PM |
| Wreck11.ROV_smooth | 369316.13 | 4698978.64 | 10/8/2015 | 1:27:27 PM |
| Wreck11.ROV_smooth | 369315.68 | 4698978.55 | 10/8/2015 | 1:27:29 PM |
| Wreck11.ROV_smooth | 369315.38 | 4698979.06 | 10/8/2015 | 1:27:31 PM |
| Wreck11.ROV_smooth | 369315.09 | 4698979.37 | 10/8/2015 | 1:27:33 PM |
| Wreck11.ROV_smooth | 369314.43 | 4698980.4 | 10/8/2015 | 1:27:35 PM |
| Wreck11.ROV_smooth | 369314.49 | 4698980.6 | 10/8/2015 | 1:27:37 PM |
| Wreck11.ROV_smooth | 369314.19 | 4698981.05 | 10/8/2015 | 1:27:39 PM |
| Wreck11.ROV_smooth | 369314 | 4698982.07 | 10/8/2015 | 1:27:41 PM |
| Wreck11.ROV_smooth | 369313.72 | 4698982.27 | 10/8/2015 | 1:27:43 PM |
| Wreck11.ROV_smooth | 369313.47 | 4698983.16 | 10/8/2015 | 1:27:45 PM |
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| Wreck11.ROV_smooth | 369315.72 | 4698982.76 | 10/8/2015 | 1:28:47 PM |
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| Wreck11.ROV_smooth | 369250.8 | 4699029.36 | 10/8/2015 | 1:36:03 PM |

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| Wreck11.ROV_smooth | 369228.68 | 4699004.28 | 10/8/2015 | 1:45:10 PM |
| Wreck11.ROV_smooth | 369229.11 | 4699003.66 | 10/8/2015 | 1:45:12 PM |

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| Wreck11.ROV_smooth | 369230.66 | 4699003.21 | 10/8/2015 | 1:45:24 PM |
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| Wreck11.ROV_smooth | 369207.67 | 4698988.86 | 10/8/2015 | 1:51:14 PM |
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| Wreck11.ROV_smooth | 369214.35 | 4698977.61 | 10/8/2015 | 1:59:55 PM |
| Wreck11.ROV_smooth | 369214.72 | 4698977.11 | 10/8/2015 | 1:59:57 PM |

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| Wreck11.ROV_smooth | 369215.67 | 4698974.12 | 10/8/2015 | 2:00:03 PM |
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| Wreck11.ROV_smooth | 369216.37 | 4698972.59 | 10/8/2015 | 2:00:07 PM |
| Wreck11.ROV_smooth | 369216.61 | 4698971.57 | 10/8/2015 | 2:00:09 PM |
| Wreck11.ROV_smooth | 369216.95 | 4698970.55 | 10/8/2015 | 2:00:11 PM |
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| Wreck11.ROV_smooth | 369218.63 | 4698963.63 | 10/8/2015 | 2:00:23 PM |
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| Wreck11.ROV_smooth | 369219.28 | 4698954.01 | 10/8/2015 | 2:00:39 PM |
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| Wreck11.ROV_smooth | 369231.7 | 4698902.78 | 10/8/2015 | 2:03:27 PM |
| Wreck11.ROV_smooth | 369231.64 | 4698903.13 | 10/8/2015 | 2:03:29 PM |
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| Wreck11.ROV_smooth | 369232.04 | 4698900.35 | 10/8/2015 | 2:03:43 PM |
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| Wreck11.ROV_smooth | 369232.84 | 4698896.2 | 10/8/2015 | 2:03:57 PM |
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| Wreck11.ROV_smooth | 369232.13 | 4698893.68 | 10/8/2015 | 2:04:59 PM |
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| Wreck11.ROV_smooth | 369225.63 | 4698894.16 | 10/8/2015 | 2:07:15 PM |
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| Wreck11.ROV_smooth | 369225.36 | 4698894.84 | 10/8/2015 | 2:07:23 PM |
| Wreck11.ROV_smooth | 369225.17 | 4698895.04 | 10/8/2015 | 2:07:25 PM |
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| Wreck11.ROV_smooth | 369225.37 | 4698893.69 | 10/8/2015 | 2:07:37 PM |

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| Wreck11.ROV_smooth | 369226.43 | 4698892.5 | 10/8/2015 | 2:08:03 PM |
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| Wreck11.ROV_smooth | 369226.35 | 4698880.3 | 10/8/2015 | 2:11:05 PM |
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| Wreck11.ROV_smooth | 369229.25 | 4698880.86 | 10/8/2015 | 2:11:19 PM |
| Wreck11.ROV_smooth | 369229.33 | 4698880.82 | 10/8/2015 | 2:11:21 PM |
| Wreck11.ROV_smooth | 369228.95 | 4698880.8 | 10/8/2015 | 2:11:23 PM |
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| Wreck11.ROV_smooth | 369231.56 | 4698883.51 | 10/8/2015 | 2:12:07 PM |
| Wreck11.ROV_smooth | 369230.95 | 4698883.72 | 10/8/2015 | 2:12:09 PM |
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| Wreck11.ROV_smooth | 369231.43 | 4698884.54 | 10/8/2015 | 2:12:23 PM |
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| Wreck11.ROV_smooth | 369231.77 | 4698884.36 | 10/8/2015 | 2:12:27 PM |
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| Wreck11.ROV_smooth | 369231.55 | 4698884.6 | 10/8/2015 | 2:12:33 PM |
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| Wreck11.ROV_smooth | 369223.93 | 4698892.23 | 10/8/2015 | 2:13:25 PM |
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| Wreck11.ROV_smooth | 369224.19 | 4698893.85 | 10/8/2015 | 2:13:33 PM |
| Wreck11.ROV_smooth | 369223.93 | 4698894.15 | 10/8/2015 | 2:13:35 PM |
| Wreck11.ROV_smooth | 369223.65 | 4698894.93 | 10/8/2015 | 2:13:37 PM |
| Wreck11.ROV_smooth | 369223.53 | 4698895.37 | 10/8/2015 | 2:13:39 PM |
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| Wreck11.ROV_smooth | 369222.47 | 4698900.63 | 10/8/2015 | 2:13:55 PM |
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| Wreck11.ROV_smooth | 369223.23 | 4698907.82 | 10/8/2015 | 2:14:13 PM |
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| Wreck11.ROV_smooth | 369222.6 | 4698924.51 | 10/8/2015 | 2:15:17 PM |

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| Wreck11.ROV_smooth | 369226.45 | 4698939.05 | 10/8/2015 | 2:20:32 PM |
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| Wreck_11-12.ROV_smooth | 369148.42 | 4698768.84 | 10/8/2015 | 4:35:33 PM |
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| Wreck_11-12.ROV_smooth | 369240.36 | 4698904.05 | 10/8/2015 | 5:10:41 PM |

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| Wreck_11-12.ROV_smooth | 369226.47 | 4698898.47 | 10/8/2015 | 5:14:55 PM |
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