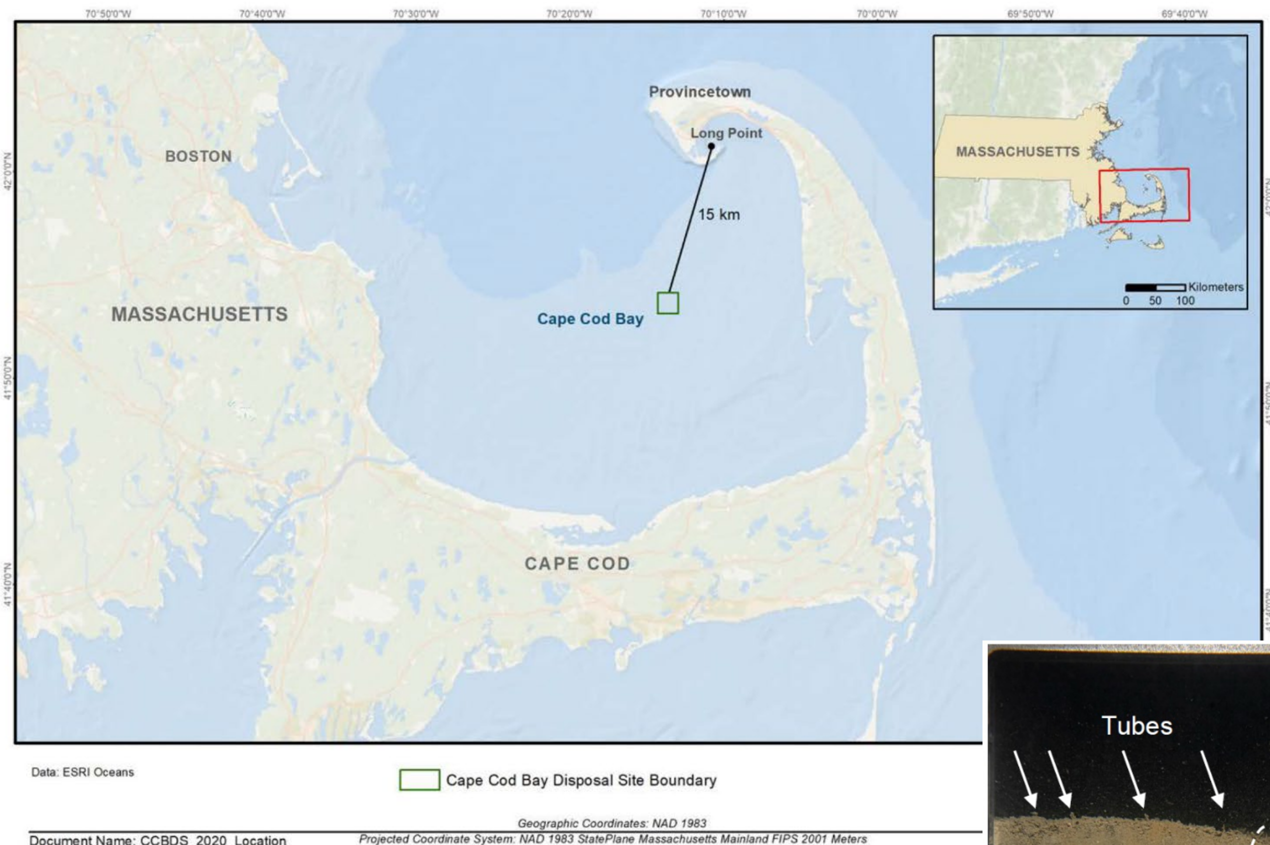
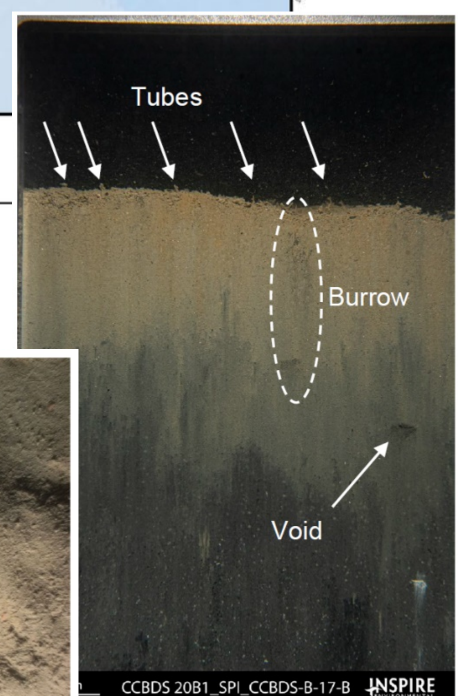
Monitoring Survey at the Cape Cod Bay Disposal Site
May/June 2020

Disposal Area Monitoring System - DAMOS





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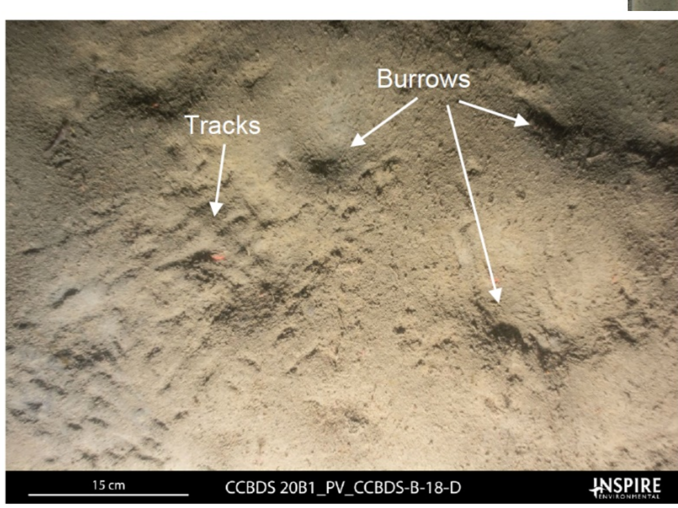

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13. ABSTRACT

Since the most recent DAMOS survey in October 2016, approximately 213,000 m^3 (279,000 yd^3) of material has been placed at Cape Cod Bay Disposal Site (CCBDS). The overall objective of the 2020 CCBDS survey was to conduct a confirmatory effort to track the recent placement of dredged material at Mounds C and D and to monitor the recovery of the benthic community at the active portion of CCBDS (Mounds C and D) and at historical Mound B.

The 2020 CCBDS confirmatory study included a 1000 × 2000-m acoustic survey over the northern portion of CCBDS and a 36 station Sediment Profile Imaging/Plan View (SPI/PV) survey. The acoustic survey included bathymetry, backscatter, and side-scan sonar imagery (from multibeam) while the SPI/PV survey featured image collection measurements at eight stations at each surveyed dredged material disposal mound within CCBDS (Mounds B, C, and D) and four stations in each of three reference areas (CCBRS, NWREF, and SWREF).

Water depths within CCBDS ranged between approximately 23.9 m and 30 m. Bathymetry measurements and a depth difference analysis revealed a peak at Mound C of 24.7 m and an increase of up to 2.9 m since the 2016 survey. New Mound D had a relatively flat surface at a depth of 28.9 m and up to 1.1 m above the seafloor. Historical Mound B had a peak at 23.9 m and did not experience a measurable change in elevation since the 2016 survey. Records of recent dredged material placement closely aligned with the acoustic observations of dredged material on the seafloor at CCBDS. Bathymetric and backscatter measurements, and side-scan sonar imagery each were consistent with the placement of dredged material at specified target locations.

The biological conditions at the three mounds (represented by aRPD [apparent redox potential discontinuity] depth and successional stage) were statistically compared to the grouped reference areas. The aRPD depths at Mounds B and C were statistically equivalent to the aRPDs from the reference areas. The aRPDs in these locations were generally deep and typical of soft sediments that are being reworked by infaunal taxa. Mound D exhibited aRPD depths that were statistically shallower than the reference areas. Despite the statistical inequivalence, aRPD depths at Mound D were not shallow enough to suggest any adverse effects to the biological community from recent material placement.

Successional stage at historical Mound B was statistically equivalent to the successional stages at the reference areas, while active Mounds C and D had statistically less advanced successional stage than the reference. These findings indicate that the benthic community at Mound B has advanced along the successional stage model to the same rank as the communities at the reference areas. Mounds C and D, while not as advanced as Mound B or the reference areas, still exhibited taxa in 2020 that have progressed as expected along the successional stage model and did not exhibit any indications of unsuitable benthic conditions. At all three mounds, there was abundant evidence of epifauna and no indication of any severe disturbance to the benthic communities from trawling or other anthropogenic impacts.

The results of the 2020 survey led to the following recommendations:

R1: The peaks of Mounds B (23.9 m) and C (24.7 m) have reached the recommended minimum water depth of 25 m. Future dredged material placement at these areas should be targeted away from the peaks to avoid further increasing peak heights.

R2: The presence of stable mounds and normal benthic recolonization indicate that the Mounds B, C, and D could accommodate additional dredged material placement utilizing a similar approach to that applied in the past.

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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 1.0. A table of common conversions can be found in Appendix A.

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LIST OF ACRONYMS

aRPD	Apparent redox potential discontinuity
ASCII	American Standard Code for Information Interchange
CAD	Confined aquatic disposal
CCBDS	Cape Cod Bay Disposal Site
CCOM/JHC	NOAA's Center for Coastal and Ocean Mapping Joint Hydrographic Center
CI	Confidence interval
CLT	Central Limit Theorem
DAMOS	Disposal Area Monitoring System
DGPS	Digital Global Positioning System
EGN	Empirical Gain Normalization
GIS	Geographic information system
GPS	Global Positioning System
GRD	Gridded data
INSPIRE	INSPIRE Environmental
MBES	Multibeam echosounder
MLLW	Mean Lower Low Water
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
QAPP	Quality Assurance Project Plan
RTK	Real time kinematic
R/V	Research vessel
SD	Standard deviation
SOP	Standard Operating Procedures
SPI	Sediment Profile Imaging
TIF	Tagged image file
USACE	U.S. Army Corps of Engineers
VDATUM	Vertical Datum Transformation

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1.0 INTRODUCTION

INSPIRE Environmental (INSPIRE) conducted acoustic and Sediment Profile Imaging (SPI) and Plan View (PV) monitoring surveys at Cape Cod Bay Disposal Site (CCBDS) in May and June 2020 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS) Program. DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns surrounding the placement of dredged material at aquatic disposal sites throughout the New England region. An introduction to the DAMOS Program and CCBDS, including brief descriptions of previous dredged material disposal and site monitoring activities, is provided below.

1.1 Overview of the DAMOS Program

The DAMOS Program features a tiered management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal are promptly identified and addressed (Germano et al. 1994). For over 40 years, the DAMOS Program has collected and evaluated dredged material 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. The data collected and evaluated during these studies provide answers to strategic questions in determining next steps in the disposal site management process. DAMOS monitoring results guide the management of disposal activities at existing sites, support planning for use of future sites, and evaluate the long-term status of historical sites (Wolf et al. 2012).

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. 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 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 data collection) are performed to characterize the height and spread of discrete dredged material deposits or mounds created at open water sites as well as the accumulation/consolidation of dredged material into confined aquatic disposal cells.

SPI and PV imaging surveys are performed in confirmatory 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 candidate sites, as baseline surveys at new sites, to evaluate inactive or historical disposal sites, and to contribute to the development of dredged material management and monitoring techniques. Focused DAMOS monitoring surveys may also feature additional types of data collection activities as deemed appropriate to achieve specific survey objectives, such as grab or core sampling of sediment for physical/chemical/biological analyses, sub-bottom profiling, or video image files.

The 2020 CCBDS survey was a confirmatory survey of the site designed to assess material placement and benthic recolonization status of CCBDS through acoustic and SPI/PV data collection and analysis.

1.2 Introduction to the Cape Cod Bay Disposal Site

CCBDS is a regional dredged material disposal site within the state waters of Massachusetts, located in Cape Cod Bay, approximately 15 km (8 nmi) southwest of Long Point, Provincetown, Massachusetts (Figure 1-1). CCBDS is defined as a 1.85 × 1.85 km (1 × 1 nmi) area on the seafloor, centered at 41º 54.406’ N, 70º 13.268’ W (NAD 83) which has a relatively flat topography and no natural bathymetric features (ENSR 2004; Figure 1-2). The seafloor slopes gently downward to the northwest across the site, with water depths ranging from 28 m (92 ft.) in the southeast corner to 31.5 m (103 ft.) in the northwest corner.

CCBDS was selected as an open water disposal site in 1990 in response to an increase in dredging needs at many regional harbors due to a steady rise in population and recreational boating activities on Cape Cod (SAIC 2003). The current site boundaries were established around the Historic Wellfleet Disposal Site, which received material from several small Wellfleet Harbor dredging projects in the 1970s and 1980s (Figure 1-2). This area of Cape Cod Bay is characterized by relatively low currents, which contributed to its selection as a depositional disposal site. An historical absence of endangered right whale sightings or commercially important lobster grounds in the vicinity also supported this site selection decision (SAIC 2003). Placement of dredged material at CCBDS began in 1994.

Monitoring and management of CCBDS is the joint responsibility of the Commonwealth of Massachusetts Department of Conservation and Recreation and the DAMOS Program. The disposal season at the site is limited to June-December due to concerns over resident and transient seasonal marine mammal populations (SAIC 2001).

1.3 Historical Dredged Material Disposal Activity

From 1994 through 2016, Cape Cod Bay Disposal Site received dredged material from numerous projects, this material has been placed at three target areas within CCBDS, denoted as Mounds A, B, and C (Figure 1-2; Table 1-1). During the winter of 1994-1995, approximately 112,000 m^3 (146,000 yd^3) of material from Wellfleet Harbor was deposited in the southeast quadrant of CCBDS forming Mound A (SAIC 2003; Figure 1-2). The disposal target buoy was then moved to the northeast quadrant of the site, and approximately 509,000 m^3 (666,000 yd^3) of material was placed at this location between 1996 and 2001, forming Mound B (SAIC 2003; Figure 1-2). In 2002, approximately 5,200 m^3 (6,800 yd^3) of material from Provincetown Harbor was deposited at a new target location in the northwest quadrant of CCBDS, initiating formation of Mound C. Later that year, a small amount of additional material [(2,500 m^3 (3,300 yd^3)] from the same dredging project was placed on top of Mound A (ENSR 2004; Figure 1-2). Between 2003-2010, approximately 137,000 m^3 (179,000 yd^3) of material was directed to Mound C in the northwest quadrant of the site (Figure-1-2). Between 2010 and 2016, approximately 270,000 m^3 (353,000 yd^3) of material originating from construction of New Bedford Harbor Confined Aquatic Disposal (CAD) Cell 3 and the Rock Harbor and Duxbury Federal Navigation Projects was placed at CCBDS. All material between 2010 and 2016 was placed at Mound C (Table 1-1; Figure 1-2).

1.4 Previous CCBDS Monitoring Events

A baseline survey was performed at CCBDS in 1994 and confirmatory surveys were performed in 1995, 1996, 2001, 2003, 2010, and 2016 (AECOM 2012, McKelvey 2018;

Table 1-2). The 2016 survey was conducted in October and featured bathymetric and SPI/PV surveys around recent and historical disposal locations. The 2016 SPI/PV survey was performed at Mounds B and C, as well as three reference areas (CCBRS, NWREF, and SWREF; Figure 1-2). Recolonization had occurred at both mounds, with stations at both mounds found to have successional stages statistically similar to reference areas. Both mounds were also found to have a mean aRPD depth consistent with reference areas, indicating a healthy benthic community at each disposal mound (McKelvey 2018).

The 2016 acoustic survey was conducted over the active northern portion of CCBDS and at all three reference areas to characterize the seafloor topography after recent dredged material placement (Figure 1-3). The 2016 acoustic survey found that material placed at CCBDS between 2010 and 2016 had accumulated at Mound C and within the boundaries of CCBDS (McKelvey 2018).

1.5 Recent Dredged Material Disposal Activity

Since the most recent DAMOS survey in October 2016, approximately 213,000 m^3 (279,000 yd^3) of material was placed at CCBDS. The material mostly originated from the Plymouth Harbor Federal Navigation Project, with small amounts of material from Gateway Marina and Sesuit Harbor (Table 1-3). Material since the October 2016 survey was placed at Mound C and at a new location, Mound D, located between Mounds C and B (Figure 1-4).

A detailed record of dredged material disposal activity at CCBDS for the period from December 2016 to May 2020, including the origin and volume of dredged material, and the disposal location, is provided in Appendix B.

1.6 2020 Survey Objectives

The overall objective of the 2020 CCBDS survey was to conduct a confirmatory effort to track the recent placement of dredged material at Mounds C and D as well as monitor the recovery of the benthic community at the recently active portions of CCBDS (Mounds C and D) and at a region of historical material placement at Mound B. The specific survey objectives were to:

- Characterize the seafloor topography and surficial features over the active northern portion of CCBDS and three reference areas (CCBRS, NWREF, and SWREF) by conducting a multibeam bathymetric survey.

- Assess benthic recolonization status (community recovery of the bottom-dwelling animals) and further evaluate the physical characteristics of surficial sediments in portions of the site with recent disposal activity (Mounds C and D), the older disposal Mound B, and the reference areas by conducting a SPI/PV imaging survey.

Table 1-1.

Estimated Volume of Historical and Recent Dredged Material Placed at CCBDS

Target Designation	Years of Disposal Activity	Volume (m^3)	Volume (yd^3)
Mound A	1994-1995	112,000	146,000
	2002	2,500	3,300
Mound B	1996-2001	509,000	666,000
Mound C	2002	5,200	6,800
	2003-2010	137,000	179,000
	2010-2016	270,000	353,000
Mounds C and D	2016-2020	213,000	279,000

Table 1-2.

Overview of Survey Activities at CCBDS

Date	Purpose of Survey	Bathymetry Area	SPI Stations (location - #)	Additional Studies	DAMOS Report/ Contribution No.	Reference
April 1994	Pre-disposal	Site: 1000 × 1000 m Ref: 1000 × 1000 m	✓*	Sub-bottom, grab sampling	NA	OSI 1995a
January 1995	Post-disposal	✓*	---	Side-scan, Sub-bottom	NA	OSI 1995b
May 1996	Monitoring	Site: 1000 × 1500 m Ref: 1000 × 1500 m	Site: 13 Ref: 39	Side-scan, sub-bottom, sediment sampling	NA	CR Environmental, Inc. 1997
August 2001	Monitoring	Site: 2100 × 2200 m	Site: 38 Ref: 16	---	144	SAIC 2003
August 2003	Monitoring	Site: 1200 × 2100 m	Site: 26 Ref: 5	---	157	ENSR 2004
September 2010	Monitoring	Site: 2000 × 2100 m Multibeam	Site: 45 Ref: 45	---	188	AECOM 2012
October 2016	Monitoring	Site: 1500 × 2000 m Ref (3): 600 × 600 m	Site: 24 Ref (3): 12	Side-scan	205	McKelvey 2018

✓* Survey was conducted; detailed data are not available (i.e., survey size, number of stations).

Table 1-3.

Disposal Activity at CCBDS Mounds C and D since the October 2016 Monitoring Survey
(per dredged material disposal logs provided by USACE, August 2020)

Permit number	**Project Name**	**Disposal Dates**	**Load volume (m^3)**	**Load volume (yd^3)**
NAE-1997-453-2016	Gateway Marina	Dec. 4 - 26, 2016	1,136	1,485
W912WJ-18-C-0020	Plymouth Harbor Federal Navigation Project	Nov. 2 - Dec. 31, 2018; Oct. 6 - Dec. 30, 2019	186,220	243,566
NAE-2015-02882	Sesuit Harbor	Oct. 31, 2018 - Jan. 1, 2019	26,000	34,006
Total			**213,356**	**279,057**

2.0 METHODS

Due to health and safety restrictions associated with the SARS COVID19 pandemic, May and June 2020 CCBDS survey data collection was conducted as two separate survey efforts. The Sediment Profile and Plan View Imaging (SPI/PV) survey was conducted by INSPIRE Environmental onboard the 92-foot R/V *Northstar Challenger* on May 6-7, 2020. The acoustic data collection survey was conducted by CR Environmental onboard the 55-foot R/V *Jamie Hanna* on June 9, 2020.

2.1 Navigation and Onboard Data Acquisition

For the acoustic survey, to ensure field team social distancing associated with COVID19 protocols, a Conex Box laboratory van was installed on the R/V *Jamie Hanna*. The Conex Box created separate workspaces for the scientific team and the vessel crew. Navigation and other system components were installed in the van. Power was supplied from the vessel's generator. The MBES survey crew was restricted to the Conex Box laboratory van while the vessel crew was restricted to the pilothouse.

Navigation onboard the R/V *Jamie Hanna* was accomplished using a Hemisphere VS-330 Real Time Kinematics (RTK) Global Positioning System (GPS) which received base station corrections through the Keynet NTRIP broadcast. Horizontal position accuracy in fixed RTK mode was approximately 2 cm. A spare Hemisphere VS-330 was available as a backup. The digital GPS (DGPS) system was serially interfaced to a laptop computer running HYPACK hydrographic survey software. HYPACK continually recorded vessel position and GPS satellite quality and provided a steering display for the vessel captain allowing him to accurately maintain the position of the vessel along pre-established acoustic survey transects. Vessel heading measurements were provided by an IxBlue Octans III fiber optic gyrocompass. The Hemisphere VS-330 served as a backup source for heading corrections.

The SPI/PV survey was conducted aboard the *Northstar Challenger*. The *Northstar Challenger* is a multi-purpose offshore utility vessel, equipped with the following navigational equipment: 2x Furuno Radars, Furuno Nav Net Chart Plotter, AIS & DGPS, and Raytheon Thermal Imaging Camera. Sample positioning was carried out by INSPIRE using a Hemisphere V102 GPS compass to accurately record vessel heading as well as a differential position accuracy of the sampling equipment to within a meter. During mobilization, the navigator conducted a positional accuracy check on the system, by placing the antenna on a known GPS point and ensuring the antenna's position fell within one meter of the known coordinates. During operations HYPACK Ultralite software was used to receive positional data from the antenna and direct the vessel to sampling stations. Once the vessel was within a 15-m diameter of the target location, the SPI/PV camera system was deployed to the seafloor. As soon as the camera system made contact with the seafloor, the navigator recorded the time and position of the camera electronically in HYPACK and the written field log. This process was repeated for four SPI/PV replicate "drops" of the SPI/PV camera system at each sampling station. After all stations were surveyed the navigator exported all recorded positional data into an Excel sheet.

2.2 Acoustic Survey

The acoustic survey included bathymetric, backscatter, and side-scan sonar data collection and processing. The bathymetric data provided measurements of water depth that, when processed, were used to map the seafloor topography. The processed data were also compared with previous surveys to track changes in the size and location of seafloor features. This technique is the primary tool of the DAMOS Program for mapping the distribution of dredged material at disposal sites. The methodology for acoustic data acquisition is described in detail in the Project QAPP (INSPIRE 2020a) and INSPIRE acoustic standard operating procedures (INSPIRE 2020b).

Multibeam backscatter and side-scan sonar data provided images that supported characterization of surficial topography, sediment texture, and roughness. Backscatter data are processed into a seamless image with corrections for topography (depth-normalized) while side-scan sonar data retains a higher resolution image without correction for topography. Comparison of synoptic acoustic data types is very useful for assessing dredged material placed on the seafloor.

2.2.1 Acoustic Survey Planning

A certified hydrographer obtained site coordinates from USACE NAE, imported them to HYPACK and ArcView GIS software, and created maps to guide survey activities. The proposed CCBDS survey design was then reviewed and approved by NAE scientists.

The acoustic survey covered the active, northern portion of CCBDS (Figure 2-1). A 1000 × 2000-m acoustic survey was selected to provide greater than 100-percent coverage of the CCBDS seafloor surveyed. Survey lines were spaced 60 m apart and cross lines were spaced 250 m apart (Figure 2-1). The acoustic survey did not include the three reference areas as these areas were previously surveyed during the 2016 monitoring effort (McKelvey 2018).

2.2.2 Acoustic Data Collection

The 2020 multibeam bathymetric survey of CCBDS was conducted on June 9, 2020. Bathymetric, acoustic backscatter, and side-scan sonar data were collected using a R2Sonic 2022 broadband multibeam echosounder (MBES). This 200-400 kHz system formed 256 1-2° beams (frequency dependent) distributed equiangularly or equidistantly across a 160° swath. The system was operated using a frequency of 200 kHz and a 0.08-millisecond pulse to optimize bathymetric and backscatter data quality. The MBES transducer was mounted amidships to the port rail of the survey vessel using a high strength adjustable boom. Offsets between the primary GPS antenna and the sonar were precisely measured and entered into HYPACK. The transducer depth below the water surface (draft) was checked and recorded at the beginning and end of data acquisition and 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.

An AML Minos-X sound velocity profiler system was used to collect sound velocity profiles (SVP) casts at frequent intervals throughout each survey day to determine the speed of sound in the local water mass for use in calibrating the MBES system. A total of eight SVP casts were acquired during the survey. Additional confirmations of proper calibration, including static draft, were obtained using the “bar check” method, in which a metal plate was lowered beneath the MBES transducer to a known depth (e.g., 5.0 m) below the water surface. “Bar-check” calibrations were accurate to within 0.01 m in tests conducted at the beginning and end of the survey.

2.2.3 Bathymetric Data Processing

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

- Conversion of RTK GPS tide data from NAVD88 elevations to Mean Lower Low Water (MLLW) elevations using NOAA's VDatum model
- Adjustment of data for tide 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

Correction of sounding depth and position (range and azimuth) for refraction due to water column stratification was conducted using a series of eight sound velocity profiles acquired by the survey team. The water column was stratified during the survey, with an approximately 25-m gradient between the surface and bottom. Stratification resulted in data artifacts associated with refraction that remained in the bathymetric surface model at a relatively fine scale (approximately 5 to 10 cm) relative to the survey depth.

Bathymetric data were filtered to accept only beams falling within an angular limit of 60° to minimize refraction artifacts. Spurious sounding solutions were flagged or rejected based on the careful examination of data in sweep and profile views.

The R2Sonics 2022 MBES system was operated at 200 kHz. At this frequency, the system has a published beam width of 2.0°. Assuming an average depth of 30 m and a maximum beam angle of 60°, the mid-swath diameter of the beam footprint was calculated at approximately 2.1 × 1.5 m (3.1 m^2). Data were reduced to a cell (grid) size of 3.0 × 3.0 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).

The combined uncertainties associated with all system elements, including calibrations, tide corrections and refraction caused by water column stratification were quantified by comparing primary survey transects with perpendicular “cross-line” transects. Data for primary transects were exported at a cell resolution of 9 m^2 using the average elevation within each cell. Data for cross-line transects were compared to the pseudo “reference surface” created using the primary transects.

Comparisons were made between cross-line and mainstay swaths to +/- 60 degrees from nadir using 3.0 × 3.0-m cell average elevations and 5-degree beam-angle increments. The mean difference between the mainstay reference surface and cross-line data was 0.03 m. The average standard deviation between cross-lines and primary lines was 0.07 m, with a mean 95% RMS confidence limit uncertainty of 0.14 m (maximum 0.18 m at 60 degrees from nadir). Mean elevation differences across the swaths ranged from 0.0 m to 0.09 m with the greatest difference at 60 degrees from nadir. This comparison documents negligible tide bias and quantifies uncertainty associated with refraction. This analysis shows compliance with USACE accuracy recommendations and National Ocean Service (NOS) standards. Note that the NOS standard for this project depth (Special Order 1A) would call for a 95th percentile confidence interval (95% CI) of 0.34 m at the maximum site depth (31.6 m) and at the mean site depth (30.1 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 IVS3D Fledermaus (V.7), ESRI ArcMap (V.10.1), and Golden Software Surfer (V. 17). 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 SHP format suitable for plotting using GIS and CAD software,
- 3-dimensional surface maps of the seabed created using 2× vertical exaggeration and artificial illumination to highlight fine-scale features not visible on contour layers (delivered in grid and TIF formats), and,
- An acoustic relief map of the survey area created using 2× vertical exaggeration, delivered in georeferenced TIF format.

2.2.4 Backscatter Data Processing

MBES backscatter data were processed using HYPACK®'s implementation of GeoCoder software developed by NOAA's Center for Coastal and Ocean Mapping Joint Hydrographic Center (CCOM/JHC). GeoCoder was used to create a mosaic best suited for substratum characterization through the use of innovative beam-angle correction algorithms. Data acquired were processed using R2Sonics' TruePix beam time series data. A trend-adaptive angle-varying gain function in Geocoder was applied to minimize artifacts associated with substrate variation within survey transects.

Backscatter data for CCBDS were next exported in ASCII format with fields for Easting, Northing, and backscatter (in dB units) using a 3.0 × 3.0-m resolution. Data were converted to grid format using Golden Software Surfer V17 software. This grid was used to generate a seamless mosaic of backscatter in GeoTIF format. A Gaussian filter was next applied to backscatter data to minimize nadir artifacts and the filtered data were used to develop a backscatter model using a 3.0 × 3.0-m grid. The grid was exported to an ESRI binary GRD format to facilitate comparison with other data layers.

2.2.5 Side-Scan Sonar Data Processing

Multibeam side-scan sonar data were processed using Chesapeake Technology, Inc. SonarWiz software. Time-varied gain adjustments were applied to data and a mosaic was constructed using the root-mean squared intensity value to represent overlapping pixels. Empirical Gain Normalization (EGN) was not used as side-scan was intended to show finer features (e.g., targets, fine bedforms) without the loss of resolution associated with EGN. This mosaic was exported in GeoTIF format using a resolution of 0.2 m per pixel. Because fine details are partially obscured in side-scan mosaics, individual GeoTIF images of each sonar file with resolutions of 0.2 m per pixel were also produced and delivered.

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 was done by rendering images and color-coded grids with sufficient transparency to allow the three-dimensional acoustic relief model to be visible underneath.

QPS Fledermaus software was used to calculate elevation difference grids between the 2020 bathymetric dataset and the DAMOS survey conducted in 2016. Elevation difference grids were calculated by subtracting the earlier survey depth estimates from the 2020 survey depth estimates at each point throughout the grid. The resulting elevation differences were contoured and displayed using GIS.

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.

2.3.1 SPI and PV Survey Planning

The CCBDS SPI/PV survey featured image collection at 36 stations, including 24 stations within CCBDS and four stations in each of three reference areas (CCBRS, NWREF, and SWREF; Figure 2-2). Stations within CCBDS were distributed across three areas; a historical disposal target area (Mound B) and two recent disposal target areas (Mound C and Mound D; Figure 2-2). Eight stations were randomly located within each of these three areas within CCBDS. Additionally, four stations were randomly located within each of the three reference areas. SPI/PV station locations are provided in Table 2-1 and actual SPI/PV station replicate locations are provided in Appendix C. The methodology for data acquisition and analysis for these images was consistent with the sampling methods described in detail in the Project QAPP (INSPIRE 2020a) and INSPIRE SPI/PV standard operating procedures (INSPIRE 2019).

2.3.2 Sediment Profile Imaging

Sediment profile imaging (SPI) is a monitoring technique used to provide data on the physical characteristics of the seafloor and the status of the benthic biological community. The technique involves deploying an underwater camera system to photograph a cross section of the sediment–water interface. In the 2020 survey at CCBDS, high-resolution SPI images were acquired using a Nikon® D7100 digital single-lens reflex camera mounted inside an Ocean Imaging® Model 3731 pressure housing system. The pressure housing sat atop a wedge-shaped steel prism with a plexiglass front faceplate and a back mirror. The mirror was mounted at a 45° angle to reflect the profile of the sediment–water interface. The camera lens looked down at the mirror, which reflected the image from the faceplate. The prism had an internal strobe mounted inside at the back of the wedge to provide illumination for the image; this chamber was filled with distilled water, so the camera always had an optically clear path. The descent of the prism into the sediment was controlled by a hydraulic piston. 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 2-3). The camera remained on the seafloor for approximately 20 seconds to ensure that a successful image had been obtained.

Test exposures of a Color Calibration Target were made on deck at the beginning and end of the 2020 survey to verify that all internal electronic systems consistently met design specifications and to provide a color standard against which final images could be checked to ensure proper color balance. 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). All camera settings and any setting changes were recorded in the field log (INSPIRE 2020c).

Each time the camera system was brought onboard, 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. Frame counts, time of image acquisition, frame stop-collar position, and the number of weights used were recorded in the field log 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 after downloading as a further quality assurance step.

2.3.3 Plan View Imaging

An Ocean Imaging® Model DSC24000 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 images 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-7100 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 SPI/PV camera system was lowered to the seafloor, the weight attached to the bounce trigger contacted the seafloor prior to the camera frame reaching the seafloor and triggered the PV camera (Figure 2-3).

During set-up and testing of the PV camera, the positions of lasers on the PV camera were checked and calibrated to ensure separation of 26 cm. Test images were also captured to confirm proper camera settings for site conditions. 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 1/15, f18, 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 30 MB each). Images were checked periodically throughout the survey to confirm that the initial camera settings were still resulting in the highest quality images possible. All camera settings and any setting changes were recorded in the field log.

Prior to field operations, the internal clock in the digital PV system was synchronized with the GPS navigation system and the SPI camera. For each PV image, a time stamp was recorded in the digital file and redundant time notes were made in the field and navigation logs. Throughout the survey, PV images were downloaded at the same time as the SPI images and evaluated to confirm 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 CCBDS allowed use of a 0.8-m trigger wire, resulting in a mean image width of 0.7 m and a mean field-of-view of 0.3 m^2.

2.3.4 SPI and PV Data Collection

The SPI/PV survey was conducted at CCBDS and reference areas on May 6-7, 2020 onboard the *Northstar Challenger.* At each station, the vessel was positioned at the target coordinates and the camera was deployed within a defined station tolerance of 15 m. At least four replicate SPI and PV images were collected at each station. The three replicate images with the best quality (adequate prism penetration, no or minimal sampling artifacts) at each station were selected for analysis (Appendices D and E).

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

2.3.5 Image Conversion and Calibration

Following completion of field operations, quality control checks were conducted of filenames, date/time stamps, and the field log. After these procedures, the NEF raw image files were color calibrated in Adobe Camera Raw® by synchronizing the raw color profiles to the Color Calibration Target that was photographed prior to field operations with the SPI camera. The raw SPI and PV images were then converted to high-resolution Photoshop Document (PSD) format files, using a lossless conversion file process and maintaining an Adobe RGB (1998) color profile. The PSD images were then calibrated and analyzed in Adobe Photoshop®. Length and area measurements were recorded as number of pixels and converted to scientific units using the calibration information. Detailed results of all SPI and PV image analyses are presented in Appendices D and E.

2.3.6 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 (Germano et al. 2011).

Measured parameters for SPI and PV images were recorded in Microsoft Excel© spreadsheets. These data were subsequently checked by one of INSPIRE's senior scientists as an independent quality assurance/quality control review before final interpretation was performed. Spatial distributions of SPI and PV parameters were mapped using ESRI ArcGIS 10.5. Map backgrounds use regional bathymetric mosaics obtained from the National Oceanic and Atmospheric Administration's National Centers for Environmental Information (NOAA NCEI 2020).

2.3.6.1 Sediment Profile Image Analysis Parameters

The parameters discussed below were assessed and/or measured and recorded for each replicate SPI image selected for analysis (Appendix D). Descriptive comments were also recorded for each. Many variables can be seen and annotated in context in SPI images from soft bottom coastal and estuarine environments (Figure 2-4).

<u>Sediment Type</u>–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 F. The presence and thickness of disposed dredged material were also assessed as described below.

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

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

<u>Apparent Redox Potential Discontinuity (aRPD) Depth</u>–The aRPD depth provides a measure of the integrated time history of the balance between near-surface oxygen conditions and biological reworking of sediments. Sediment particles exposed to oxygenated waters

oxidize and lighten in color to brown or light gray. As the particles are buried or moved down by biological activity, they are exposed to reduced oxygen concentrations in subsurface pore waters and their oxic coating slowly reduces, changing color to dark gray or black. When biological activity is high, the aRPD depth increases; when it is low or absent, the aRPD depth decreases. The aRPD depth was measured by assessing color and reflectance boundaries within the images.

Mud Clasts – When fine-grained, cohesive sediments are disturbed, either by physical bottom scour or faunal activity (e.g., decapod foraging) intact clumps of sediment are often scattered across the seafloor. The number of clasts observed at the sediment–water interface was counted and their oxidation state assessed. The detection of reduced mud clasts in an obviously aerobic setting suggests a recent origin (Germano 1983). Mud clasts that are artifacts of SPI sampling (mud clots can fall off the back of the prism or wiper blade) are not recorded in the analysis sheet but may be noted in the “Comments” field.

Dredge Material Layer Depth and Thickness – The depth below the sediment–water interface of dredge material layer was measured. Additionally, the thickness of the dredged material layer, from 1 mm to 20 cm (the height of the SPI optical window) was measured. If the layer extended below the depth of prism penetration this was noted.

Biological Mixing – The depth to which sediments are bioturbated, or the biological mixing depth, can be an important parameter for studying nutrient or contaminant flux, as well as organic enrichment, in sediments. In this study, the minimum and maximum linear distances from the sediment surface to subsurface voids were measured. The latter parameter represents the maximum observed particle mixing depth of head-down feeders, mainly polychaetes. The number of subsurface voids were counted for each SPI replicate.

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 (e.g., dredged material disposal) (Pearson and Rosenberg 1978; Rhoads and Germano 1982; Rhoads and Boyer 1982). This continuum has been divided subjectively into four stages: Stage 0, indicative of a sediment column that is largely devoid of macrofauna, occurs immediately following a physical disturbance or in close proximity to an organic enrichment source; Stage 1 is the initial recolonizing tiny, densely populated polychaete assemblages; Stage 2 is the start of the transition to head-down deposit feeders;

and Stage 3 is the mature, equilibrium community of deep-dwelling, head-down deposit feeders (Figure 2-5). Successional stage was assigned by assessing the types of species and related activities (e.g., feeding voids) apparent in the images. Biogenic particle mixing depths can be estimated by measuring the maximum and minimum depths of imaged fauna, burrows, or feeding voids in the sediment column.

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.

2.3.6.2 Plan View Image Analysis Parameters

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 (Figure 2-6). 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.

For each replicate PV image selected for analysis, analysts calculated the image size and field-of-view and the following were recorded: sediment type; oxidation state of the surface sediment; presence and type of bedforms; presence of *Beggiatoa* and estimates of cover extent; dredged material presence; presence of burrows, tubes, tracks/trails, and debris; types of epifauna and flora; number of fish; and descriptive comments (Appendix E).

2.3.7 Data Quality Assurance and Quality Control

Measures were taken both during field data collection and during post-collection analysis for data quality assurance and control in alignment with the project QAPP (INSPIRE 2020a). These included but were not limited to:

- Systems were tested prior to and during survey activities to ensure calibration and operation,
- A full backup system (including tools, parts, and electronics) was carried in the field, and
- Image data collected was time stamped both digitally and in hand-written logs to ensure proper identification and synchronization with navigational data.

2.4 Statistical Analyses on aRPD and Successional Stage

The objective of this survey was 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 parameter values between sampled disposal areas (Mound B, Mound C, and Mound D) and reference areas (CCBRS, NWREF, and SWREF). The aRPD depth and successional stage measured in each image are the best indicators of infaunal activity measured by SPI and were, therefore, used in this comparative analysis. Standard boxplots were generated for visual assessment of the central tendency and variation in each of these parameters within each disposal area and each reference area. Tests rejecting the inequivalence between the reference and disposal areas were conducted, as described in detail below.

Traditionally, the objective of this study would be addressed using point null hypotheses of the form "There is no difference in benthic conditions between the reference area and the disposal target areas." However, in this instance, an approach using bioequivalence or interval testing was considered to be more informative than the point null hypothesis test of "no difference" (Germano 1999). One reason is that there is always some small difference, and the statistical significance of this difference may or may not be ecologically meaningful. Without an associated power analysis, the results of traditional point null hypothesis testing often provide an inadequate ecological assessment.

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

H_0: $d \le -\delta$ or $d \ge \delta$ (presumes the difference is great)

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

where d is the difference between a reference mean and a site mean. If the null hypothesis is rejected, then it can be 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/noise and is therefore not ecologically meaningful. Previously established δ values of 1 for aRPD, and 0.5 for successional stage rank on the 0–3 scale, were used.

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

In this survey, six distinct areas were sampled, three of which were categorized as reference locations (CCBRS, NWREF, and SWREF) and another three were disposal locations (Mound B, Mound C, and Mound D). The difference equation of interest was the linear contrast of the average of the three reference means minus each disposal area mean, or

$$\hat{d} = \tfrac{1}{3}\,(\mathrm{Mean}_{\mathrm{CCBRS}} + \mathrm{Mean}_{\mathrm{NWREF}} + \mathrm{Mean}_{\mathrm{SWREF}}) - (\mathrm{Mean}_{\mathrm{Disposal}}) \qquad \text{[Eq. 1]}$$

where $\mathrm{Mean}_{\mathrm{Disposal}}$ was the mean for one of the disposal areas (Mounds B, C, or D).

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 had no effect on the reference mean when sample size was equal among these areas, but it ensured that the variance is truly the residual variance within a single population with a constant mean.

The standard error of each difference equation was calculated using Equation 2, where 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:

$se(\hat{d})$ standard error of the difference equation

$\hat{d}$ observed difference in means between the reference and the disposal area

c_j coefficients for the j means in the difference equation, $\hat{d}$ (i.e., for [Eq. 1] shown above, the coefficients were ⅓ for each of the three reference locations, and -1 for the disposal area

S_j^2 variance for the j^{th} area. If we can assume equal variances, a single pooled residual variance estimate can be substituted for each group, equal to the mean square error from an ANOVA.

n_j number of stations for the j^{th} area

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

Thus, the decision rule was to reject H_0 if

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

where:

$t_{\alpha,\upsilon}$ 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, it was the residual degrees of freedom from an ANOVA on all groups (total number of samples minus the number of groups); if separate variance estimates were used, degrees of freedom were calculated based on the Welch-Satterthwaite estimation (Satterthwaite 1946).

Validity of the normality and equal variance assumptions was tested using Shapiro-Wilk's test for normality on the area residuals (α=0.05) and Levene's test for equality of variances among the six areas (α =0.05). If normality was not rejected but equality of variances was, then the variance for the difference equation was based on separate variances for each group. If systematic deviations from normality were identified, then a nonparametric bootstrapped interval was used (Appendix G). Bootstrapping is a statistical resampling procedure that uses the sample data to represent the entire population to construct confidence limits around population parameters. Bootstrapping does not make assumptions about the distribution of the data; it assumes only that the sample data are representative of the underlying population, so random sampling is a prerequisite for appropriate application of this method. Bootstrapping procedures entail resampling, with replacement, from the observed sample of size n. Each time the sample is resampled, a summary statistic (e.g., mean or standard deviation) of the bootstrapped sample is computed and stored. After repeating this procedure many times, a summary of the bootstrapped statistics is used to construct the confidence limit.

Table 2-1.

CCBDS 2020 Survey Target SPI/PV Station Locations

Station ID	Area	Latitude (NAD 1983)	Longitude (NAD 1983)	X (NAD 1983 State Plane MA Mainland meters)	Y (NAD 1983 State Plane MA Mainland meters)
1	C	41.911802	-70.228023	305523.377	852059.9609
2	C	41.910999	-70.227659	305554.8684	851971.2908
3	C	41.910745	-70.226673	305637.1103	851944.264
4	C	41.91252	-70.229092	305433.4505	852138.3846
5	C	41.911436	-70.228929	305448.8068	852018.1815
6	C	41.912134	-70.22659	305641.6339	852098.674
7	C	41.911829	-70.227039	305604.9126	852064.2566
8	C	41.912471	-70.225646	305719.4006	852137.2542
9	D	41.911865	-70.222289	305998.8774	852074.1531
10	D	41.911859	-70.220816	306121.0675	852075.2248
11	D	41.912677	-70.221681	306047.9761	852165.0112
12	D	41.911859	-70.22277	305959.037	852072.8028
13	D	41.910733	-70.220563	306143.9385	851950.5878
14	D	41.91008	-70.222884	305952.5412	851875.1512
15	D	41.911903	-70.223431	305904.0948	852076.8838
16	D	41.912252	-70.22232	305995.6973	852117.0214
17	B	41.91142	-70.216605	306471.1592	852031.7578
18	B	41.912755	-70.217027	306433.873	852179.4879
19	B	41.91069	-70.214828	306619.8046	851952.8983
20	B	41.912693	-70.214486	306644.8042	852175.7977
21	B	41.911633	-70.213293	306745.567	852059.5114
22	B	41.911778	-70.217524	306394.2825	852070.3506
23	B	41.910205	-70.214256	306668.0833	851899.7862
24	B	41.911041	-70.214709	306629.0881	851991.9991
25	CCBRS	41.95941	-70.265253	302358.4547	857301.8432
26	CCBRS	41.957115	-70.266957	302220.8231	857044.9631
27	CCBRS	41.957837	-70.265956	302302.6893	857126.2609
28	CCBRS	41.959246	-70.268447	302093.8954	857279.8265
29	NWREF	41.932653	-70.243316	304220.5799	854356.8877
30	NWREF	41.930792	-70.242451	304295.4102	854151.2312
31	NWREF	41.931211	-70.245199	304066.7888	854194.3866
32	NWREF	41.933853	-70.244276	304138.9991	854488.9519
33	SWREF	41.88029	-70.264267	302567.4871	848516.1447
34	SWREF	41.883121	-70.265187	302486.5206	848829.4216
35	SWREF	41.880669	-70.269042	302170.565	848552.5065
36	SWREF	41.882538	-70.268169	302239.9742	848761.1238

3.0 RESULTS

An acoustic survey was conducted over the northern portion of CCBDS and a SPI/PV survey was conducted over three northern dredged material disposal mounds within CCBDS and three reference areas. The objectives of the survey were to characterize seafloor topography and surficial features and assess the benthic recolonization status of the survey area. The results from these surveys are presented below.

3.1 Acoustic Survey

3.1.1 Bathymetry

The bathymetry of the northern portion of CCBDS as surveyed in 2020 revealed three mound features rising above a relatively flat seafloor. Multibeam bathymetric data rendered as an acoustic relief model (color scale with hillshading) provided a detailed representation of the surface of the study area seafloor (Figure 3-1). The seafloor was approximately 30 m deep at the deepest portions of the surveyed area and as shallow as 23.9 m at the top of disposal Mound B located in the northeastern portion of CCBDS. Active Mound C peaked at 24.7 m and newly created Mound D was relatively flat and rose 1.1 m above the seafloor.

Historical Mound B was observed to be the largest mound, with a distinct 70 × 50-m peak rising 6.1 m above the seafloor. Mound B had an approximately 250 × 150-m oval footprint rising above the seafloor along a southeast-northwest axis. In profile view, Mound B has a relatively steep slope on the southeast side and a more gradual elongated slope on the northeast side (Figure 3-2). Distinct pock-marked disposal features were observed in surficial sediments throughout Mound B and the surrounding apron.

Active Mound C, located in the northwestern area, was observed to be elevated 5.3 m above the ambient seafloor at its highest point. The peak of Mound C was relatively small (less than 50 × 50 m) and situated on the northern portion of the mound area. Overall, Mound C had a 250 × 200-m roughly rectangular footprint rising above the seafloor and featuring clumpy, irregular features. Mound C also revealed a large relatively thin (<1 m) apron covering nearly the entire circular Mound C sampling area and extending beyond to the south.

A newly created and active Mound D was observed at roughly the mid-point between Mounds C and B during the 2020 acoustic survey. The new Mound D was elevated 0.5 to

1.1 m above seafloor and was flat and relatively featureless. Mound D was an approximately 250 × 150-m oval oriented to the north-northwest by south-southeast. Mound D was nearly flat and smooth and did not reveal the types of irregular, clumpy, or pock-mark features that were observed at Mounds B and C.

3.1.2 Acoustic Backscatter and Side-Scan Sonar

Acoustic backscatter provides an indication of the nature of surficial sediment present in the survey area. Unfiltered backscatter imagery of the disposal site revealed patterns of dredged material disposal in three distinct mound areas within the northern portion of CCBDS (Figure 3-3). Filtered backscatter over acoustic hillshaded relief presents a quantitative assessment of surface characteristics independent of slope effects and provides a more readily interpreted map (Figure 3-4). Stronger backscatter returns indicate coarser, rougher, or harder surficial sediments relative to surrounding sediments and are shown in orange and yellow. Relatively coarser, rougher, or harder sediments were observed in the three disposal mound areas in the northern portion of CCBDS (Figure 3-4). The strongest backscatter returns were observed at Mound B and the northern portion of Mound C. Backscatter returns at newly created Mound D were weaker than those of Mounds B and C, but stronger than those of the surrounding seafloor. Backscatter data revealed patterns in the nature of surficial dredged material placed at Mounds B, C, and D with stronger returns on the peaks of Mounds B and C and on the margins of Mound D.

Side-scan sonar imagery derived from MBES also provided a clear representation of dredged material placed at Mounds B, C, and D. Processing MBES data into side-scan sonar imagery depicts the surface relief and texture of the seafloor with higher resolution than quantitative backscatter (0.2 m vs. 3 m, Sections 2.2.4, 2.2.5) and can reveal more detail (compare Figures 3-3 and 3-5). Mound B and the northern portion of Mound C showed the strongest intensity returns from surficial features in the side-scan sonar imagery across the surveyed area at CCBDS (Figure 3-5). Side-scan imagery revealed fine-scale textures and roughness above ambient levels in all three mound areas and were aligned with the surface topography observed in the hillshaded bathymetry (compare Figures 3-1, 3-4, and 3-5). Side-scan sonar results across the CCBDS surveyed area were consistent with the placement of dredged material in the areas at Mound B, C, and D. There was no evidence in any of the acoustic results of significant spatial displacement of deposited material.

3.1.3 Comparison with Previous Bathymetry

The bathymetry data from the 2020 survey was compared with bathymetry data from the previous survey conducted at CCBDS in 2016, which also covered the northern portion of CCBDS. Comparison of bathymetry measurements between survey years serves to document placement of dredged material and any potential changes in elevation associated with sediment compaction or transport.

A subtraction of the bottom elevation in the 2016 survey from the 2020 elevation was conducted to capture differences in elevation of the seafloor between survey years (Figure 3-6). Seafloor elevation was observed to increase between 2016 and 2020 at two discrete areas, Mound C and Mound D. Increased mound elevations at these locations were co-located with the records of dredged material placement since the 2016 survey (Table 1-1; Figures 1-4 and 3-6).

Elevation changes were greatest at Mound C. Mound C elevations increased by 0.2 to 2.9 m over an area of approximately 250 × 350 m and extending beyond the Mound C sampling area to the northwest and southeast (Figure 3-6). Mound D did not exist in 2016 and appeared as an oval-shaped area with an elevation of 0.5 to 1.1 m with an apron tailing to the southeast in 2020 (Figure 3-6). No significant changes in elevation were observed at Mound B. Small decreases (e.g., 0.2 m and shown in light blue) were observed in the Mound B area and were similar in magnitude to bathymetric measurement uncertainty.

3.2 Sediment Profile and Plan View Imaging

The primary purpose of the SPI/PV survey at CCBDS was to characterize the physical features of the surface sediments and assess the status of benthic colonization on the selected disposal mounds and to compare disposal site results with reference area conditions. SPI/PV images were collected at a total of 36 stations: eight in each mound area (B, C, and D) and four in each reference area (CCBRS, NWREF and SWREF) as shown in Figure 3-7. A summary of key SPI/PV image measurements for each station is provided in Tables 3-1 through 3-4 and a complete set of results in Appendices D and E. SPI/PV results for the reference area stations and CCBDS stations are provided below.

3.2.1 Reference Area Stations

In May 2020, a total of 12 SPI/PV stations were sampled across the three reference areas. This included paired SPI and PV image collection at four stations within each of the three reference areas, CCBRS, NWREF, and SWREF (Figure 3-7). These reference areas were used to represent ambient sediment conditions of the region relative to CCBDS.

3.2.1.1 Physical Sediment Characteristics

There was little variability of physical sediment characteristics observed in the SPI across the three reference areas (Figure 3-8). All stations sampled with SPI at CCBRS and NWREF exhibited very fine sand over silt/clay (Table 3-1a; Figures 3-8 and 3-9). SWREF depicted some variability in the sediment, with silt/clay and very fine sand over silt/clay documented (Table 3-1a; Figures 3-8 and 3-9). SWREF was the shallowest reference area, with a mean station water depth of 30.6 m (Table 3-1a) while NWREF had a mean station depth of 34.1 m (Table 3-1a). CCBRS was the deepest reference area with a mean station depth of 38.0 m (Table 3-1a). There was no variability in surficial sediment types observed in the PV at the reference areas (Figure 3-10). All stations at the reference areas exhibited sand or finer surficial sediment (Table 3-1a; Figures 3-10 and 3-11).

The similarities in sediment compaction across the reference areas were evident in the camera penetration depths, although the weight and stop settings used on the system changed throughout the survey (Figure 3-12; Appendix D; INSPIRE 2020c). Because of the variable system settings, prism penetration could not be used to directly analyze sediment load-bearing capacity. However, basic observations about the sediment's load-bearing capacity were made. Prism penetration was high across the three reference areas with a range of 13.5 cm at Station NWREF-30 to a maximum of 18.2 cm at Station SWREF-35 (Table 3-1a; Figure 3-12). Generally, all stations sampled across the three reference areas exhibited deep penetration depths typical of soft sediments with low load-bearing capacity.

Small scale boundary roughness values across the three reference areas ranged from a minimum of 0.7 to a maximum of 1.8 cm, with an overall mean of 1.4 cm (Standard Deviation [SD]±0.3) (Table 3-1a; Figure 3-13). Most stations across all three reference areas depicted small-scale boundary roughness that was biogenic in origin (e.g., burrow openings, fecal mounds, fecal stacks, foraging depressions) (Table 3-1a; Figure 3-14). Two stations at SWREF had a mix of small-scale physical and biological features that contributed to the boundary roughness (Table 3-1a; Figure 3-14).

3.2.1.2 Biological Conditions and Benthic Recolonization

Mean aRPD depths were generally similar across the three reference areas. Mean aRPD depth ranged from a minimum of 1.7 cm at Station SWREF-33 to a maximum of 3.7 cm at Station SWREF-35, with an overall reference area mean of 2.9 cm (SD±0.6) (Table 3-1b; Figure 3-15).

Evidence of mature, deposit-feeding infaunal (Stage 3) assemblages was found at all three reference areas, manifested as subsurface feeding voids in SPI replicates, large burrows visible in PV replicates, or presence of deep-burrowing polychaetes in SPI replicates (Table 3-1b; Figures 3-16 and 3-17). Assemblages of Stage 1 on 3 fauna were the predominant successional stage at the reference areas, where deep burrowing polychaetes and/or subsurface feeding voids were frequently observed in combination with small tubes at the sediment water interface (Table 3-1b; Figures 3-16 and 3-17).

Subsurface feeding voids in SPI were observed at all three reference areas, with a mean of 0.8 voids (SD±0.7) observed per image (Table 3-1b; Figure 3-18). The mean feeding void depth ranged with a mean station maximum depth below the sediment water interface of 17.0 cm and mean station minimum depth of 5.9 cm (Table 3-1b; Figure 3-19).

The widespread presence of Stage 3 infauna detected in the sediment profile images was further supported in the corresponding plan view images from the reference areas. All reference area stations showed tubes and burrow openings at the sediment surface (Table 3-1b; Figure 3-14). There also was evidence of epifauna in the form of tracks, pits, and organisms, including brittle stars and shrimp (Table 3-1b).

There was no evidence of low dissolved oxygen in the overlying water or signs of methane in the subsurface sediments at any of the reference area stations (Table 3-1b).

3.2.2 Disposal Site Stations

SPI and PV images were collected across three northern placement mounds within CCBDS. These mounds included Mound B, that has not received material since the previous survey in 2016, and the active Mounds C and D where material placement has occurred since 2016 (Tables 1-1 and 1-3; Figure 1-4). A total of 8 stations were sampled in May 2020 at each of the three mounds within CCBDS (Figure 3-7).

3.2.2.1 Physical Sediment Characteristics

Depth across the CCBDS surveyed area ranged from a minimum of 27.8 m at Station 24 at Mound B to a maximum of 34.5 m at Station 14 at Mound D (Figure 3-1). Surface sediments at stations sampled at active Mounds C and D were homogeneous with all stations exhibiting silt/clay (Tables 3-3a and 3-4a; Figure 3-8). In contrast, historical Mound B stations exhibited a surficial layer of very fine sand with buried silt/clay layers (Table 3-2a; Figure 3-8).

The majority of the silt/clay layers at all three mounds showed characteristics of dredged material, often with evidence of highly reduced material (i.e., dark gray to black) with light gray, black, and red clay as well as silt and poorly sorted grain sizes (Figures 3-20 and 3-21). Dredged material was documented at all stations at Mound C and the majority of stations at Mounds B and D (Tables 3-2a, 3-3a, and 3-4a; Figure 3-20). Stations 14 and 15 at Mound D and Station 18 at Mound B were located near the perimeters of raised disposal areas and did not exhibit dredged material in the SPI images (Figure 3-20). Stations 19 and 24 were located near the highest point of elevation at Mound B and exhibited very little penetration in the SPI that may have inhibited the ability to detect buried dredged material. Hard bottom was also observed in PV images that likely contributed to the minimal SPI penetration (Figures 3-20 and 3-22).

Where present at historical Mound B, dredged material was found to be buried beneath a layer of reworked very fine sand (Figures 3-20 and 3-23). At active Mounds C and D, the entire sediment column imaged in the SPI was found to be dredged material, with most stations exhibiting evidence of the sediment being actively reworked by infauna (Figures 3-20 and 3-23).

Camera prism penetration depths at all three disposal mounds were generally deep and indicative of soft sediments, similar to observations at the reference areas (Figure 3-12). Mean prism penetration depth at Mounds C and D were 18.4 cm (SD±1.0) and 17.7 cm (SD±1.3), respectively (Tables 3-3a and 3-4a). At Mound B, three stations had penetration depths of less than 15 cm (2.6 cm at Station 19, 11.8 cm at Station 23, and 2.5 cm at Station 24) and the resulting a mean prism penetration depth at Mound B was 13.0 cm (SD±6.8) (Table 3-2a).

Boundary roughness values at all three disposal mounds at CCBDS were very similar to the reference area, with stations at CCBDS ranging from 0.5 cm to 1.7 cm. The mean boundary roughness was 1.1 cm (SD±0.3) at Mound B, 1.1 cm (SD±0.4) at Mound C, and 1.0 cm (SD±0.4) at Mound D (Tables 3-2a, 3-3a, and 3-4a; Figure 3-13). Boundary roughness at CCBDS stations was attributed to biogenic processes such as burrows (Figure 3-24).

3.2.2.2 Biological Conditions and Benthic Recolonization

Mean station aRPD depths at CCBDS ranged from a minimum of 1.1 cm to a maximum of 3.7 cm (Tables 3-2b, 3-3b, and 3-4b; Figure 3-1). The mean aRPD depth at Mound B was 2.7 cm (SD±0.9), at Mound C was 2.9 cm (SD±0.5), and at Mound D was 2.0 cm (SD±0.5) (Tables 3-2b, 3-3b, and 3-4b; Figures 3-15 and 3-25). Station 19 at Mound B had an indeterminate aRPD because of insufficient of prism penetration (Table 3-2b; Figure 3-15).

At historical Mound B, evidence of mature, Stage 3 deposit-feeding assemblages was found at the majority of stations sampled; 6 out of 8 stations had at least one replicate SPI or PV image with evidence of Stage 3 taxa (Table 3-2b; Figure 3-16). This included direct observations of deep burrowing polychaetes, presence of subsurface feeding voids, and/or occurrences of large burrow openings on the sediment surface (Figure 3-26). The maximum depth of feeding void structures, when present, ranged from 6.2 to 15.9 cm with an overall Mound B mean of 11.5 cm (SD±4.7) (Table 3-2b; Figures 3-18 and 3-19). The results at Mound B suggest a healthy benthic community that exhibited similar biological characteristics to the communities found at the reference areas.

At active Mound C, Stage 3 fauna were found in at least one replicate SPI or PV at half of the stations, with Stage 2 being the most common successional stage (Table 3-3b; Figure 3-16). When present, subsurface feeding voids were found at a mean maximum depth of 9.8 cm (SD±2.7) at Mound C (Table 3-3b; Figures 3-18 and 3-19). The results at the active Mound C suggest a benthic community that has experienced somewhat recent disturbance, dissimilar to the community at historical Mound B, but exhibited an expected amount of recovery and would be expected to continue to progress towards the healthy communities exhibited by the reference stations.

At active Mound D, Stage 3 fauna were found in at least one SPI or PV replicate at 2 of the 8 stations, with Stage 2 being the most common successional stage (Table 3-4b; Figure 3-16). Evidence of Stage 2 fauna included polychaete tubes at the sediment–water interface and shallow burrowing in the sediment column (Figure 3-26). When present, subsurface feeding voids were found at a mean maximum depth of 5.7 cm (SD±0.3) at Mound D (Table 3-4b; Figures 3-18 and 3-19). The results at the active Mound D suggest a benthic community that has experienced somewhat recent disturbance, dissimilar to the community at historical Mound B and more similar to the community at the other active Mound C but exhibited an expected amount of recovery and would be expected to continue to progress towards the healthy communities exhibited by the reference stations. No stations at CCBDS sampled in 2020 were classified as lower than Stage 2 organisms.

The epifauna observed in PV images varied between mounds within CCBDS. Brittle stars, hermit crabs, gastropods, and shrimp, were observed in the PV at active Mounds C and D (Tables 3-3b and 3-4b). At historical Mound B, where a surficial layer of very fine sand was found at every station and hard bottom was observed in the PV at two stations, epifauna observed was more diverse and also included hydroids, encrusting sponges, burrowing anemones (Table 3-2b; Figure 3-22). Evidence of biological activity in the form of burrow openings, tracks, and tubes was documented in the plan view images across CCBDS (Tables 3-2b, 3-3b, and 3-4b).

3.2.3 Statistical Comparisons

Statistical comparisons were carried out on two different variables, aRPD depth and successional stage ranking, that are related to the health of the benthic community (See Section 2.4 for methods). Successional stage rank and aRPD depth were calculated for each Mound surveyed in 2020 at CCBDS and compared to the grouped reference area values for the same two variables. The values found at the reference areas are representative of background or ambient biological conditions in the area.

3.2.3.1 aRPD Depth Comparisons

Area mean aRPD depths at Mound B, Mound C, and Mound D were 2.7, 2.9, and 2.0 cm, respectively, comparable to the grand mean of the reference areas (2.9 cm; Table 3-5; Figure 3-27). Historical Mound B had the largest variability in aRPD depth across stations (standard deviation of 0.9) (Table 3-5; Figure 3-27).

A statistical inequivalence test was performed to determine whether the differences observed in mean aRPD values between the grand mean of the three reference areas and each of the three disposal areas were significantly similar. The station mean aRPD data from all six areas were combined to assess normality and estimate pooled variance. Results for the normality test indicated that each area's residuals, i.e., each observation minus the area mean, was not significantly different from a normal distribution (Shapiro-Wilk's test p-value = 0.34). Levene's test for equality of variances was not rejected (p = 0.34), so a single pooled variance estimate could be used for all groups. The confidence interval for the difference equations was constructed using parametric estimates.

The confidence regions for the difference between the mean of the reference areas (2.9 cm) versus Mound B disposal area (2.7 cm) and versus Mound C disposal area (2.9 cm) were each contained within the interval [-1 cm, +1 cm] (Table 3-5). The conclusion was that the aRPD values from each of these two disposal areas were significantly equivalent to the pooled reference areas in the 2020 survey, i.e., there was no difference in aRPD depth between these two disposal areas and reference areas. The difference in means between reference areas (2.9 cm) and Mound D (2.0 cm) was 0.9 cm and the confidence region was not contained within the interval [-1 cm, +1 cm] (Table 3-5). The conclusion was that the aRPD depths at Mound D were not equivalent to the pooled reference areas aRPD depths; the mean aRPD depth at Mound D was significantly shallower than the mean reference area aRPD depth.

The results of the statistical comparisons of aRPD values between the three mounds and the reference areas show that the historical Mound B and the active Mound C depicted aRPD depths statistically similar to those at the reference area. These findings suggest that the sediments at the two mounds have experienced a similar amount of biological reworking from their benthic communities as those at the reference areas. Mound D exhibited aRPD values statistically less than the reference areas. This suggests that the benthic communities at active Mound D have not achieved the same amount of reworking of surficial sediments as those at historical Mound B, active Mound C, or the reference areas.

3.2.3.2 Successional Stage Comparisons

To evaluate these successional stages numerically, a successional stage rank variable was applied to each image. A value of 3 was assigned to Stage 3, 2 on 3, or 1 on 3 designations, a value of 2 was applied to Stage 2 or 1 on 2, a value of 1 was applied to Stage 1, intermediate ranks were assigned to the transitional assemblages (2.5 for Stage 2 transitioning to Stage 3, and 1.5 for 1 transition to 2), and images from which the stage could not be determined were excluded from calculations. The maximum successional stage rank among replicates was used to represent the station value.

Bootstrapping was used to construct confidence intervals between the mean successional stage at disposal areas Mound B, Mound C, and Mound D versus the pooled reference areas. Bootstrapping is a statistical resampling procedure that uses the sample data to represent the entire population to construct confidence limits around population parameters (See Section 2.4). The confidence region for the difference between the mean successional stage rank of the pooled reference areas (2.92) versus Mound B (2.88) was contained within the interval [-0.5, +0.5] (Table 3-6; Figure 3-28), which indicates that the mean successional stages at Mound B was statistically equivalent to the pooled reference areas. The confidence region for the differences between the mean successional stage rank of the reference areas (2.92) versus Mound C (2.63) and Mound D (2.56) were not fully contained within the interval [-0.5, +0.5] (Table 3-6; Figure 3-28), indicating the successional stage at these two disposal areas were statistically inequivalent from the reference areas.

The results of the statistical comparisons of successional stage rank between the three mounds and the reference areas show that the historical Mound B exhibited successional stages statistically similar to those at the reference area. These findings suggest that the benthic community at Mound B has advanced along the successional stage model to the same rank as the communities at the reference areas. Both active mounds C and D exhibited successional stage ranks statistically less than the reference areas. This suggests that the benthic communities at the active portions of CCBDS have not advanced through the successional stage model at the historical Mound B or the reference areas.

Table 3-1a.

Summary of CCBDS Reference Area Sediment Profile and Plan View Imaging Physical Results, May 2020

Area	Station ID	SPI Replicate (n)	Water Depth (m)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Predominant Boundary Roughness Type	SPI Predominant Sediment Type	Dredged Material Presence	Mean Dredged Material Thickness (cm)	Dredged Material > Penetration	Buried Dredged Material Presence	Mean Dredged Material Depth (cm)	PV Replicate (n)	PV Predominant Sediment Type	Predominant Surface Oxidation	Dredged Material Presence
CCBRS	25	3	38.1	17.1	1.7	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	3	Sand	Oxidized	No
CCBRS	26	3	37.8	17.0	1.5	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	3	Sand	Oxidized	No
CCBRS	27	3	37.8	16.1	0.7	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	2	Sand	Oxidized	No
CCBRS	28	3	38.4	16.6	1.1	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	1	Sand	Oxidized	No
NWREF	29	3	33.9	15.5	1.4	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	3	Sand	Oxidized	No
NWREF	30	3	33.9	13.5	1.0	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	3	Sand	Oxidized	No
NWREF	31	3	34.3	15.5	1.2	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	1	Sand	Oxidized	No
NWREF	32	3	34.3	14.2	1.7	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	2	Sand	Oxidized	No
SWREF	33	3	30.5	17.9	1.3	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	1	Sand	Oxidized	No
SWREF	34	3	30.8	17.8	1.7	Physical/Biological	Silt/clay	No	N/A	No	N/A	N/A	2	Sand	Oxidized	No
SWREF	35	3	30.2	18.2	1.6	Physical/Biological	Silt/clay	No	N/A	No	N/A	N/A	1	Sand	Oxidized	No
SWREF	36	3	30.8	17.5	1.8	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	1	Sand	Oxidized	No
		n = 12														
		Max	38.4	18.2	1.8											
		Min	30.2	13.5	0.7											
		Mean	34.2	16.4	1.4											
		SD	3.2	1.5	0.3											

N/A=Not Applicable

Table 3-1b.

Summary of CCBDS Reference Area Sediment Profile and Plan View Imaging Biological Results, May 2020

Area	Station ID	SPI Replicate (n)	Mean aRPD Depth (cm)	Presence of Methane	Sediment Oxygen Demand Level	Mean Subsurface Feeding Voids	Mean Maximum Void Depth (cm)	Highest Successional Stage[1]	PV Replicate (n)	PV Beggiatoa Presence	PV Beggiatoa Type/Extent	Tubes Presence	Burrow Presence	Tracks Presence	Epifauna Present	Flora Present	Mean Fish Present
CCBRS	25	3	3.3	No	Medium	2.3	15.4	1 on 3	3	No	None	Yes	Yes	No	None	None	0.3
CCBRS	26	3	2.6	No	Medium	0.0	N/A	2 -> 3	3	No	None	Yes	Yes	No	None	None	0.3
CCBRS	27	3	3.2	No	Medium	0.3	17.0	1 on 3	2	No	None	Yes	Yes	No	Shrimp	None	0.0
CCBRS	28	3	2.3	No	Medium	0.3	6.7	1 on 3	1	No	None	Yes	Yes	No	None	None	0.0
NWREF	29	3	3.6	No	Medium	1.0	10.8	2 on 3	3	No	None	Yes	Yes	No	None	None	0.0
NWREF	30	3	3.2	No	Medium	0.7	10.4	2 on 3	3	No	None	Yes	Yes	No	Brittle Star(s), Shrimp	None	0.0
NWREF	31	3	3.2	No	Medium	0.0	N/A	2 -> 3	1	No	None	Yes	Yes	No	None	None	0.0
NWREF	32	3	2.1	No	Medium	0.7	12.2	2 on 3	2	No	None	Yes	Yes	Yes	Shrimp	None	0.0
SWREF	33	3	1.7	No	Medium	0.0	N/A	1 on 3	1	No	None	Yes	Yes	Yes	Shrimp	None	0.0
SWREF	34	3	2.7	No	Medium	1.0	9.2	1 on 3	2	No	None	Yes	Yes	Yes	Shrimp	None	0.0
SWREF	35	3	3.7	No	Medium	1.7	8.9	1 on 3	1	No	None	Yes	Yes	Yes	Shrimp	None	0.0
SWREF	36	3	3.1	No	Medium	1.0	12.7	2 on 3	1	No	None	Yes	Yes	Yes	Shrimp	None	0.0
		n = 12															
		Max	3.7			2.3	17.0										0.3
		Min	1.7			0.0	6.7										0.0
		Mean	2.9			0.8	11.5										0.1
		SD	0.6			0.7	3.3										0.1

N/A=Not Applicable

[1]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 3-2a.

Summary of CCBDS Mound B Sediment Profile and Plan View Imaging Physical Results, May 2020

Area	Station ID	SPI Replicate (n)	Water Depth (m)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Predominant Boundary Roughness Type	SPI Predominant Sediment Type	SPI Dredged Material Presence	Mean Dredged Material Thickness (cm)	Dredged Material > Penetration	Buried Dredged Material Presence	Mean Dredged Material Depth (cm)	PV Replicate (n)	PV Predominant Sediment Type	Predominant Surface Oxidation	PV Dredged Material Presence
Mound B	17	3	32.3	15.8	1.1	Biological	Very fine sand over silt/clay	Yes	15.8	Yes	Yes	0.0	2	Sand	Oxidized	No
Mound B	18	3	34.2	18.3	1.4	Biological	Very fine sand over silt/clay	No	N/A	No	N/A	N/A	2	Sand	Oxidized	No
Mound B	19	3	30.8	2.6	0.9	Biological	Very fine sand over silt/clay	IND	IND	No	IND	IND	3	Sand	Oxidized	No
Mound B	20	3	33.2	17.9	0.9	Biological	Very fine sand over silt/clay	Yes	17.9	Yes	Yes	0.0	3	Sand	Oxidized	No
Mound B	21	3	32.6	17.1	0.9	Biological	Very fine sand over silt/clay	Yes	17.1	Yes	Yes	0.0	1	Sand	Oxidized	No
Mound B	22	3	33.6	17.9	1.4	Biological	Very fine sand over silt/clay	Yes	17.9	Yes	Yes	0.0	1	Sand	Oxidized	No
Mound B	23	3	32.9	11.8	0.8	Biological	Very fine sand over silt/clay	Yes	11.8	Yes	Yes	0.0	2	Sand	Oxidized	No
Mound B	24	3	27.8	2.5	1.2	Biological	Very fine sand	IND	IND	No	IND	IND	3	Gravelly Sand	Oxidized	Yes
		n = 8														
		Max	34.2	18.3	1.4				17.9			0.0				
		Min	27.8	2.5	0.8				11.8			0.0				
		Mean	32.2	13.0	1.1				16.1			0.0				
		SD	2.0	6.8	0.3				2.6			0.0				

IND=Indeterminate
N/A=Not Applicable

Table 3-2b.

Summary of CCBDS Mound B Sediment Profile and Plan View Imaging Biological Results, May 2020

Area	Station ID	SPI Replicate (n)	Mean aRPD Depth (cm)	Presence of Methane	Sediment Oxygen Demand Level	Mean Subsurface Feeding Voids	Mean Maximum Void Depth (cm)	Highest Successional Stage[1]	PV Replicate (n)	PV Beggiatoa Presence	PV Beggiatoa Type/Extent	Tubes Presence	Burrow Presence	Tracks Presence	Epifauna Present	Flora Present	Mean Fish Present
Mound B	17	3	3.1	No	Medium	1.0	6.9	2 on 3	2	No	None	Yes	Yes	Yes	Burrowing Anemone(s), Gastropod(s), Shrimp	None	0.0
Mound B	18	3	3.2	No	Low	0.3	13.2	2 on 3	2	No	None	Yes	Yes	Yes	Burrowing Anemone(s), Shrimp	None	0.0
Mound B	19	3	IND	No	Low	0.0	N/A	2 -> 3	3	Yes	Patches	Yes	Yes	Yes	Burrowing Anemone(s), Encrusting Sponge(s), Shrimp	None	0.0
Mound B	20	3	3.5	No	Low	0.7	15.5	2 on 3	3	No	None	Yes	Yes	Yes	Shrimp	None	0.0
Mound B	21	3	3.3	No	Low	0.7	15.9	2 on 3	1	No	None	Yes	Yes	Yes	Burrowing Anemone(s)	None	0.0
Mound B	22	3	1.8	No	Medium	0.0	N/A	1 on 3	1	No	None	Yes	Yes	Yes	Hermit Crab(s), Shrimp	None	0.0
Mound B	23	3	2.9	No	Low	0.3	6.2	2 on 3	2	No	None	Yes	Yes	Yes	Burrowing Anemone(s), Gastropod(s), Shrimp	None	0.0
Mound B	24	3	1.1	No	Medium	0.0	N/A	2 -> 3	3	No	None	Yes	Yes	Yes	Burrowing Anemone(s), Crab(s), Encrusting Sponge(s), Hermit Crab(s), Hydroid(s)	None	0.0
		n = 8															
		Max	3.5			1.0	15.9										0.0
		Min	1.1			0.0	6.2										0.0
		Mean	2.7			0.4	11.5										0.0
		SD	0.9			0.4	4.7										0.0

IND=Indeterminate
N/A=Not Applicable
[1]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 3-3a.

Summary of CCBDS Mound C Sediment Profile and Plan View Imaging Physical Results, May 2020

Area	Station ID	SPI Replicate (n)	Water Depth (m)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Predominant Boundary Roughness Type	SPI Predominant Sediment Type	SPI Dredged Material Presence	Mean Dredged Material Thickness (cm)	Dredged Material > Penetration	Buried Dredged Material Presence	Mean Dredged Material Depth (cm)	PV Replicate (n)	PV Predominant Sediment Type	Predominant Surface Oxidation	PV Dredged Material Presence
Mound C	01	3	31.7	17.2	1.5	Biological	Silt/clay	Yes	17.2	Yes	No	0.0	1	Sand	Oxidized	No
Mound C	02	3	29.0	18.2	1.4	Biological	Silt/clay	Yes	18.2	Yes	No	0.0	3	Sand	Oxidized	No
Mound C	03	3	30.5	17.0	1.7	Biological	Silt/clay	Yes	17.0	Yes	No	0.0	3	Sand	Oxidized	No
Mound C	04	3	31.7	18.8	0.7	Biological	Silt/clay	Yes	18.8	Yes	No	0.0	2	Sand	Oxidized	No
Mound C	05	3	31.1	18.9	0.6	Biological	Silt/clay	Yes	18.9	Yes	No	0.0	2	Sand	Oxidized	No
Mound C	06	3	30.8	19.4	0.7	Biological	Silt/clay	Yes	19.4	Yes	No	0.0	2	Sand	Oxidized	No
Mound C	07	3	32.6	18.0	1.3	Biological	Silt/clay	Yes	18.0	Yes	No	0.0	1	Sand	Oxidized	No
Mound C	08	3	32.3	19.7	0.9	Physical/Biological	Silt/clay	Yes	19.7	Yes	No	0.0	1	Sand	Oxidized	No
		n = 8														
		Max	32.6	19.7	1.7				19.7			0.0				
		Min	29.0	17.0	0.6				17.0			0.0				
		Mean	31.2	18.4	1.1				18.4			0.0				
		SD	1.2	1.0	0.4				1.0			0.0				

Table 3-3b.

Summary of CCBDS Mound C Sediment Profile and Plan View Imaging Biological Results, May 2020

Area	Station ID	SPI Replicate (n)	Mean aRPD Depth (cm)	Presence of Methane	Sediment Oxygen Demand Level	Mean Subsurface Feeding Voids	Mean Maximum Void Depth (cm)	Highest Successional Stage[1]	PV Replicate (n)	PV Beggiatoa Presence	PV Beggiatoa Type/Extent	Tubes Presence	Burrow Presence	Tracks Presence	Epifauna Present	Flora Present	Mean Fish Present
Mound C	01	3	2.4	No	Medium	0.3	8.8	2 on 3	1	No	None	Yes	Yes	No	None	None	0.0
Mound C	02	3	2.8	No	Medium	1.0	13.4	1 on 3	3	No	None	Yes	Yes	No	None	None	0.0
Mound C	03	3	2.5	No	Medium	0.0	N/A	2	3	No	None	Yes	Yes	Yes	Gastropod(s), Shrimp	None	0.3
Mound C	04	3	3.7	No	Medium	0.0	N/A	2 -> 3	2	No	None	Yes	Yes	Yes	None	None	0.0
Mound C	05	3	3.1	No	Medium	0.0	N/A	2	2	No	None	Yes	Yes	Yes	Hermit Crab(s)	None	0.0
Mound C	06	3	3.7	No	Medium	0.0	N/A	2 -> 3	2	No	None	Yes	Yes	No	Shrimp	None	0.0
Mound C	07	3	2.8	No	Medium	1.3	7.1	2 on 3	1	No	None	Yes	Yes	Yes	Hermit Crab(s)	None	0.0
Mound C	08	3	2.7	No	Medium	0.3	9.9	2 on 3	1	No	None	Yes	Yes	No	Gastropod(s), Shrimp	None	0.0
		n = 8															
		Max	3.7			1.3	13.4										0.3
		Min	2.4			0.0	7.1										0.0
		Mean	2.9			0.4	9.8										0.0
		SD	0.5			0.5	2.7										0.1

N/A=Not Applicable
[1]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 3-4a.

Summary of CCBDS Mound D Sediment Profile and Plan View Imaging Physical Results, May 2020

Area	Station ID	SPI Replicate (n)	Water Depth (m)	Mean Prism Penetration Depth (cm)	Mean Boundary Roughness (cm)	Predominant Boundary Roughness Type	SPI Predominant Sediment Type	SPI Dredged Material Presence	Mean Dredged Material Thickness (cm)	Dredged Material > Penetration	Buried Dredged Material Presence	Mean Dredged Material Depth (cm)	PV Replicate (n)	PV Predominant Sediment Type	Predominant Surface Oxidation	PV Dredged Material Presence
Mound D	09	3	32.9	18.3	0.8	Biological	Silt/clay	Yes	18.3	Yes	No	0.0	3	Sand	Oxidized	No
Mound D	10	3	32.7	17.7	1.5	Biological	Silt/clay	Yes	17.7	Yes	No	0.0	1	Sand	Oxidized	No
Mound D	11	3	33.1	17.6	0.6	Biological	Silt/clay	Yes	17.6	Yes	No	0.0	2	Sand	Oxidized	No
Mound D	12	3	32.9	15.9	0.8	Biological	Silt/clay	Yes	15.9	Yes	No	0.0	3	Sand	Oxidized	No
Mound D	13	3	34.2	19.5	1.3	Biological	Silt/clay	Yes	19.5	Yes	No	0.0	1	Sand	Oxidized	No
Mound D	14	3	34.5	16.5	1.3	Biological	Silt/clay	No	N/A	No	N/A	N/A	1	Sand	Oxidized	No
Mound D	15	3	33.9	16.9	0.5	Biological	Silt/clay	No	N/A	No	N/A	N/A	1	Sand	Oxidized	No
Mound D	16	3	32.9	19.3	1.3	Biological	Silt/clay	Yes	19.3	Yes	No	0.0	1	Sand	Oxidized	No
		n = 8														
		Max	34.5	19.5	1.5				19.5			0.0				
		Min	32.7	15.9	0.5				15.9			0.0				
		Mean	33.4	17.7	1.0				18.0			0.0				
		SD	0.7	1.3	0.4				1.3			0.0				

N/A=Not Applicable

Table 3-4b.

Summary of CCBDS Mound D Sediment Profile and Plan View Imaging Biological Results, May 2020

Area	Station ID	SPI Replicate (n)	Mean aRPD Depth (cm)	Presence of Methane	Sediment Oxygen Demand Level	Mean Subsurface Feeding Voids	Mean Maximum Void Depth (cm)	Highest Successional Stage[1]	PV Replicate (n)	PV Beggiatoa Presence	PV Beggiatoa Type/Extent	Tubes Presence	Burrow Presence	Tracks Presence	Epifauna Present	Flora Present	Mean Fish Present
Mound D	09	3	1.8	No	Medium	0.0	N/A	2 -> 3	3	No	None	Yes	Yes	Yes	Shrimp	None	0.3
Mound D	10	3	1.5	No	Medium	0.0	N/A	2 -> 3	1	No	None	Yes	No	Yes	None	None	0.0
Mound D	11	3	2.1	No	Medium	0.3	5.4	1 on 3	2	No	None	Yes	No	Yes	Shrimp	None	0.0
Mound D	12	3	1.6	No	Medium	0.0	N/A	2 -> 3	3	No	None	Yes	Yes	Yes	None	None	0.0
Mound D	13	3	2.4	No	Medium	0.0	N/A	2 -> 3	1	No	None	Yes	Yes	No	Brittle Star(s)	None	0.0
Mound D	14	3	1.8	No	Medium	0.3	5.9	2 on 3	1	No	None	Yes	Yes	No	Brittle Star(s), Shrimp	None	0.0
Mound D	15	3	2.9	No	Medium	0.0	N/A	2	1	No	None	Yes	Yes	No	None	None	0.0
Mound D	16	3	1.9	No	Medium	0.0	N/A	2 -> 3	1	No	None	Yes	Yes	Yes	None	None	0.0
		n = 8															
		Max	2.9			0.3	5.9										0.3
		Min	1.5			0.0	5.4										0.0
		Mean	2.0			0.1	5.7										0.0
		SD	0.5			0.2	0.3										0.1

N/A=Not Applicable

[1]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 3-5.

Summary Statistics and Results of Inequivalence Hypothesis Testing for aRPD Values

Difference Equation	Observed Difference ($\hat{d}$)	se $\hat{d}$	*df* for se	Confidence Bounds (D_L to D_U)[1]	Results[2]	n (REF)	n (Mound)
$Mean_{REF} - Mean_{MoundB}$	0.19	0.36	17	-0.43 to 0.82	s	12	7
$Mean_{REF} - Mean_{MoundC}$	-0.06	0.20	18	-0.41 to 0.30	s	12	8
$Mean_{REF} - Mean_{MoundD}$	0.90	0.19	18	0.56 to 1.24	d	12	8

[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.

Table 3-6.

Summary Statistics and Results of Inequivalence Hypothesis Testing for Successional Stage Values

Difference Equation	**Observed Difference ($\hat{d}$)**	**se $\hat{d}$**	***Number of Bootstrap Replicates***	**Confidence Bounds (D_L to D_U)[1]**	**Results[2]**	**n (REF)**	**n (Mound)**
$Mean_{REF} - Mean_{MoundB}$	0.04	0.09	1000	-0.19 to 0.19	s	12	8
$Mean_{REF} - Mean_{MoundC}$	0.29	0.15	1000	-0.02 to 0.53	d	12	8
$Mean_{REF} - Mean_{MoundD}$	0.35	0.12	1000	0.14 to 0.63	d	12	8

[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 ± 0.5.
d = Fail to reject the null hypothesis of inequivalence between the two group means, the two group means are different.

4.0 DISCUSSION

One objective of the 2020 CCBDS survey was to characterize the seafloor topography and surficial features of the northern, active portion of CCBDS by completing a high-resolution acoustic survey. The acoustic survey was designed to test the hypothesis that recently placed dredged material would be found in the specified target disposal areas at CCBDS. A second objective was to characterize benthic recolonization status and further define the physical characteristics of surficial sediment in the northern portion of CCBDS by completing a SPI/PV imaging survey at both CCBDS and the three reference areas. The benthic habitat survey was designed to test the hypothesis that benthic community recovery from dredged material placement would be observed to be ongoing following the recovery paradigm described in the tiered management protocol (Germano et al. 1994) at CCBDS Mounds B, C, and D. Survey findings relative to these hypotheses are discussed below.

4.1 Distribution of Dredged Material

The high-resolution acoustic survey revealed three distinct mounds in the surveyed portion of CCBDS (Figure 3-1). The peaks of the mounds were observed at 23.9 m (Mound B), 24.7 m (Mound C), and 28.9 m (Mound D) rising up to as much as 6.1 m above the 30 m deep surrounding seafloor. The 2020 acoustic survey revealed notable changes in the seafloor due to dredged material placement. Based on the 2020 depth difference analysis, the height of active Mound C was observed to have increased by 0.2 to 2.9 m since the 2016 survey and a new Mound D was observed to have a relatively flat surface that had increased to up to 1.1 m above the seafloor (Figure 3-6). The elevation of the historic Mound B did not experience a measurable elevation change since 2016 and remained 6.1 m above the seafloor.

Bathymetric and depth difference findings were consistent with the dredged material placement records for the period of 2016 and 2020 (Table 1-3 and Figure 1-4). The majority of dredged material was placed in the northwest portion Mound C and the largest elevation increase was observed in the same area. Similarly, the location of new Mound D is co-located with placement record locations (Figures 1-4 and 3-6).

Acoustic backscatter and side-scan sonar imagery provided further confirmation of dredged material placement locations. Stronger backscatter returns indicative of relatively coarser, rougher, or harder sediments were observed at each of the three mound areas in the northern portion of CCBDS (Figures 3-3 and 3-4). The strongest backscatter returns were observed in the central portion of Mound B and the northwestern portion of Mound C. Backscatter returns at newly created Mound D were weaker than those of Mounds B and C, but stronger than those of the surrounding seafloor. Similarly, side-scan sonar imagery characterized the areas that received dredged material on the seafloor as acoustically different from surrounding sediments at each of the three mounds (Figure 3-5). Dredged material placement resulted in characteristic patterns on the seafloor including circular pits with raised rims, irregular hummocky topography, and relatively smooth areas (Figure 3-1).

Since the last survey at CCBDS in October 2016, dredged material placement from the Plymouth Harbor Federal Navigation Project (Table 1-3) formed a new mound (Mound D) between Mounds B and C with a smooth, plateaued surface (Figures 1-4, 3-1, and 3-6). In the same timeframe, dredged material placement from the Plymouth Harbor Federal Navigation Project, Sesuit Harbor, and Gateway Marina added elevation to Mound C in the northwest of CCBDS (Figures 1-4, 3-1, and 3-6).

The 2020 acoustic survey resulted in bathymetric, backscatter, and side-scan sonar results that were consistent with the presence of dredged material in the Mounds B, C and D areas. The 2020 survey served to confirm the hypothesis that dredged material had been placed at the specified target locations since the 2016 survey and that the existing mounds (Mounds B and C) were stable features on the seafloor.

4.2 Benthic Recolonization and Community Composition

The 2020 CCBDS SPI/PV survey resulted in an assessment of benthic recolonization status at Mounds B, C, and D and a comparison between CCBDS mound and reference area conditions. SPI/PV images were collected at three disposal mounds B, C, and D and at the three reference areas (CCBRS, NWREF, and SWREF) (Figure 3-7). Dredged material had been placed at Mounds C and D since the last SPI/PV survey in 2016 (Figure 1-4). The condition of the benthic community surveyed in 2020 was expected to be earlier in the stages of recovery within the context of the successional stage model at Mounds C and D, where material had been placed since the last survey. At Mound B, where the benthic community has had over 4 years to recover from any disturbance from material placement, the benthic community was expected to be more advanced along the recovery model.

The biological conditions at the three mounds (represented by aRPD depth and successional stage) were statistically compared to the grouped reference areas. The aRPD depths at Mounds B and C were statistically equivalent to the aRPDs from the reference areas (Table 3-5; Figures 3-15 and 3-27). The aRPDs in these locations were generally deep and typical of soft sediments that are being reworked by infaunal taxa (Figure 3-15). This suggests that the sediments at Mounds B and C have experienced a similar amount of biological reworking from their benthic communities as those at the reference areas. Mound D exhibited aRPD depths that were statistically lower than the reference areas (Table 3-5). This suggests that the benthic communities at active Mound D have not achieved the same amount of reworking of surficial sediments as those at historical Mound B, active Mound C, or the reference areas. The statistical inequivalence of aRPD depths at Mound D indicates potential adverse effects from recent material placement on the biological community. However, other indicators of impairment (e.g., *Beggiatoa* presence and methane presence) are not present and maximum infaunal successional stage in this area was statistically similar to the reference areas. Taken together, this suggests that the biological community at Mound D has a lower degree of recolonization (e.g., lower activity of deep burrowing infauna working to deepen the aRPD depth) but is tracking on an expected recovery trajectory following recent disturbance.

Successional stage at Mound B was found to be statistically equivalent to the successional stages found at the reference areas, while Mounds C and D had statistically less advanced successional stage than the reference areas (Table 3-6; Figure 3-28). These findings suggest that the benthic community at Mound B has advanced along the successional stage model to the same rank as the communities at the reference areas but the benthic communities at the active portions of CCBDS have not advanced through the successional stage model at the historical Mound B or the reference areas. The results from the successional stage comparisons are not surprising, as Mound B that has not received any new material since 2016 and has progressed along the successional model, with evidence of Stage 3 taxa documented at many of the stations (Figures 3-16, 3-18, and 3-19). Mounds C and D, where material had been placed within the four years prior to the 2020 survey, exhibited less-advanced successional stages than at the reference areas and Mound B, but still exhibited taxa in 2020 that have progressed as expected along the successional stage model (Figures 3-16, 3-18, and 3-19) and did not exhibit any indications of unsuitable benthic conditions. At all three mounds, there was abundant evidence of epifauna and no indication of any severe disturbance to the benthic communities from trawling or other anthropogenic impacts. Profile images from mound areas did not have evidence of methane or low dissolved oxygen.

The two stations at the historical Mound B that exhibited shallow prism penetration also depicted evidence of gravels in the PV images and the presence of burrowing anemones (*Ceriantharia sp.*) in both the PV and SPI (Figure 3-22). Burrowing anemones are known to occur on soft and hard substrata (Davies et al. 2014; Howell et al. 2010; Stampar et al. 2015). They are filter feeders that extend from their burrows into the water column to catch food and are also surface deposit feeders (Eleftheriou and Basford 1983; URI GSO 2019). These unique features were only documented at Stations 19 and 24 at the highest point of the highest and oldest mound in the surveyed CCBDS area. The presence of filter feeding taxa suggests that there is movement of water as filter feeders rely on hydrodynamics to catch food as it passes by. Furthermore, the presence of sand and small gravels as compared to the silt/clays at other stations suggest that these stations may experience the winnowing of fines through bottom currents. Although there is no evidence of significant sediment transport in the SPI and PV, and no change in acoustic depth difference between 2016 and 2020, it is possible that mounds at CCBDS that reach the elevation of the current peak of Mound B and now also Mound C (approximately 25 m deep) could experience seafloor conditions where minor and localized winnowing of material occurs.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The May-June 2020 acoustic and SPI/PV surveys were conducted to support characterization of surficial sediments and benthic habitat conditions in the northern portion of CCBDS. The surveys assessed changes in the study area since the last survey in October of 2016. The 2020 acoustic and SPI/PV surveys resulted in the following observations:

- Dredged material placed at active Mound C since the 2016 survey resulted in an elevation increase of up to 2.9 m above the seafloor and a peak at 24.7 m deep. Mound C also broadened and had a 250 × 200-m footprint rising 2 m above the seafloor and a large relatively thin (<1 m) apron covering nearly the entire circular Mound C sampling area. There were no observations of significant spatial displacement of deposited material.

- Dredged material placed at active new Mound D since the 2016 survey resulted in an elevation increase of 0.5 to 1.1 m above the seafloor and a flat and relatively featureless surface. Mound D was an approximately 250 × 150-m plateaued oval. There were no observations of significant spatial displacement of deposited material.

- The peak of historical Mound B remained at a depth of 23.9 m. There was no measurable change in elevation observed at Mound B since 2016 and no observations of significant spatial displacement of deposited material.

- The benthic communities at historical Mound B, that had not received material since the previous survey in 2016, had recovered consistent with the expected recovery paradigm. Mound B was statistically ecologically equivalent (successional stage and aRPD depth) to reference stations, confirming a full recovery at the mound.

- Active Mounds C and D, which had received material since the previous survey in 2016, showed recovery consistent with the successional stage paradigm. Mound C exhibited aRPD depths statistically the same as both Mound B and the reference areas, while Mound D exhibited depths that were not indicative of adverse benthic conditions, but that had not yet reached statistical equivalence with the reference areas. Neither active mound had successional stage rankings statistically similar to the reference areas, but both mounds exhibited evidence of advanced fauna that demonstrated that the communities were recovering from recent material placement.

The results of the 2020 survey led to the following recommendations:

R1: The peaks of Mounds B (23.9 m) and C (24.7 m) have reached the recommended minimum water depth of 25 m. Future dredged material placement at these areas should be targeted away from the peaks to avoid further increasing peak heights.

R2: The presence of stable mounds and normal benthic recolonization indicate that the Mounds B, C, and D could accommodate additional dredged material placement utilizing a similar approach to that applied in the past.

6.0 REFERENCES

AECOM. 2012. Monitoring Survey at the Cape Cod Bay Disposal Site, September 2010. DAMOS Contribution No. 188. U.S. Army Corps of Engineers, New England District, Concord, MA, 135 pp.

CR Environmental. 1997. Final Report Cape Cod Bay Disposal Site first year monitoring. Commonwealth of Massachusetts Executive Office of Environmental Affairs, Department of Environmental Management, Office of Waterways, Hingham, MA.

Davies, J. S.; Howell, K. L.; Stewart, H. A.; Guinan, J.; Golding, N. 2014. Defining biological assemblages (biotopes) of conservation interest in the submarine canyons of the South West Approaches (offshore United Kingdom) for use in marine habitat mapping. Deep Sea Research Part II: Topical Studies in Oceanography, 104, 208-229.

Eleftheriou, A.; Basford, D. J. 1983. The general behaviour and feeding of *Cerianthus lloydii* Gosse (Anthozoa, Coelenterata). Cahiers de Biologie Marine, 24, 147-158.

ENSR. 2004. Monitoring Survey at the Cape Cod Bay Disposal Site, August 2003. DAMOS Contribution No. 157. U.S. Army Corps of Engineers, New England District, Concord, MA, 74 pp.

Fredette, T. J.; French, G. T. 2004. Understanding the physical and environmental consequences of dredged material disposal: history in New England and current perspectives. Mar. Pollut. Bull. 49:93–102.

Germano, J. D. 1983. Infaunal succession in Long Island Sound: animal sediment interactions and the effects of predation [dissertation]. New Haven (CT): Yale University.

Germano, J. D. 1999. Ecology, statistics, and the art of misdiagnosis: The need for a paradigm shift. Environ. Rev. 7(4):167–190.

Germano, J. D.; Rhoads, D. C.; Lunz, J. D. 1994. An Integrated, Tiered Approach to Monitoring and Management of Dredged Material Disposal Sites in the New England Regions. DAMOS Contribution No. 87. U.S. Army Corps of Engineers, New England Division, Waltham, MA, 67 pp.

Germano, J. D.; Rhoads, D. C.; Valente, R. M.; Carey, D. A.; Solan, M. 2011. The use of sediment-profile imaging (SPI) for environmental impact assessments and monitoring studies: lessons learned from the past four decades. Oceanogr. Mar. Biol. Ann. Rev. 49:235–285.

Howell, K. L.; Davies, J. S.; Narayanaswamy, B. E. 2010. Identifying deep-sea megafaunal epibenthic assemblages for use in habitat mapping and marine protected area network design. Journal of the Marine Biological Association of the United Kingdom, 90 (01), 33.

INSPIRE. 2019. Standard Operating Procedure (SOP) for Sediment Profile and Plan View Imaging Sample Collection and Image Analysis. Prepared by INSPIRE Environmental, Newport, RI. Revision 1 March 2019.

INSPIRE. 2020a. Quality Assurance Project Plan (QAPP) for the Disposal Area Monitoring System (DAMOS) Program. Prepared for the U.S. Army Corps of Engineers, New England District under Contract No. W912WJ-19-D-0010. Submitted by INSPIRE Environmental, Newport, RI. September 2020.

INSPIRE. 2020b. Standard Operating Procedure (SOP) for Acoustic Surveys. Prepared by INSPIRE Environmental, Newport, RI. Revision 2 January 2020.

INSPIRE. 2020c. 2020 Cape Cod Bay and Rhode Island Sound Disposal Sites Sediment Profile and Plan View Imaging Survey Cruise Report. Prepared for the U.S. Army Corps of Engineers, New England District under Contract No. W912WJ-19-D-0010, Delivery Order W912WJ19F0126, Tasks 4a and 5a. Submitted by INSPIRE Environmental, Newport, RI. May 2020.

McBride, G. B. 1999. Equivalence tests can enhance environmental science and management. Aust. New Zeal. J. Stat. 41(1):19–29.

McKelvey, Z. 2018. Monitoring Survey at the Cape Cod Bay Disposal Site, October 2016. DAMOS Contribution No. 205. U.S. Army Corps of Engineers, New England District, Concord, MA, 98 pp.

NOAA NCEI. 2020. H06563: NOS Hydrographic Survey, 1940-12-31. https://www.ngdc.noaa.gov/nos/H06001-H08000/H06563.html. Accessed December 2020.

Ocean Surveys, Inc. 1995a. Final report pre-disposal surveys, Cape Cod Bay Disposal Site, Cape Cod Bay, Massachusetts. OSI Report #94ES024F. Old Saybrook, CT.

Ocean Surveys, Inc. 1995b. Final report post-disposal surveys, Cape Cod Bay Disposal Site, Cape Cod Bay, Massachusetts. OSI Report #94ES117. Old Saybrook, CT.

Pearson, T. H.; Rosenberg, R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. 16: 229-311.

Rhoads, D. C.; Boyer, L. F. 1982. The effects of marine benthos on physical properties of sediments. In: McCall, P.L. and M.J.S. Tevesz, editors. Animal-sediment relations. New York (NY): Plenum Press. p. 3-52.

Rhoads, D. C.; Germano, J. D. 1982. Characterization of organism-sediment relations using sediment profile imaging: an efficient method of remote ecological monitoring of the seafloor (REMOTS System). Mar. Ecol. Progr. 8: 115-128.

SAIC. 2003. Monitoring survey at the Cape Cod Bay Disposal Site, August 2001. DAMOS Contribution No. 144 (SAIC Report No. 574). US Army Corps of Engineers, New England Division, Concord, MA.

Satterthwaite, F. E. 1946. "An Approximate Distribution of Estimates of Variance Components", Biometrics Bulletin, Vol. 2, No. 6, pp. 110-114.

Schuirmann, D. J. 1987. A comparison of the two one-sided tests procedure and the power approach for assessing the equivalence of average bioavailability. J. Pharmacokinet. Biopharm. 15:657–680.

Stampar, S. N.; Beneti, J. S.; Acuña, F. H.; Morandini, A. C. 2015. Ultrastructure and tube formation in Ceriantharia (Cnidaria, Anthozoa). Zoologischer Anzeiger - A Journal of Comparative Zoology, 254, 67-71.

University of Rhode Island Graduate School of Oceanography (URI GSO). 2019. Narragansett: Baywide Survey, August 2018.

USACE. 2013. Engineering and Design - Hydrographic Surveying. Manual No. EM 1110- 2-1003. November 2013.

Wolf, S.; Fredette, T. J.; Loyd, R. B. 2012. Thirty-Five Years of Dredged Material Disposal Area Monitoring – Current Work and Perspectives of the DAMOS Program. WEDA Journal of Dredging Engineering, Vol. 12, No. 2, p. 24-41.

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MONITORING SURVEY AT THE
CAPE COD BAY DISPOSAL SITE
MAY/JUNE 2020

CONTRIBUTION # 209

July 2021

FIGURES

Contract No. W912WJ-19-D-0010
Delivery Order W912WJ19F0126

Funded and Managed by:
New England District
U.S. Army Corps of Engineers
696 Virginia Road
Concord, MA 01742-2751

Prepared by:
INSPIRE Environmental
513 Broadway
Newport, RI 02840

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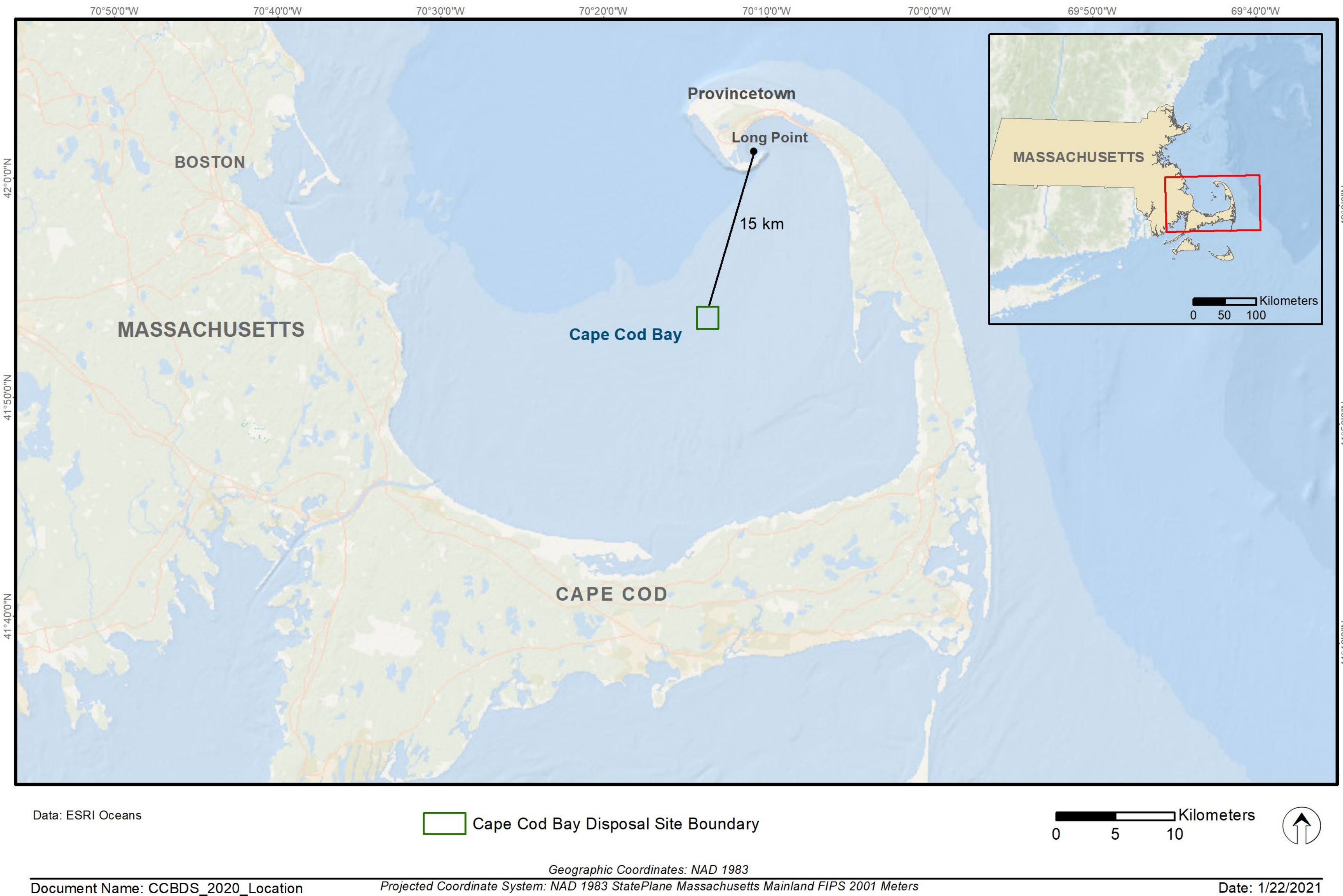

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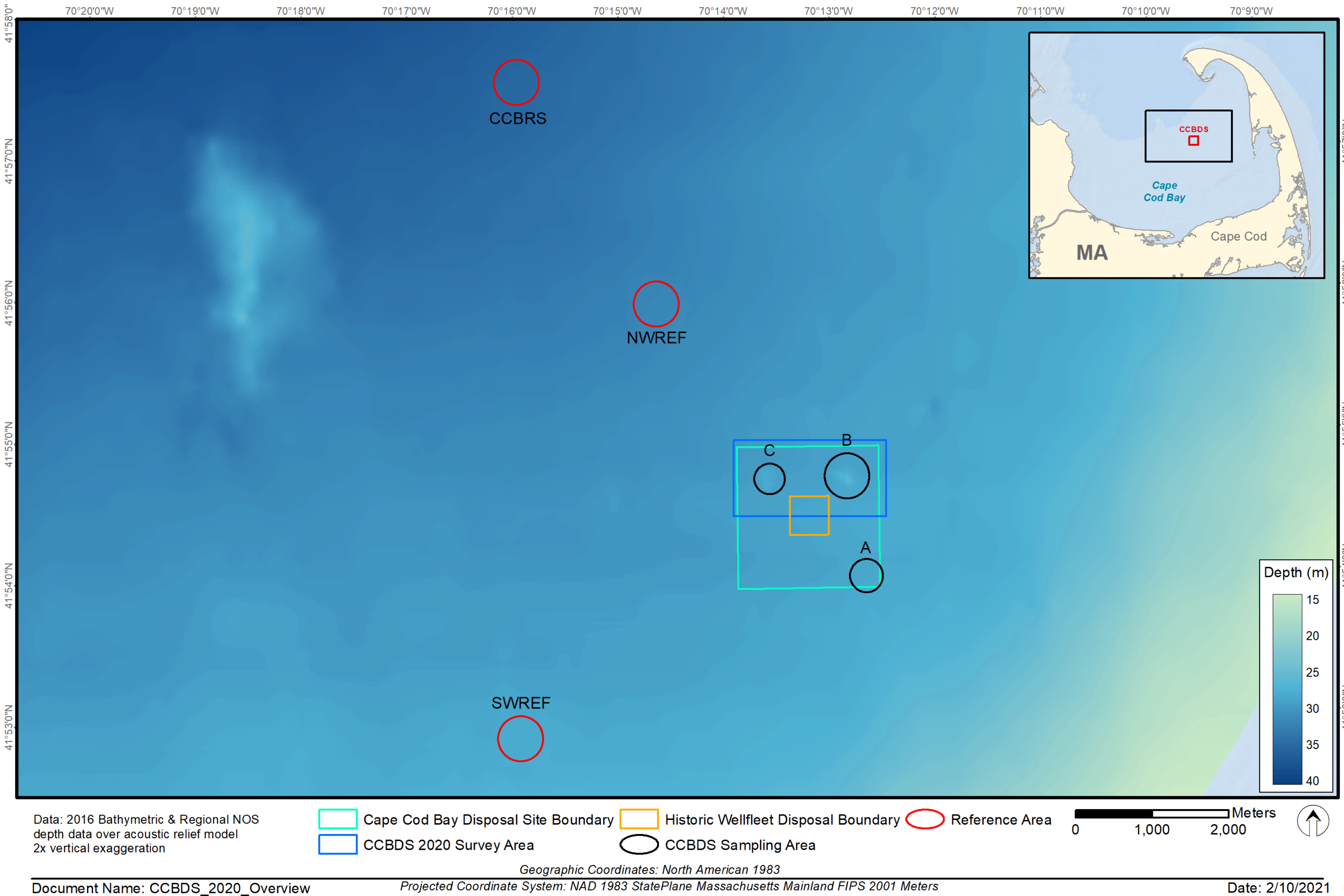

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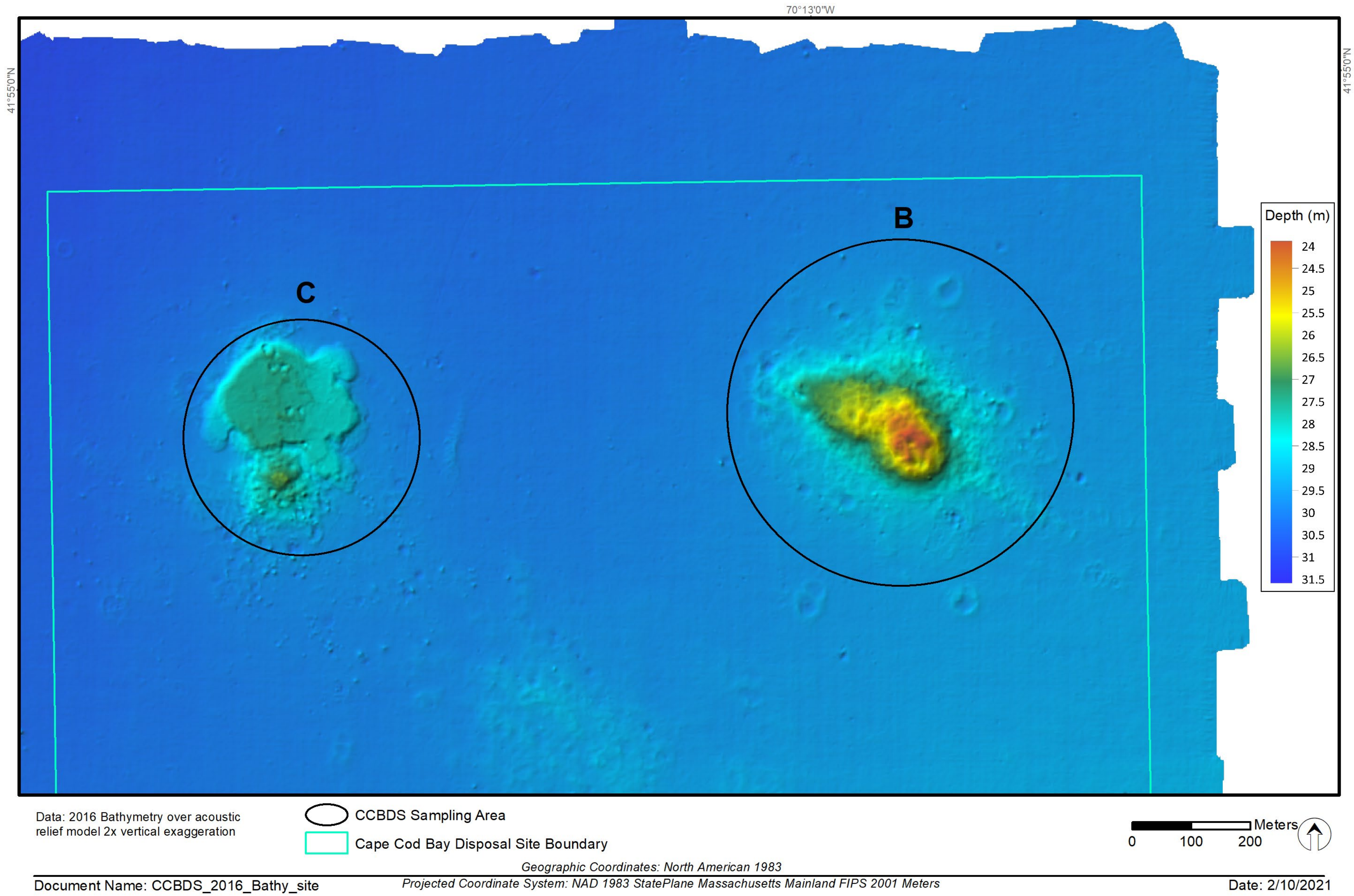

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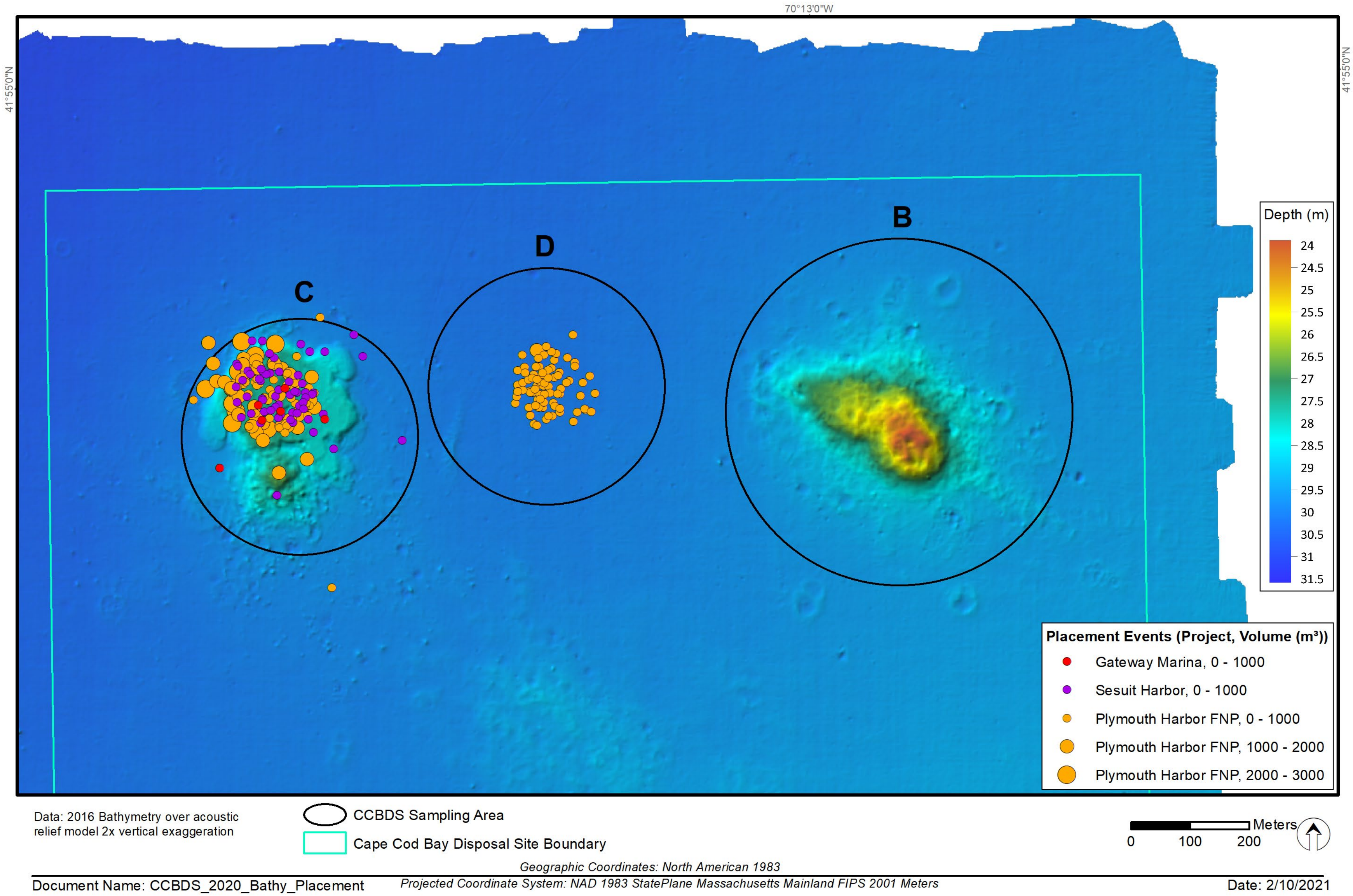

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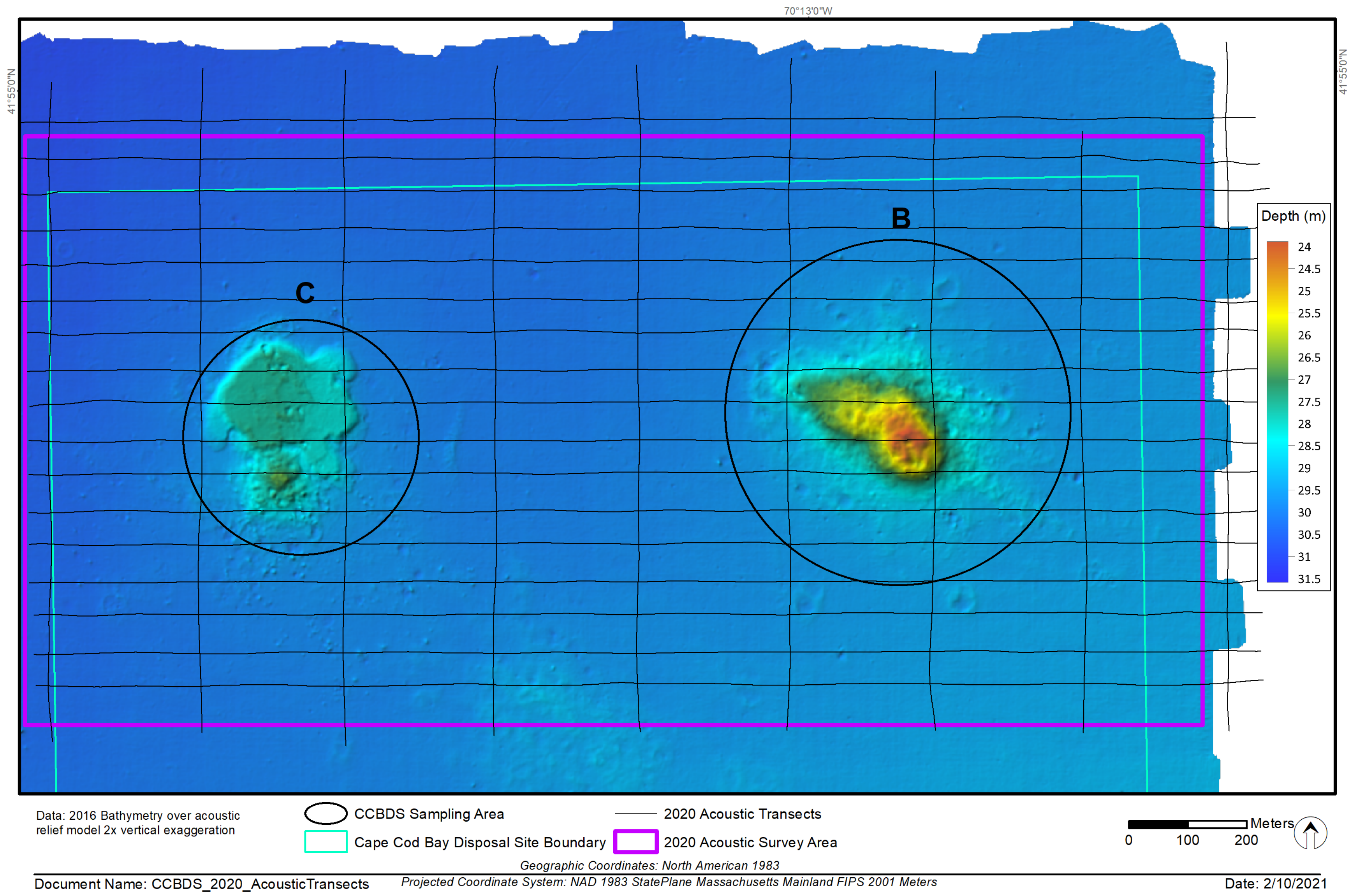

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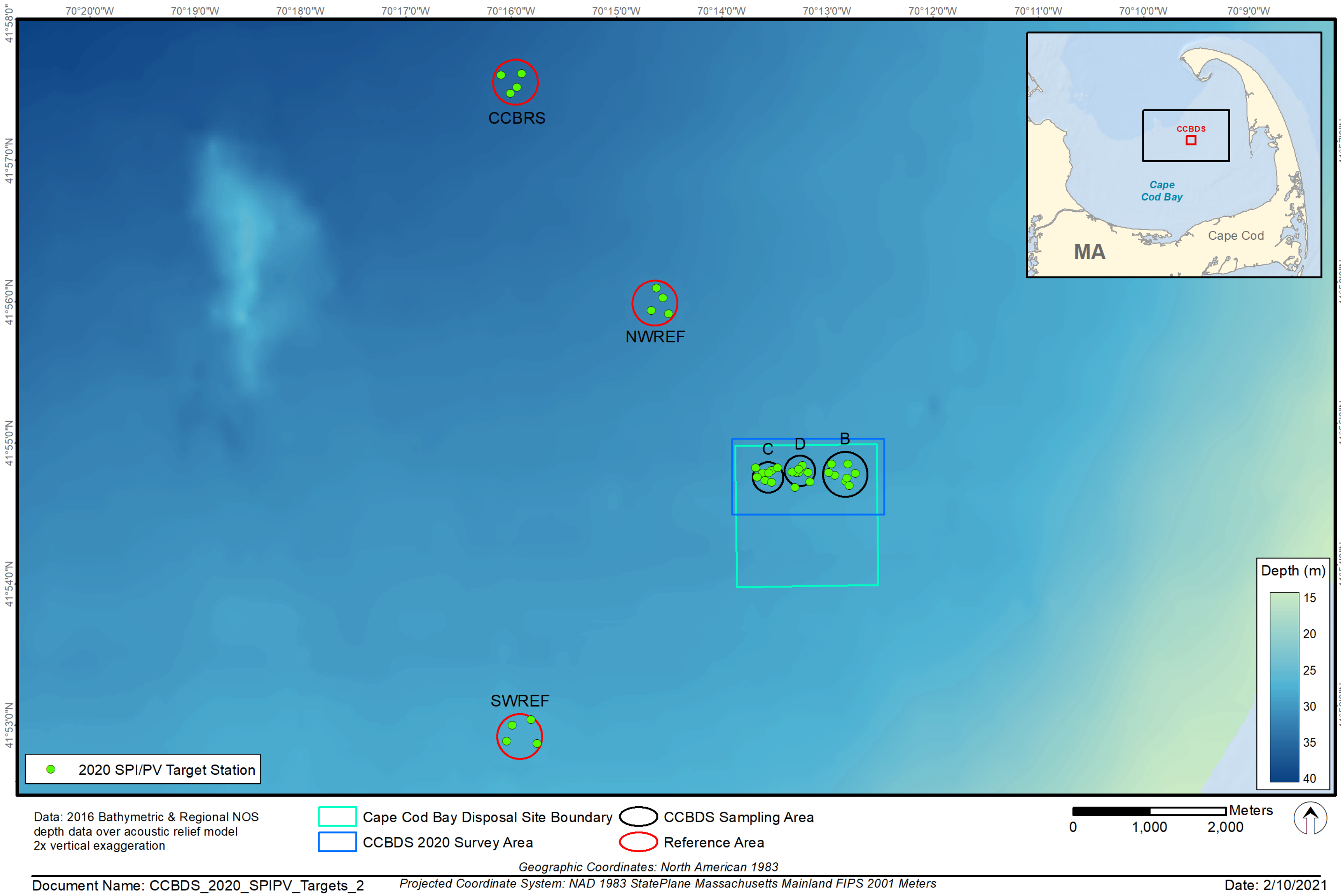

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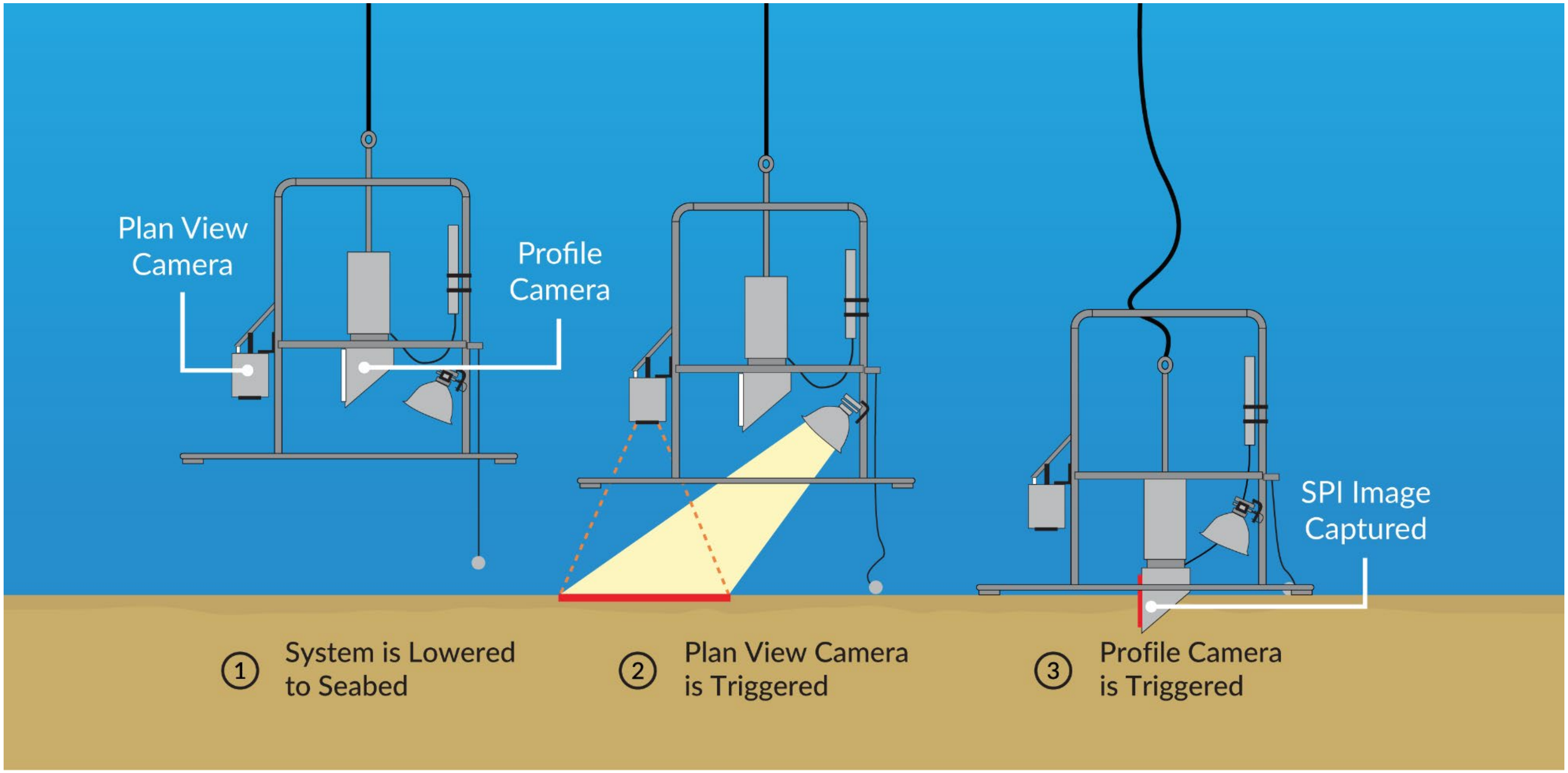

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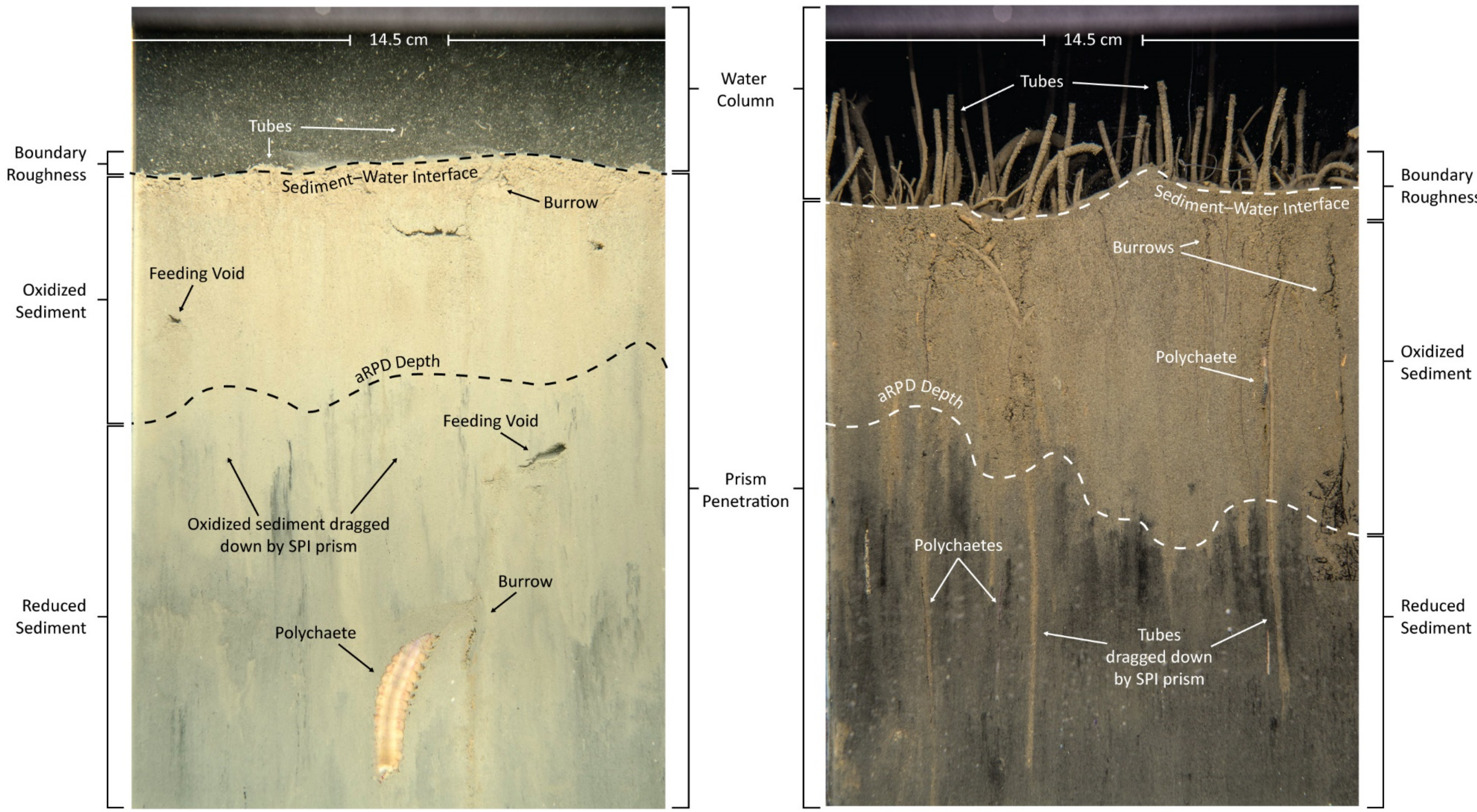

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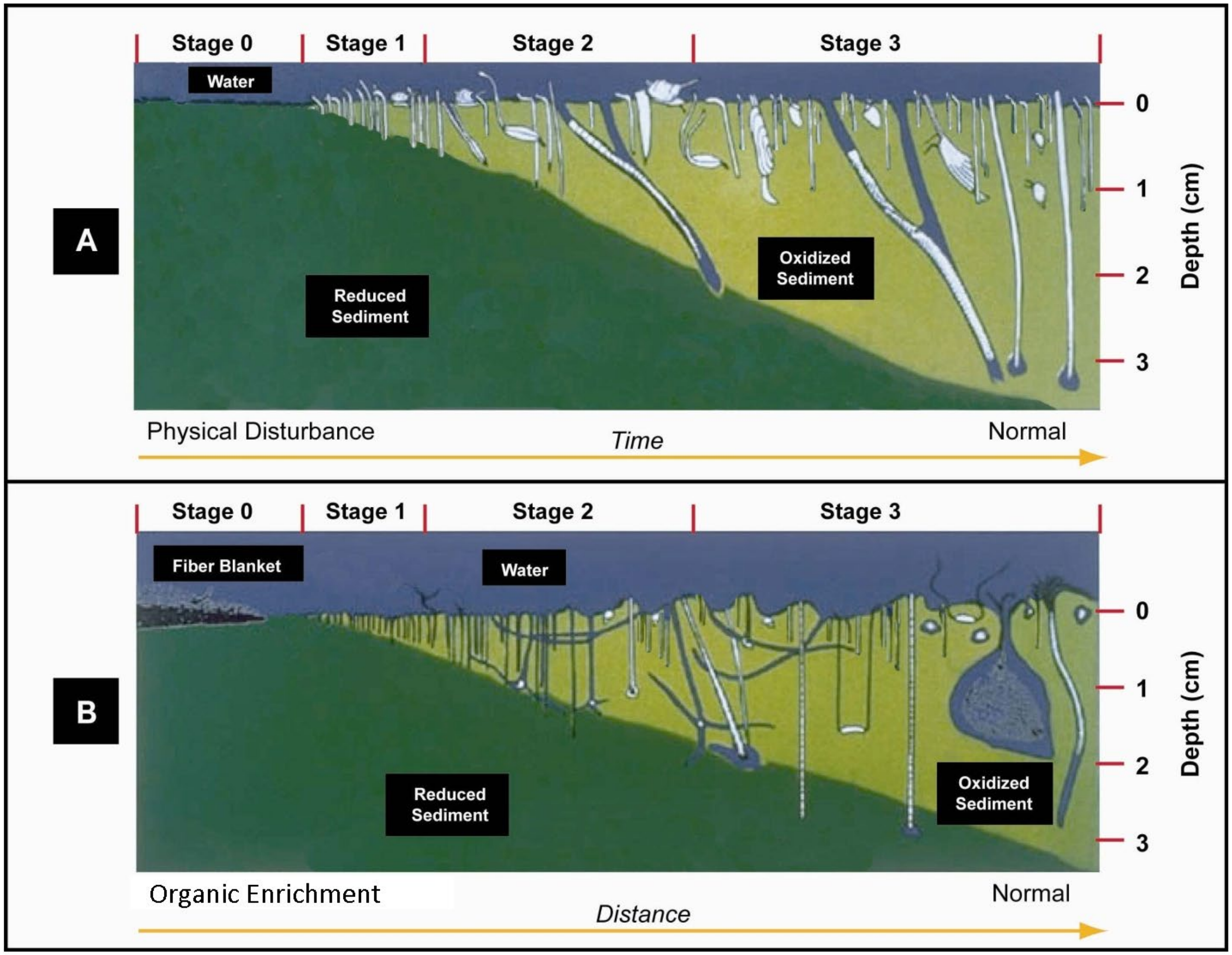

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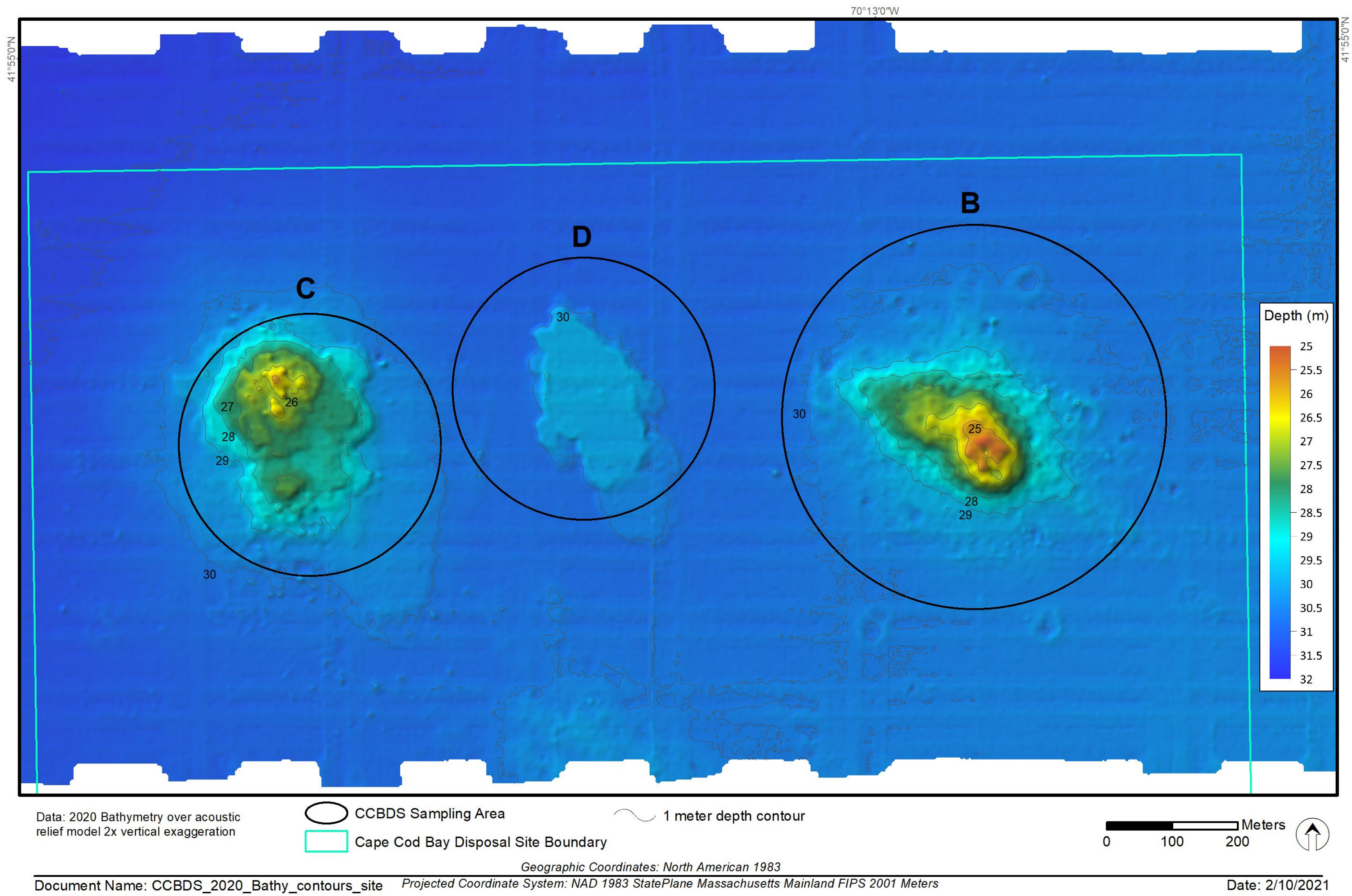

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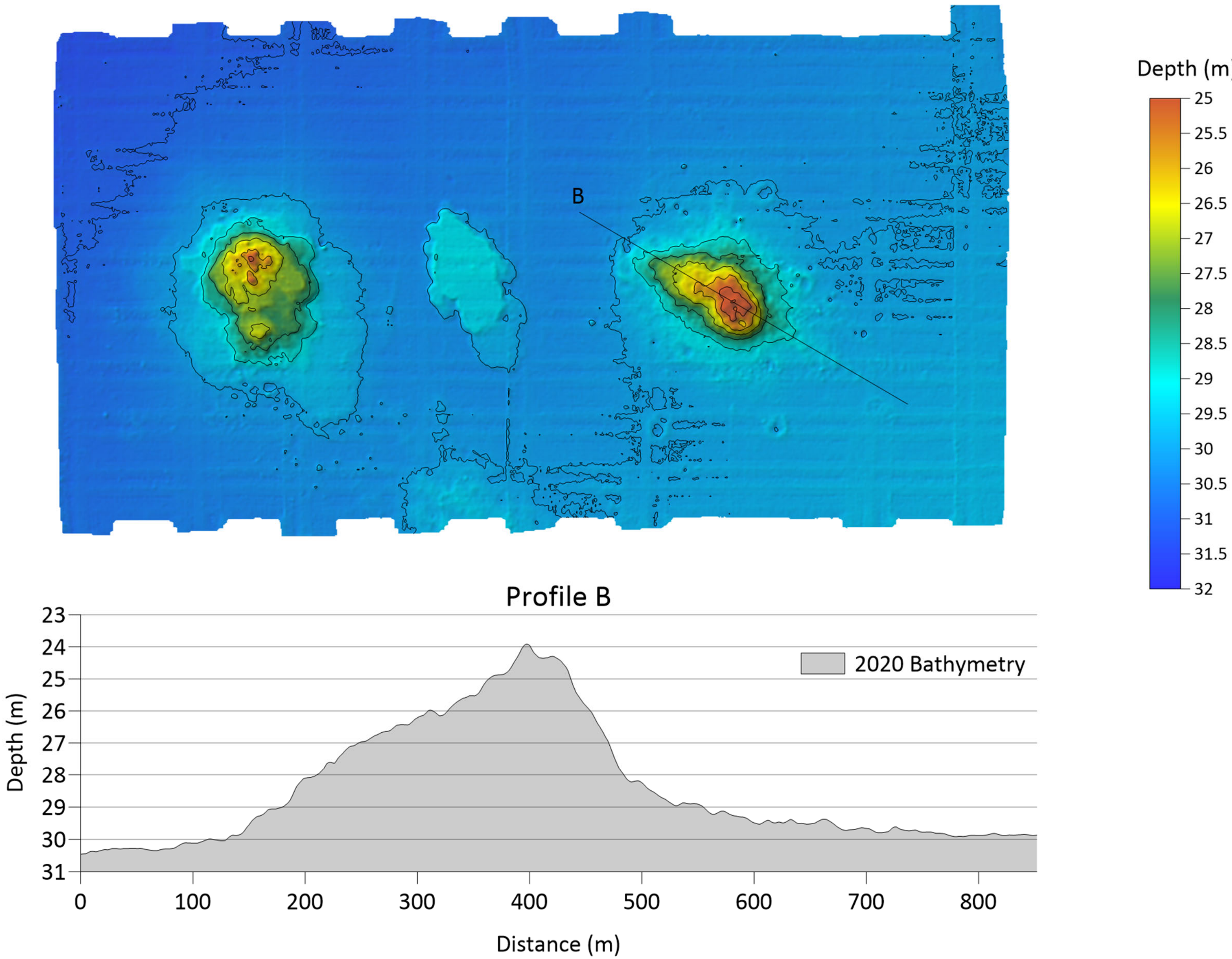

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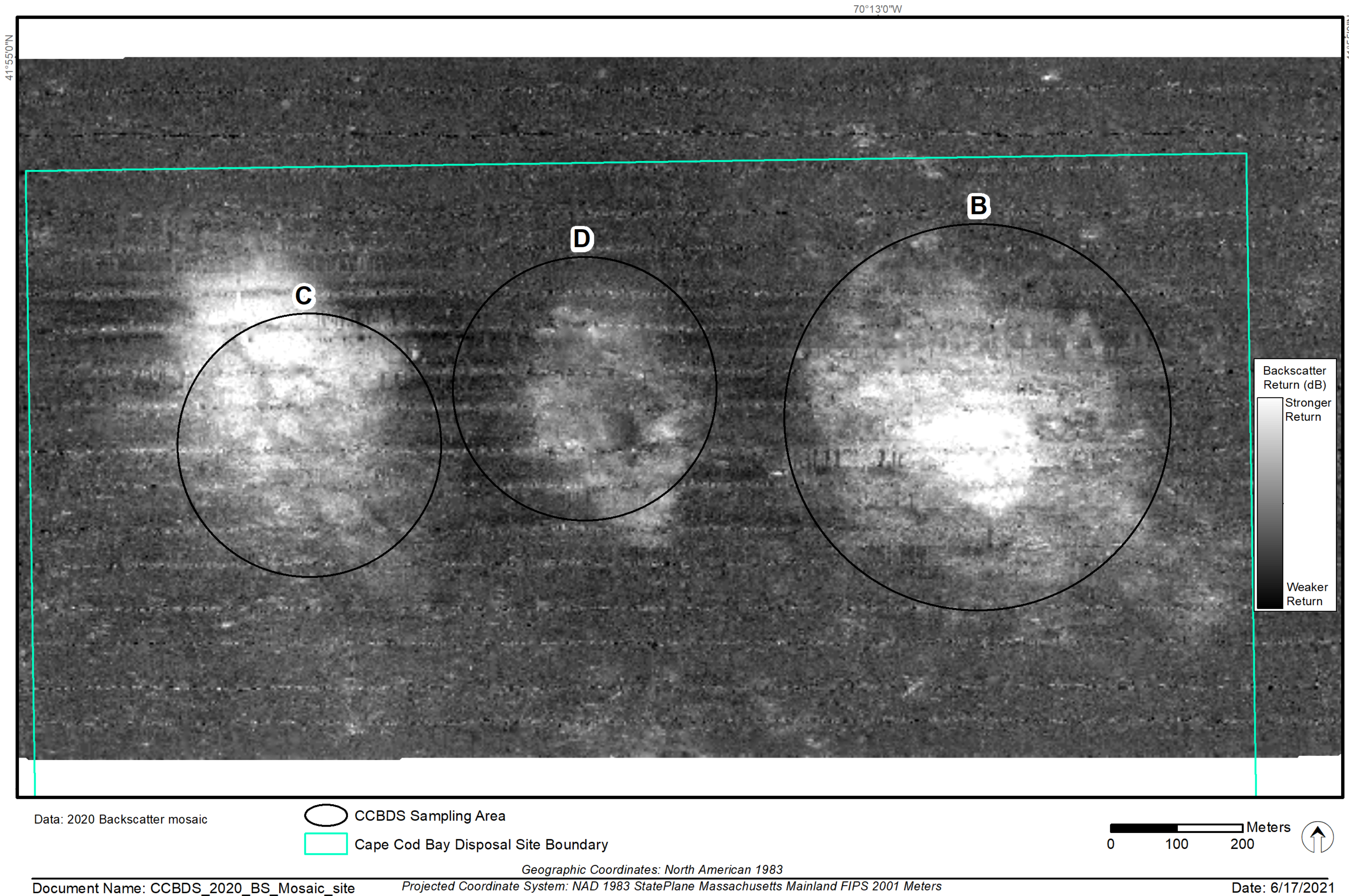

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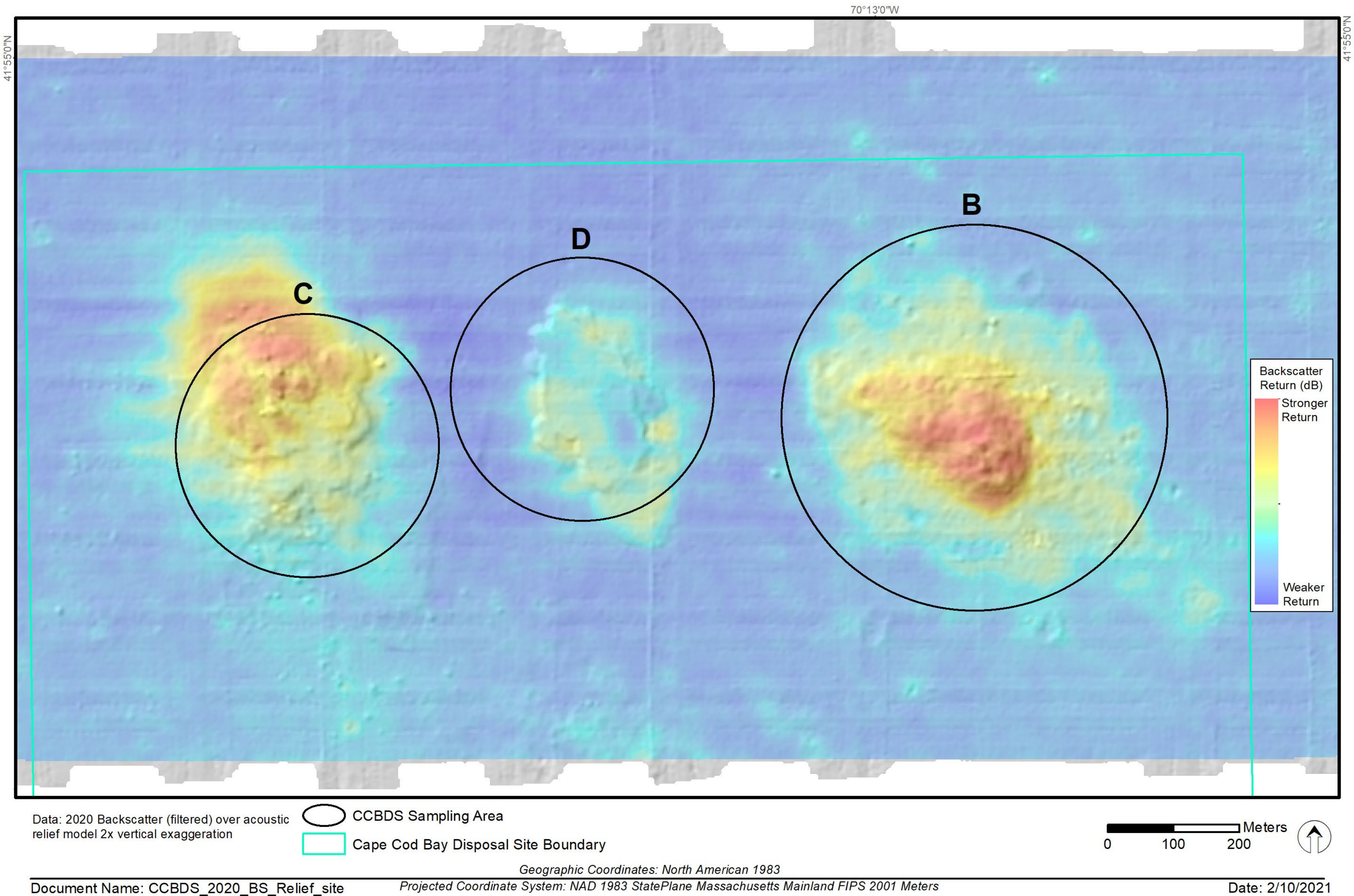

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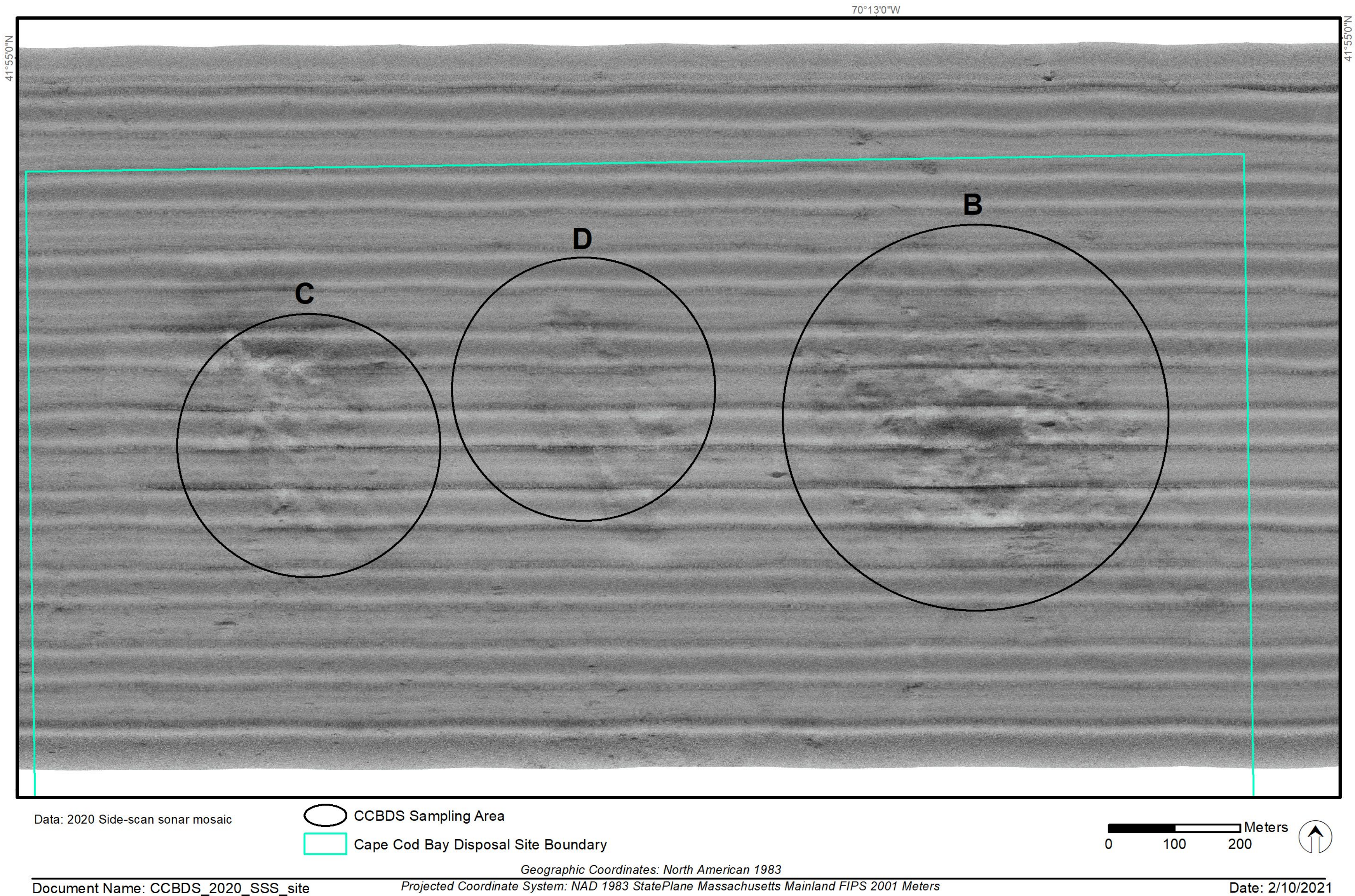

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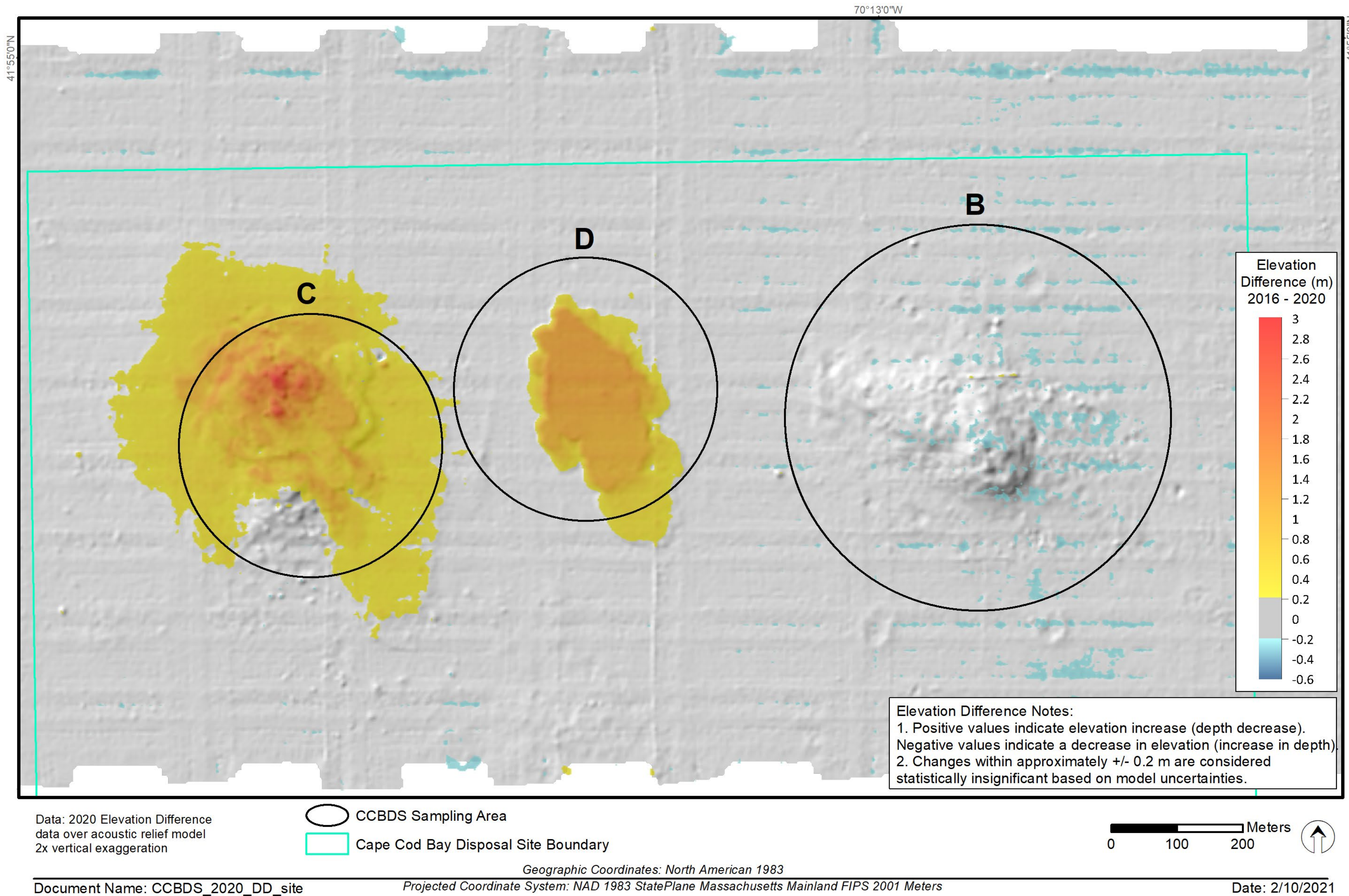

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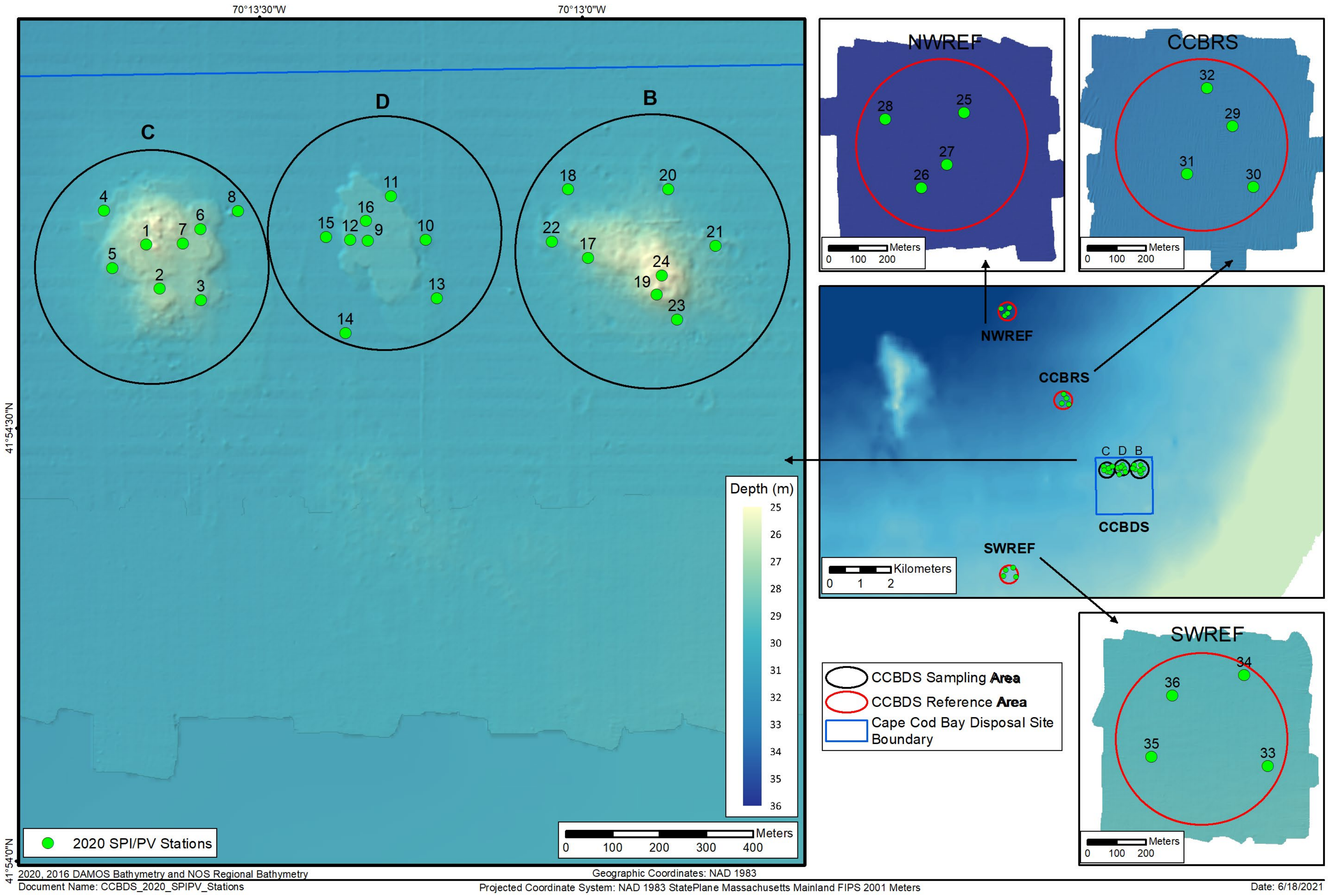

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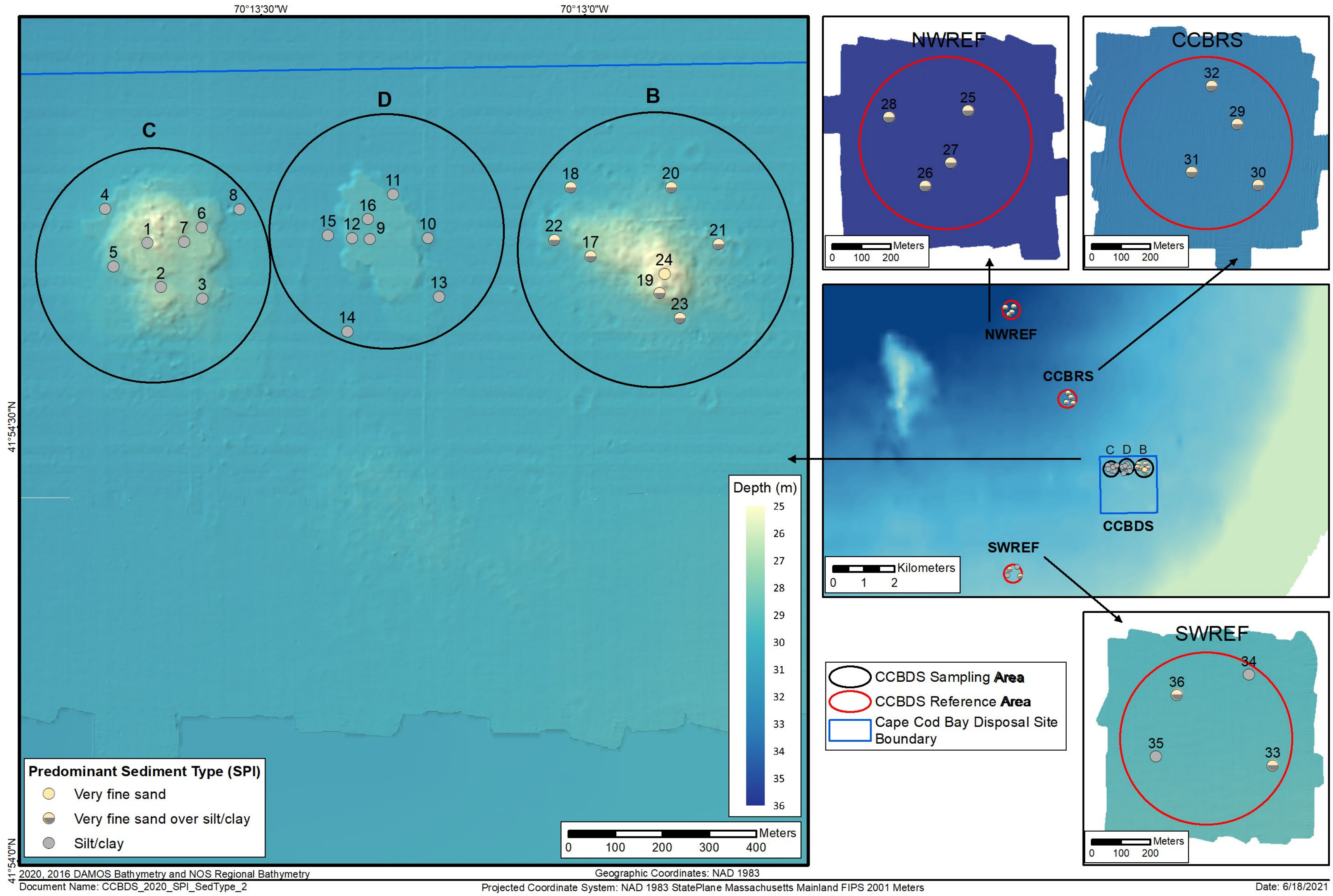

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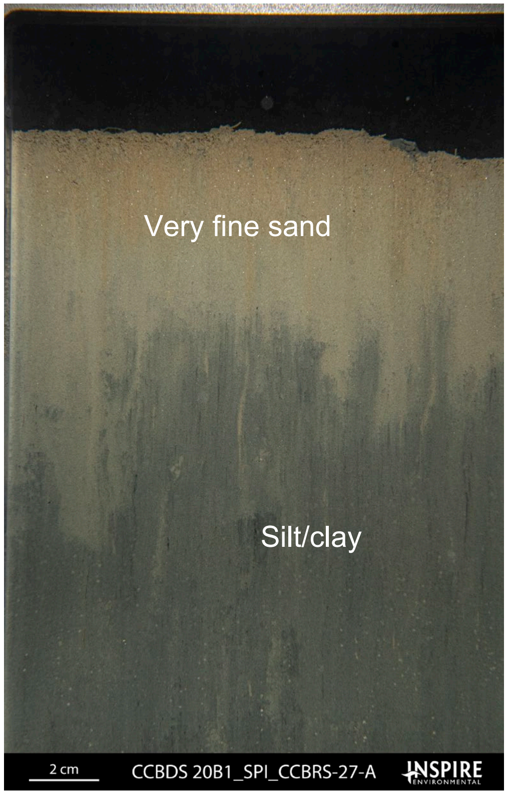
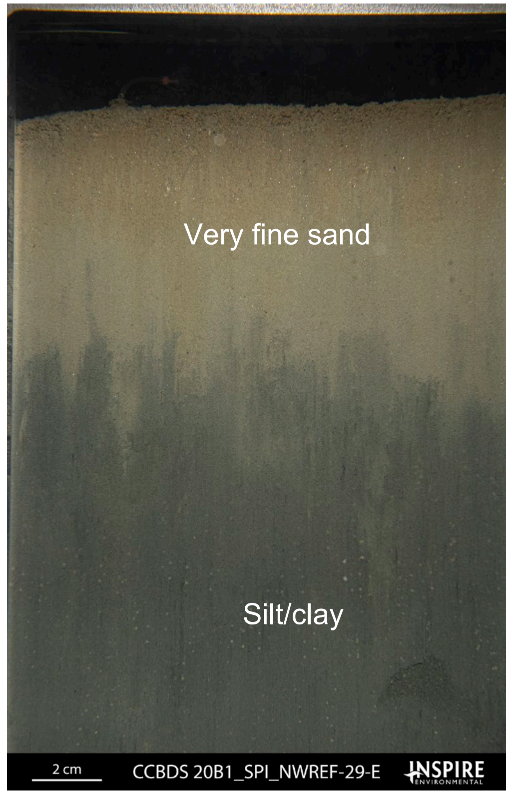
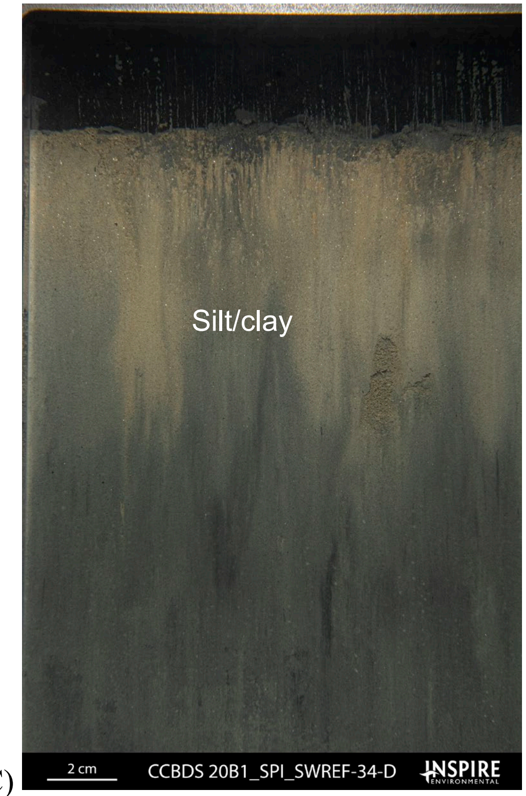
(A) 

(B) 

(C) 

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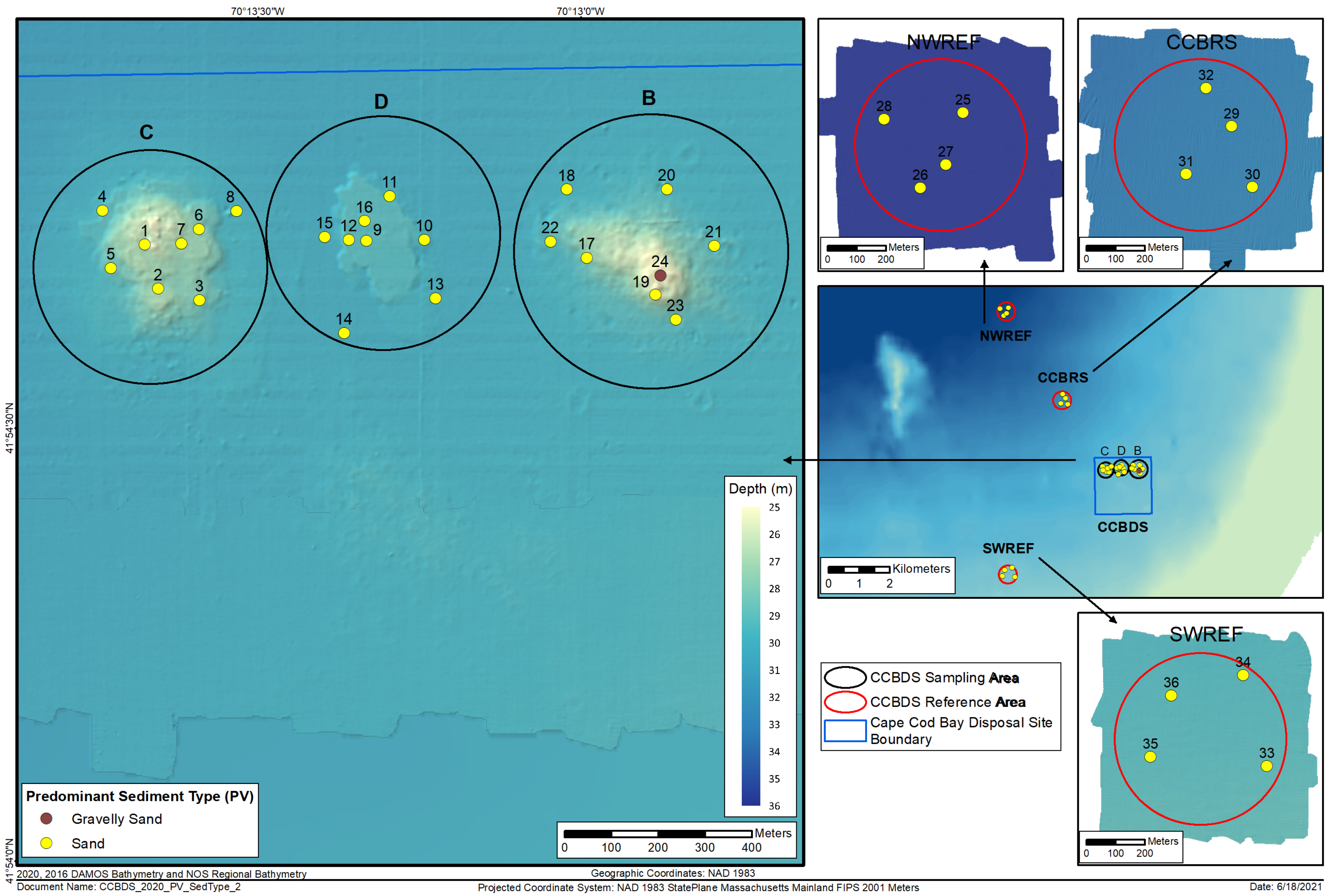

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(A)

(B)

(C)

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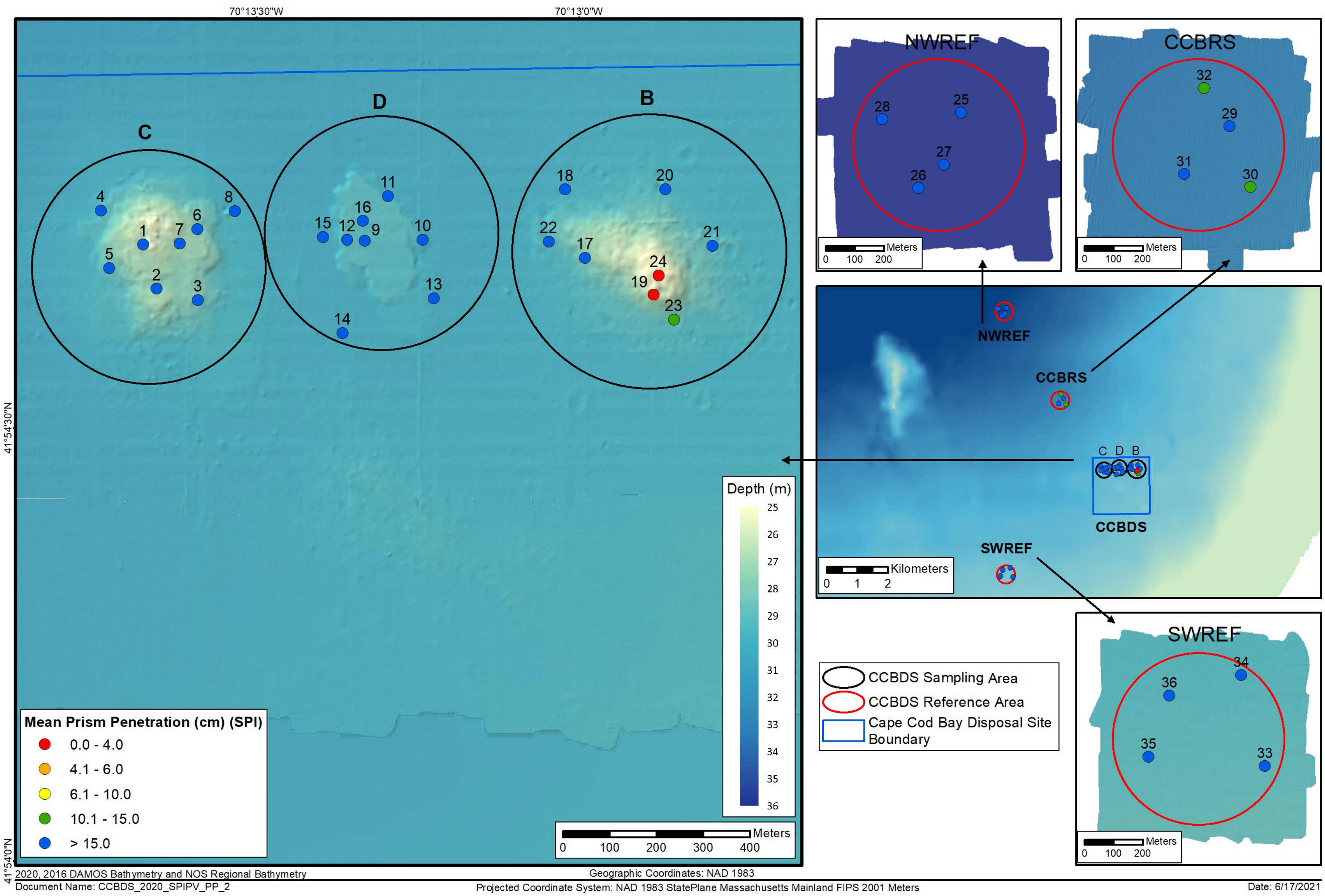

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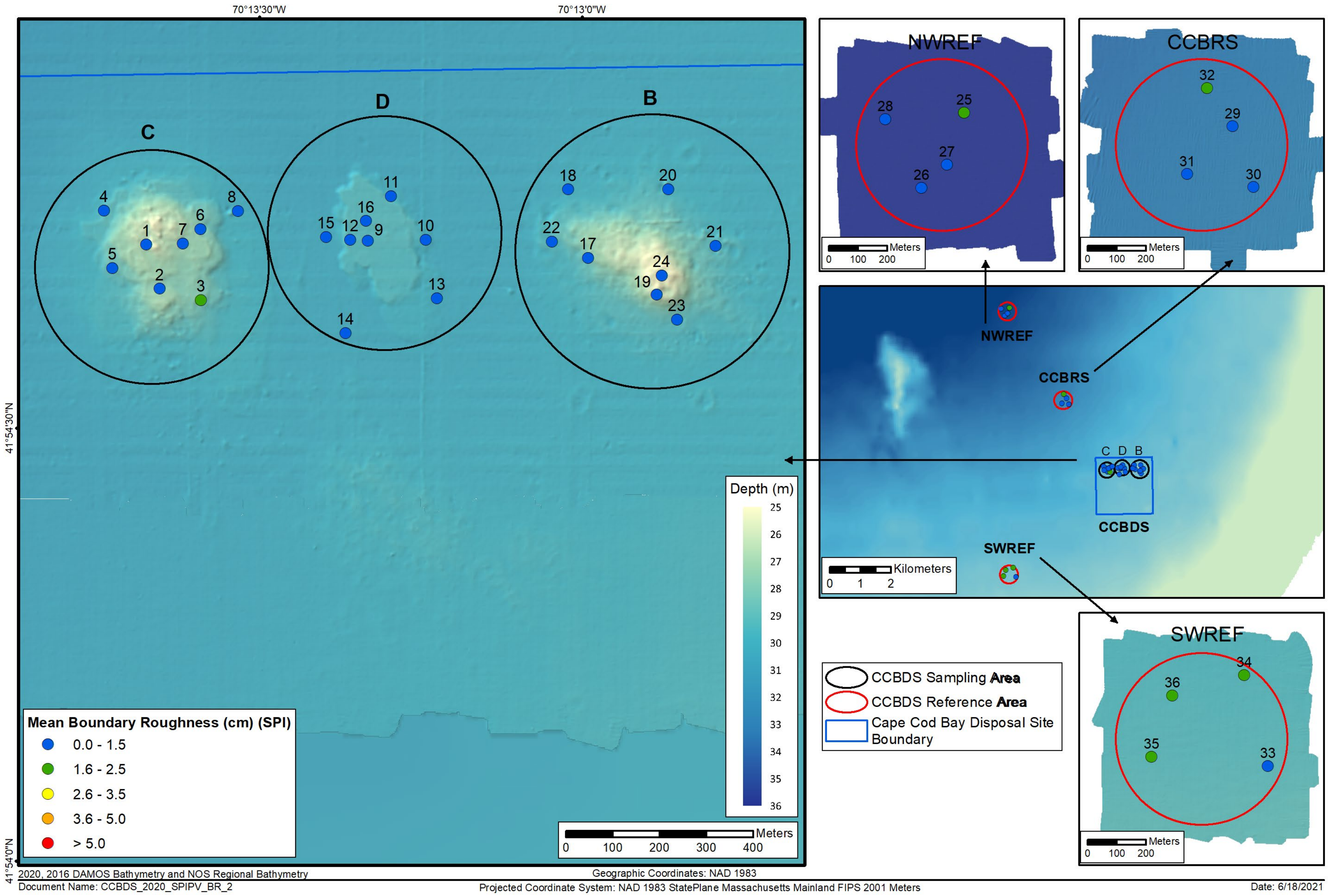

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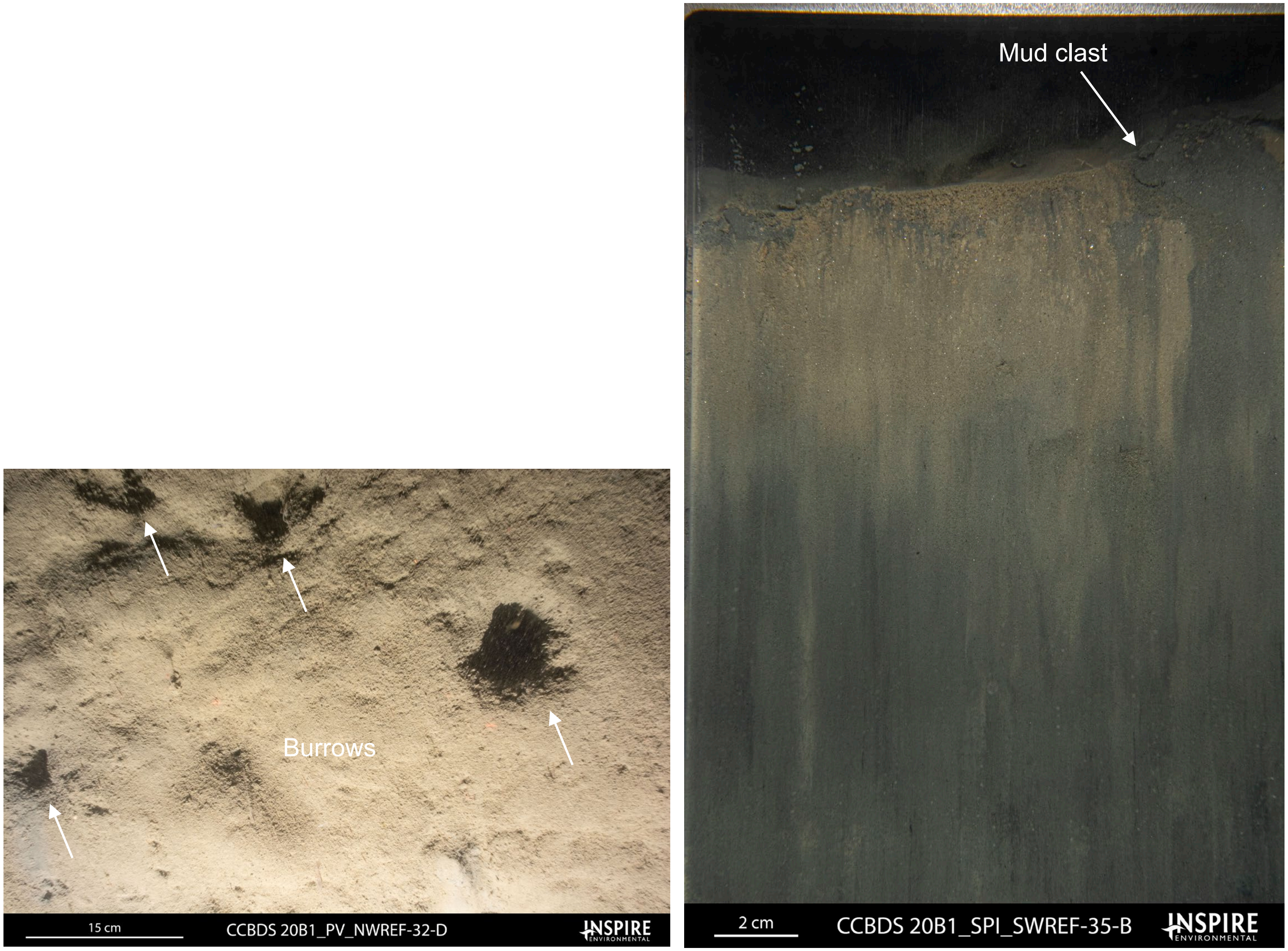

(A) (B)

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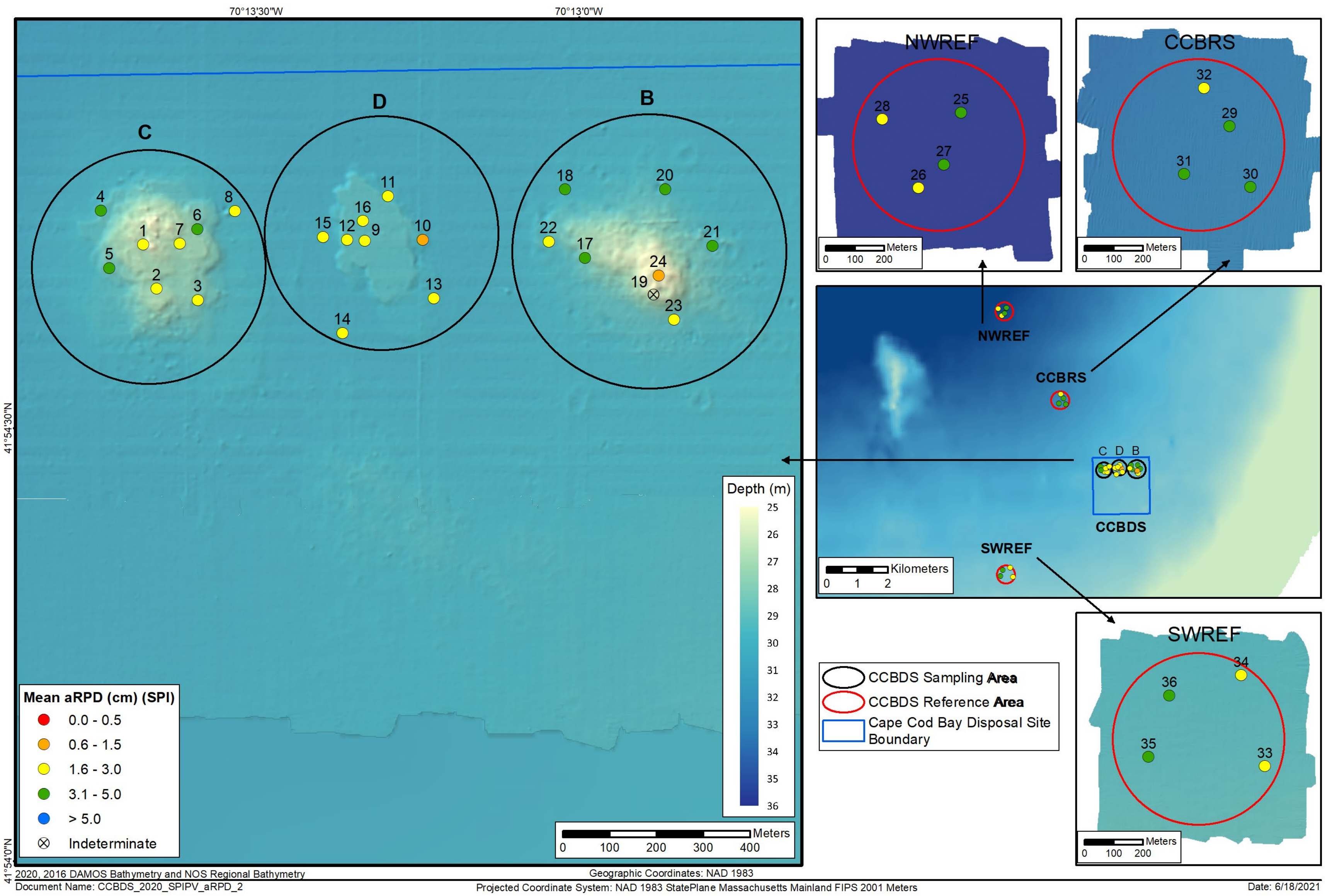

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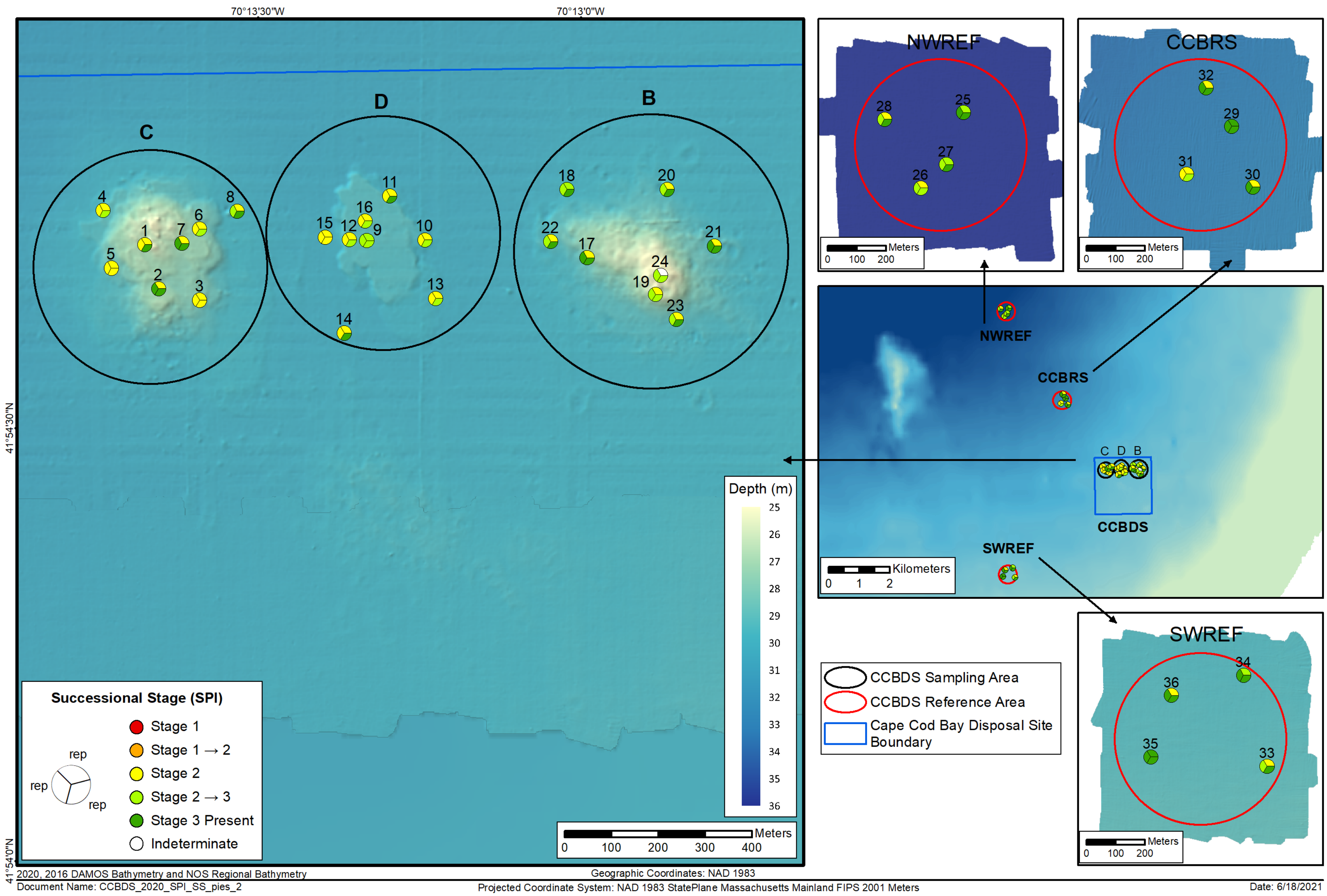

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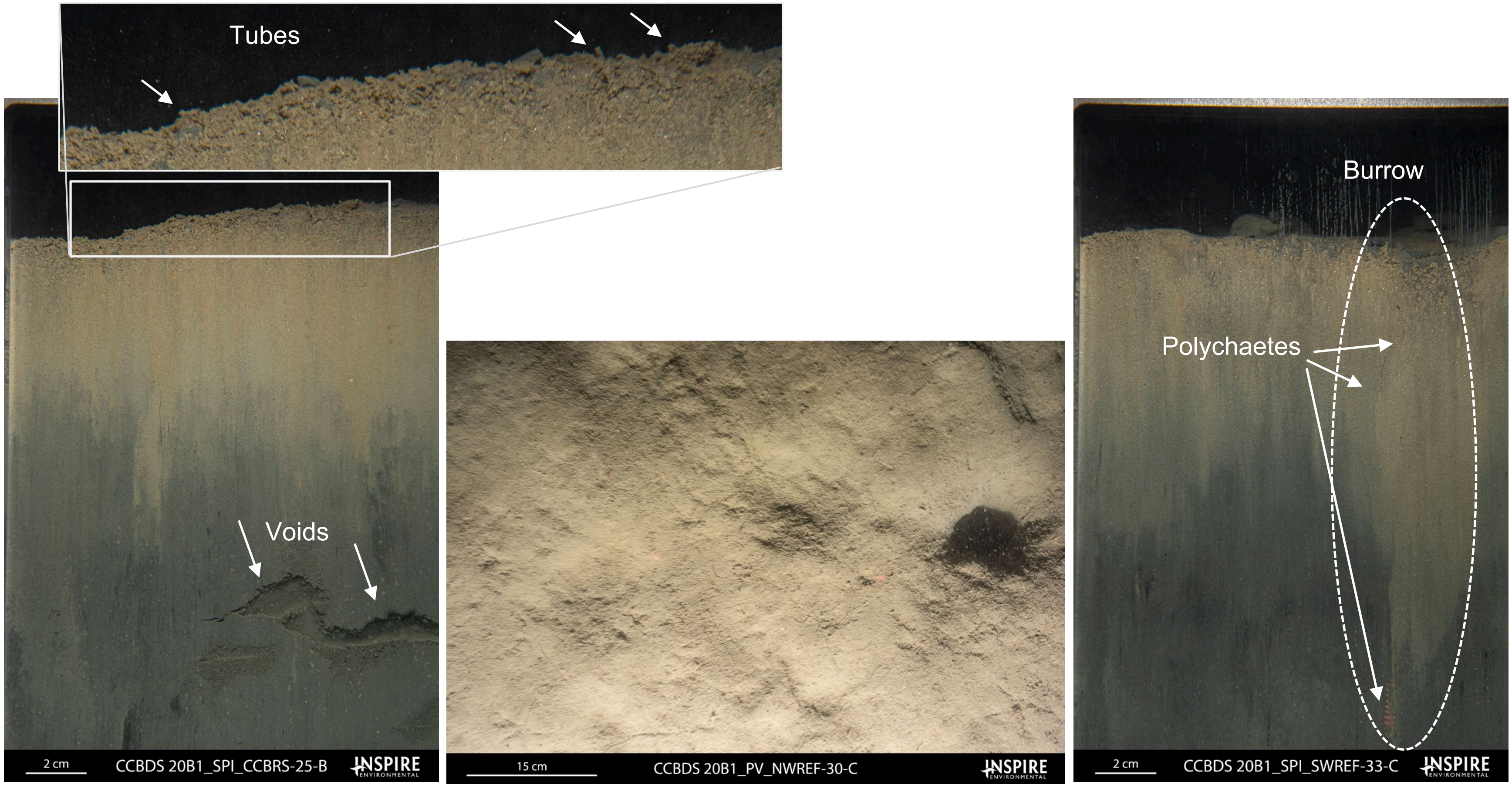
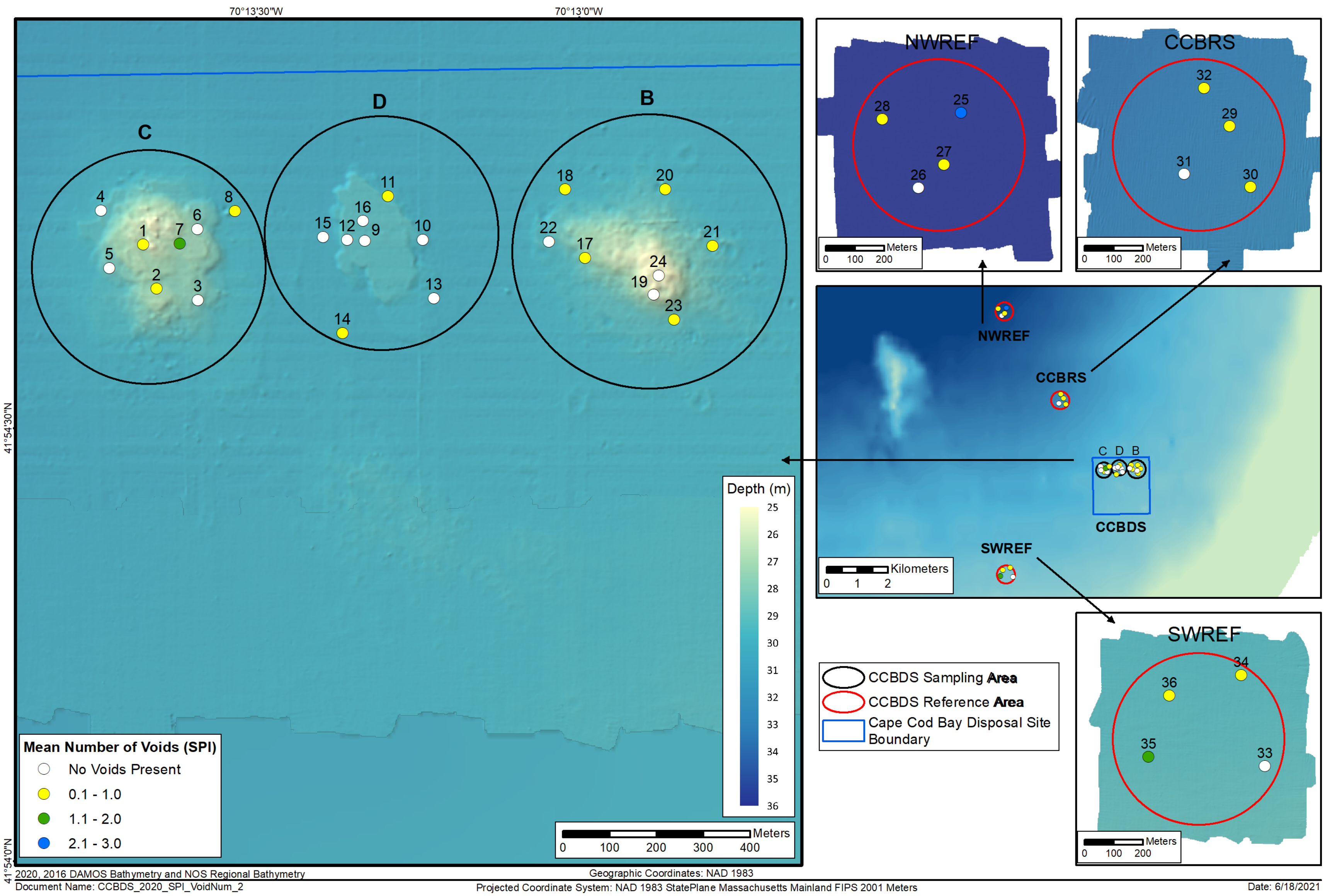


(A) (B) (C)

Figure 3-17. Profile and plan view images depicting infaunal successional stages as well as other biological characteristics found at the three CCBDS reference areas at (A) Stage 1 on 3 at Station CCBRS-25 with Stage 1 tubes at the sediment–water interface and large, open feeding voids within the sediment; (B) Stage 2 on 3 at Station NWREF-30 where tubes, burrows, and brittle star burrows were observed across the surface; and (C) Stage 1 on 3 at Station SWREF-33 evidenced by a burrow visible beginning at the sediment water interface and moving to depth with multiple visible polychaetes



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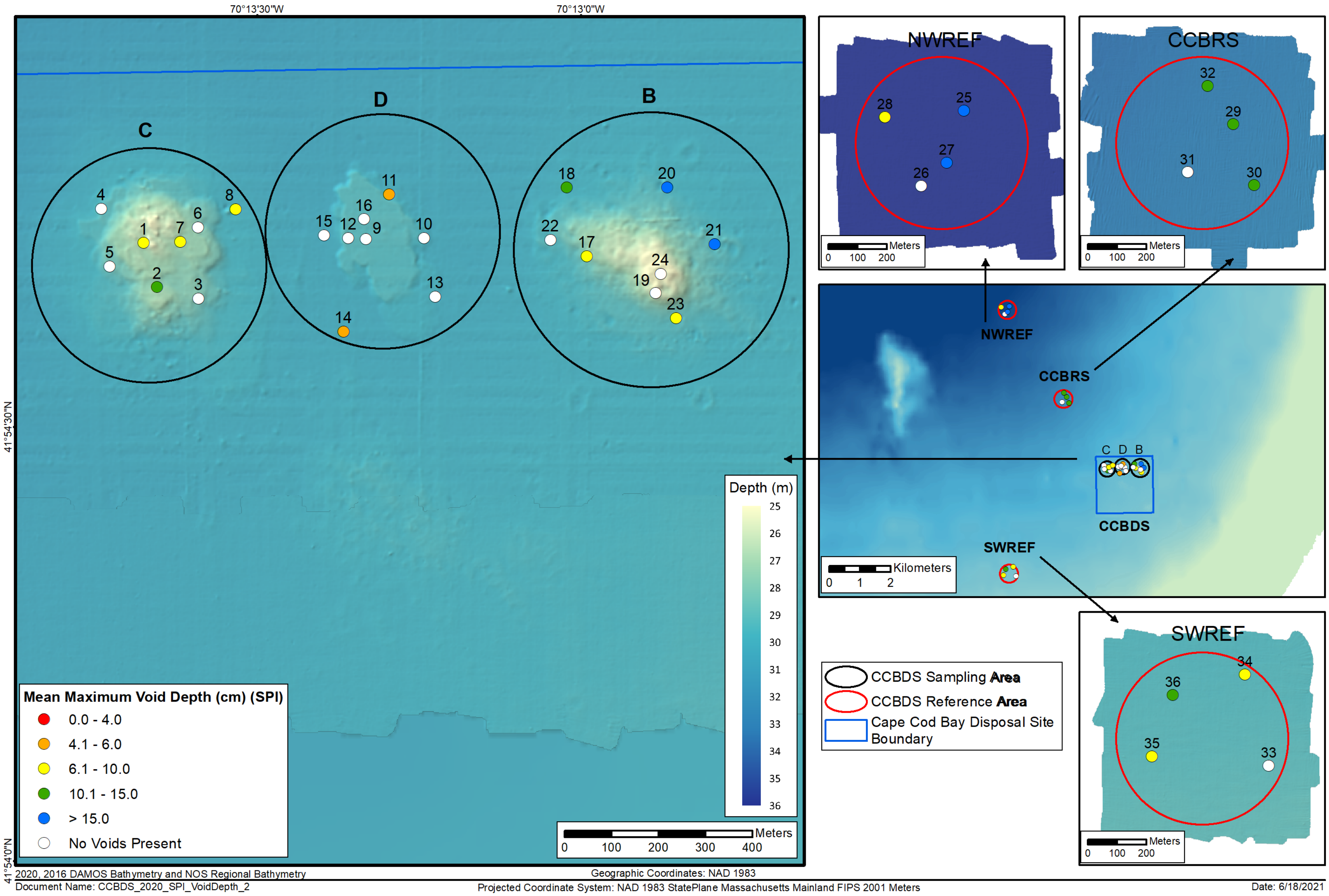

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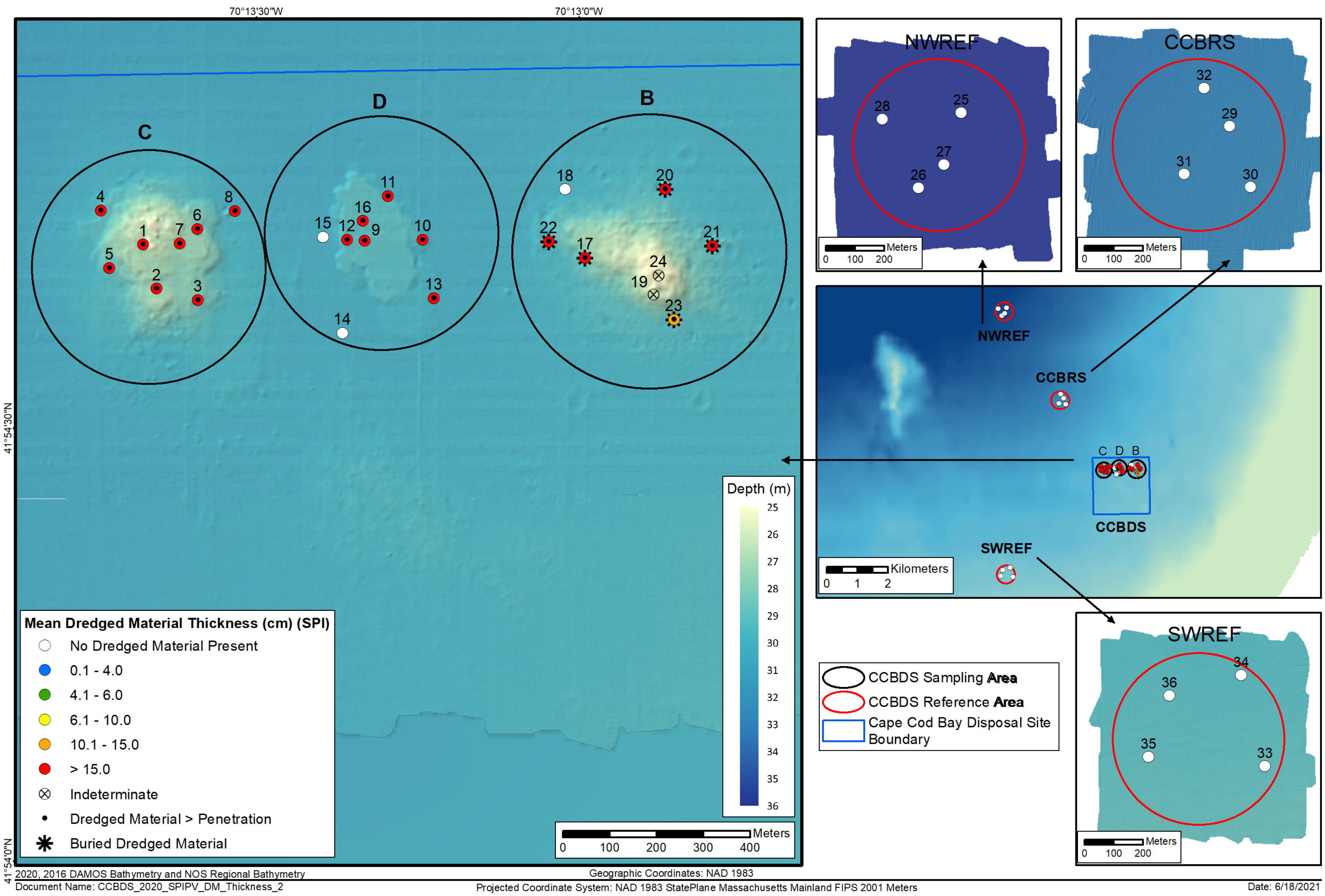

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(A) (B) (C)

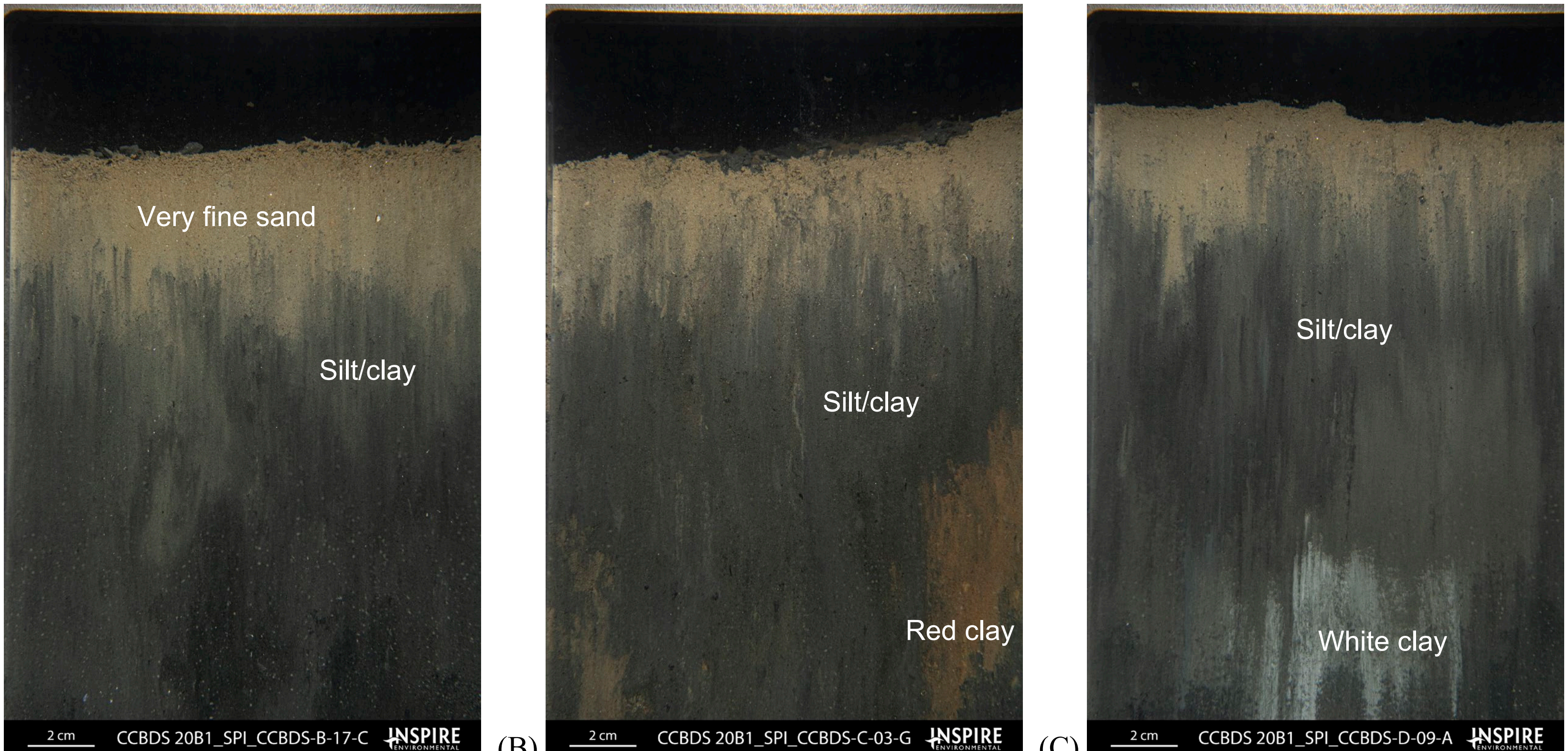
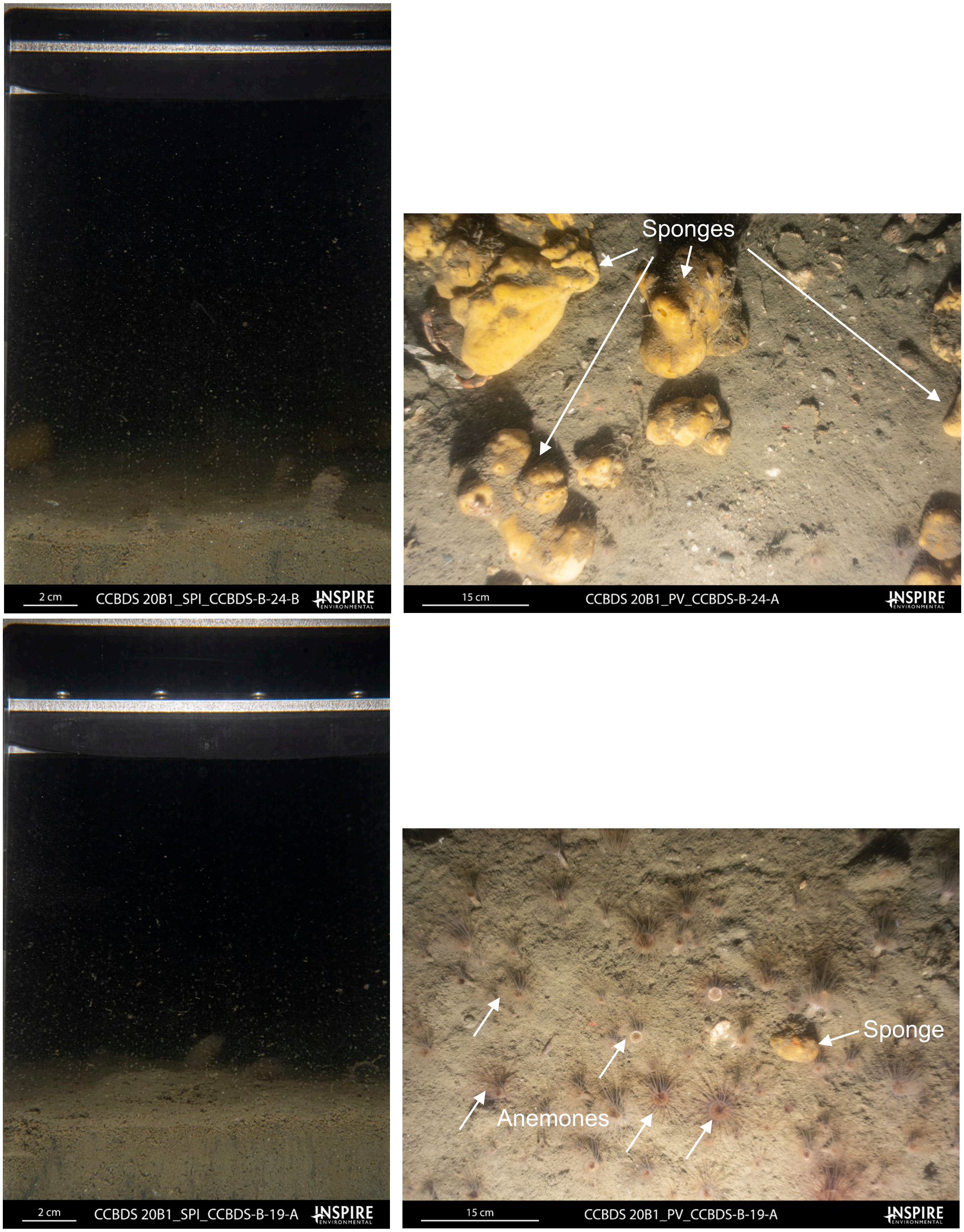


Figure 3-21. Profile images depicting dredged material at CCBDS (A) very fine sand over silt/clay with intermixed reduced, black clay at Station 17 at Mound B; (B) silt/clay with intermixed red clay at Station 03 at Mound C; and (C) silt/clay with intermixed white clay at Station 09 at Mound D



(A)

(B)

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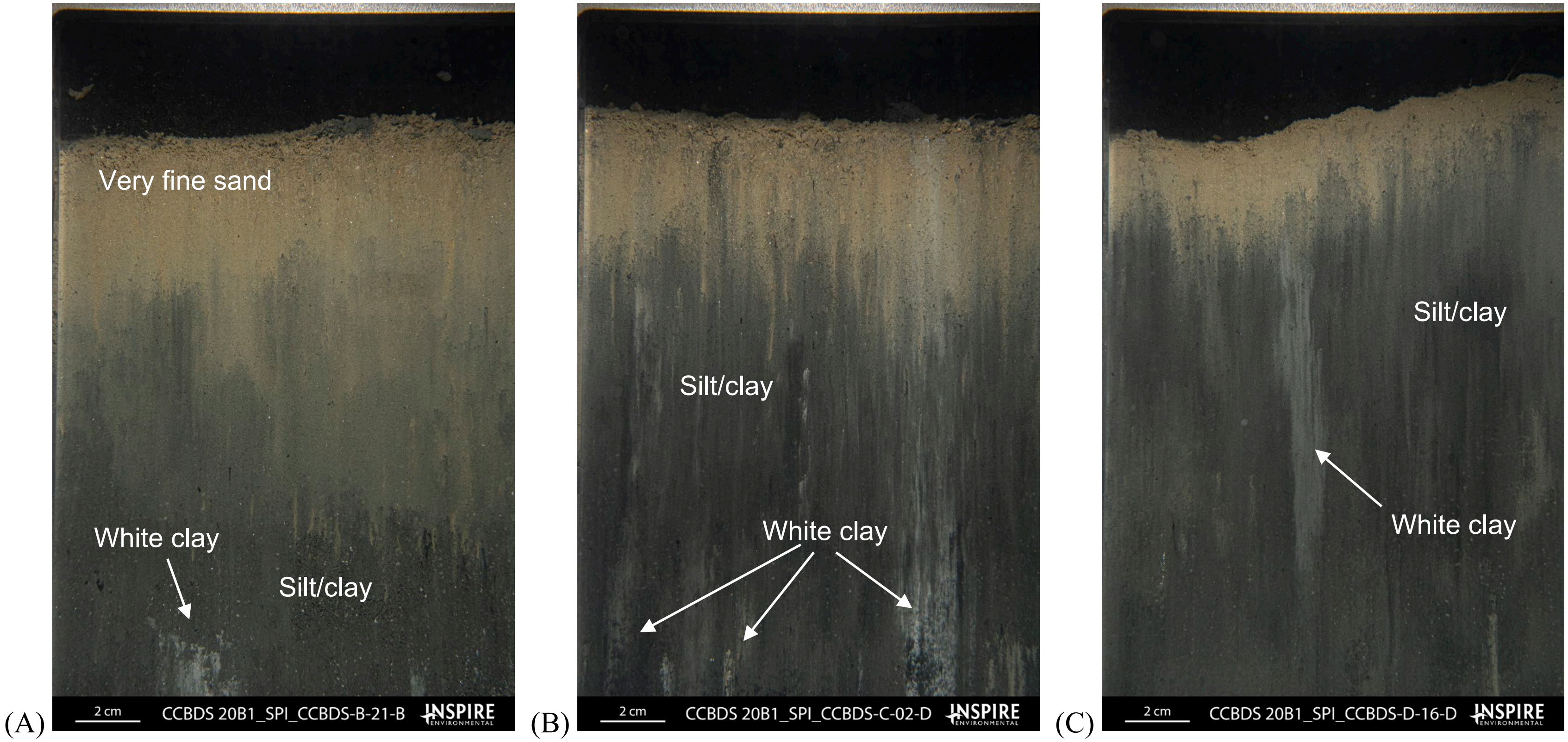
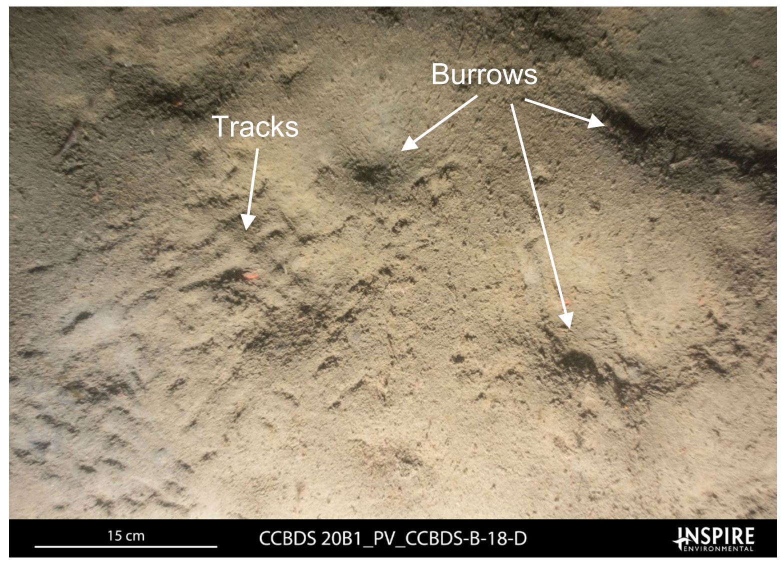


Figure 3-23. Profile images depicting dredged material at CCBDS (A) very fine sand over a buried layer of silt/clay with intermixed white clay at Station 21 at Mound B; (B) slightly reworked silt/clay with white clay intermixed throughout at Station 02 at Mound C; and (C) slightly reworked silt/clay with intermixed white clay at Station 16 at Mound D

(A)



(B)

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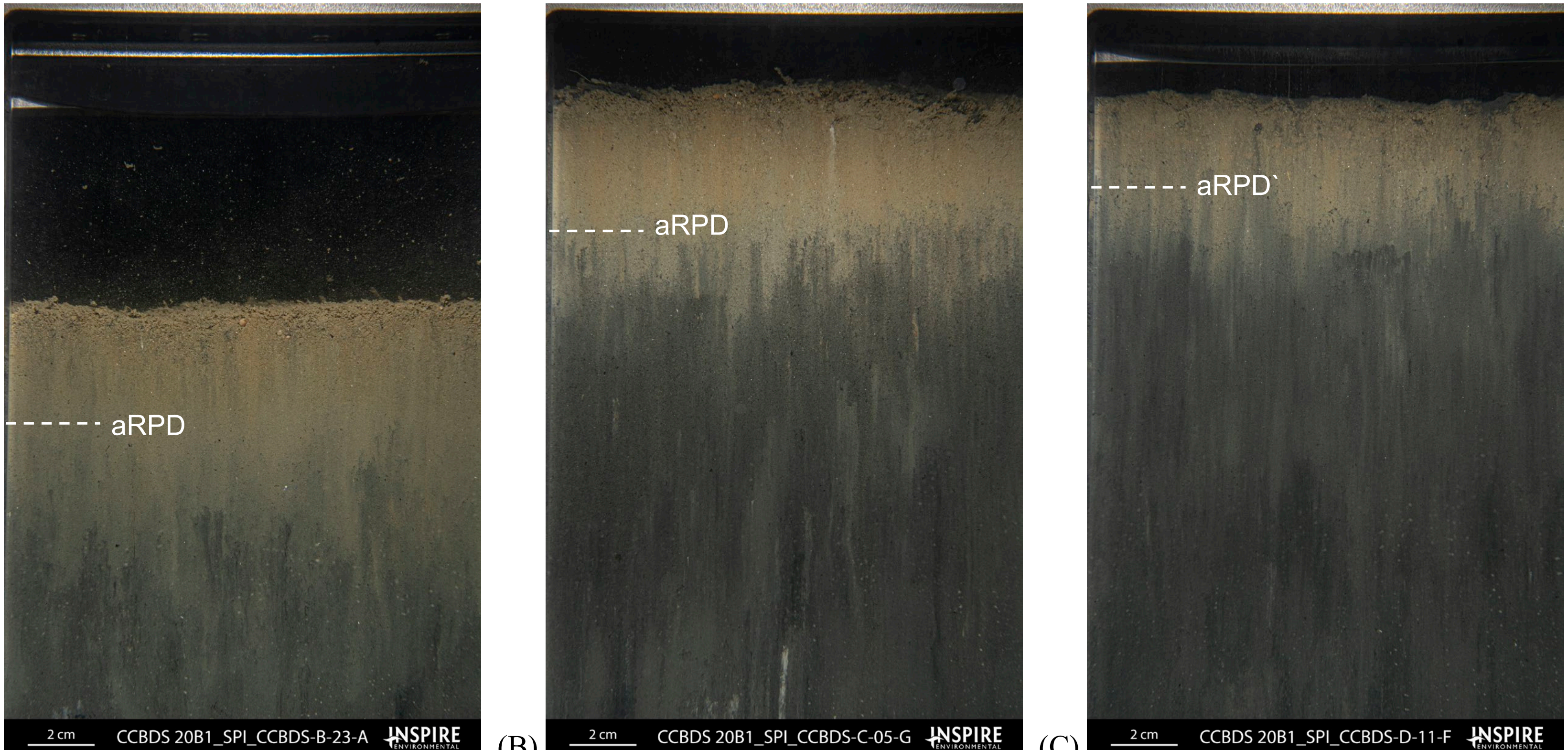

(A) (B) (C)

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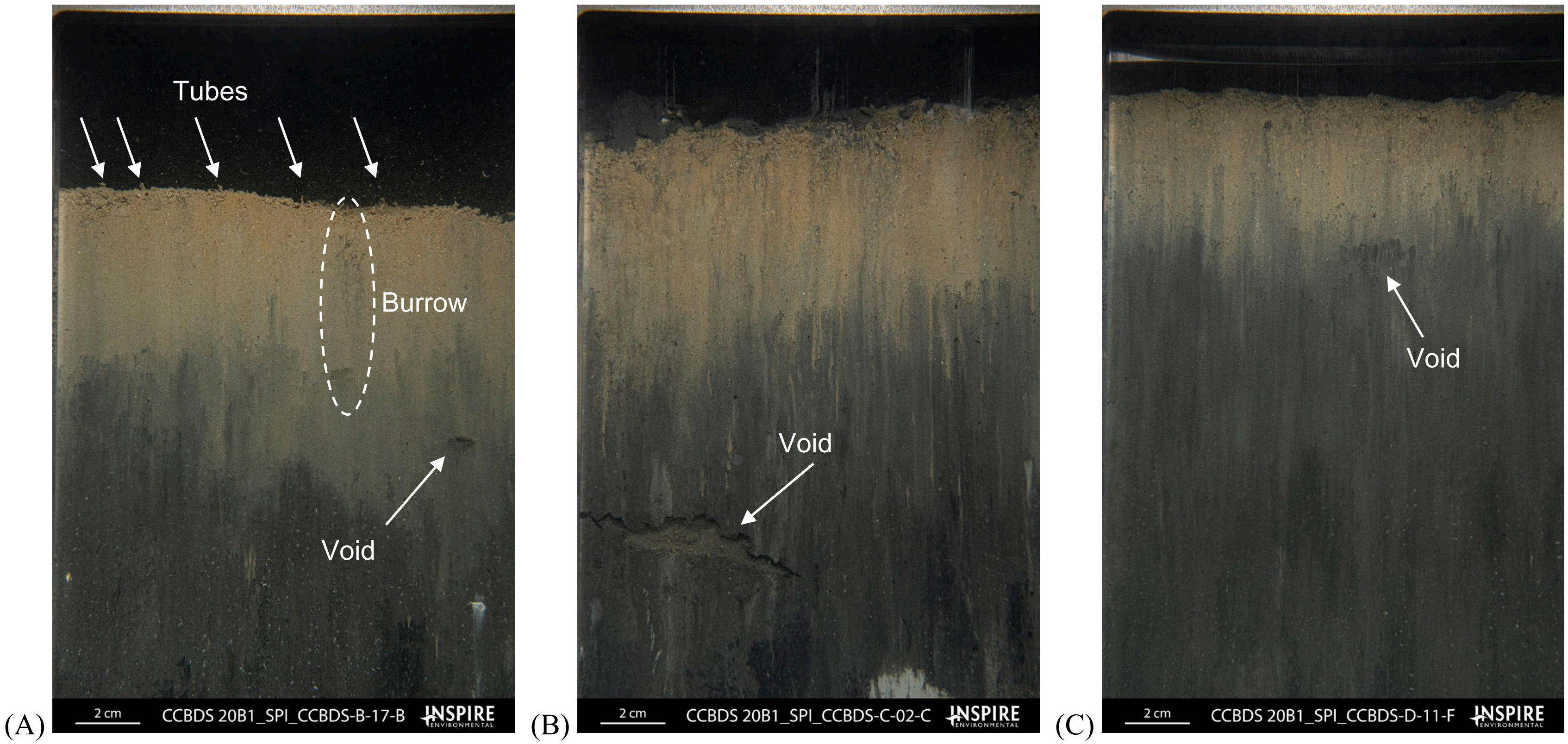
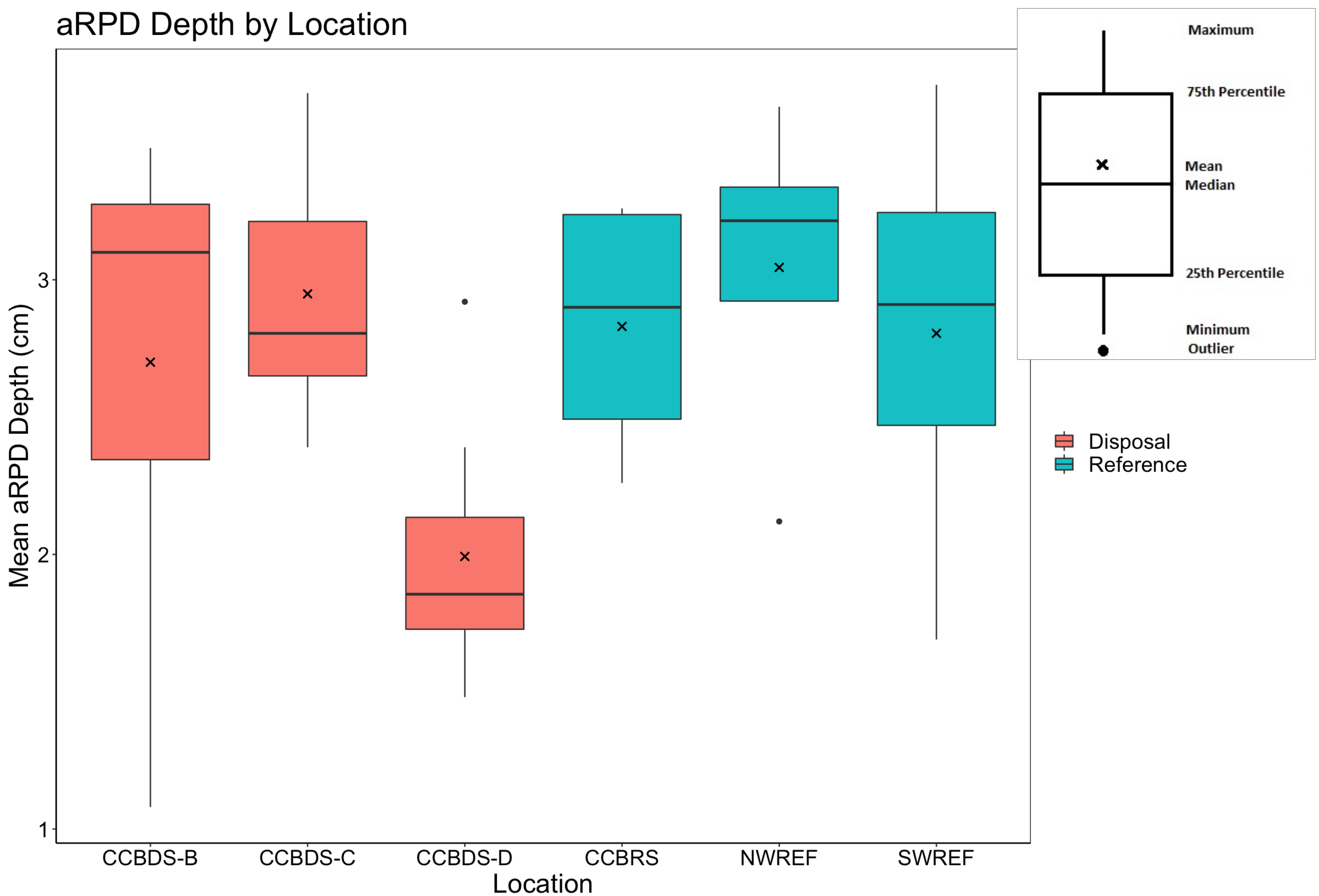


Figure 3-26. Profile images depicting infaunal successional stages as well as other biological characteristics found at the three CCBDS mounds (A) Stage 2 on 3 with tubes and a burrow at the sediment–water interface and feeding voids beneath the aRPD boundary at Mound B Station 17; (B) Stage 1 on 3 with a very large feeding void beneath the aRPD boundary at Mound C Station 02; and (C) Stage 1 on 3 with a shallow, infilled void just beneath the aRPD boundary at Mound D Station 11



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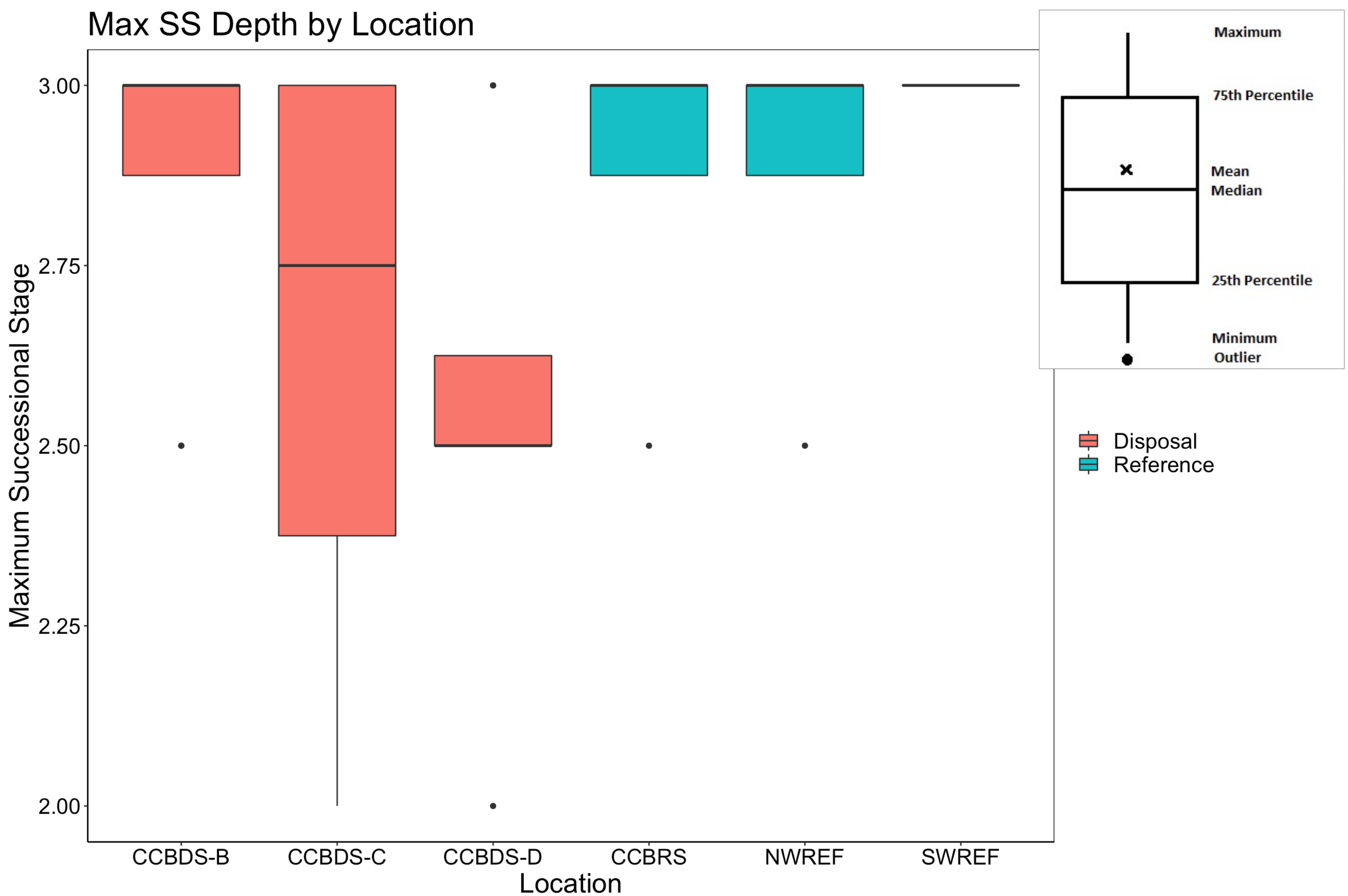

Figure 3-28. Box plot showing the distribution of station mean successional stage ranking by location

MONITORING SURVEY AT THE CAPE COD BAY DISPOSAL SITE MAY/JUNE 2020

CONTRIBUTION # 209

July 2021

APPENDICES

Contract No. W912WJ-19-D-0010
Delivery Order W912WJ19F0126

Funded and Managed by:
New England District
U.S. Army Corps of Engineers
696 Virginia Road
Concord, MA 01742-2751

Prepared by:
INSPIRE Environmental
513 Broadway
Newport, RI 02840

LIST OF APPENDICES

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	3.2808 ft	1 foot	0.3048 m
1 m		1 ft	
1 square meter	10.7639 ft^2	1 square foot	0.0929 m^2
1 m^2		1 ft^2	
1 kilometer	0.6214 mi	1 mile	1.6093 km
1 km		1 mi	
1 cubic meter	1.3080 yd^3	1 cubic yard	0.7646 m^3
1 m^3		1 yd^3	
1 centimeter	0.3937 in	1 inch	2.54 cm
1 cm		1 in	

APPENDIX B

CCBDS DISPOSAL LOG DATA FROM DEC 2016 TO JAN 2019

Note:

Disposal Log Data provided by USACE NAE, August 27, 2020

Target Site Code	Project Name	Placement Date	Load Volume (CM)	Load Volume (CY)	Placement Latitude	Placement Longitude	Permit Number
CCBDS	Gateway Marina	12/4/2016	247	323	41.91170	-70.22757	NAE-1997-453-2016
CCBDS	Gateway Marina	12/6/2016	32	42	41.91085	-70.22883	NAE-1997-453-2016
CCBDS	Gateway Marina	12/8/2016	34	44	41.91180	-70.22802	NAE-1997-453-2016
CCBDS	Gateway Marina	12/11/2016	290	379	41.91157	-70.22795	NAE-1997-453-2016
CCBDS	Gateway Marina	12/14/2016	302	395	41.91157	-70.22667	NAE-1997-453-2016
CCBDS	Gateway Marina	12/26/2016	231	302	41.91205	-70.22747	NAE-1997-453-2016
CCBDS	Plymouth Harbor FNP	11/2/2018	1,450	1,896	41.91147	-70.22755	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/4/2018	992	1,298	41.91152	-70.22735	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/4/2018	1,529	2,000	41.91153	-70.22793	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/5/2018	1,038	1,358	41.91205	-70.22855	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/6/2018	1,577	2,063	41.91235	-70.22817	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/6/2018	956	1,251	41.91253	-70.22722	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/7/2018	1,521	1,990	41.91235	-70.22753	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/8/2018	1,053	1,377	41.91195	-70.22760	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/8/2018	968	1,266	41.91198	-70.22773	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/9/2018	915	1,197	41.91212	-70.22800	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/11/2018	864	1,130	41.91205	-70.22747	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/12/2018	1,002	1,311	41.91170	-70.22705	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/12/2018	980	1,282	41.91228	-70.22742	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/13/2018	1,022	1,337	41.91230	-70.22823	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/15/2018	1,004	1,313	41.91162	-70.22807	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/15/2018	933	1,220	41.91145	-70.22760	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/17/2018	1,000	1,308	41.91205	-70.22698	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/17/2018	1,019	1,333	41.91178	-70.22810	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/18/2018	965	1,263	41.91160	-70.22780	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/18/2018	990	1,295	41.91168	-70.22808	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/19/2018	927	1,212	41.91148	-70.22745	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/20/2018	926	1,212	41.91187	-70.22782	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/23/2018	942	1,233	41.91215	-70.22808	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/23/2018	947	1,239	41.91210	-70.22743	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/24/2018	965	1,262	41.91218	-70.22770	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/25/2018	977	1,277	41.91148	-70.22822	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/26/2018	508	665	41.91215	-70.22827	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/28/2018	508	664	41.91197	-70.22822	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/28/2018	934	1,222	41.91175	-70.22720	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/30/2018	512	670	41.91203	-70.22778	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/30/2018	999	1,307	41.91213	-70.22727	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/1/2018	512	669	41.91178	-70.22698	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/1/2018	612	801	41.91189	-70.22934	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/1/2018	925	1,210	41.91138	-70.22749	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/2/2018	1,565	2,047	41.91244	-70.22893	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/2/2018	1,248	1,632	41.91251	-70.22831	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/2/2018	1,530	2,002	41.91276	-70.22902	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/3/2018	1,023	1,338	41.91243	-70.22768	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/3/2018	501	655	41.91240	-70.22773	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/3/2018	1,932	2,527	41.91164	-70.22721	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/3/2018	1,605	2,099	41.91219	-70.22834	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/3/2018	939	1,229	41.91177	-70.22707	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/3/2018	1,830	2,394	41.91218	-70.22887	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/4/2018	492	644	41.91195	-70.22772	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/4/2018	1,626	2,127	41.91145	-70.22723	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/4/2018	1,922	2,514	41.91097	-70.22705	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/4/2018	986	1,290	41.91212	-70.22832	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/5/2018	1,643	2,148	41.91213	-70.22729	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/5/2018	496	649	41.91182	-70.22705	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/5/2018	2,243	2,934	41.91171	-70.22847	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/5/2018	984	1,288	41.91182	-70.22727	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/6/2018	1,190	1,556	41.91194	-70.22841	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/6/2018	528	690	41.91215	-70.22827	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/6/2018	1,040	1,360	41.91175	-70.22688	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/7/2018	1,738	2,273	41.91216	-70.22870	W912WJ-18-C-0020

Target Site Code	Project Name	Placement Date	Load Volume (CM)	Load Volume (CY)	Placement Latitude	Placement Longitude	Permit Number
CCBDS	Plymouth Harbor FNP	12/8/2018	473	618	41.91190	-70.22735	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/8/2018	1,825	2,388	41.91076	-70.22762	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/8/2018	1,717	2,245	41.91186	-70.22696	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/8/2018	957	1,252	41.91163	-70.22702	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/9/2018	2,349	3,073	41.91232	-70.22841	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/9/2018	1,733	2,266	41.91156	-70.22739	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/9/2018	2,190	2,864	41.91278	-70.22834	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/10/2018	499	652	41.91197	-70.22687	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/10/2018	1,636	2,140	41.91221	-70.22692	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/10/2018	2,228	2,914	41.91153	-70.22856	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/10/2018	1,512	1,978	41.91148	-70.22744	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/11/2018	1,691	2,211	41.91206	-70.22856	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/11/2018	1,573	2,057	41.91227	-70.22737	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/11/2018	2,221	2,905	41.91273	-70.22765	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/12/2018	1,665	2,178	41.91239	-70.22814	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/12/2018	537	703	41.91208	-70.22845	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/12/2018	2,165	2,832	41.91144	-70.22783	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/12/2018	1,529	1,999	41.91139	-70.22807	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/13/2018	1,934	2,530	41.91126	-70.22794	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/13/2018	1,633	2,137	41.91248	-70.22806	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/13/2018	2,293	2,999	41.91206	-70.22909	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/14/2018	988	1,292	41.91220	-70.22805	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/14/2018	1,740	2,276	41.91242	-70.22833	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/14/2018	957	1,252	41.91210	-70.22805	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/14/2018	2,260	2,956	41.91184	-70.22854	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/14/2018	1,706	2,232	41.91148	-70.22816	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/15/2018	2,248	2,940	41.91256	-70.22807	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/15/2018	1,563	2,044	41.91236	-70.22802	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/15/2018	2,184	2,856	41.91207	-70.22853	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/16/2018	1,485	1,943	41.91166	-70.22842	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/19/2018	907	1,186	41.91237	-70.22760	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/20/2018	936	1,224	41.91220	-70.22803	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/23/2018	918	1,200	41.91192	-70.22790	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/30/2018	885	1,157	41.90900	-70.22658	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/31/2018	925	1,210	41.91242	-70.22805	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/6/2019	867	1,133	41.91193	-70.22242	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/7/2019	818	1,071	41.91238	-70.22155	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/8/2019	964	1,261	41.91148	-70.22160	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/8/2019	731	957	41.91145	-70.22240	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/13/2019	885	1,157	41.91198	-70.22265	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/14/2019	893	1,169	41.91205	-70.22273	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/15/2019	914	1,195	41.91177	-70.22278	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/16/2019	859	1,123	41.91170	-70.22222	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/18/2019	963	1,259	41.91165	-70.22135	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/19/2019	848	1,110	41.91210	-70.22167	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/19/2019	913	1,194	41.91195	-70.22248	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/20/2019	874	1,143	41.91208	-70.22262	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/21/2019	642	840	41.91157	-70.22203	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/22/2019	859	1,124	41.91170	-70.22230	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/24/2019	830	1,086	41.91195	-70.22273	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/24/2019	866	1,132	41.91230	-70.22260	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/24/2019	908	1,187	41.91158	-70.22248	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/25/2019	978	1,280	41.91312	-70.22673	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/26/2019	923	1,207	41.91227	-70.22272	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/26/2019	879	1,149	41.91143	-70.22235	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/29/2019	926	1,211	41.91190	-70.22187	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/30/2019	905	1,184	41.91203	-70.22233	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/30/2019	881	1,152	41.91280	-70.22158	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	10/31/2019	955	1,249	41.91250	-70.22218	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/2/2019	952	1,245	41.91178	-70.22220	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/2/2019	877	1,147	41.91245	-70.22230	W912WJ-18-C-0020

Target Site Code	Project Name	Placement Date	Load Volume (CM)	Load Volume (CY)	Placement Latitude	Placement Longitude	Permit Number
CCBDS	Plymouth Harbor FNP	11/3/2019	925	1,210	41.91162	-70.22152	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/3/2019	919	1,202	41.91207	-70.22140	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/4/2019	876	1,146	41.91167	-70.22137	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/5/2019	1,040	1,361	41.91257	-70.22232	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/5/2019	882	1,154	41.91245	-70.22170	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/6/2019	918	1,201	41.91182	-70.22232	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/7/2019	914	1,196	41.91203	-70.22220	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/7/2019	887	1,160	41.91190	-70.22227	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/9/2019	867	1,134	41.91230	-70.22203	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/10/2019	906	1,185	41.91232	-70.22228	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/10/2019	919	1,202	41.91242	-70.22197	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/11/2019	858	1,122	41.91210	-70.22228	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/12/2019	907	1,187	41.91215	-70.22198	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/14/2019	568	743	41.91152	-70.22215	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/14/2019	899	1,176	41.91250	-70.22262	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/15/2019	891	1,166	41.91217	-70.22125	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/15/2019	901	1,178	41.91252	-70.22193	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/19/2019	895	1,171	41.91202	-70.22210	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/20/2019	959	1,254	41.91170	-70.22250	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/21/2019	927	1,212	41.91193	-70.22247	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/21/2019	878	1,149	41.91177	-70.22200	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/22/2019	929	1,216	41.91255	-70.22203	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/23/2019	864	1,131	41.91198	-70.22185	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/23/2019	871	1,139	41.91173	-70.22237	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/24/2019	865	1,132	41.91187	-70.22145	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/25/2019	882	1,153	41.91223	-70.22187	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/26/2019	858	1,122	41.91187	-70.22275	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/26/2019	926	1,211	41.91263	-70.22213	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/27/2019	835	1,092	41.91197	-70.22262	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/27/2019	916	1,198	41.91227	-70.22210	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	11/30/2019	853	1,115	41.91220	-70.22223	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/1/2019	901	1,179	41.91162	-70.22187	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/4/2019	815	1,066	41.91190	-70.22115	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/5/2019	953	1,247	41.91162	-70.22123	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/6/2019	879	1,150	41.91198	-70.22237	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/6/2019	897	1,173	41.91207	-70.22218	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/7/2019	974	1,273	41.91215	-70.22210	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/7/2019	824	1,077	41.91192	-70.22207	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/8/2019	946	1,237	41.91212	-70.22250	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/10/2019	905	1,184	41.91232	-70.22235	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/11/2019	904	1,183	41.91220	-70.22240	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/12/2019	899	1,175	41.91232	-70.22258	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/13/2019	925	1,210	41.91232	-70.22155	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/16/2019	865	1,132	41.91157	-70.22210	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/17/2019	886	1,158	41.91190	-70.22192	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/18/2019	593	776	41.91190	-70.22218	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/20/2019	975	1,275	41.91172	-70.22198	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/21/2019	950	1,242	41.91195	-70.22273	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/21/2019	845	1,105	41.91215	-70.22243	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/22/2019	866	1,132	41.91218	-70.22190	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/22/2019	916	1,198	41.91168	-70.22187	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/23/2019	920	1,204	41.91213	-70.22233	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/23/2019	875	1,144	41.91183	-70.22227	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/27/2019	526	688	41.91207	-70.22173	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/28/2019	713	933	41.91223	-70.22222	W912WJ-18-C-0020
CCBDS	Plymouth Harbor FNP	12/30/2019	920	1,204	41.91223	-70.22257	W912WJ-18-C-0020
CCBDS	Sesuit Harbor	10/31/2018	248	325	41.91278	-70.22792	NAE-2015-02882
CCBDS	Sesuit Harbor	11/1/2018	570	746	41.91285	-70.22605	NAE-2015-02882
CCBDS	Sesuit Harbor	11/1/2018	260	339	41.91193	-70.22767	NAE-2015-02882
CCBDS	Sesuit Harbor	11/5/2018	920	1,204	41.91252	-70.22768	NAE-2015-02882
CCBDS	Sesuit Harbor	11/6/2018	620	811	41.91193	-70.22825	NAE-2015-02882

Target Site Code	Project Name	Placement Date	Load Volume (CM)	Load Volume (CY)	Placement Latitude	Placement Longitude	Permit Number
CCBDS	Sesuit Harbor	11/7/2018	764	999	41.91217	-70.22797	NAE-2015-02882
CCBDS	Sesuit Harbor	11/8/2018	941	1,230	41.91215	-70.22738	NAE-2015-02882
CCBDS	Sesuit Harbor	11/10/2018	375	491	41.91197	-70.22690	NAE-2015-02882
CCBDS	Sesuit Harbor	11/12/2018	319	418	41.91260	-70.22665	NAE-2015-02882
CCBDS	Sesuit Harbor	11/15/2018	950	1,242	41.91230	-70.22758	NAE-2015-02882
CCBDS	Sesuit Harbor	11/15/2018	293	384	41.91162	-70.22837	NAE-2015-02882
CCBDS	Sesuit Harbor	11/17/2018	604	790	41.91232	-70.22822	NAE-2015-02882
CCBDS	Sesuit Harbor	11/17/2018	366	478	41.91252	-70.22587	NAE-2015-02882
CCBDS	Sesuit Harbor	11/18/2018	335	439	41.91208	-70.22847	NAE-2015-02882
CCBDS	Sesuit Harbor	11/18/2018	474	620	41.91190	-70.22793	NAE-2015-02882
CCBDS	Sesuit Harbor	11/19/2018	316	413	41.91177	-70.22718	NAE-2015-02882
CCBDS	Sesuit Harbor	11/20/2018	273	357	41.91167	-70.22817	NAE-2015-02882
CCBDS	Sesuit Harbor	11/24/2018	303	396	41.91123	-70.22510	NAE-2015-02882
CCBDS	Sesuit Harbor	11/24/2018	693	906	41.91198	-70.22705	NAE-2015-02882
CCBDS	Sesuit Harbor	11/24/2018	391	511	41.91195	-70.22692	NAE-2015-02882
CCBDS	Sesuit Harbor	11/25/2018	557	728	41.91180	-70.22760	NAE-2015-02882
CCBDS	Sesuit Harbor	11/26/2018	294	384	41.91157	-70.22795	NAE-2015-02882
CCBDS	Sesuit Harbor	11/30/2018	722	945	41.91198	-70.22723	NAE-2015-02882
CCBDS	Sesuit Harbor	12/1/2018	472	618	41.91178	-70.22718	NAE-2015-02882
CCBDS	Sesuit Harbor	12/1/2018	27	35	41.91165	-70.22757	NAE-2015-02882
CCBDS	Sesuit Harbor	12/1/2018	866	1,133	41.91185	-70.22845	NAE-2015-02882
CCBDS	Sesuit Harbor	12/1/2018	28	37	41.91195	-70.22737	NAE-2015-02882
CCBDS	Sesuit Harbor	12/2/2018	183	240	41.91260	-70.22695	NAE-2015-02882
CCBDS	Sesuit Harbor	12/2/2018	767	1,003	41.91218	-70.22833	NAE-2015-02882
CCBDS	Sesuit Harbor	12/3/2018	280	367	41.91232	-70.22793	NAE-2015-02882
CCBDS	Sesuit Harbor	12/3/2018	299	391	41.91190	-70.22705	NAE-2015-02882
CCBDS	Sesuit Harbor	12/5/2018	6	8	41.91177	-70.22767	NAE-2015-02882
CCBDS	Sesuit Harbor	12/5/2018	0	0	41.91112	-70.22650	NAE-2015-02882
CCBDS	Sesuit Harbor	12/6/2018	737	964	41.91183	-70.22710	NAE-2015-02882
CCBDS	Sesuit Harbor	12/7/2018	717	938	41.91228	-70.22777	NAE-2015-02882
CCBDS	Sesuit Harbor	12/7/2018	318	416	41.91173	-70.22710	NAE-2015-02882
CCBDS	Sesuit Harbor	12/7/2018	797	1,042	41.91200	-70.22727	NAE-2015-02882
CCBDS	Sesuit Harbor	12/7/2018	251	328	41.91157	-70.22700	NAE-2015-02882
CCBDS	Sesuit Harbor	12/8/2018	267	349	41.91170	-70.22790	NAE-2015-02882
CCBDS	Sesuit Harbor	12/9/2018	254	332	41.91153	-70.22732	NAE-2015-02882
CCBDS	Sesuit Harbor	12/10/2018	1	1	41.91137	-70.22690	NAE-2015-02882
CCBDS	Sesuit Harbor	12/10/2018	183	240	41.91042	-70.22767	NAE-2015-02882
CCBDS	Sesuit Harbor	12/11/2018	199	260	41.91272	-70.22713	NAE-2015-02882
CCBDS	Sesuit Harbor	12/12/2018	251	328	41.91153	-70.22798	NAE-2015-02882
CCBDS	Sesuit Harbor	12/12/2018	585	765	41.91243	-70.22845	NAE-2015-02882
CCBDS	Sesuit Harbor	12/13/2018	0	0	41.91240	-70.22842	NAE-2015-02882
CCBDS	Sesuit Harbor	12/14/2018	780	1,020	41.91227	-70.22818	NAE-2015-02882
CCBDS	Sesuit Harbor	12/14/2018	256	334	41.91172	-70.22777	NAE-2015-02882
CCBDS	Sesuit Harbor	12/20/2018	350	458	41.91165	-70.22670	NAE-2015-02882
CCBDS	Sesuit Harbor	12/23/2018	545	712	41.91220	-70.22800	NAE-2015-02882
CCBDS	Sesuit Harbor	12/24/2018	331	432	41.91168	-70.22733	NAE-2015-02882
CCBDS	Sesuit Harbor	12/26/2018	261	341	41.91160	-70.22762	NAE-2015-02882
CCBDS	Sesuit Harbor	12/26/2018	470	614	41.91212	-70.22712	NAE-2015-02882
CCBDS	Sesuit Harbor	12/27/2018	270	353	41.91258	-70.22778	NAE-2015-02882
CCBDS	Sesuit Harbor	12/27/2018	714	933	41.91278	-70.22813	NAE-2015-02882
CCBDS	Sesuit Harbor	12/28/2018	231	302	41.91167	-70.22723	NAE-2015-02882
CCBDS	Sesuit Harbor	12/29/2018	714	935	41.91188	-70.22793	NAE-2015-02882
CCBDS	Sesuit Harbor	12/29/2018	255	334	41.91203	-70.22760	NAE-2015-02882
CCBDS	Sesuit Harbor	12/29/2018	696	910	41.91227	-70.22785	NAE-2015-02882
CCBDS	Sesuit Harbor	12/30/2018	260	340	41.91225	-70.22720	NAE-2015-02882
CCBDS	Sesuit Harbor	12/31/2018	241	316	41.91157	-70.22737	NAE-2015-02882
CCBDS	Sesuit Harbor	12/31/2018	364	477	41.91235	-70.22795	NAE-2015-02882
CCBDS	Sesuit Harbor	1/1/2019	186	244	41.90513	-70.22500	NAE-2015-02882
		Total	**213,346**	**279,057**			

APPENDIX C

ACTUAL SPI/PV REPLICATE LOCATIONS

SampleType	Category	Area	StationID	Replicate	Date	Time	X_MassMainland_m	Y_MassMainland_m	Lat_N_WGS84	Lon_W_WGS84	Depth_m	Comments
SPI/PV	Reference	SWREF	35	A	5/6/2020	18:48:57	302169.87	848549.31	41.88064	70.26905	30.2	
SPI/PV	Reference	SWREF	35	B	5/6/2020	18:49:43	302169.75	848551.58	41.88066	70.26905	30.2	
SPI/PV	Reference	SWREF	35	C	5/6/2020	18:50:26	302171.20	848550.18	41.88065	70.26903	30.2	
SPI/PV	Reference	SWREF	35	D	5/6/2020	18:51:09	302169.66	848550.14	41.88065	70.26905	30.2	
SPI/PV	Reference	SWREF	33	A	5/6/2020	18:58:08	302567.94	848517.43	41.88030	70.26426	30.5	
SPI/PV	Reference	SWREF	33	B	5/6/2020	18:58:56	302568.40	848518.04	41.88031	70.26426	30.5	
SPI/PV	Reference	SWREF	33	C	5/6/2020	18:59:36	302568.65	848515.99	41.88029	70.26425	30.5	
SPI/PV	Reference	SWREF	33	D	5/6/2020	19:00:14	302568.52	848516.60	41.88029	70.26425	30.5	
SPI/PV	Reference	SWREF	34	A	5/6/2020	19:06:11	302489.20	848827.65	41.88310	70.26516	30.8	
SPI/PV	Reference	SWREF	34	B	5/6/2020	19:06:50	302487.59	848828.30	41.88311	70.26517	30.8	
SPI/PV	Reference	SWREF	34	C	5/6/2020	19:07:28	302486.19	848827.70	41.88311	70.26519	30.8	
SPI/PV	Reference	SWREF	34	D	5/6/2020	19:08:07	302485.68	848825.33	41.88308	70.26520	30.8	
SPI/PV	Reference	SWREF	36	A	5/6/2020	19:12:40	302240.73	848759.35	41.88252	70.26816	30.8	
SPI/PV	Reference	SWREF	36	B	5/6/2020	19:13:20	302241.97	848759.43	41.88252	70.26815	30.8	
SPI/PV	Reference	SWREF	36	C	5/6/2020	19:14:03	302241.92	848760.02	41.88253	70.26815	30.8	
SPI/PV	Reference	SWREF	36	D	5/6/2020	19:14:47	302242.82	848760.04	41.88253	70.26814	30.8	
SPI/PV	Disposal	Mound C	03	A	5/6/2020	19:55:56	305637.63	851942.79	41.91073	70.22667	30.5	
SPI/PV	Disposal	Mound C	03	B	5/6/2020	19:56:37	305638.93	851945.22	41.91075	70.22665	30.5	
SPI/PV	Disposal	Mound C	03	C	5/6/2020	19:57:15	305639.42	851945.26	41.91075	70.22664	30.5	
SPI/PV	Disposal	Mound C	03	D	5/6/2020	19:57:54	305638.40	851943.79	41.91074	70.22666	30.5	
SPI/PV	Disposal	Mound C	02	A	5/6/2020	20:01:36	305554.10	851969.10	41.91098	70.22767	29.0	
SPI/PV	Disposal	Mound C	02	B	5/6/2020	20:02:17	305555.61	851970.40	41.91099	70.22765	29.0	
SPI/PV	Disposal	Mound C	02	C	5/6/2020	20:03:01	305556.77	851975.79	41.91104	70.22764	29.0	
SPI/PV	Disposal	Mound C	02	D	5/6/2020	20:03:48	305554.50	851969.79	41.91099	70.22766	29.0	
SPI/PV	Disposal	Mound C	05	A	5/6/2020	20:09:17	305448.57	852016.45	41.91142	70.22893	31.1	
SPI/PV	Disposal	Mound C	05	B	5/6/2020	20:09:58	305450.74	852016.13	41.91142	70.22891	31.1	
SPI/PV	Disposal	Mound C	05	C	5/6/2020	20:10:46	305453.10	852013.14	41.91139	70.22888	31.1	
SPI/PV	Disposal	Mound C	05	D	5/6/2020	20:11:30	305454.04	852016.47	41.91142	70.22887	31.1	
SPI/PV	Disposal	Mound C	04	A	5/6/2020	20:15:29	305435.18	852136.53	41.91250	70.22907	31.7	
SPI/PV	Disposal	Mound C	04	B	5/6/2020	20:16:12	305436.74	852138.20	41.91252	70.22905	31.7	
SPI/PV	Disposal	Mound C	04	C	5/6/2020	20:16:58	305435.92	852135.94	41.91250	70.22906	31.7	
SPI/PV	Disposal	Mound C	04	D	5/6/2020	20:17:37	305433.61	852134.29	41.91248	70.22909	31.7	
SPI/PV	Disposal	Mound C	01	A	5/6/2020	20:20:29	305524.82	852063.51	41.91183	70.22800	31.7	
SPI/PV	Disposal	Mound C	01	B	5/6/2020	20:21:12	305524.11	852060.60	41.91181	70.22801	31.7	
SPI/PV	Disposal	Mound C	01	C	5/6/2020	20:21:50	305524.90	852059.56	41.91180	70.22800	31.7	
SPI/PV	Disposal	Mound C	01	D	5/6/2020	20:22:29	305523.82	852060.93	41.91181	70.22802	31.7	
SPI/PV	Disposal	Mound C	07	A	5/6/2020	20:27:13	305603.90	852065.90	41.91184	70.22705	32.6	
SPI/PV	Disposal	Mound C	07	B	5/6/2020	20:27:55	305603.98	852065.60	41.91184	70.22705	32.6	
SPI/PV	Disposal	Mound C	07	C	5/6/2020	20:28:35	305605.38	852064.84	41.91183	70.22703	32.6	
SPI/PV	Disposal	Mound C	07	D	5/6/2020	20:29:15	305606.35	852064.04	41.91183	70.22702	32.6	
SPI/PV	Disposal	Mound C	06	A	5/6/2020	20:33:36	305645.36	852097.95	41.91213	70.22655	30.8	
SPI/PV	Disposal	Mound C	06	B	5/6/2020	20:34:18	305645.10	852097.25	41.91212	70.22655	30.8	
SPI/PV	Disposal	Mound C	06	C	5/6/2020	20:35:02	305643.33	852094.07	41.91209	70.22657	30.8	
SPI/PV	Disposal	Mound C	06	D	5/6/2020	20:35:44	305641.45	852096.66	41.91212	70.22659	30.8	
SPI/PV	Disposal	Mound C	08	A	5/6/2020	20:38:57	305722.01	852135.08	41.91245	70.22562	32.3	
SPI/PV	Disposal	Mound C	08	B	5/6/2020	20:39:42	305719.80	852136.40	41.91246	70.22564	32.3	
SPI/PV	Disposal	Mound C	08	C	5/6/2020	20:40:25	305719.64	852136.01	41.91246	70.22564	32.3	
SPI/PV	Disposal	Mound C	08	D	5/6/2020	20:41:05	305719.72	852135.62	41.91246	70.22564	32.3	
SPI	Disposal	Mound C	06	E	5/6/2020	21:21:12	305642.01	852096.42	41.91211	70.22659	30.8	SPI only.
SPI	Disposal	Mound C	06	F	5/6/2020	21:21:54	305642.35	852095.19	41.91210	70.22658	30.8	SPI only.
SPI	Disposal	Mound C	06	G	5/6/2020	21:22:39	305641.16	852096.65	41.91212	70.22660	30.8	SPI only.
SPI	Disposal	Mound C	04	E	5/6/2020	21:28:22	305434.73	852137.41	41.91251	70.22908	31.7	SPI only.
SPI	Disposal	Mound C	04	F	5/6/2020	21:29:11	305436.42	852136.83	41.91251	70.22906	31.7	SPI only.

SampleType	Category	Area	StationID	Replicate	Date	Time	X_MassMainland_m	Y_MassMainland_m	Lat_N_WGS84	Lon_W_WGS84	Depth_m	Comments
SPI	Disposal	Mound C	04	G	5/6/2020	21:29:58	305434.35	852137.97	41.91252	70.22908	31.7	SPI only.
SPI	Disposal	Mound C	05	E	5/6/2020	21:32:56	305449.36	852020.29	41.91145	70.22892	31.1	SPI only.
SPI	Disposal	Mound C	05	F	5/6/2020	21:33:38	305449.59	852017.42	41.91143	70.22892	31.1	SPI only.
SPI	Disposal	Mound C	05	G	5/6/2020	21:34:13	305449.46	852019.44	41.91145	70.22892	31.1	SPI only.
SPI	Disposal	Mound C	03	E	5/6/2020	21:37:50	305641.87	851944.68	41.91075	70.22662	30.5	SPI only.
SPI	Disposal	Mound C	03	F	5/6/2020	21:38:32	305638.91	851943.92	41.91074	70.22665	30.5	SPI only.
SPI	Disposal	Mound C	03	G	5/6/2020	21:39:16	305634.72	851943.15	41.91074	70.22670	30.5	SPI only.
SPI/PV	Disposal	Mound D	15	A	5/6/2020	21:53:51	305904.79	852077.16	41.91191	70.22342	33.9	
SPI/PV	Disposal	Mound D	15	B	5/6/2020	21:54:37	305906.42	852076.57	41.91190	70.22340	33.9	
SPI/PV	Disposal	Mound D	15	C	5/6/2020	21:55:20	305905.72	852076.82	41.91190	70.22341	33.9	
SPI/PV	Disposal	Mound D	15	D	5/6/2020	21:55:59	305906.64	852076.06	41.91190	70.22340	33.9	
SPI/PV	Disposal	Mound D	12	A	5/6/2020	22:00:39	305962.02	852073.76	41.91187	70.22273	32.9	
SPI/PV	Disposal	Mound D	12	B	5/6/2020	22:01:26	305959.67	852070.48	41.91184	70.22276	32.9	
SPI/PV	Disposal	Mound D	12	C	5/6/2020	22:02:10	305957.55	852071.80	41.91185	70.22279	32.9	
SPI/PV	Disposal	Mound D	12	D	5/6/2020	22:02:52	305956.03	852070.46	41.91184	70.22281	32.9	
SPI/PV	Disposal	Mound D	09	A	5/6/2020	22:07:26	305999.44	852072.09	41.91185	70.22228	32.9	
SPI/PV	Disposal	Mound D	09	B	5/6/2020	22:08:07	305996.36	852071.02	41.91184	70.22232	32.9	
SPI/PV	Disposal	Mound D	09	C	5/6/2020	22:08:48	305996.77	852073.78	41.91186	70.22231	32.9	
SPI/PV	Disposal	Mound D	09	D	5/6/2020	22:09:31	305998.57	852073.49	41.91186	70.22229	32.9	
SPI/PV	Disposal	Mound D	16	A	5/6/2020	22:13:54	305995.58	852114.11	41.91223	70.22232	32.9	
SPI/PV	Disposal	Mound D	16	B	5/6/2020	22:14:43	305993.84	852115.94	41.91224	70.22234	32.9	
SPI/PV	Disposal	Mound D	16	C	5/6/2020	22:15:20	305993.97	852114.93	41.91223	70.22234	32.9	
SPI/PV	Disposal	Mound D	16	D	5/6/2020	22:16:04	305996.09	852114.02	41.91222	70.22232	32.9	
SPI/PV	Disposal	Mound D	11	A	5/6/2020	22:19:49	306047.43	852166.26	41.91269	70.22169	33.9	
SPI/PV	Disposal	Mound D	11	B	5/6/2020	22:20:32	306047.14	852164.75	41.91267	70.22169	33.9	
SPI/PV	Disposal	Mound D	11	C	5/6/2020	22:21:17	306046.15	852166.03	41.91269	70.22170	33.9	
SPI/PV	Disposal	Mound D	11	D	5/6/2020	22:21:59	306046.30	852168.08	41.91270	70.22170	33.9	
SPI/PV	Disposal	Mound D	10	A	5/6/2020	22:25:30	306123.92	852073.48	41.91184	70.22078	33.6	
SPI/PV	Disposal	Mound D	10	B	5/6/2020	22:26:14	306122.67	852074.40	41.91185	70.22080	33.6	
SPI/PV	Disposal	Mound D	10	C	5/6/2020	22:26:57	306121.52	852075.40	41.91186	70.22081	33.6	
SPI/PV	Disposal	Mound D	10	D	5/6/2020	22:27:49	306121.35	852076.78	41.91187	70.22081	33.6	
SPI/PV	Disposal	Mound D	13	A	5/6/2020	22:31:17	306147.03	851948.47	41.91071	70.22053	34.2	
SPI/PV	Disposal	Mound D	13	B	5/6/2020	22:32:05	306144.65	851949.56	41.91072	70.22055	34.2	
SPI/PV	Disposal	Mound D	13	C	5/6/2020	22:32:47	306143.57	851950.02	41.91073	70.22057	34.2	
SPI/PV	Disposal	Mound D	13	D	5/6/2020	22:33:35	306144.28	851948.36	41.91071	70.22056	34.2	
SPI/PV	Disposal	Mound D	14	A	5/6/2020	22:37:53	305953.99	851876.66	41.91009	70.22287	34.5	
SPI/PV	Disposal	Mound D	14	B	5/6/2020	22:38:36	305951.24	851876.63	41.91009	70.22290	34.5	
SPI/PV	Disposal	Mound D	14	C	5/6/2020	22:39:23	305951.70	851875.08	41.91008	70.22289	34.5	
SPI/PV	Disposal	Mound D	14	D	5/6/2020	22:40:07	305952.90	851875.49	41.91008	70.22288	34.5	
SPI	Disposal	Mound D	14	E	5/6/2020	23:23:27	305951.56	851874.26	41.91007	70.22290	34.5	SPI only.
SPI	Disposal	Mound D	14	F	5/6/2020	23:24:18	305950.61	851874.60	41.91008	70.22291	34.5	SPI only.
SPI	Disposal	Mound D	14	G	5/6/2020	23:25:09	305951.27	851875.81	41.91009	70.22290	34.5	SPI only.
SPI	Disposal	Mound D	14	H	5/6/2020	23:25:52	305949.61	851872.58	41.91006	70.22292	34.5	SPI only.
SPI	Disposal	Mound D	15	E	5/6/2020	23:30:49	305910.39	852079.54	41.91193	70.22335	33.9	SPI only.
SPI	Disposal	Mound D	15	F	5/6/2020	23:31:35	305905.39	852078.14	41.91191	70.22342	33.9	SPI only.
SPI	Disposal	Mound D	15	G	5/6/2020	23:32:44	305907.23	852073.41	41.91187	70.22339	33.9	SPI only.
SPI	Disposal	Mound D	15	H	5/6/2020	23:33:35	305903.02	852075.55	41.91189	70.22344	33.9	SPI only.
SPI	Disposal	Mound D	12	E	5/6/2020	23:38:30	305964.53	852076.31	41.91189	70.22270	32.9	SPI only.
SPI	Disposal	Mound D	12	F	5/6/2020	23:39:17	305956.31	852078.30	41.91191	70.22280	32.9	SPI only.
SPI	Disposal	Mound D	12	G	5/6/2020	23:40:00	305957.56	852076.38	41.91189	70.22279	32.9	SPI only.
SPI	Disposal	Mound D	12	H	5/6/2020	23:40:50	305956.47	852073.96	41.91187	70.22280	32.9	SPI only.
SPI	Disposal	Mound D	10	E	5/6/2020	23:45:11	306123.51	852078.69	41.91189	70.22079	33.6	SPI only.
SPI	Disposal	Mound D	10	F	5/6/2020	23:45:57	306120.41	852077.25	41.91188	70.22082	33.6	SPI only.

SampleType	Category	Area	StationID	Replicate	Date	Time	X_MassMainland_m	Y_MassMainland_m	Lat_N_WGS84	Lon_W_WGS84	Depth_m	Comments
SPI	Disposal	Mound D	10	G	5/6/2020	23:46:37	306118.68	852076.96	41.91187	70.22084	33.6	SPI only.
SPI	Disposal	Mound D	10	H	5/6/2020	23:47:21	306121.37	852074.55	41.91185	70.22081	33.6	SPI only.
SPI	Disposal	Mound D	11	E	5/6/2020	23:53:35	306048.74	852167.34	41.91270	70.22167	33.9	SPI only.
SPI	Disposal	Mound D	11	F	5/6/2020	23:54:19	306046.53	852169.71	41.91272	70.22170	33.9	SPI only.
SPI	Disposal	Mound D	11	G	5/6/2020	23:55:01	306047.25	852168.65	41.91271	70.22169	33.9	SPI only.
SPI	Disposal	Mound D	11	H	5/6/2020	23:55:44	306049.05	852167.78	41.91270	70.22167	33.9	SPI only.
SPI/PV	Disposal	Mound B	22	A	5/7/2020	0:20:35	306392.89	852070.01	41.91177	70.21754	33.6	
SPI/PV	Disposal	Mound B	22	B	5/7/2020	0:21:30	306392.40	852072.24	41.91180	70.21755	33.6	
SPI/PV	Disposal	Mound B	22	C	5/7/2020	0:22:27	306392.73	852071.48	41.91179	70.21754	33.6	
SPI/PV	Disposal	Mound B	22	D	5/7/2020	0:23:23	306392.33	852069.91	41.91177	70.21755	33.6	
SPI/PV	Disposal	Mound B	18	A	5/7/2020	0:30:23	306427.90	852181.53	41.91277	70.21710	34.2	
SPI/PV	Disposal	Mound B	18	B	5/7/2020	0:31:28	306429.45	852182.45	41.91278	70.21708	34.2	
SPI/PV	Disposal	Mound B	18	C	5/7/2020	0:32:25	306429.64	852182.43	41.91278	70.21708	34.2	
SPI/PV	Disposal	Mound B	18	D	5/7/2020	0:33:31	306431.60	852181.01	41.91277	70.21705	34.2	
SPI/PV	Disposal	Mound B	20	A	5/7/2020	0:43:18	306642.03	852181.63	41.91275	70.21452	33.2	
SPI/PV	Disposal	Mound B	20	B	5/7/2020	0:44:18	306643.63	852178.73	41.91272	70.21450	33.2	
SPI/PV	Disposal	Mound B	20	C	5/7/2020	0:45:17	306641.99	852179.66	41.91273	70.21452	33.2	
SPI/PV	Disposal	Mound B	20	D	5/7/2020	0:46:17	306644.30	852175.67	41.91269	70.21449	33.2	
SPI/PV	Disposal	Mound B	21	A	5/7/2020	0:54:06	306743.39	852060.58	41.91164	70.21332	32.6	
SPI/PV	Disposal	Mound B	21	B	5/7/2020	0:55:03	306743.38	852061.11	41.91165	70.21332	32.6	
SPI/PV	Disposal	Mound B	21	C	5/7/2020	0:56:03	306742.77	852059.67	41.91163	70.21333	32.6	
SPI/PV	Disposal	Mound B	21	D	5/7/2020	0:57:00	306742.96	852060.50	41.91164	70.21332	32.6	
SPI/PV	Disposal	Mound B	23	A	5/7/2020	1:02:16	306661.60	851903.10	41.91024	70.21433	32.9	
SPI/PV	Disposal	Mound B	23	B	5/7/2020	1:03:16	306664.90	851903.05	41.91024	70.21429	32.9	
SPI/PV	Disposal	Mound B	23	C	5/7/2020	1:04:15	306665.36	851902.01	41.91023	70.21429	32.9	
SPI/PV	Disposal	Mound B	23	D	5/7/2020	1:05:18	306665.93	851903.84	41.91024	70.21428	32.9	
SPI/PV	Disposal	Mound B	19	A	5/7/2020	1:13:13	306617.09	851956.86	41.91073	70.21486	30.8	
SPI/PV	Disposal	Mound B	19	B	5/7/2020	1:14:21	306615.70	851955.37	41.91071	70.21488	30.8	
SPI/PV	Disposal	Mound B	19	C	5/7/2020	1:15:23	306615.05	851953.05	41.91069	70.21489	30.8	
SPI/PV	Disposal	Mound B	19	D	5/7/2020	1:16:23	306616.39	851956.01	41.91072	70.21487	30.8	
SPI/PV	Disposal	Mound B	24	A	5/7/2020	1:24:32	306628.03	851997.33	41.91109	70.21472	27.8	
SPI/PV	Disposal	Mound B	24	B	5/7/2020	1:25:26	306625.25	851997.04	41.91109	70.21475	27.8	
SPI/PV	Disposal	Mound B	24	C	5/7/2020	1:26:23	306623.59	851995.75	41.91108	70.21477	27.8	
SPI/PV	Disposal	Mound B	24	D	5/7/2020	1:27:24	306623.51	851993.98	41.91106	70.21478	27.8	
SPI/PV	Disposal	Mound B	17	A	5/7/2020	1:32:54	306470.71	852035.30	41.91145	70.21661	32.3	
SPI/PV	Disposal	Mound B	17	B	5/7/2020	1:33:54	306469.40	852033.03	41.91143	70.21663	32.3	
SPI/PV	Disposal	Mound B	17	C	5/7/2020	1:34:54	306470.21	852035.20	41.91145	70.21662	32.3	
SPI/PV	Disposal	Mound B	17	D	5/7/2020	1:35:53	306466.52	852035.22	41.91145	70.21666	32.3	
SPI	Disposal	Mound D	10	I	5/7/2020	2:16:55	306116.41	852078.93	41.91189	70.22087	32.3	SPI only.
SPI	Disposal	Mound D	10	J	5/7/2020	2:17:48	306117.39	852080.25	41.91190	70.22086	32.3	SPI only.
SPI	Disposal	Mound D	10	K	5/7/2020	2:18:47	306117.04	852080.62	41.91191	70.22086	32.3	SPI only.
SPI	Disposal	Mound D	10	L	5/7/2020	2:19:47	306117.19	852080.15	41.91190	70.22086	32.3	SPI only.
SPI	Disposal	Mound D	11	I	5/7/2020	2:26:32	306044.15	852168.79	41.91271	70.22173	31.7	SPI only.
SPI	Disposal	Mound D	11	J	5/7/2020	2:27:28	306045.43	852169.11	41.91271	70.22171	31.7	SPI only.
SPI	Disposal	Mound D	11	K	5/7/2020	2:28:42	306043.25	852171.66	41.91274	70.22174	31.7	SPI only - Out of watch circle ~0.5 meter.
SPI	Disposal	Mound D	11	L	5/7/2020	2:29:43	306045.41	852170.84	41.91273	70.22171	31.7	SPI only.
SPI/PV	Reference	NWREF	30	A	5/7/2020	3:04:15	304295.09	854157.65	41.93085	70.24245	35.1	
SPI/PV	Reference	NWREF	30	B	5/7/2020	3:05:14	304291.62	854157.81	41.93085	70.24250	35.1	
SPI/PV	Reference	NWREF	30	C	5/7/2020	3:08:01	304293.73	854154.12	41.93082	70.24247	35.1	
SPI/PV	Reference	NWREF	30	D	5/7/2020	3:08:58	304296.53	854155.55	41.93083	70.24244	35.1	
SPI/PV	Reference	NWREF	31	A	5/7/2020	3:15:28	304065.11	854196.43	41.93123	70.24522	35.1	
SPI/PV	Reference	NWREF	31	B	5/7/2020	3:16:25	304065.95	854196.41	41.93123	70.24521	35.1	

SampleType	Category	Area	StationID	Replicate	Date	Time	X_MassMainland_m	Y_MassMainland_m	Lat_N_WGS84	Lon_W_WGS84	Depth_m	Comments
SPI/PV	Reference	NWREF	31	C	5/7/2020	3:17:24	304063.33	854200.78	41.93127	70.24524	35.1	
SPI/PV	Reference	NWREF	31	D	5/7/2020	3:19:35	304064.65	854199.65	41.93126	70.24522	35.1	
SPI/PV	Reference	NWREF	29	A	5/7/2020	3:29:36	304221.16	854358.86	41.93267	70.24331	35.1	
SPI/PV	Reference	NWREF	29	B	5/7/2020	3:30:32	304222.92	854361.78	41.93270	70.24329	35.1	
SPI/PV	Reference	NWREF	29	C	5/7/2020	3:31:32	304219.79	854359.14	41.93267	70.24333	35.1	
SPI/PV	Reference	NWREF	29	D	5/7/2020	3:32:32	304218.69	854359.89	41.93268	70.24334	35.1	
SPI/PV	Reference	NWREF	32	A	5/7/2020	3:37:28	304138.86	854493.35	41.93389	70.24428	35.1	
SPI/PV	Reference	NWREF	32	B	5/7/2020	3:38:22	304139.88	854492.61	41.93389	70.24427	35.1	
SPI/PV	Reference	NWREF	32	C	5/7/2020	3:39:23	304138.41	854492.51	41.93389	70.24428	35.1	
SPI/PV	Reference	NWREF	32	D	5/7/2020	3:40:25	304133.17	854490.84	41.93387	70.24435	35.1	
SPI	Reference	NWREF	30	E	5/7/2020	4:46:15	304292.22	854151.72	41.93080	70.24249	33.9	SPI only.
SPI	Reference	NWREF	30	F	5/7/2020	4:47:13	304292.27	854149.73	41.93078	70.24249	33.9	SPI only.
SPI	Reference	NWREF	30	G	5/7/2020	4:48:07	304298.34	854151.40	41.93079	70.24242	33.9	SPI only.
SPI	Reference	NWREF	30	H	5/7/2020	4:49:01	304297.34	854152.60	41.93080	70.24243	33.9	SPI only.
SPI	Reference	NWREF	31	E	5/7/2020	4:54:41	304061.47	854198.36	41.93125	70.24526	33.9	SPI only.
SPI	Reference	NWREF	31	F	5/7/2020	4:55:39	304068.42	854194.18	41.93121	70.24518	33.9	SPI only.
SPI	Reference	NWREF	31	G	5/7/2020	4:56:39	304067.94	854195.13	41.93122	70.24519	33.9	SPI only.
SPI	Reference	NWREF	31	H	5/7/2020	4:57:32	304066.94	854194.26	41.93121	70.24520	33.9	SPI only.
SPI	Reference	NWREF	29	E	5/7/2020	5:04:14	304220.23	854359.79	41.93268	70.24332	33.9	SPI only.
SPI	Reference	NWREF	29	F	5/7/2020	5:05:19	304215.33	854360.34	41.93269	70.24338	33.9	SPI only.
SPI	Reference	NWREF	29	G	5/7/2020	5:06:18	304216.76	854358.36	41.93267	70.24336	33.9	SPI only.
SPI	Reference	NWREF	29	H	5/7/2020	5:07:16	304220.16	854357.14	41.93266	70.24332	33.9	SPI only.
SPI	Reference	NWREF	32	E	5/7/2020	5:11:53	304139.71	854494.60	41.93390	70.24427	33.9	SPI only.
SPI	Reference	NWREF	32	F	5/7/2020	5:12:50	304137.12	854488.46	41.93385	70.24430	33.9	SPI only.
SPI	Reference	NWREF	32	G	5/7/2020	5:13:47	304139.14	854490.28	41.93387	70.24427	33.9	SPI only.
SPI	Reference	NWREF	32	H	5/7/2020	5:14:45	304138.90	854489.00	41.93385	70.24428	33.9	SPI only.
SPI/PV	Reference	CCBRS	26	A	5/7/2020	5:46:53	302215.98	857047.27	41.95714	70.26702	37.8	
SPI/PV	Reference	CCBRS	26	B	5/7/2020	5:47:53	302222.53	857044.90	41.95711	70.26694	37.8	
SPI/PV	Reference	CCBRS	26	C	5/7/2020	5:48:52	302220.72	857046.24	41.95713	70.26696	37.8	
SPI/PV	Reference	CCBRS	26	D	5/7/2020	5:49:50	302223.30	857047.36	41.95714	70.26693	37.8	
SPI/PV	Reference	CCBRS	27	A	5/7/2020	5:55:41	302303.14	857127.75	41.95785	70.26595	37.8	
SPI/PV	Reference	CCBRS	27	B	5/7/2020	5:56:36	302303.50	857126.88	41.95784	70.26595	37.8	
SPI/PV	Reference	CCBRS	27	C	5/7/2020	5:57:35	302305.80	857123.00	41.95781	70.26592	37.8	
SPI/PV	Reference	CCBRS	27	D	5/7/2020	5:58:33	302306.14	857130.28	41.95787	70.26591	37.8	
SPI/PV	Reference	CCBRS	28	A	5/7/2020	6:06:31	302092.41	857282.66	41.95927	70.26846	38.4	
SPI/PV	Reference	CCBRS	28	B	5/7/2020	6:07:29	302093.60	857280.19	41.95925	70.26845	38.4	
SPI/PV	Reference	CCBRS	28	C	5/7/2020	6:08:26	302092.42	857281.22	41.95926	70.26846	38.4	
SPI/PV	Reference	CCBRS	28	D	5/7/2020	6:09:23	302090.95	857280.13	41.95925	70.26848	38.4	
SPI/PV	Reference	CCBRS	25	A	5/7/2020	6:16:53	302361.79	857305.48	41.95944	70.26521	38.1	
SPI/PV	Reference	CCBRS	25	B	5/7/2020	6:17:49	302356.06	857300.53	41.95940	70.26528	38.1	
SPI/PV	Reference	CCBRS	25	C	5/7/2020	6:18:46	302353.59	857304.97	41.95944	70.26531	38.1	
SPI/PV	Reference	CCBRS	25	D	5/7/2020	6:19:46	302357.67	857303.10	41.95942	70.26526	38.1	

APPENDIX D

SEDIMENT PROFILE IMAGE ANALYSIS RESULTS

Notes:

IND=Indeterminate

N/A=Not Applicable

Grain Size: “/” indicates layer of one phi size range over another.

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).

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Image Width (cm)	Grain Size Major Mode (phi)	Grain Size Minimum (phi)	Grain Size Maximum (phi)	Grain Size Range (phi)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Over-penetration?	Boundary Roughness (cm)
Mound C	Disposal	01	A	31.7	5/6/2020	20:20:34	14	1	14.62	>4	>4	2	>4 to 2	16.03	15.62	16.36	No	0.73
Mound C	Disposal	01	C	31.7	5/6/2020	20:21:54	14	1	14.62	>4	>4	3	>4 to 3	17.37	16.64	17.80	No	1.16
Mound C	Disposal	01	D	31.7	5/6/2020	20:22:33	14	1	14.62	>4	>4	2	>4 to 2	18.12	17.15	19.65	No	2.50
Mound C	Disposal	02	A	29.0	5/6/2020	20:01:40	14	1	14.62	>4	>4	2	>4 to 2	17.83	16.79	19.11	No	2.32
Mound C	Disposal	02	C	29.0	5/6/2020	20:03:05	14	1	14.62	>4	>4	2	>4 to 2	18.61	17.88	19.17	No	1.29
Mound C	Disposal	02	D	29.0	5/6/2020	20:03:52	14	1	14.62	>4	>4	2	>4 to 2	18.30	18.02	18.71	No	0.69
Mound C	Disposal	03	E	30.5	5/6/2020	21:37:55	13	0	14.62	>4	>4	3	>4 to 3	15.36	14.48	16.20	No	1.72
Mound C	Disposal	03	F	30.5	5/6/2020	21:38:37	13	0	14.62	>4	>4	3	>4 to 3	18.16	17.32	19.15	No	1.83
Mound C	Disposal	03	G	30.5	5/6/2020	21:39:18	13	0	14.62	>4	>4	3	>4 to 3	17.57	17.01	18.65	No	1.64
Mound C	Disposal	04	A	31.7	5/6/2020	20:15:34	14	1	14.62	>4	>4	3	>4 to 3	20.42	20.24	20.55	No	0.31
Mound C	Disposal	04	E	31.7	5/6/2020	21:28:26	13	0	14.62	>4	>4	2	>4 to 2	18.55	18.15	19.29	No	1.15
Mound C	Disposal	04	G	31.7	5/6/2020	21:30:03	13	0	14.62	>4	>4	2	>4 to 2	17.58	17.16	17.90	No	0.74
Mound C	Disposal	05	C	31.1	5/6/2020	20:10:47	14	1	14.62	>4	>4	3	>4 to 3	18.54	18.25	18.75	No	0.49
Mound C	Disposal	05	E	31.1	5/6/2020	21:33:00	13	0	14.62	>4	>4	2	>4 to 2	18.82	18.43	19.17	No	0.73
Mound C	Disposal	05	G	31.1	5/6/2020	21:34:18	13	0	14.62	>4	>4	3	>4 to 3	19.33	18.95	19.55	No	0.59
Mound C	Disposal	06	D	30.8	5/6/2020	20:35:49	14	1	14.62	>4	>4	2	>4 to 2	20.52	20.31	20.71	No	0.41
Mound C	Disposal	06	E	30.8	5/6/2020	21:21:13	13	0	14.62	>4	>4	2	>4 to 2	18.81	18.15	19.43	No	1.28
Mound C	Disposal	06	G	30.8	5/6/2020	21:22:42	13	0	14.62	>4	>4	2	>4 to 2	18.79	18.61	18.98	No	0.37

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Image Width (cm)	Grain Size Major Mode (phi)	Grain Size Minimum (phi)	Grain Size Maximum (phi)	Grain Size Range (phi)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Over-penetration?	Boundary Roughness (cm)
Mound C	Disposal	07	A	32.6	5/6/2020	20:27:18	14	1	14.62	>4	>4	3	>4 to 3	17.80	17.54	17.99	No	0.45
Mound C	Disposal	07	B	32.6	5/6/2020	20:28:00	14	1	14.62	>4	>4	2	>4 to 2	18.53	17.77	20.04	No	2.27
Mound C	Disposal	07	D	32.6	5/6/2020	20:29:20	14	1	14.62	>4	>4	2	>4 to 2	17.79	17.29	18.41	No	1.12
Mound C	Disposal	08	A	32.3	5/6/2020	20:39:01	14	1	14.62	>4	>4	2	>4 to 2	20.19	20.00	20.57	No	0.57
Mound C	Disposal	08	C	32.3	5/6/2020	20:40:29	14	1	14.62	>4	>4	3	>4 to 3	19.52	19.21	20.09	No	0.88
Mound C	Disposal	08	D	32.3	5/6/2020	20:41:09	14	1	14.62	>4	>4	3	>4 to 3	19.27	18.53	19.90	No	1.37
Mound D	Disposal	09	A	32.9	5/6/2020	22:07:26	13	0	14.62	>4	>4	2	>4 to 2	18.59	18.11	18.96	No	0.86
Mound D	Disposal	09	B	32.9	5/6/2020	22:08:12	13	0	14.62	>4	>4	3	>4 to 3	18.35	18.19	18.76	No	0.58
Mound D	Disposal	09	C	32.9	5/6/2020	22:08:53	13	0	14.62	>4	>4	1	>4 to 1	17.96	17.38	18.32	No	0.95
Mound D	Disposal	10	A	33.6	5/6/2020	22:25:36	13	0	14.62	>4	>4	2	>4 to 2	19.08	17.87	19.90	No	2.03
Mound D	Disposal	10	I	32.3	5/7/2020	2:16:56	10	0	14.62	>4	>4	3	>4 to 3	16.69	16.44	16.83	No	0.39
Mound D	Disposal	10	J	32.3	5/7/2020	2:17:52	10	0	14.62	>4	>4	3	>4 to 3	17.21	15.79	17.88	No	2.09
Mound D	Disposal	11	E	33.9	5/6/2020	23:53:39	11	0	14.62	>4	>4	3	>4 to 3	17.06	16.83	17.37	No	0.54
Mound D	Disposal	11	F	33.9	5/6/2020	23:54:25	11	0	14.62	>4	>4	3	>4 to 3	19.03	18.77	19.26	No	0.49
Mound D	Disposal	11	J	31.7	5/7/2020	2:27:32	10	0	14.62	>4	>4	3	>4 to 3	16.85	16.35	17.21	No	0.86
Mound D	Disposal	12	A	32.9	5/6/2020	22:00:44	13	0	14.62	>4	>4	3	>4 to 3	19.50	19.27	19.80	No	0.53
Mound D	Disposal	12	E	32.9	5/6/2020	23:38:33	11	0	14.62	>4	>4	3	>4 to 3	13.99	13.56	15.25	No	1.69
Mound D	Disposal	12	F	32.9	5/6/2020	23:39:22	11	0	14.62	>4	>4	3	>4 to 3	14.13	13.96	14.27	No	0.31
Mound D	Disposal	13	A	34.2	5/6/2020	22:31:19	13	0	14.62	>4	>4	3	>4 to 3	19.02	18.51	19.59	No	1.08
Mound D	Disposal	13	B	34.2	5/6/2020	22:32:09	13	0	14.62	>4	>4	1	>4 to 1	20.07	19.72	20.41	No	0.68
Mound D	Disposal	13	D	34.2	5/6/2020	22:33:40	13	0	14.62	>4	>4	1	>4 to 1	19.35	18.54	20.62	No	2.08

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Image Width (cm)	Grain Size Major Mode (phi)	Grain Size Minimum (phi)	Grain Size Maximum (phi)	Grain Size Range (phi)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Over-penetration?	Boundary Roughness (cm)
Mound D	Disposal	14	E	34.5	5/6/2020	23:23:32	11	0	14.62	>4	>4	3	>4 to 3	16.80	16.33	17.59	No	1.26
Mound D	Disposal	14	F	34.5	5/6/2020	23:24:22	11	0	14.62	>4	>4	3	>4 to 3	16.63	16.15	17.40	No	1.25
Mound D	Disposal	14	G	34.5	5/6/2020	23:25:13	11	0	14.62	>4	>4	3	>4 to 3	16.07	15.43	16.74	No	1.31
Mound D	Disposal	15	E	33.9	5/6/2020	23:30:49	11	0	14.62	>4	>4	2	>4 to 2	17.85	17.61	18.18	No	0.56
Mound D	Disposal	15	F	33.9	5/6/2020	23:31:36	11	0	14.62	>4	>4	3	>4 to 3	16.85	16.57	17.02	No	0.45
Mound D	Disposal	15	G	33.9	5/6/2020	23:32:44	11	0	14.62	>4	>4	3	>4 to 3	16.00	15.81	16.19	No	0.38
Mound D	Disposal	16	A	32.9	5/6/2020	22:14:00	13	0	14.62	>4	>4	2	>4 to 2	19.63	19.01	20.02	No	1.01
Mound D	Disposal	16	B	32.9	5/6/2020	22:14:43	13	0	14.62	>4	>4	3	>4 to 3	19.87	19.55	20.21	No	0.65
Mound D	Disposal	16	D	32.9	5/6/2020	22:16:09	13	0	14.62	>4	>4	3	>4 to 3	18.42	17.34	19.67	No	2.33
Mound B	Disposal	17	A	32.3	5/7/2020	1:32:57	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	14.16	13.28	14.79	No	1.51
Mound B	Disposal	17	B	32.3	5/7/2020	1:33:59	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	15.74	15.18	16.14	No	0.96
Mound B	Disposal	17	C	32.3	5/7/2020	1:34:58	12	0	14.62	4 to 3/>4	>4	0	>4 to 0	17.44	17.11	17.88	No	0.77
Mound B	Disposal	18	A	34.2	5/7/2020	0:30:27	12	0	14.62	4 to 3/>4	>4	1	>4 to 1	17.14	16.70	17.88	No	1.18
Mound B	Disposal	18	B	34.2	5/7/2020	0:31:33	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	19.92	19.69	20.13	No	0.44
Mound B	Disposal	18	D	34.2	5/7/2020	0:33:36	12	0	14.62	4 to 3/>4	>4	1	>4 to 1	17.85	16.18	18.83	No	2.65
Mound B	Disposal	19	A	30.8	5/7/2020	1:13:17	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	3.04	2.76	3.48	No	0.72
Mound B	Disposal	19	B	30.8	5/7/2020	1:14:25	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	2.49	1.62	2.91	No	1.29
Mound B	Disposal	19	D	30.8	5/7/2020	1:16:27	12	0	14.62	4 to 3/>4	>4	0	>4 to 0	2.27	1.94	2.52	No	0.58
Mound B	Disposal	20	A	33.2	5/7/2020	0:43:21	12	0	14.62	4 to 3/>4	>4	1	>4 to 1	17.66	16.95	17.94	No	0.99
Mound B	Disposal	20	B	33.2	5/7/2020	0:44:22	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	17.12	16.82	17.63	No	0.80
Mound B	Disposal	20	C	33.2	5/7/2020	0:45:21	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	19.06	18.57	19.33	No	0.76
Mound B	Disposal	21	A	32.6	5/7/2020	0:54:05	12	0	14.62	4 to 3/>4	>4	1	>4 to 1	16.61	16.33	16.74	No	0.41
Mound B	Disposal	21	B	32.6	5/7/2020	0:55:07	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	17.91	17.36	18.41	No	1.05
Mound B	Disposal	21	C	32.6	5/7/2020	0:56:07	12	0	14.62	4 to 3/>4	>4	1	>4 to 1	16.70	16.04	17.18	No	1.14

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Image Width (cm)	Grain Size Major Mode (phi)	Grain Size Minimum (phi)	Grain Size Maximum (phi)	Grain Size Range (phi)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Over-penetration?	Boundary Roughness (cm)
Mound B	Disposal	22	A	33.6	5/7/2020	0:20:40	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	15.32	14.55	16.32	No	1.77
Mound B	Disposal	22	B	33.6	5/7/2020	0:21:35	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	19.81	19.13	20.37	No	1.24
Mound B	Disposal	22	D	33.6	5/7/2020	0:23:28	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	18.53	17.96	19.24	No	1.28
Mound B	Disposal	23	A	32.9	5/7/2020	1:02:20	12	0	14.62	4 to 3/>4	>4	0	>4 to 0	12.68	12.37	12.85	No	0.48
Mound B	Disposal	23	B	32.9	5/7/2020	1:03:20	12	0	14.62	4 to 3/>4	>4	1	>4 to 1	10.48	9.84	11.12	No	1.27
Mound B	Disposal	23	C	32.9	5/7/2020	1:04:19	12	0	14.62	4 to 3/>4	>4	0	>4 to 0	12.15	11.76	12.55	No	0.79
Mound B	Disposal	24	A	27.8	5/7/2020	1:24:34	12	0	14.62	3 to 2	>4	-2	>4 to -2	2.86	2.24	3.35	No	1.11
Mound B	Disposal	24	B	27.8	5/7/2020	1:25:31	12	0	14.62	4 to 3	>4	2	>4 to 2	1.89	1.41	2.21	No	0.80
Mound B	Disposal	24	C	27.8	5/7/2020	1:26:27	12	0	14.62	4 to 3	>4	1	>4 to 1	2.73	1.53	3.24	No	1.71
CCBRS	Reference	25	A	38.1	5/7/2020	6:16:58	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	17.85	16.59	18.99	No	2.40
CCBRS	Reference	25	B	38.1	5/7/2020	6:17:55	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	17.74	16.98	18.29	No	1.32
CCBRS	Reference	25	D	38.1	5/7/2020	6:19:51	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	15.77	14.70	16.14	No	1.44
CCBRS	Reference	26	A	37.8	5/7/2020	5:46:58	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	16.56	16.22	17.19	No	0.97
CCBRS	Reference	26	B	37.8	5/7/2020	5:47:58	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	18.26	17.21	19.01	No	1.80
CCBRS	Reference	26	D	37.8	5/7/2020	5:49:55	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	16.13	15.31	16.92	No	1.61
CCBRS	Reference	27	A	37.8	5/7/2020	5:55:45	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	17.99	17.29	18.31	No	1.02
CCBRS	Reference	27	B	37.8	5/7/2020	5:56:42	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	18.74	18.45	18.97	No	0.52
CCBRS	Reference	27	D	37.8	5/7/2020	5:58:39	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	11.43	11.12	11.72	No	0.60
CCBRS	Reference	28	A	38.4	5/7/2020	6:06:35	12	0	14.62	4 to 3/>4	>4	3	>4 to 3	14.65	14.19	15.52	No	1.33
CCBRS	Reference	28	B	38.4	5/7/2020	6:07:33	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	18.82	18.45	19.24	No	0.78
CCBRS	Reference	28	D	38.4	5/7/2020	6:09:29	12	0	14.62	4 to 3/>4	>4	2	>4 to 2	16.27	15.62	16.78	No	1.17
NWREF	Reference	29	E	33.9	5/7/2020	5:04:18	11	0	14.62	4 to 3/>4	>4	3	>4 to 3	18.89	18.37	19.24	No	0.88
NWREF	Reference	29	F	33.9	5/7/2020	5:05:23	11	0	14.62	4 to 3/>4	>4	2	>4 to 2	14.48	13.87	15.27	No	1.40
NWREF	Reference	29	H	33.9	5/7/2020	5:07:20	11	0	14.62	4 to 3/>4	>4	3	>4 to 3	12.98	11.59	13.59	No	2.00
NWREF	Reference	30	F	33.9	5/7/2020	4:47:17	11	0	14.62	4 to 3/>4	>4	3	>4 to 3	11.91	11.42	12.68	No	1.26
NWREF	Reference	30	G	33.9	5/7/2020	4:48:12	11	0	14.62	4 to 3/>4	>4	2	>4 to 2	15.64	15.38	15.85	No	0.48

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Image Width (cm)	Grain Size Major Mode (phi)	Grain Size Minimum (phi)	Grain Size Maximum (phi)	Grain Size Range (phi)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Over-penetration?	Boundary Roughness (cm)
NWREF	Reference	30	H	33.9	5/7/2020	4:49:06	11	0	14.62	4 to 3/>4	>4	3	>4 to 3	13.00	12.36	13.48	No	1.12
NWREF	Reference	31	A	35.1	5/7/2020	3:15:33	14	0	14.62	4 to 3/>4	>4	3	>4 to 3	18.48	17.87	19.30	No	1.43
NWREF	Reference	31	E	33.9	5/7/2020	4:54:45	11	0	14.62	4 to 3/>4	>4	3	>4 to 3	12.71	12.34	12.93	No	0.58
NWREF	Reference	31	G	33.9	5/7/2020	4:56:43	11	0	14.62	4 to 3/>4	>4	3	>4 to 3	15.41	14.67	16.21	No	1.53
NWREF	Reference	32	D	35.1	5/7/2020	3:40:28	14	0	14.62	4 to 3/>4	>4	2	>4 to 2	17.15	15.79	18.72	No	2.93
NWREF	Reference	32	E	33.9	5/7/2020	5:11:58	11	0	14.62	4 to 3/>4	>4	2	>4 to 2	14.45	14.00	14.84	No	0.84
NWREF	Reference	32	G	33.9	5/7/2020	5:13:52	11	0	14.62	4 to 3/>4	>4	2	>4 to 2	10.95	10.54	11.73	No	1.19
SWREF	Reference	33	A	30.5	5/6/2020	18:58:11	14	2	14.62	4 to 3/>4	>4	2	>4 to 2	18.70	17.84	19.85	No	2.01
SWREF	Reference	33	C	30.5	5/6/2020	18:59:38	14	2	14.62	>4	>4	2	>4 to 2	17.08	16.29	17.46	No	1.17
SWREF	Reference	33	D	30.5	5/6/2020	19:00:17	14	2	14.62	4 to 3/>4	>4	2	>4 to 2	17.94	17.41	18.26	No	0.86
SWREF	Reference	34	B	30.8	5/6/2020	19:06:53	14	2	14.62	>4	>4	2	>4 to 2	17.75	16.38	18.92	No	2.54
SWREF	Reference	34	C	30.8	5/6/2020	19:07:31	14	2	14.62	>4	>4	2	>4 to 2	17.67	17.17	18.92	No	1.75
SWREF	Reference	34	D	30.8	5/6/2020	19:08:10	14	2	14.62	>4	>4	2	>4 to 2	18.12	17.72	18.42	No	0.70
SWREF	Reference	35	A	30.2	5/6/2020	18:48:59	14	2	14.62	4 to 3/>4	>4	1	>4 to 1	19.92	19.53	20.48	No	0.94
SWREF	Reference	35	B	30.2	5/6/2020	18:49:45	14	2	14.62	>4	>4	1	>4 to 1	17.71	16.49	19.06	No	2.57
SWREF	Reference	35	C	30.2	5/6/2020	18:50:28	14	2	14.62	>4	>4	2	>4 to 2	16.93	16.17	17.47	No	1.30
SWREF	Reference	36	A	30.8	5/6/2020	19:12:43	14	2	14.62	4 to 3/>4	>4	3	>4 to 3	18.79	18.11	19.31	No	1.19
SWREF	Reference	36	B	30.8	5/6/2020	19:13:24	14	2	14.62	4 to 3/>4	>4	2	>4 to 2	14.88	14.33	15.45	No	1.12
SWREF	Reference	36	C	30.8	5/6/2020	19:14:07	14	2	14.62	4 to 3/>4	>4	2	>4 to 2	18.77	16.98	19.96	No	2.98

StationID	Replicate	Boundary Roughness Type	aRPD Mean (cm)	aRPD > Pen	Mud Clast Number	Mud Clast State	Dredged Material Present?	Dredged Material Layer Mean Thickness (cm)	Dredged Material Layer Minimum Thickness (cm)	Dredged Material Layer Maximum Thickness (cm)	Mean Dredged Material Depth (cm)	Buried Dredged Material?	Dredged Material > Pen
01	A	Biological	2.50	No	0	None	Yes	16.03	15.62	16.36	0.00	No	Yes
01	C	Biological	3.10	No	0	None	Yes	17.37	16.64	17.80	0.00	No	Yes
01	D	Biological	1.56	No	0	None	Yes	18.12	17.15	19.65	0.00	No	Yes
02	A	Biological	3.31	No	0	None	Yes	17.83	16.79	19.11	0.00	No	Yes
02	C	Biological	2.75	No	1	Reduced	Yes	18.61	17.88	19.17	0.00	No	Yes
02	D	Biological	2.26	No	0	None	Yes	18.30	18.02	18.71	0.00	No	Yes
03	E	Biological	2.90	No	0	None	Yes	15.36	14.48	16.20	0.00	No	Yes
03	F	Biological	2.54	No	0	None	Yes	18.16	17.32	19.15	0.00	No	Yes
03	G	Biological	1.97	No	0	None	Yes	17.57	17.01	18.65	0.00	No	Yes
04	A	Biological	3.07	No	0	None	Yes	20.42	20.24	20.55	0.00	No	Yes
04	E	Biological	4.08	No	0	None	Yes	18.55	18.15	19.29	0.00	No	Yes
04	G	Biological	3.86	No	2	Reduced	Yes	17.58	17.16	17.90	0.00	No	Yes
05	C	Biological	2.67	No	0	None	Yes	18.54	18.25	18.75	0.00	No	Yes
05	E	Biological	2.90	No	0	None	Yes	18.82	18.43	19.17	0.00	No	Yes
05	G	Biological	3.62	No	0	None	Yes	19.33	18.95	19.55	0.00	No	Yes
06	D	Biological	4.23	No	0	None	Yes	20.52	20.31	20.71	0.00	No	Yes
06	E	Biological	3.65	No	0	None	Yes	18.81	18.15	19.43	0.00	No	Yes
06	G	Biological	3.17	No	0	None	Yes	18.79	18.61	18.98	0.00	No	Yes

StationID	Replicate	Boundary Roughness Type	aRPD Mean (cm)	aRPD > Pen	Mud Clast Number	Mud Clast State	Dredged Material Present?	Dredged Material Layer Mean Thickness (cm)	Dredged Material Layer Minimum Thickness (cm)	Dredged Material Layer Maximum Thickness (cm)	Mean Dredged Material Depth (cm)	Buried Dredged Material?	Dredged Material > Pen
07	A	Biological	3.78	No	0	None	Yes	17.80	17.54	17.99	0.00	No	Yes
07	B	Biological	2.87	No	0	None	Yes	18.53	17.77	20.04	0.00	No	Yes
07	D	Biological	1.86	No	0	None	Yes	17.79	17.29	18.41	0.00	No	Yes
08	A	Physical/Biological	2.38	No	0	None	Yes	20.19	20.00	20.57	0.00	No	Yes
08	C	Biological	2.61	No	1	Reduced	Yes	19.52	19.21	20.09	0.00	No	Yes
08	D	Physical/Biological	3.14	No	0	None	Yes	19.27	18.53	19.90	0.00	No	Yes
09	A	Biological	1.56	No	0	None	Yes	18.59	18.11	18.96	0.00	No	Yes
09	B	Biological	1.90	No	0	None	Yes	18.35	18.19	18.76	0.00	No	Yes
09	C	Biological	2.04	No	0	None	Yes	17.96	17.38	18.32	0.00	No	Yes
10	A	Biological	1.61	No	0	None	Yes	19.08	17.87	19.90	0.00	No	Yes
10	I	Biological	1.42	No	0	None	Yes	16.69	16.44	16.83	0.00	No	Yes
10	J	Biological	1.41	No	0	None	Yes	17.21	15.79	17.88	0.00	No	Yes
11	E	Biological	2.29	No	0	None	Yes	17.06	16.83	17.37	0.00	No	Yes
11	F	Biological	1.59	No	0	None	Yes	19.03	18.77	19.26	0.00	No	Yes
11	J	Biological	2.28	No	0	None	Yes	16.85	16.35	17.21	0.00	No	Yes
12	A	Biological	1.78	No	0	None	Yes	19.50	19.27	19.80	0.00	No	Yes
12	E	Biological	1.15	No	0	None	Yes	13.99	13.56	15.25	0.00	No	Yes
12	F	Biological	1.94	No	0	None	Yes	14.13	13.96	14.27	0.00	No	Yes
13	A	Biological	2.34	No	0	None	Yes	19.02	18.51	19.59	0.00	No	Yes
13	B	Biological	3.37	No	0	None	Yes	20.07	19.72	20.41	0.00	No	Yes
13	D	Biological	1.45	No	0	None	Yes	19.35	18.54	20.62	0.00	No	Yes

StationID	Replicate	Boundary Roughness Type	aRPD Mean (cm)	aRPD > Pen	Mud Clast Number	Mud Clast State	Dredged Material Present?	Dredged Material Layer Mean Thickness (cm)	Dredged Material Layer Minimum Thickness (cm)	Dredged Material Layer Maximum Thickness (cm)	Mean Dredged Material Depth (cm)	Buried Dredged Material?	Dredged Material > Pen
14	E	Biological	1.00	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
14	F	Biological	2.39	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
14	G	Biological	1.89	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
15	E	Biological	3.95	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
15	F	Biological	1.74	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
15	G	Biological	3.06	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
16	A	Biological	1.69	No	0	None	Yes	19.63	19.01	20.02	0.00	No	No
16	B	Biological	2.39	No	0	None	Yes	19.87	19.55	20.21	0.00	No	Yes
16	D	Biological	1.52	No	0	None	Yes	18.42	17.34	19.67	0.00	No	Yes
17	A	Biological	3.54	No	0	None	Yes	14.16	13.28	14.79	0.00	Yes	Yes
17	B	Biological	3.42	No	0	None	Yes	15.74	15.18	16.14	0.00	Yes	Yes
17	C	Biological	2.33	No	0	None	Yes	17.44	17.11	17.88	0.00	Yes	Yes
18	A	Biological	4.80	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
18	B	Biological	2.12	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
18	D	Biological	2.75	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
19	A	Biological	IND	No	0	None	IND	IND	IND	IND	IND	IND	No
19	B	Biological	IND	No	0	None	IND	IND	IND	IND	IND	IND	No
19	D	Biological	IND	No	0	None	IND	IND	IND	IND	IND	IND	No
20	A	Biological	3.46	No	0	None	Yes	17.66	16.95	17.94	0.00	Yes	Yes
20	B	Biological	3.52	No	0	None	Yes	17.12	16.82	17.63	0.00	Yes	Yes
20	C	Biological	3.47	No	0	None	Yes	19.06	18.57	19.33	0.00	Yes	Yes
21	A	Biological	4.08	No	0	None	Yes	16.61	16.33	16.74	0.00	Yes	Yes
21	B	Biological	3.15	No	0	None	Yes	17.91	17.36	18.41	0.00	Yes	Yes
21	C	Biological	2.76	No	0	None	Yes	16.70	16.04	17.18	0.00	Yes	Yes

StationID	Replicate	Boundary Roughness Type	aRPD Mean (cm)	aRPD > Pen	Mud Clast Number	Mud Clast State	Dredged Material Present?	Dredged Material Layer Mean Thickness (cm)	Dredged Material Layer Minimum Thickness (cm)	Dredged Material Layer Maximum Thickness (cm)	Mean Dredged Material Depth (cm)	Buried Dredged Material?	Dredged Material > Pen
22	A	Physical/Biological	1.85	No	0	None	Yes	15.32	14.55	16.32	0.00	Yes	Yes
22	B	Biological	2.03	No	0	None	Yes	19.81	19.13	20.37	0.00	Yes	Yes
22	D	Biological	1.42	No	0	None	Yes	18.53	17.96	19.24	0.00	Yes	Yes
23	A	Biological	3.18	No	0	None	Yes	12.68	12.37	12.85	0.00	Yes	Yes
23	B	Biological	2.58	No	0	None	Yes	10.48	9.84	11.12	0.00	Yes	Yes
23	C	Biological	3.01	No	0	None	Yes	12.15	11.76	12.55	0.00	Yes	Yes
24	A	Physical/Biological	IND	No	0	None	IND	IND	IND	IND	IND	IND	No
24	B	Biological	IND	Yes	0	None	IND	IND	IND	IND	IND	IND	No
24	C	Biological	1.08	No	0	None	IND	IND	IND	IND	IND	IND	No
25	A	Biological	3.55	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
25	B	Biological	3.23	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
25	D	Biological	2.99	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
26	A	Biological	2.95	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
26	B	Biological	2.33	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
26	D	Biological	2.44	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
27	A	Biological	3.44	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
27	B	Biological	3.03	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
27	D	Biological	IND	No	2	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
28	A	Physical/Biological	2.91	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
28	B	Biological	2.06	No	1	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
28	D	Biological	1.82	No	3	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
29	E	Biological	4.33	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
29	F	Biological	3.79	No	1	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
29	H	Biological	2.76	No	2	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
30	F	Biological	2.97	No	1	Reduced/Oxidized	No	N/A	N/A	N/A	N/A	N/A	No
30	G	Biological	3.48	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No

StationID	Replicate	Boundary Roughness Type	aRPD Mean (cm)	aRPD > Pen	Mud Clast Number	Mud Clast State	Dredged Material Present?	Dredged Material Layer Mean Thickness (cm)	Dredged Material Layer Minimum Thickness (cm)	Dredged Material Layer Maximum Thickness (cm)	Mean Dredged Material Depth (cm)	Buried Dredged Material?	Dredged Material > Pen
30	H	Physical/Biological	3.14	No	3	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
31	A	Biological	3.41	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
31	E	Biological	3.84	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
31	G	Biological	2.46	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
32	D	Biological	2.50	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
32	E	Biological	1.74	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
32	G	Physical/Biological	2.13	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
33	A	Biological	1.28	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
33	C	Physical/Biological	1.93	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
33	D	Biological	1.85	No	1	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
34	B	Biological	3.18	No	2	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
34	C	Physical/Biological	2.86	No	4	Reduced/Oxidized	No	N/A	N/A	N/A	N/A	N/A	No
34	D	Physical/Biological	2.15	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
35	A	Biological	4.33	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
35	B	Physical/Biological	3.33	No	1	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
35	C	Physical/Biological	3.46	No	1	Reduced	No	N/A	N/A	N/A	N/A	N/A	No
36	A	Biological	3.88	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
36	B	Biological	1.68	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No
36	C	Physical/Biological	3.71	No	0	None	No	N/A	N/A	N/A	N/A	N/A	No

StationID	Replicate	Dredged Material Notes	Methane Present?	Low DO Present?	Sediment Oxygen Demand	Beggiatoa Present?	Beggiatoa Type/Extent	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)
01	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	1	8.19	8.77
01	C	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
01	D	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
02	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	2	8.24	12.41
02	C	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Some light clay visible at depth.	No	No	Medium	No	None	1	12.39	14.47
02	D	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Light clay visible in streak from SWI to depth in portion of image.	No	No	Medium	No	None	0	N/A	N/A
03	E	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
03	F	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
03	G	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Right side of image in reduced sediment contains what appears to be a patch of red clay.	No	No	Medium	No	None	0	N/A	N/A
04	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
04	E	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Small patches of white clay visible in the reduced layer of sediment.	No	No	Medium	No	None	0	N/A	N/A
04	G	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. A few patches at aRPD boundary appear to possibly have wood bits intermixed with sediment.	No	No	Medium	No	None	0	N/A	N/A
05	C	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Small patches of white clay visible in the reduced layer of sediment.	No	No	Medium	No	None	0	N/A	N/A
05	E	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Small patches of white clay visible in the reduced layer of sediment. Possible small bits of wood scattered about sediment column with a concentration near aRPD boundary.	No	No	Medium	No	None	0	N/A	N/A
05	G	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Small patches of white clay visible in the reduced layer of sediment. Possible small bits of wood scattered about sediment column with a concentration near aRPD boundary.	No	No	Medium	No	None	0	N/A	N/A
06	D	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
06	E	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
06	G	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Different optical reflectance and texture to sediment in lower right quadrant of image.	No	No	Medium	No	None	0	N/A	N/A

StationID	Replicate	Dredged Material Notes	Methane Present?	Low DO Present?	Sediment Oxygen Demand	Beggiatoa Present?	Beggiatoa Type/Extent	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)
07	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	3	1.40	11.06
07	B	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
07	D	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	1	2.88	3.22
08	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
08	C	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	1	8.14	9.85
08	D	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
09	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Reduced layer is patchy with varying sediments, particularly a patch of white clay.	No	No	Medium	No	None	0	N/A	N/A
09	B	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Reduced layer is patchy with varying sediments, particularly a patch of white clay.	No	No	Medium	No	None	0	N/A	N/A
09	C	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Reduced layer is patchy with varying sediments, particularly a patch of white clay.	No	No	Medium	No	None	0	N/A	N/A
10	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Reduced layer is patchy with varying sediments, particularly a small patch of white clay.	No	No	Medium	No	None	0	N/A	N/A
10	I	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Reduced layer has some layering within, likely old disposals.	No	No	Medium	No	None	0	N/A	N/A
10	J	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Reduced layer has some layering within, likely old disposals.	No	No	Medium	No	None	0	N/A	N/A
11	E	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
11	F	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	1	4.41	5.42
11	J	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
12	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
12	E	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
12	F	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
13	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
13	B	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
13	D	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A

StationID	Replicate	Dredged Material Notes	Methane Present?	Low DO Present?	Sediment Oxygen Demand	Beggiatoa Present?	Beggiatoa Type/Extent	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)
14	E		No	No	Medium	No	None	0	N/A	N/A
14	F		No	No	Medium	No	None	0	N/A	N/A
14	G		No	No	Medium	No	None	1	4.08	5.90
15	E		No	No	Medium	No	None	0	N/A	N/A
15	F		No	No	Medium	No	None	0	N/A	N/A
15	G		No	No	Medium	No	None	0	N/A	N/A
16	A	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. Small patch of white clay at depth.	No	No	Medium	No	None	0	N/A	N/A
16	B	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced.	No	No	Medium	No	None	0	N/A	N/A
16	D	Entire visible sediment column appears to be dredged material based on higher organic load than reference stations. Upper layer has been reworked and oxygen introduced. A patch of white clay has been dragged from near aRPD boundary to depth.	No	No	Medium	No	None	0	N/A	N/A
17	A	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Medium	No	None	1	5.86	5.97
17	B	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment and a small patch of white clay.	No	No	Medium	No	None	2	4.69	7.85
17	C	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Medium	No	None	0	N/A	N/A
18	A		No	No	Low	No	None	0	N/A	N/A
18	B		No	No	Low	No	None	1	12.54	13.24
18	D		No	No	Low	No	None	0	N/A	N/A
19	A		No	No	Low	No	None	0	N/A	N/A
19	B		No	No	Low	No	None	0	N/A	N/A
19	D		No	No	Low	No	None	0	N/A	N/A
20	A	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Low	No	None	2	13.16	15.49
20	B	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Low	No	None	0	N/A	N/A
20	C	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Low	No	None	0	N/A	N/A
21	A	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Low	No	None	1	14.87	15.10
21	B	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment and a small patch of white clay.	No	No	Low	No	None	0	N/A	N/A
21	C	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment and a small patch of white clay.	No	No	Low	No	None	1	16.08	16.63

StationID	Replicate	Dredged Material Notes	Methane Present?	Low DO Present?	Sediment Oxygen Demand	Beggiatoa Present?	Beggiatoa Type/Extent	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)
22	A	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Medium	No	None	0	N/A	N/A
22	B	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Medium	No	None	0	N/A	N/A
22	D	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment.	No	No	Medium	No	None	0	N/A	N/A
23	A	Sparse, heavily reworked dredged material at depth visible as patches of highly reduced sediment and a small patch of white clay.	No	No	Low	No	None	0	N/A	N/A
23	B	Sparse, heavily reworked dredged material at depth visible as a patch of highly reduced sediment.	No	No	Medium	No	None	1	4.97	6.24
23	C	Sparse, heavily reworked dredged material at depth visible as a patch of highly reduced sediment.	No	No	Low	No	None	0	N/A	N/A
24	A		No	No	Low	No	None	0	N/A	N/A
24	B		No	No	Low	No	None	0	N/A	N/A
24	C		No	No	Low	No	None	0	N/A	N/A
25	A		No	No	Low	No	None	0	N/A	N/A
25	B		No	No	Low	No	None	3	12.34	14.97
25	D		No	No	Low	No	None	4	9.58	15.76
26	A		No	No	Low	No	None	0	N/A	N/A
26	B		No	No	Low	No	None	0	N/A	N/A
26	D		No	No	Low	No	None	0	N/A	N/A
27	A		No	No	Low	No	None	0	N/A	N/A
27	B		No	No	Low	No	None	1	16.43	17.04
27	D		No	No	Low	No	None	0	N/A	N/A
28	A		No	No	Low	No	None	0	N/A	N/A
28	B		No	No	Low	No	None	0	N/A	N/A
28	D		No	No	Low	No	None	1	5.93	6.67
29	E		No	No	Low	No	None	1	16.18	17.65
29	F		No	No	Low	No	None	1	6.39	7.92
29	H		No	No	Low	No	None	1	6.01	6.84
30	F		No	No	Low	No	None	0	N/A	N/A
30	G		No	No	Low	No	None	1	8.90	9.63

StationID	Replicate	Dredged Material Notes	Methane Present?	Low DO Present?	Sediment Oxygen Demand	Beggiatoa Present?	Beggiatoa Type/Extent	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)
30	H		No	No	Low	No	None	1	10.40	11.20
31	A		No	No	Low	No	None	0	N/A	N/A
31	E		No	No	Low	No	None	0	N/A	N/A
31	G		No	No	Low	No	None	0	N/A	N/A
32	D		No	No	Low	No	None	1	14.60	16.55
32	E		No	No	Low	No	None	0	N/A	N/A
32	G		No	No	Low	No	None	1	6.23	7.88
33	A		No	No	Low	No	None	0	N/A	N/A
33	C		No	No	Low	No	None	0	N/A	N/A
33	D		No	No	Low	No	None	0	N/A	N/A
34	B		No	No	Low	No	None	0	N/A	N/A
34	C		No	No	Low	No	None	2	8.29	10.06
34	D		No	No	Low	No	None	1	5.51	8.40
35	A		No	No	Low	No	None	2	12.13	14.57
35	B		No	No	Low	No	None	2	4.23	7.50
35	C		No	No	Low	No	None	1	4.28	4.54
36	A		No	No	Low	No	None	1	15.95	16.28
36	B		No	No	Medium	No	None	0	N/A	N/A
36	C		No	No	Medium	No	None	2	6.28	9.10

StationID	Replicate	Successional Stage	Comment
01	A	2 on 3	Silt/clay dredged material reworked at SWI but still high organic load from aRPD boundary to depth. Stage 2 tubes at SWI, many burrows highlighted by oxygenated sediment in reduced sediment and an infilled void beneath aRPD boundary.
01	C	2	Silt/clay dredged material reworked at SWI but still high organic load from aRPD boundary to depth. Stage 2 tubes at SWI, and a large burrow beginning at SWI and bringing oxygenated sediment all the way beyond camera penetration. Also many burrows highlighted by oxygenated sediment in reduced sediment and some visible worms in burrows..
01	D	2	Silt/clay dredged material reworked in upper centimeters. Stage 2 tubes at SWI. High organic loading beneath reworked layer. Visible worms in burrows beyond aRPD boundary.
02	A	1 on 3	Silt/clay dredged material reworked in upper centimeters. Stage 1 tubes at SWI with a very large, open void and an infilled void beneath aRPD boundary.
02	C	1 on 3	Silt/clay dredged material with some reduced material at SWI. White clay also visible within reduced layer. Stage 1 tubes at SWI with dredged material reworked in upper centimeters. Large, partially infilled burrow at depth.
02	D	2	Silt/clay dredged material that has been reworked near SWI. Stage 2 tubes and amphipod structures at SWI. Burrows and worms in burrows visible in reduced portion of sediment column beneath aRPD boundary.
03	E	2	Silt/clay dredged material that has been reworked near SWI. Stage 2 tubes at SWI and burrows visible moving beyond aRPD boundary.
03	F	2	Silt/clay dredged material that has been reworked near SWI. Stage 2 tubes and amphipod structures at SWI. Burrows and worms in burrows visible in reduced portion of sediment column beneath aRPD boundary.
03	G	2	Silt/clay dredged material that has been reworked near SWI. Stage 1 and 2 tubes at SWI and many burrows/worms in burrows throughout sediment column. A patch of red clay within the reduced layer of sediment to the right of image.
04	A	2 -> 3	Silt/clay dredged material that has been reworked near SWI. Stage 2 tubes and amphipod structures at SWI. Burrows and worms in burrows visible in reduced portion of sediment column beneath aRPD boundary.
04	E	2	Silt/clay dredged material that has been reworked in upper centimeters of sediment. Stage 2 and 1 tubes at SWI and burrows visible throughout sediment column.
04	G	2	Silt/clay dredged material that has been reworked in upper centimeters of sediment. Angular, reduced mud clasts at SWI an artifact of previous camera replicate. Possible wood bits intermixed in sediment at aRPD boundary.
05	C	2	Silt/clay dredged material that has been reworked in upper centimeters of sediment. Stage 1 tubes at SWI and burrows moving beyond aRPD boundary in to reduced sediment. Small patches of white clay also visible in reduced sediment.
05	E	2	Silt/clay dredged material that has been reworked in upper centimeters of sediment. Stage 2 and 1 tubes at SWI and burrows visible throughout sediment column. White clay and possible wood bits in sediment column.
05	G	2	Silt/clay dredged material that has been reworked in upper centimeters of sediment. Stage 2 and 1 tubes at SWI and burrows, many with worms visible, throughout sediment column. White clay and possible wood bits in sediment column.
06	D	2 -> 3	Silt/clay dredged material that has been reworked. Some layering at depth, possible relic layers of material. Visible burrows, some with worms, moving beyond aRPD boundary.
06	E	2	Silt/clay dredged material that has been reworked at SWI. Stage 2 tubes at SWI and worms in burrows visible.
06	G	2	Silt/clay dredged material reworked near SWI. Stage 2 and 1 tubes at SWI. Burrows bringing oxygen beyond aRPD boundary. Possible large mud/clay patch in right of reduced layer of sediment.

StationID	Replicate	Successional Stage	Comment
07	A	2 on 3	Silt/clay dredged material reworked in upper centimeters of sediment. Stage 2 tubes at SWI. Partially infilled void just beneath SWI. An infilled void and an open void in reduced sediment. Many burrows visible moving oxygenated sediment beyond aRPD boundary.
07	B	2	Silt/clay dredged material reworked in upper centimeters of sediment. Stage 2 and 1 tubes at SWI. Open burrow near aRPD boundary. Burrows bringing oxygenated sediment in to reduced sediment layer.
07	D	2 on 3	Silt/clay dredged material partially reworked near SWI. Stage 2 tubes at SWI and a partially infilled void at aRPD boundary. Many burrows in reduced sediment visible by oxygenated sediment.
08	A	2 -> 3	Silt/clay dredged material with some reworking in upper centimeters. Stage 1 tubes at SWI. Stage 2 amphipod structure also visible at SWI. Burrows visible beyond aRPD boundary by oxygenated sediment.
08	C	2 on 3	Silt/clay dredged material with Stage 2 tubes and amphipod structures at SWI. Reworking of material in upper centimeters, worms visible in burrows, burrows visible in reduced sediment layer, and an infilled void beneath aRPD boundary.
08	D	2	Silt/clay dredged material with some reduced material at SWI but also clear evidence of reworking near SWI. Many Stage 2 tubes at SWI.
09	A	2 -> 3	Silt/clay dredged material slightly reworked at sediment surface. At depth, a variety of sediment types appear to be present, with patches of varying reflectance, a patch of white clay most obvious.
09	B	2 -> 3	Silt/clay dredged material slightly reworked at sediment surface. At depth, a variety of sediment types appear to be present, with patches of varying reflectance, a patch of white clay most obvious. Many small burrows, a few with visible worms present throughout sediment column.
09	C	2 -> 3	Silt/clay dredged material slightly reworked at sediment surface. At depth, a variety of sediment types appear to be present, with patches of varying reflectance, a patch of white clay most obvious. Stage 2 tubes at SWI.
10	A	2 -> 3	Silt/clay dredged material slightly reworked at sediment surface. A Stage 2 tube and small, Stage 1 tubes at SWI. Some burrowing visible in sediment.
10	I	2	Silt/clay dredged material slightly reworked at sediment surface. Stage 2 tubes at SWI and burrows visible through oxygenated sediment in the reduced layer.
10	J	2	Silt/clay dredged material slightly reworked at sediment surface. Stage 2 tube at SWI and burrows visible through oxygenated sediment in the reduced layer.
11	E	2	Silt/clay dredged material slightly reworked at sediment surface. Stage 1 and 2 tubes at SWI.
11	F	1 on 3	Silt/clay dredged material slightly reworked at sediment surface. An infilled void right at aRPD boundary.
11	J	2	Silt/clay dredged material slightly reworked at sediment surface. Stage 2 tubes at SWI.
12	A	2 -> 3	Silt/clay dredged material slightly reworked at sediment surface. Stage 1 tubes at SWI and evidence of burrowing beyond aRPD boundary visible in oxygenated sediment within the reduced layer.
12	E	2	Silt/clay dredged material slightly reworked at sediment surface. Evidence of burrowing throughout sediment, visible as oxygenated sediment in reduced layer. Stage 1 tubes at SWI.
12	F	2	Silt/clay dredged material slightly reworked at sediment surface. Evidence of burrowing throughout sediment, visible as oxygenated sediment in reduced layer. Stage 1 and 2 tubes at SWI.
13	A	2 -> 3	Silt/clay dredged material slightly reworked at the sediment surface. Oxygenated sediments in the reduced layer evidence of burrowing. Stage 1 tubes at SWI.
13	B	2	Silt/clay dredged material slightly reworked at the sediment surface. Oxygenated sediments in the reduced layer evidence of burrowing. Stage 1 tubes at SWI.
13	D	2	Silt/clay dredged material slightly reworked at the sediment surface, with some reduced sediment still at SWI. Oxygenated sediments in the reduced layer evidence of burrowing. Stage 1 and Stage 2 tubes at SWI.

StationID	Replicate	Successional Stage	Comment
14	E	2	Silt/clay dredged material slightly reworked at SWI with relic layers at depth. Stage 2 tubes at SWI.
14	F	2	Silt/clay dredged material slightly reworked at SWI with relic layers at depth. Stage 2 tube at SWI and burrowing beyond aRPD boundary present.
14	G	2 on 3	Silt/clay dredged material slightly reworked at SWI with relic layers at depth. Stage 2 tubes at SWI and burrowing beyond aRPD boundary present. Infilled burrow at SWI moving to infilled void at aRPD boundary
15	E	2	Many Stage 2 tubes at SWI and burrows visible beyond aRPD boundary.
15	F	2	Burrowing beyond aRPD boundary present.
15	G	2	Stage 2 tubes at SWI. Burrowing evident throughout sediment column. Dark specks near and below aRPD boundary possibly wood, some kind of organic decomposition.
16	A	2 -> 3	Silt/clay dredged material reworked near SWI. Many Stage 1 tubes at SWI and a Stage 2 tube also present. Burrowing evident throughout sediment column.
16	B	2	Silt/clay dredged material reworked in upper centimeters but also with some reduced sediment at SWI. Stage 1 tubes at SWI. Burrowing evident throughout sediment column. Dark specks near and below aRPD boundary possibly wood, some kind of organic decomposition.
16	D	2	Silt/clay dredged material reworked near SWI. Many Stage 1 tubes at SWI and a Stage 2 tube also present. Burrowing evident throughout sediment column. A patch of white clay near aRPD boundary has been dragged down to depth from camera penetration.
17	A	2 on 3	Very fine sand over silt/clay that is likely highly reworked dredged material with no discernable layer. Stage 2 tubes at SWI and a collapsed void just beneath aRPD boundary.
17	B	2 on 3	Very fine sand over silt/clay that is likely highly reworked dredged material with no discernable layer. Stage 2 tubes at SWI, an infilled void near aRPD with associated burrow visible beginning at SWI, and a partially infilled void just beneath aRPD boundary.
17	C	2	Very fine sand over silt/clay that is likely highly reworked dredged material with no discernible layer. Many Stage 2 tubes at SWI and evidence of burrowing.
18	A	2 -> 3	Very fine sand over silt/clay. Amphipod structure at SWI. Burrows evident moving oxygenated sediment down in to the reduced sediment.
18	B	2 on 3	Very fine sand over silt/clay. Amphipod structure and Stage 2 tubes at SWI. Infilled void in reduced sediment at left of image. Visible worms in burrows above aRPD boundary and burrows moving sediment beyond aRPD boundary.
18	D	2 -> 3	Very fine sand over silt/clay. Stage 2 tubes at SWI. Burrows above aRPD boundary and burrows moving sediment beyond aRPD boundary.
19	A	2 -> 3	A thin layer of very fine sand over silt/clay with shallow penetration. Visible sediment has many burrows. Stage 2 tubes in background of image at SWI and aRPD not able to be determined.
19	B	2 -> 3	A thin layer of very fine sand over silt/clay with shallow penetration. Visible sediment has many burrows. Stage 2 tubes in background of image at SWI and aRPD not able to be determined.
19	D	2	A thin layer of very fine sand over silt/clay with shallow penetration. Visible sediment has many burrows. aRPD not able to be determined.
20	A	2 on 3	Very fine sand over silt/clay. Many Stage 2 tubes at SWI, visible worms in burrows throughout sediment column, and patches of highly reduced sediment at depth likely to be DM. A pair of infilled voids at depth.
20	B	2 -> 3	Very fine sand over silt/clay. Stage 1 and 2 tubes at SWI and burrowing throughout sediment column. A few reduced patches at depth likely old DM.
20	C	2	Very fine sand over silt/clay. Stage 1 and 2 tubes at SWI and burrowing throughout sediment column. A few reduced patches at depth likely old DM.
21	A	2 on 3	Very fine sand over silt/clay. Stage 2 tubes and amphipod structure at SWI. Burrowing evident throughout sediment column. A partially collapsed void at depth. Patches of highly reduced material at depth likely DM.
21	B	2	Very fine sand over silt/clay. Stage 2 tubes and amphipod structure at SWI. Burrowing evident throughout sediment column. Patches of highly reduced material and white clay at depth likely DM.
21	C	2 on 3	Very fine sand over silt/clay. Stage 2 tubes and amphipod structure at SWI. Burrowing evident throughout sediment column. Patches of highly reduced material and white clay at depth likely DM. An infilled void at depth.

StationID	Replicate	Successional Stage	Comment
22	A	2 -> 3	Very fine sand over silt/clay. Stage 2 tube in background of SWI. SWI shaped partially by burrowing and partially by rippling of sediment surface. Burrowing throughout sediment column and reduced sediment near depth likely old DM.
22	B	2	Very fine sand over silt/clay. A Stage 2 tube at SWI. Burrowing evident throughout sediment column. Patches of reduced sediment at depth likely DM.
22	D	1 on 3	Very fine sand over silt/clay. Stage 1 tubes at SWI. Burrowing evident throughout sediment column. Large worms in burrows at depth. Patches of reduced sediment at depth likely DM.
23	A	2 -> 3	Very fine sand over silt/clay. Stage 1 and 2 tubes at SWI. Burrowing evident throughout sediment column. A highly reduced patch of sediment and a small patch of white clay at depth likely DM.
23	B	2 on 3	Very fine sand over silt/clay. Stage 2 tubes at SWI. A large, open void beneath aRPD boundary. Burrowing evident throughout. A highly reduced patch of sediment at depth likely DM.
23	C	2	Very fine sand over silt/clay. Stage 2 tubes at SWI and burrowing evident throughout sediment column.
24	A	IND	Fine sand with intermixed fine pebbles. Low penetration with no visible aRPD or infauna.
24	B	2 -> 3	Very fine sand with minimal penetration. Burrowing anemones visible in background of image at SWI.
24	C	2 -> 3	Very fine sand with minimal penetration. Stage 1 tubes at SWI and visible worms in burrows in sediment column.
25	A	2 -> 3	Thin layer of very fine sand over silt/clay with deep aRPD. Small stage 1 tubes and larger stage 2 tubes at SWI. Evidence of deep burrowing but no visible evidence of stage 3 organisms.
25	B	1 on 3	Thin layer of very fine sand over silt/clay with deep aRPD. Small tubes at SWI with visible worms in burrows moving beyond aRPD boundary and open voids at depth.
25	D	1 on 3	Thin layer of very fine sand over silt/clay with deep aRPD. Small tubes at SWI and many open voids at depth.
26	A	2 -> 3	Thin layer of very fine sand over silt/clay with deep aRPD. Stage 2 tubes at SWI and visible worms in burrows beyond aRPD boundary.
26	B	2 -> 3	Thin layer of very fine sand over silt/clay with many visible worms in burrows beginning near SWI and continuing to depth.
26	D	2	Thin layer of very fine sand over silt/clay with deep aRPD. Stage 2 tubes at SWI and visible worms in burrows beyond aRPD boundary.
27	A	2 -> 3	Thin layer of very fine sand over silt/clay with deep aRPD. Stage 2 tubes at SWI and visible worms in burrows beyond aRPD boundary.
27	B	1 on 3	Thin layer of very fine sand over silt/clay with deep aRPD. Small stage 1 tubes at SWI, visible worms in burrows beyond aRPD boundary, and an infilled void at depth.
27	D	2 -> 3	Thin layer of very fine sand over silt/clay with a few mud clasts at SWI. SWI appears to have been disturbed recently, making aRPD determination difficult. Visible worms in burrows throughout sediment column.
28	A	2 -> 3	Thin layer of very fine sand over silt/clay with Stage 1 and 2 tubes at the SWI. A well-developed aRPD and many visible worms beyond the aRPD boundary but no visible voids
28	B	2	Thin layer of very fine sand over silt/clay with a reduced mud clast at SWI that is certainly a camera artifact based on it's angularity. Burrowing evident moving beyond aRPD boundary and a worm in a burrow at depth.
28	D	1 on 3	Thin layer of very fine sand over silt/clay with multiple reduced camera artifact mud clasts at SWI. Stage 1 tubes at SWI, worms in burrows throughout sediment column and an infilled void just beyond aRPD boundary.
29	E	2 on 3	Very fine sand over silt/clay with a corymorpha hydroid at SWI. Worms in burrows visible throughout sediment column and a large, infilled void at depth.
29	F	1 on 3	Very fine sand over silt/clay with a large camera artifact mud clast at SWI. Stage 1 tubes at SWI, a partially infilled void beneath aRPD boundary, and visible worms in burrows beyond aRPD boundary.
29	H	1 on 3	Very fine sand over silt/clay with angular camera artifact mud clasts at SWI. Stage 1 tubes at SWI and an infilled void and worms in burrows beyond aRPD boundary.
30	F	2	Very fine sand over silt/clay with a rounded, slightly oxidized clast at the SWI with many tubes attached to clast, as well as other Stage 2 tubes at the SWI. Worms in burrows above and beyond the aRPD boundary.
30	G	1 on 3	Very fine sand over silt/clay slightly less consolidated at the SWI. Stage 1 tubes at SWI and an infilled void and visible worms in burrows beyond the aRPD boundary.

StationID	Replicate	Successional Stage	Comment
30	H	2 on 3	Very fine sand over silt/clay with possible substrate at SWI. Reduced mud clasts at SWI and something in background of image covered in Stage 2 worms. More Stage 2 worms at SWI and an infilled void beyond aRPD boundary.
31	A	2 -> 3	Very fine sand over silt/clay with Stage 1 and 2 tubes at the SWI. A well-developed aRPD and many visible worms beyond the aRPD boundary but no visible voids
31	E	2	Very fine sand over silt/clay with amphipod towers at SWI and visible worms in burrows throughout sediment column.
31	G	2	Very fine sand over silt/clay with Stage 1 and 2 tubes at the SWI. A well-developed aRPD and many visible worms beyond the aRPD boundary but no visible voids
32	D	2 on 3	Very fine sand over silt/clay with amphipod structures at SWI and a large, open void at depth. Worms visible in burrows throughout sediment column.
32	E	2	Very fine sand over silt/clay with amphipod structures and stage 1 tubes at SWI. Visible worms in burrows beyond aRPD boundary.
32	G	1 on 3	Very fine sand over silt/clay with a SWI that appears to have been recently disturbed. Stage 1 tubes at SWI and a partially infilled void at depth.
33	A	2 -> 3	Very fine sand over silt/clay with small tubes at SWI. Worms in burrows near and above aRPD boundary.
33	C	1 on 3	Silt/clay with what appears to be a recently disturbed SWI with reduced and oxidized sediment intermixed . A small tube visible at the SWI, and a burrow opening at SWI with a large worm visible at depth associated with the burrow.
33	D	2	Very fine sand over silt/clay with small tubes and a mud clast at SWI. Large worm visible in burrow above aRPD boundary and a deep burrow bringing oxidized sediment to depth visible.
34	B	2 -> 3	Silt/clay with a disturbed SWI, based on angular mud clasts likely from a previous replicate image. The aRPD has been obscured by the disturbance. Worms visible in burrows from SWI to depth.
34	C	1 on 3	Silt/clay with a disturbed SWI, based on angular mud clasts likely from a previous replicate image. The aRPD has been obscured by the disturbance in a portion of the SWI. An open void and a partially infilled void beneath aRPD boundary.
34	D	1 on 3	Silt/clay with what appears to be a recently disturbed SWI with reduced and oxidized sediment intermixed. A burrow evidenced by oxidized sediment at SWI moving down beyond aRPD boundary visible. An infilled void beneath aRPD boundary.
35	A	1 on 3	Very fine sand over silt/clay with many small tubes at SWI. A partially infilled void and an infilled void at depth.
35	B	1 on 3	Silt/clay with a reduced mud clast at SWI suggesting a disturbance at some point. Two infilled voids in the sediment column and many small tubes at SWI.
35	C	1 on 3	Silt/clay with a disturbed SWI with intermixed oxidized and reduced sediment as well as an angular mud clast at SWI likely from a previous replicate. A few small tubes at SWI and a large burrow with associated open void begins at SWI and continues a few centimeters down in to sediment.
36	A	2 on 3	Very fine sand over silt/clay with Stage 1 and 2 tubes at the SWI. A well-developed aRPD, worms visible in burrows, and an open void at depth.
36	B	2	Very fine sand over silt/clay with a disturbed SWI, likely from a previous camera replicate. Disturbance has obscured aRPD but there is a visible worm in a burrow at depth.
36	C	2 on 3	Very fine sand over silt/clay with a slightly disturbed SWI. Stage 2 tubes at SWI and two infilled voids just beneath aRPD boundary.

APPENDIX E

PLAN VIEW IMAGE ANALYSIS RESULTS

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Image Width (cm)	Image Height (cm)	Field of View	Sediment Type	Surface Oxidation	Bedforms	Beggiatoa Present?	Beggiatoa Type/Extent	Dredged Material Present?
Mound C	Disposal	01	A	31.7	5/6/2020	20:20:26	71.69	47.79	0.34	Sand	Oxidized	None	No	None	No
Mound C	Disposal	02	A	29.0	5/6/2020	20:01:32	75.44	50.29	0.38	Sand	Oxidized	None	No	None	No
Mound C	Disposal	02	B	29.0	5/6/2020	20:02:13	67.74	45.16	0.31	Sand	Oxidized	None	No	None	No
Mound C	Disposal	02	C	29.0	5/6/2020	20:02:56	71.79	47.86	0.34	Sand	Oxidized	None	No	None	No
Mound C	Disposal	03	A	30.5	5/6/2020	19:55:50	78.95	52.63	0.42	Sand	Oxidized	None	No	None	No
Mound C	Disposal	03	B	30.5	5/6/2020	19:56:29	80.70	53.80	0.43	Sand	Oxidized	None	No	None	No
Mound C	Disposal	03	C	30.5	5/6/2020	19:57:10	70.11	46.74	0.33	Sand	Oxidized	None	No	None	No
Mound C	Disposal	04	A	31.7	5/6/2020	20:15:26	71.89	47.93	0.34	Sand	Oxidized	None	No	None	No
Mound C	Disposal	04	B	31.7	5/6/2020	20:16:08	70.72	47.14	0.33	Sand	Oxidized	None	No	None	No
Mound C	Disposal	05	A	31.1	5/6/2020	20:09:13	77.96	51.97	0.41	Sand	Oxidized	None	No	None	No
Mound C	Disposal	05	D	31.1	5/6/2020	20:11:26	80.33	53.55	0.43	Sand	Oxidized	None	No	None	No
Mound C	Disposal	06	A	30.8	5/6/2020	20:33:32	72.90	48.60	0.35	Sand	Oxidized	None	No	None	No
Mound C	Disposal	06	D	30.8	5/6/2020	20:35:41	68.69	45.79	0.31	Sand	Oxidized	None	No	None	No
Mound C	Disposal	07	A	32.6	5/6/2020	20:27:10	73.93	49.29	0.36	Sand	Oxidized	None	No	None	No
Mound C	Disposal	08	A	32.3	5/6/2020	20:38:53	68.69	45.79	0.31	Sand	Oxidized	None	No	None	No
Mound D	Disposal	09	A	32.9	5/6/2020	22:07:18	68.78	45.86	0.32	Sand	Oxidized	Hummocks	No	None	No
Mound D	Disposal	09	B	32.9	5/6/2020	22:08:03	75.54	50.36	0.38	Sand	Oxidized	Hummocks	No	None	No
Mound D	Disposal	09	C	32.9	5/6/2020	22:08:44	69.49	46.33	0.32	Sand	Oxidized	Hummocks	No	None	No
Mound D	Disposal	10	A	33.6	5/6/2020	22:25:27	67.47	44.98	0.30	Sand	Oxidized	None	No	None	No
Mound D	Disposal	11	A	33.9	5/6/2020	22:19:43	65.74	43.83	0.29	Sand	Oxidized	None	No	None	No
Mound D	Disposal	11	C	33.9	5/6/2020	22:21:14	65.80	43.86	0.29	Sand	Oxidized	None	No	None	No
Mound D	Disposal	12	A	32.9	5/6/2020	22:00:36	68.63	45.75	0.31	Sand	Oxidized	None	No	None	No
Mound D	Disposal	12	B	32.9	5/6/2020	22:01:20	67.42	44.94	0.30	Sand	Oxidized	None	No	None	No

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Image Width (cm)	Image Height (cm)	Field of View	Sediment Type	Surface Oxidation	Bedforms	Beggiatoa Present?	Beggiatoa Type/Extent	Dredged Material Present?
Mound D	Disposal	12	C	32.9	5/6/2020	22:02:05	66.19	44.12	0.29	Sand	Oxidized	None	No	None	No
Mound D	Disposal	13	A	34.2	5/6/2020	22:31:10	67.62	45.08	0.30	Sand	Oxidized	None	No	None	No
Mound D	Disposal	14	A	34.5	5/6/2020	22:37:49	68.69	45.79	0.31	Sand	Oxidized	None	No	None	No
Mound D	Disposal	15	A	33.9	5/6/2020	21:53:48	64.30	42.87	0.28	Sand	Oxidized	None	No	None	No
Mound D	Disposal	16	A	32.9	5/6/2020	22:13:51	70.94	47.29	0.34	Sand	Oxidized	None	No	None	No
Mound B	Disposal	17	A	32.3	5/7/2020	1:32:49	66.84	44.56	0.30	Sand	Oxidized	None	No	None	No
Mound B	Disposal	17	B	32.3	5/7/2020	1:33:50	64.54	43.03	0.28	Sand	Oxidized	None	No	None	No
Mound B	Disposal	18	A	34.2	5/7/2020	0:30:18	70.56	47.04	0.33	Sand	Oxidized	None	No	None	No
Mound B	Disposal	18	D	34.2	5/7/2020	0:33:27	63.13	42.09	0.27	Sand	Oxidized	None	No	None	No
Mound B	Disposal	19	A	30.8	5/7/2020	1:13:09	70.94	47.29	0.34	Sand	Oxidized	None	No	None	No
Mound B	Disposal	19	B	30.8	5/7/2020	1:14:17	70.68	47.12	0.33	Sand	Oxidized	None	No	None	No
Mound B	Disposal	19	C	30.8	5/7/2020	1:15:19	68.78	45.86	0.32	Sand	>50% Oxidized	None	Yes	Patches	No
Mound B	Disposal	20	A	33.2	5/7/2020	0:43:12	68.57	45.71	0.31	Sand	Oxidized	None	No	None	No
Mound B	Disposal	20	B	33.2	5/7/2020	0:44:13	68.45	45.63	0.31	Sand	Oxidized	None	No	None	No
Mound B	Disposal	20	D	33.2	5/7/2020	0:46:13	67.21	44.81	0.30	Sand	Oxidized	None	No	None	No
Mound B	Disposal	21	A	32.6	5/7/2020	0:53:57	68.84	45.90	0.32	Sand	Oxidized	None	No	None	No
Mound B	Disposal	22	A	33.6	5/7/2020	0:20:31	66.27	44.18	0.29	Sand	Oxidized	None	No	None	No
Mound B	Disposal	23	A	32.9	5/7/2020	1:02:11	68.27	45.51	0.31	Sand	Oxidized	None	No	None	No
Mound B	Disposal	23	B	32.9	5/7/2020	1:03:12	67.65	45.10	0.31	Sand	Oxidized	None	No	None	No
Mound B	Disposal	24	A	27.8	5/7/2020	1:24:25	78.39	52.26	0.41	Gravelly Sand	Oxidized	None	No	None	Yes
Mound B	Disposal	24	B	27.8	5/7/2020	1:25:23	77.73	51.82	0.40	Gravelly Sand	Oxidized	None	No	None	Yes

Area	Category	StationID	Replicate	Water Depth (m)	Date	Time	Image Width (cm)	Image Height (cm)	Field of View	Sediment Type	Surface Oxidation	Bedforms	Beggiatoa Present?	Beggiatoa Type/Extent	Dredged Material Present?
Mound B	Disposal	24	C	27.8	5/7/2020	1:26:19	75.76	50.51	0.38	Gravelly Sand	Oxidized	None	No	None	Yes
CCBRS	Reference	25	A	38.1	5/7/2020	6:16:49	72.97	48.64	0.35	Sand	Oxidized	None	No	None	No
CCBRS	Reference	25	C	38.1	5/7/2020	6:18:42	69.15	46.10	0.32	Sand	Oxidized	None	No	None	No
CCBRS	Reference	25	D	38.1	5/7/2020	6:19:42	65.46	43.64	0.29	Sand	Oxidized	None	No	None	No
CCBRS	Reference	26	A	37.8	5/7/2020	5:46:49	63.73	42.48	0.27	Sand	Oxidized	None	No	None	No
CCBRS	Reference	26	B	37.8	5/7/2020	5:47:49	67.07	44.71	0.30	Sand	Oxidized	None	No	None	No
CCBRS	Reference	26	C	37.8	5/7/2020	5:48:48	70.30	46.87	0.33	Sand	Oxidized	None	No	None	No
CCBRS	Reference	27	A	37.8	5/7/2020	5:55:35	71.01	47.34	0.34	Sand	Oxidized	None	No	None	No
CCBRS	Reference	27	D	37.8	5/7/2020	5:58:29	70.46	46.97	0.33	Sand	Oxidized	None	No	None	No
CCBRS	Reference	28	A	38.4	5/7/2020	6:06:26	74.18	49.45	0.37	Sand	Oxidized	None	No	None	No
NWREF	Reference	29	A	35.1	5/7/2020	3:29:32	72.66	48.44	0.35	Sand	Oxidized	None	No	None	No
NWREF	Reference	29	B	35.1	5/7/2020	3:30:28	73.93	49.29	0.36	Sand	Oxidized	None	No	None	No
NWREF	Reference	29	C	35.1	5/7/2020	3:31:28	69.00	46.00	0.32	Sand	Oxidized	None	No	None	No
NWREF	Reference	30	A	35.1	5/7/2020	3:04:11	67.53	45.02	0.30	Sand	Oxidized	None	No	None	No
NWREF	Reference	30	B	35.1	5/7/2020	3:05:10	69.58	46.39	0.32	Sand	Oxidized	None	No	None	No
NWREF	Reference	30	C	35.1	5/7/2020	3:07:57	71.27	47.51	0.34	Sand	Oxidized	None	No	None	No
NWREF	Reference	31	A	35.1	5/7/2020	3:15:24	75.73	50.49	0.38	Sand	Oxidized	None	No	None	No
NWREF	Reference	32	A	35.1	5/7/2020	3:37:23	70.27	46.85	0.33	Sand	Oxidized	None	No	None	No
NWREF	Reference	32	D	35.1	5/7/2020	3:40:19	63.47	42.31	0.27	Sand	Oxidized	None	No	None	No
SWREF	Reference	33	A	30.5	5/6/2020	18:58:04	73.52	49.01	0.36	Sand	Oxidized	Hummocks	No	None	No
SWREF	Reference	34	A	30.8	5/6/2020	19:06:08	72.80	48.53	0.35	Sand	Oxidized	None	No	None	No
SWREF	Reference	34	B	30.8	5/6/2020	19:06:46	73.45	48.96	0.36	Sand	Oxidized	None	No	None	No
SWREF	Reference	35	A	30.2	5/6/2020	18:48:53	67.15	44.77	0.30	Sand	Oxidized	None	No	None	No
SWREF	Reference	36	A	30.8	5/6/2020	19:12:36	71.56	47.71	0.34	Sand	Oxidized	None	No	None	No

StationID	Replicate	Dredged Material Notes	Debris	Tubes	Burrows	Tracks	Epifauna	Flora	Number of Fish
01	A		None	Yes	Yes	No	None	None	0
02	A		None	Yes	Yes	No	None	None	0
02	B		None	Yes	Yes	No	None	None	0
02	C		None	Yes	Yes	No	None	None	0
03	A		None	Yes	Yes	No	Gastropod(s), Shrimp	None	0
03	B		Linear Debris Feature	Yes	Yes	Yes	Gastropod(s), Shrimp	None	1
03	C		None	Yes	Yes	No	Gastropod(s)	None	0
04	A		None	Yes	Yes	Yes	None	None	0
04	B		None	Yes	Yes	No	None	None	0
05	A		None	Yes	Yes	Yes	None	None	0
05	D		None	Yes	Yes	Yes	Hermit Crab(s)	None	0
06	A		None	Yes	Yes	No	Shrimp	None	0
06	D		None	Yes	Yes	No	None	None	0
07	A		None	Yes	Yes	Yes	Hermit Crab(s)	None	0
08	A		None	Yes	Yes	No	Gastropod(s), Shrimp	None	0
09	A		None	Yes	Yes	Yes	Shrimp	None	0
09	B		None	Yes	Yes	Yes	None	None	1
09	C		None	Yes	Yes	Yes	None	None	0
10	A		None	Yes	No	Yes	None	None	0
11	A		None	Yes	No	Yes	Shrimp	None	0
11	C		None	Yes	No	Yes	None	None	0
12	A		None	Yes	No	No	None	None	0
12	B		None	Yes	Yes	Yes	None	None	0

StationID	Replicate	Dredged Material Notes	Debris	Tubes	Burrows	Tracks	Epifauna	Flora	Number of Fish
12	C		None	Yes	No	Yes	None	None	0
13	A		None	Yes	Yes	No	Brittle Star(s)	None	0
14	A		None	Yes	Yes	No	Brittle Star(s), Shrimp	None	0
15	A		None	Yes	Yes	No	None	None	0
16	A		None	Yes	Yes	Yes	None	None	0
17	A		None	Yes	Yes	Yes	Burrowing Anemone(s), Gastropod(s), Shrimp	None	0
17	B		None	Yes	Yes	No	Shrimp	None	0
18	A		None	Yes	Yes	Yes	Burrowing Anemone(s), Shrimp	None	0
18	D		None	Yes	Yes	Yes	Shrimp	None	0
19	A		None	Yes	No	No	Burrowing Anemone(s), Encrusting Sponge, Shrimp	None	0
19	B		None	Yes	Yes	Yes	Burrowing Anemone(s), Encrusting Sponge(s)	None	0
19	C		None	Yes	Yes	No	None	None	0
20	A		None	Yes	Yes	Yes	Shrimp	None	0
20	B		None	Yes	Yes	No	Shrimp	None	0
20	D		None	Yes	Yes	No	None	None	0
21	A		None	Yes	Yes	Yes	Burrowing Anemone(s)	None	0
22	A		None	Yes	Yes	Yes	Hermit Crab(s), Shrimp	None	0
23	A		None	Yes	Yes	Yes	Burrowing Anemone(s), Gastropod(s), Shrimp	None	0
23	B		None	Yes	Yes	Yes	Burrowing Anemone(s), Gastropod(s), Shrimp	None	0
24	A	Gravels and shell fragments	None	Yes	Yes	No	Burrowing Anemone(s), Crab(s), Encrusting Sponge(s), Hydroid(s)	None	0
24	B	Gravels and shell fragments	None	Yes	Yes	No	Burrowing Anemone(s), Encrusting Sponge(s), Hermit Crab(s), Hydroid(s)	None	0

StationID	Replicate	Dredged Material Notes	Debris	Tubes	Burrows	Tracks	Epifauna	Flora	Number of Fish
24	C	Gravels and shell fragments	None	Yes	Yes	Yes	Burrowing Anemone(s), Encrusting Sponge(s), Hermit Crab(s), Hydroid(s)	None	0
25	A		None	Yes	Yes	No	None	None	1
25	C		None	Yes	Yes	No	None	None	0
25	D		None	Yes	Yes	No	None	None	0
26	A		None	Yes	Yes	No	None	None	1
26	B		None	Yes	Yes	No	None	None	0
26	C		None	Yes	Yes	No	None	None	0
27	A		None	Yes	Yes	No	None	None	0
27	D		None	Yes	Yes	No	Shrimp	None	0
28	A		None	Yes	Yes	No	None	None	0
29	A		None	Yes	Yes	No	None	None	0
29	B		None	Yes	Yes	No	None	None	0
29	C		None	Yes	Yes	No	None	None	0
30	A		None	Yes	Yes	No	Brittle Star(s), Shrimp	None	0
30	B		None	Yes	Yes	No	Brittle Star(s)	None	0
30	C		None	Yes	Yes	No	Brittle Star(s)	None	0
31	A		None	Yes	Yes	No	None	None	0
32	A		None	Yes	Yes	Yes	Shrimp	None	0
32	D		None	Yes	Yes	No	Shrimp	None	0
33	A		None	Yes	Yes	Yes	Shrimp	None	0
34	A		None	Yes	Yes	No	None	None	0
34	B		None	Yes	Yes	Yes	Shrimp	None	0
35	A		None	Yes	Yes	Yes	Shrimp	None	0
36	A		None	Yes	Yes	Yes	Shrimp	None	0

StationID	Replicate	Comments
01	A	Sandy sediment surface with many small tubes and a few burrows visible.
02	A	Sandy sediment surface with many small tubes and a few burrows visible.
02	B	Sandy sediment surface with many small tubes and a few burrows visible, one quite large.
02	C	Sandy sediment surface with many burrows, a few large and with associated reduced sediment on the surface surrounding them. Small tubes also visible.
03	A	Sandy sediment surface with many small tubes and a few burrows. A shrimp in upper right corner of image and a very small gastropod approximately 11 o'clock from left laser
03	B	Sandy sediment with a large line laying on sediment surface running top to bottom through entire image. Much growth on line, along with small tube and burrows on rest of sediment surface. Potential tracks in upper left corner of image. A shrimp to right of line in bottom of image and a gastropod straight up from right laser. Some sort of fish on top of line.
03	C	Sandy sediment surface with many small tubes and burrows. Multiple small gastropods scattered about sediment surface.
04	A	Sandy sediment surface with many small tubes. Burrows, a few with associated reduced sediment also present. Some sort of arthropod tracks run across image.
04	B	Sandy sediment surface with many small tubes and burrows.
05	A	Sandy sediment with many small tubes, a few burrows, one with associated reduced sediment, and arthropod tracks across sediment surface.
05	D	Sandy sediment with many small tubes and burrows throughout image. A hermit crab just above right laser. Unknown translucent grouping, possibly some sort of egg casing to left of left laser. Arthropod tracks in image. Raised groupings of tubes on right edge of image.
06	A	Sandy sediment surface with many small tubes and burrows. A shrimp in bottom center of image
06	D	Sandy sediment surface with many small tubes and burrows.
07	A	Sandy sediment with small tubes and burrows throughout. Some arthropod tracks on sediment surface. A pair of hermit crabs near left laser.
08	A	Sandy sediment with a large patch of reduced sediment at the surface. Tubes and burrows present across entire image, including reduced portion. A small gastropod and a shrimp in upper center of image on reduced sediment.
09	A	Sandy sediment with small tubes and a few burrows. A hummock in right of image. Arthropod tracks in left of image moving top to bottom. A shrimp in lower right.
09	B	Sandy sediment with small tubes and many tracks at surface. A few burrows, possibly associated mounds of sediment at left of image. A fish and some hummocks and trenches in right of image.
09	C	Sandy sediment with tubes and tracks at sediment surface. Some burrows, some with associated reduced sediment at sediment surface.
10	A	Sandy surface with a few large tubes visible scattered about the surface. Small burrows and tracks also present.
11	A	Sandy surface with small tubes and burrows scattered throughout image. Arthropod tracks in top right of image.
11	C	Sandy surface with small tubes and burrows scattered throughout image. Arthropod tracks in top right of image. Sediment plume obscures bottom left of image.
12	A	Sandy surface with small tubes and burrows scattered throughout image.
12	B	Sandy surface with a sediment plume in left of image. Visible seabed exhibits small tubes and burrows, one with associated reduced sediment. Arthropod tracks through image center.

StationID	Replicate	Comments
12	C	Sandy surface with a sediment plume in upper portion of image. Visible seabed exhibits small tubes, burrows, and arthropod tracks.
13	A	Sandy sediment surface with many large burrows, at least 10 visible brittle stars, and multiple brittle star burrows visible.
14	A	Sandy sediment with a few very large burrows, multiple brittle star burrows, multiple brittle stars on sediment surface, and a shrimp in depression about right laser.
15	A	Sandy sediment with a few large burrows, a couple with associated reduced sediment at the surface. Small tubes also at sediment surface.
16	A	Sandy sediment with arthropod tracks across sediment surface. Tubes and a few small burrows also present.
17	A	Sandy sediment with a few large burrows and many small tubes. Tracks throughout. Many shrimp in right half of image. A small gastropod near large burrow in upper right of image. A burrowing anemone to right of right laser.
17	B	Sandy sediment with many small tubes at sediment surface and a few small burrows. A gathering of shrimps in bottom right corner of image.
18	A	Sandy sediment with a few large burrows, many small tubes, and arthropod tracks in upper left corner of image. A shrimp in upper right quadrant of image and a burrowing anemone in lower right of image.
18	D	Sandy sediment dense with tubes and a few large burrows. A shrimp in upper left of image. Arthropod tracks dense on sediment surface.
19	A	Sandy sediment dense with burrowing anemones. An encrusting sponge under right laser. A few shrimp scattered amongst burrowing anemones.
19	B	Sandy sediment dense with burrowing anemones and tracks. A small grouping of encrusting sponge below left laser. Burrows with associated reduced sediment present.
19	C	Sandy sediment with many small patches of Beggiatoa on sediment surface. Groupings of large tubes, a cobble, and small burrows also present throughout image.
20	A	Sandy sediment with small tubes throughout. A few large burrows and some arthropod tracks at sediment surface. A pair of shrimp in the center of image.
20	B	Sandy sediment with small tubes throughout. A few large burrows and some arthropod tracks at sediment surface. A few shrimp scattered about image.
20	D	Sandy sediment with many small tubes and a few burrows at sediment surface.
21	A	Sandy sediment with many tubes and a few burrows scattered about. A burrowing anemone in upper left of image.
22	A	Sandy sediment with many small tubes at sediment surface. Multiple shrimp scattered about image and a hermit crab above right laser.
23	A	Sandy sediment with many burrowing anemones, small tubes, small gastropods, and burrows throughout image. A few shrimp present at sediment surface. Arthropod tracks in upper left of image.
23	B	Sandy sediment with many burrowing anemones, small tubes, small gastropods, and burrows throughout image. A few shrimp present at sediment surface.
24	A	Sand with a few intermixed pebbles. Large encrusting sponges present throughout image, likely on hard substrate. A pair of burrowing anemones in lower right of image. A crab on bottom left encrusting sponge. Hydroids on hard substrate.
24	B	Sand with encrusting sponges likely on hard substrate. Hydroids intermixed with encrusting sponges. Sandy surface contains many burrowing anemones and a hermit crab.

StationID	Replicate	Comments
24	C	Sand with many small burrows, tubes, and burrowing anemones present. A few small encrusting sponges and a patch of hydroids. A hermit crab next to right laser.
25	A	Sandy bottom with tubes and burrows ranging from small to quite large. Small fish in middle right of image.
25	C	Sandy bottom with many tubes and burrows at sediment surface.
25	D	Sandy bottom with many tubes and burrows at sediment surface.
26	A	Sandy bottom with many tubes and burrows at sediment surface. Fish partially in frame on left side of image. A few shell fragments at sediment surface.
26	B	Sandy bottom with many tubes and a large burrow at sediment surface.
26	C	Sandy bottom with some disturbance at sediment surface. A few sediment plumes in water column. Large burrows and tubes throughout image.
27	A	Sandy bottom with many tubes and burrows across sediment surface.
27	D	Sandy bottom with many tubes and a few burrows at the sediment surface. A shrimp near the right laser.
28	A	Sandy bottom with many small tubes at sediment surface. Many large burrows also visible.
29	A	Sandy bottom with small tubes and a few large burrows. Burrow at right of image surrounded by more reduced sediment.
29	B	Sandy bottom with small tubes and a few large burrows.
29	C	Sandy bottom with small tubes and a very large burrow.
30	A	Sandy bottom with many brittle stars and brittle star burrows. A shrimp in upper right of image.
30	B	Sandy bottom with many brittle stars and brittle star burrows. Other burrows, some large, and many tubes also at sediment surface.
30	C	Sandy bottom with tubes and a few brittle stars. A few raised areas on sediment but difficult to determine if hard substrate or just sediment.
31	A	Sandy bottom with many tubes at sediment surface and large burrows across entire image.
32	A	Sandy bottom with many burrows. Some tubes and possible tracks on sediment surface. A pair of shrimp near the left laser.
32	D	Sandy bottom with many tubes and a few large burrows at the sediment surface. Possibly a shrimp at middle bottom of image.
33	A	Sandy bottom with tubes and some small burrows scattered about. A low spot with a mound near it in upper left corner. A shrimp in bottom right quadrant and tracks in bottom left corner.
34	A	Sandy bottom with large burrows in a circular pattern. Possibly a sea star burrow. Small tubes throughout.
34	B	Sandy bottom with a few large burrows, tubes throughout the image, and a shrimp near top left burrow. Tracks scattered across sediment surface.
35	A	Sandy bottom with a few large burrows, many with reduced sediment associated with them. Some tracks running across the sediment surface and a shrimp in the middle of the image.
36	A	Sandy bottom with burrows and tubes across sediment surface. A few sets of tracks in right half of image and a pair of shrimp, one in the water column in upper left corner.

APPENDIX F

GRAIN SIZE SCALE FOR SEDIMENTS

APPENDIX F

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 G

NON-PARAMETRIC BOOTSTRAPPED CONFIDENCE LIMITS

APPENDIX G

Non-parametric Bootstrapped Confidence Limits

Bootstrapping is a statistical resampling procedure that uses the sample data to represent the entire population in order to construct confidence limits around population parameters. Bootstrapping assumes only that the sample data are representative of the underlying population, so random sampling is a prerequisite for appropriate application of this method.

Bootstrapping procedures entail resampling, with replacement, from the observed sample of size n. Each time the sample is resampled, a summary statistic (e.g., mean or standard deviation) of the bootstrapped sample is computed and stored. After repeating this procedure many times, a summary of the bootstrapped statistics is used to construct the confidence limit. For the bootstrap-*t* method (e.g., Manly 1997, pp. 56-59; or Lunneborg 2000, pp. 129-131), the bootstrapped statistic (T) is a pivotal statistic, which means that the distribution of T is the same for all values of the true mean (θ). The bootstrap-*t* is essentially the "Studentized" version (i.e., subtract the mean and divide by the standard error, as is done to obtain the Student *t*-distribution for the sample mean) of the statistic of interest. This approach is quite versatile, and can be applied to construct a confidence interval around any linear combination of means (Lunneborg 2000, p. 364).

For the purpose of constructing a confidence interval around the true value for the linear combination of means ($\Theta = \mu_{Ref} - \mu_{Mound}$) the pivotal statistic T for the true difference is defined as

$$T = \frac{d - \theta}{SE(d)} \qquad \text{(Eq. A-1)}$$

We assume that this is adequately approximated by the bootstrap sampling distribution of T, denoted T*:

$$T^* = \frac{d^* - \hat{\theta}}{SE(d^*)} \qquad \text{(Eq. A-2)}$$

This distribution is comprised of the studentized statistic (T^*_B) computed from a large number (B) of randomly chosen bootstrapped samples y_1^*, y_2^*, ... y_B^* from each of the four groups or populations. Here, d^* is the linear combination of group means for the bootstrapped sample; $\hat{\theta}$ is the observed difference in sample means from the original samples; $SE(d^*)$ is the estimated standard error of the linear contrast.

The 5th and the 95th quantiles of the T^* distribution ($T^*_{0.05}$ and $T^*_{0.95}$, respectively) satisfy the equations:

$$\Pr[\frac{\theta - d}{SE(d)} > T^*_{0.05}] = 0.95 \qquad \text{(Eq. A-3a)}$$

$$\Pr[\frac{\theta - d}{SE(d)} < T^*_{0.95}] = 0.95 \qquad \text{(Eq. A-3b)}$$

Rearranging these equations yields 95% confidence in each of the following two inequalities:

$$\Pr[d + T^*_{0.05}\, SE(d) < \theta] = 0.95 \qquad \text{(Eq. A-4a)}$$

$$\Pr[d + T^*_{0.95}\, SE(d) > \theta] = 0.95 \qquad \text{(Eq. A-4b)}$$

Bootstrapping is used to estimate the values $T^*_{0.05}$, $T^*_{0.95}$ and $SE(d)$. The left side of equation A-4a represents the 95% lower confidence limit on the difference equation ($\mu_y - \mu_x$); the left side of equation A-4b is the 95% upper confidence limit on the difference equation. Based on the two one-sided testing (TOST) approach presented in McBride (1999), if the bounds computed by Equations A-4a and A-4b are fully contained within the interval [–δ , +δ], then we conclude equivalence within δ units.

The specific steps used to compute the 95% upper and 95% lower confidence limits on the difference between two means using the bootstrap-*t* method are described below.

1. Bootstrap (sample with replacement from the original sample of size n) B = 10,000 samples from each of the four populations (1 pooled reference group and 3 mounds) separately.
2. Compute the T^*_B statistic for each bootstrapped set of independent samples. T^*_i is the bootstrapped-*t* statistic computed from the i^{th} bootstrap sample, defined by the following equation

$$T^*_i = \frac{\sum_{j=1}^{4} c_j \bar{y}^*_{ji} - \sum_{j=1}^{4} c_j \bar{y}_j}{SE\left(\sum_{j=1}^{4} c_j \bar{y}^*_{ji}\right)} = \frac{\sum_{j=1}^{4} c_j \bar{y}^*_{ji} - \sum_{j=1}^{4} c_j \bar{y}_j}{\sqrt{\sum_{j=1}^{4} s^2_{y^*ji} c_j^2 / n_j}} \qquad \text{(Eq. A-5)}$$

   where $\bar{y}^*_{ji}$, and $s^2_{y^*_{ji}}$ are the means and variances for the i^{th} bootstrapped sample from the j^{th} group (j=1 to 4); and $\bar{y}_j$ is the observed mean for the j^{th} group.

   Multiplying these group means by their respective coefficients c_j ($^1/3$, -1, -1, -1) and summing the products yields the difference equation we wish to test (Equation 1). This step produces 10,000 values of the bootstrapped-*t* statistic which comprise the "bootstrap-*t* distribution".

3. Compute the standard deviation of the 10,000 bootstrapped linear combinations, $\sum_{j=1}^{4} c_j\, \bar{y}^*_{ji}$ and save it as $SE(d)$. This is the bootstrap estimate of the true standard error.
4. Find $T^*_{0.05}$ and $T^*_{0.95,}$ the 5th and 95th quantiles of the bootstrap-*t* distribution generated in Step 2. These values satisfy Equations A- 3a and A-3b.
5. Applying Equations A-4a and A-4b using the values $T^*_{0.05}$ and $T^*_{0.95}$ found in Step 4 gives the bootstrap-*t* estimate of the 95% lower and upper confidence limits on the difference equation, i.e.,

$$95\%\ \text{LCL} = \sum_{j=1}^{4} c_j\, \bar{y}_j + T^*_{0.05}\, SE(d) \qquad \text{(Eq. A-6a)}$$

$$95\%\ \text{UCL} = \sum_{j=1}^{4} c_j \bar{y}_j + T^*_{0.95}\, SE(d) \qquad \text{(Eq. A-6b)}$$

where $(\sum_{j=1}^{4} c_j \bar{y}_j)$ is the linear combination expressing the difference between the mean of the reference group and the mean of the three disposal mounds based on the original sample observations, and *SE(d)* is the standard deviation of the bootstrapped differences computed in Step 3.

References

Lunneborg, Clifford E. 2000. Data Analysis by Resampling: Concepts and Applications. Duxbury. 556 pp. + Appendices.

Manly, Bryan F.J. 1997. Randomization, Bootstrap and Monte Carlo Methods in Biology. Second edition. Chapman & Hall, London. 340 pp. + Appendices