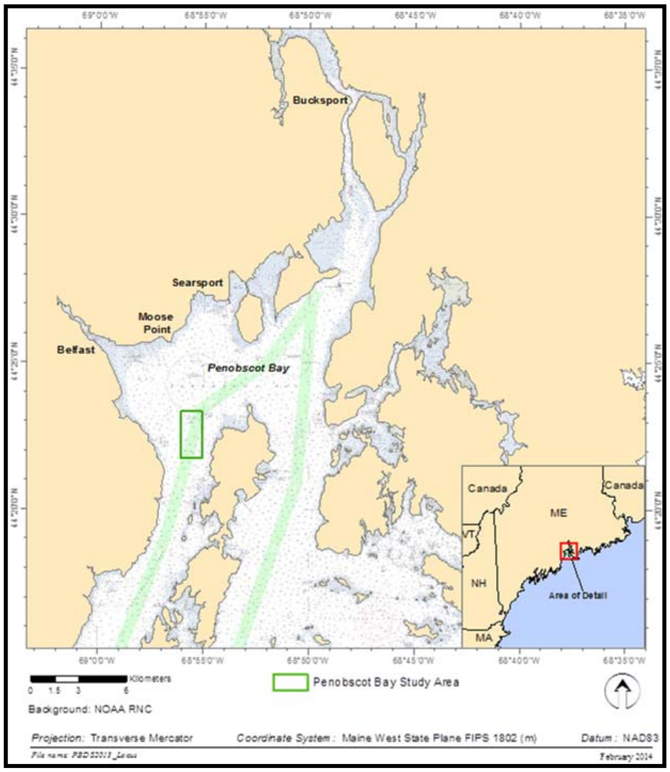
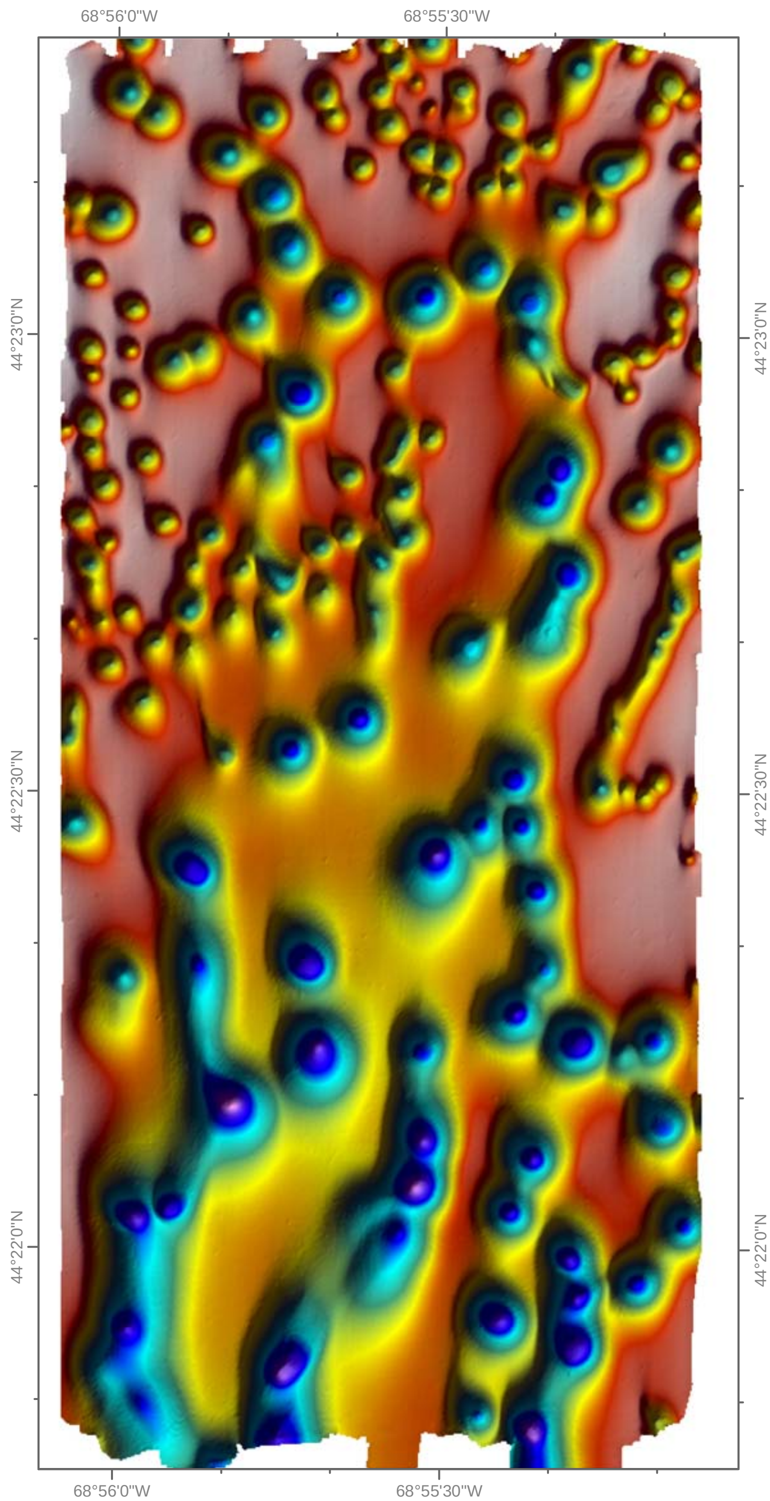
Data Summary Report of the Penobscot Bay Study Area
August 2013 Monitoring Survey

Disposal Area Monitoring System DAMOS





DAMOS
DISPOSAL AREA MONITORING SYSTEM

Data Summary Report 2013-02
September 2014

US Army Corps of Engineers®
New England District

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

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aRPD	apparent redox potential discontinuity
CAD	computer-aided design
CCOM/JHC	Center for Coastal and Ocean Mapping Joint Hydrographic Center
CO-OPS	Center for Operational Oceanographic Products and Services
CTD	conductivity-temperature-depth
DAMOS	Disposal Area Monitoring System
DGPS	differential global positioning system
GIS	graphic information system
GPS	global positioning system
JPEG	Joint Photographic Experts Group
MBES	Multibeam Echo Sounder
MLLW	mean lower low water
NAE	New England District
NEF	Nikon Electronic Format
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
PBSA	Penobscot Bay study area
PPS	pulse-per-second
PV	plan-view
RGB	red green blue (file format)
SBAS	satellite-based differential corrections
SHP	shapefile or geospatial data file
SOP	Standard Operating Procedures
SPI	sediment-profile imaging
TIF	tagged image file
TOC	total organic carbon
TZM	tide zoning model
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey

1.0 INTRODUCTION

An area of the seafloor in the upper reaches of Penobscot Bay, Maine was surveyed in August 2013 in support of the Searsport Harbor navigation improvement project located in Searsport, Maine, several miles north of the study area. The survey was conducted to enhance understanding of the physical and biological characteristics of the seafloor to support an assessment of potentially placing dredged material from the planned Searsport navigation improvement project. The survey featured collection of acoustic data, sediment-profile and plan-view imaging, and benthic grab sampling for biological assessment and was conducted under the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS) Program.

1.1 Overview of the 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. The DAMOS Program is tasked with managing existing dredged material disposal sites to ensure that any potential adverse environmental impacts associated with dredged material placement are promptly identified and addressed (Germano et al. 1994). In some cases, the DAMOS Program conducts special surveys to support other objectives related to NAE's dredging and disposal operations. The 2013 Penobscot Bay survey was a special DAMOS study designed to support assessment of the study area for suitability for dredged material placement.

The DAMOS Program has developed a sequence of survey monitoring techniques to characterize physical and biological conditions on the seafloor. Sequential acoustic monitoring surveys (including bathymetric, acoustic backscatter, and side-scan sonar data collection) are conducted to characterize the seafloor topography and surficial sediments. Sediment-profile imaging (SPI) and plan-view underwater camera photography (referred to as plan-view [PV] imaging) surveys are performed to provide further physical characterization of the seafloor and to support evaluation of seafloor (benthic) habitat conditions. Each type of data collection activity provides useful information to support characterization of seafloor conditions. Special DAMOS monitoring surveys may also feature additional types of data collection activities as deemed appropriate to achieve specific survey objectives, such as benthic grab sampling to support biological characterization.

1.2 Introduction to the Penobscot Bay Study Area

The Penobscot Bay study area (PBSA) is located along the western navigation passage of Penobscot Bay on the central Maine coast (Figure 1-1). The study area was a 1,200 × 2,500 m (3,900 × 8,200 ft) rectangle situated approximately 4.5 km (2.8 miles) south-southeast of Moose Point (Figure 1-2). The study area was defined to characterize the seafloor in a broad area to the west of the northern end of Islesboro Island, part of which is marked on historical National Oceanic and Atmospheric Administration (NOAA) charts as having been previously used for dredged material disposal (Figure 1-2).

The dominant features of the region are its many deep depressions, also known as pockmarks, and the north-south oriented tidal scour troughs in the southern area (Figure 1-3). The pockmarks have been attributed to methane gas release from Holocene sediments (Brothers et al. 2012). Within the study area, there are more than one hundred of these crater-shaped pockmarks, extending as deep as 45 m (148 ft) below the surrounding seafloor (Figure 1-4). The pockmarks are set into a relatively flat surrounding seafloor with water depths increasing from approximately 28 m (90 ft) in the north to 34 m (110 ft) in the south. In the southern portion of the survey area, tidal scour appears to have deepened the seafloor. Individual pockmarks tend to be nearly circular and vary from smaller features (e.g., 20 m [66 ft] deep and 60 m [200 ft] in diameter), primarily in the northern area, to larger features (e.g., 45 m [150 ft] deep and 150 m [490 ft] in diameter), primarily in the south. In the southern area, three deep, north-south oriented troughs are observed.

Existing characterization of this area is based on the following previously conducted surveys:

- A multibeam bathymetric survey conducted by NOAA in 1998,
- A high-resolution bathymetric survey conducted by the U.S. Geological Survey (USGS) agency (Andrews et al. 2010),
- A seismic reflection survey conducted by Rogers et al. (2006), and
- Sediment grabs collected by USACE NAE contractor in May 2008 as part of a draft Environmental Assessment (USACE 2013).

1.3 Survey Objectives

The 2013 Penobscot Bay survey was designed to address the following two objectives within and around the pockmarks:

- Characterize the seafloor topography and surficial features by completing a high-resolution acoustic survey, and
- Characterize surficial sediment and biological conditions using sediment-profile imaging and benthic grab sampling and analysis.

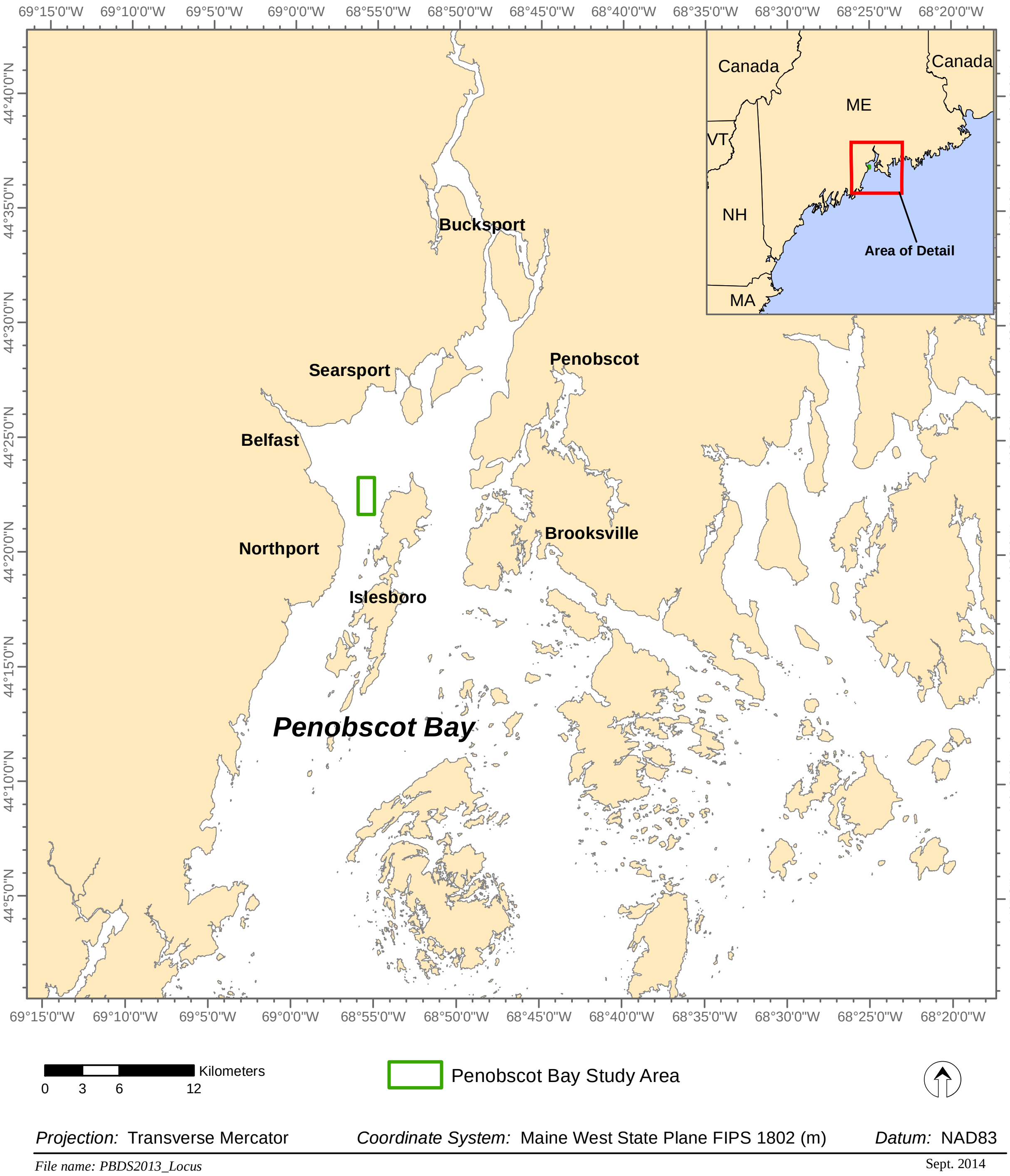


Figure 1-1. Location of the Penobscot Bay study area (PBSA)

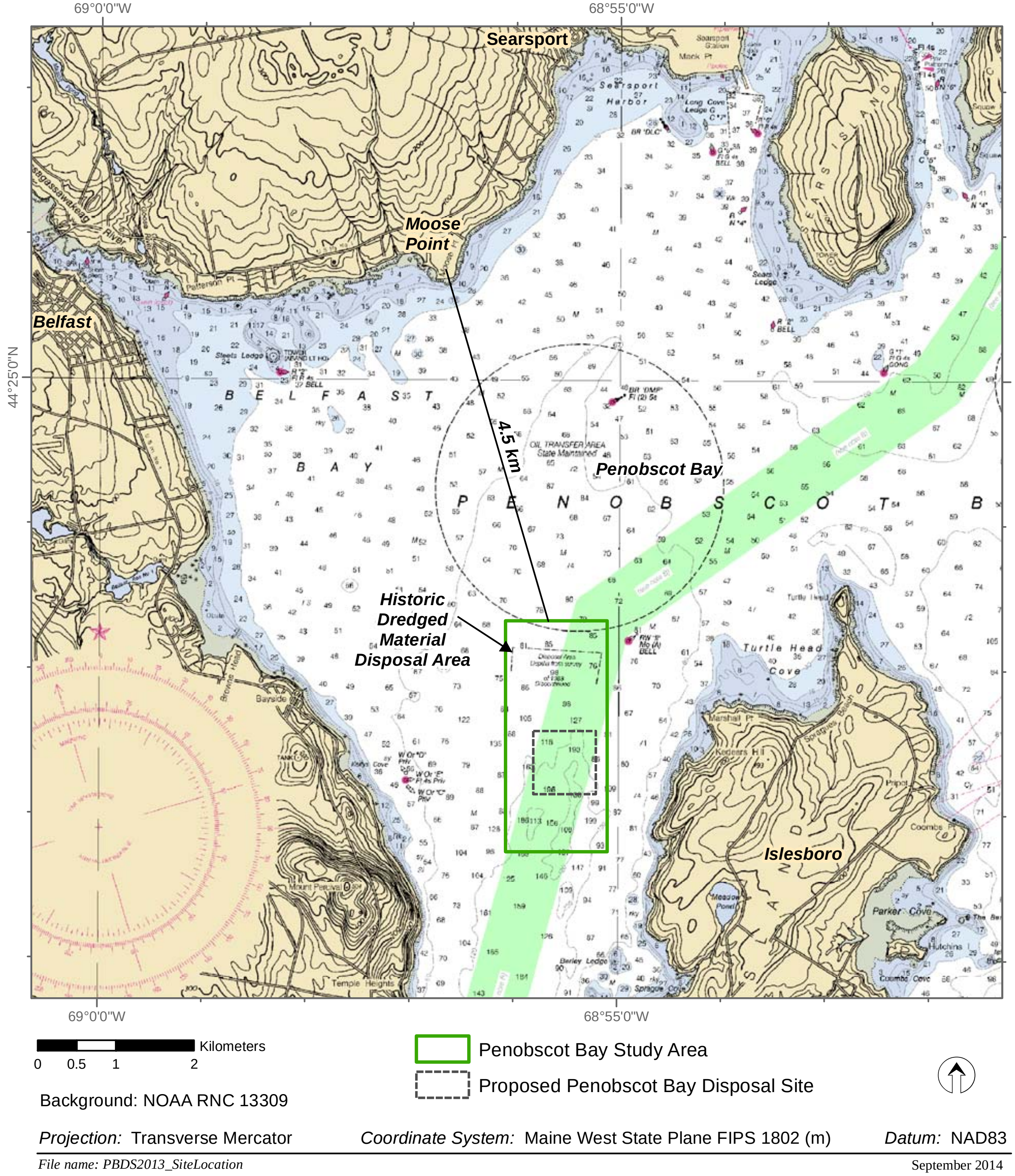


Figure 1-2. PBSA boundary in upper Penobscot Bay

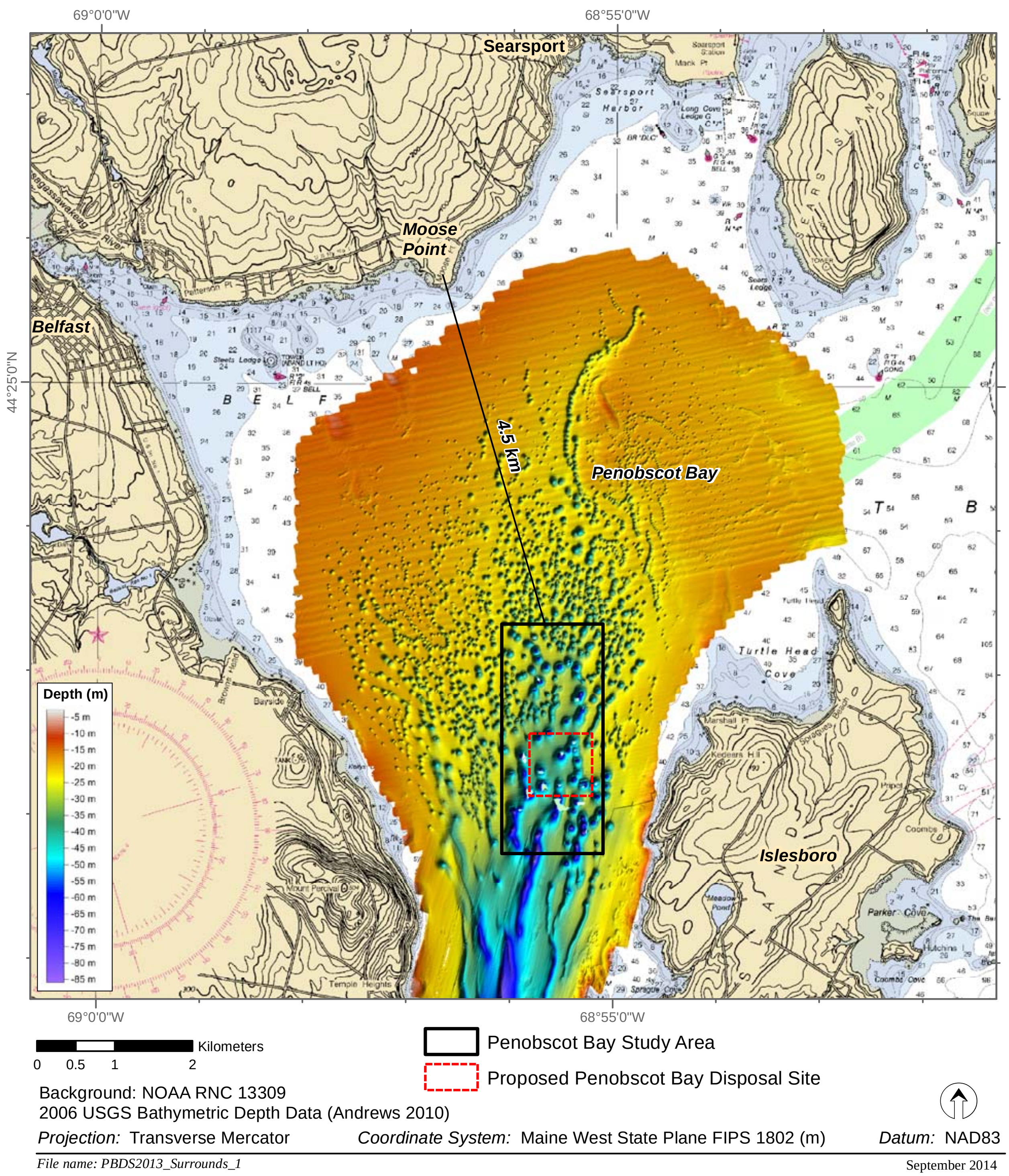


Figure 1-3. Bathymetry of PBSA and surrounding area based on USGS 2006 bathymetric survey (Andrews 2010)

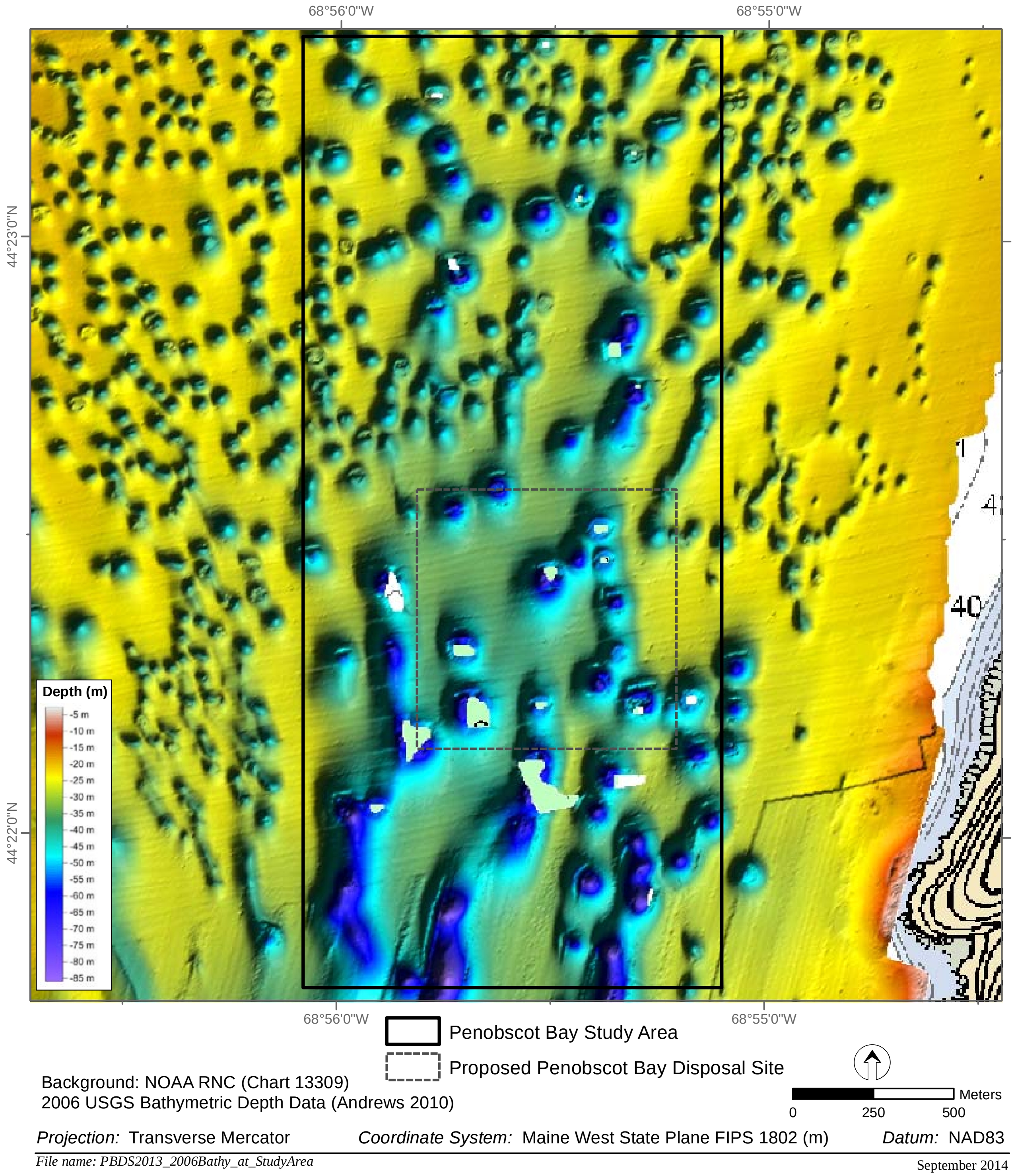


Figure 1-4. Bathymetry of PBSA based on USGS 2006 bathymetric survey (Andrews 2010)

2.0 METHODS

The August 2013 survey at the Penobscot Bay study area was conducted by a team of investigators from DAMOSVision (CoastalVision, CR Environmental, and Germano & Associates) and Battelle aboard the 55-foot R/V *Jamie Hanna*. The acoustic survey was conducted on 19 August, the benthic grab survey was conducted on 20 August, and the SPI/PV survey was conducted on 21 August 2013. An overview of the methods used to collect, process, and analyze the survey data is provided below. Detailed Standard Operating Procedures (SOPs) for data collection and processing are available in Carey et al. (2013).

2.1 Navigation and On-Board Data Acquisition

Navigation for the survey was accomplished using a Hemisphere VS-110 12-channel Differential Global Positioning System (DGPS) and Digital Compass system capable of receiving satellite-based differential corrections (SBAS) and U.S. Coast Guard (USCG) Beacon corrections. Trimble DGPS systems were available as necessary as backups. Both systems are capable of sub-meter horizontal position accuracy. The DGPS system was interfaced to a laptop computer running HYPACK MAX® hydrographic survey software. HYPACK MAX® continually recorded vessel position and DGPS satellite quality and provided a steering display for the vessel captain to accurately maintain the position of the vessel along pre-established survey transects and selected targets.

Vessel heading measurements were provided up to 20 times per second by a dual-antenna Hemisphere VS-110 Crescent Digital compass accurate to within 0.05°. The pulse-per-second (PPS) signals from the DGPS system were hardware interfaced to HYPACK using a translation circuit and provided microsecond level accuracy of data stream time-tagging from each sensor.

2.2 Acoustic Survey

The acoustic survey in this study included bathymetric, 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. Backscatter and side-scan sonar data provided images that supported characterization of surficial topography, sediment texture, and roughness.

2.2.1 Acoustic Survey Planning

The acoustic survey featured a high spatial resolution survey of PBSA. DAMOSVision hydrographers coordinated with USACE NAE scientists and reviewed alternative survey areas. For PBSA, a 1,200 × 2,500 m area was selected with a series of survey lines spaced 50 m apart and cross-tie lines spaced 500 m apart (Figure 2-1). The survey was designed to provide greater than 100-percent coverage of the seafloor within the survey area, i.e., there was overlapping coverage of each mapping transect for improved accuracy. Hydrographers obtained site coordinates, imported them to ArcGIS software, and created planning maps. The proposed survey area encompassing the entire site was then reviewed and approved by NAE scientists.

2.2.2 Acoustic Data Collection

The 2013 multibeam bathymetric survey of PBSA was conducted on 19 August 2013 and was executed to provide greater than 100-percent coverage of the seafloor within the study area. Data layers generated by the survey included bathymetric, acoustic backscatter, and side-scan sonar data and were collected using a Reson 8101 Multibeam Echo Sounder (MBES). This 240-kHz system forms 101 1.5° beams distributed equiangular across a 150° swath. The MBES transducer was mounted amidships to the port rail of the survey vessel using a high strength adjustable boom, and offsets between the primary DGPS 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.

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

2.2.3 Bathymetric Data Processing

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

- Adjustment of data for tide fluctuations
- Correction of ray bending associated with refraction in the water column

- Removal of spurious points associated with water column interference or system errors
- Development of a grid surface representing depth solutions
- Statistical estimation of sounding solution uncertainty
- Generation of data visualization products

NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) provided a Tide Zoning Model (TZM) calculated specifically for this survey area. The model applied corrections of 6 to 12 minutes and height corrections of 0.96 to 0.98 to the six-minute Mean Lower Low Water (MLLW) data series acquired at NOAA's Bar Harbor Tide Station (#8413320). Bathymetric data processed using the TZM displayed slightly elevated uncertainty along cross-tie lines when compared to data processed using raw Bar Harbor tide data. Therefore, the raw Bar Harbor tide data were used to correct the final bathymetric data set.

Correction of sounding depth and position (range and azimuth) associated with refraction due to water column stratification was conducted using a series of six sound-velocity profiles acquired by the survey team. Data artifacts associated with refraction remain in the bathymetric surface model at a relatively fine scale (generally less than 5 to 10 cm) relative to the survey depth. Bathymetric data were filtered to accept only beams falling within an angular limit of 50° to minimize refraction artifacts. Spurious sounding solutions were flagged or rejected based on the careful examination of data on a sweep-specific basis.

The 240 kHz Reson 8101 MBES system has a published nadir beam width of 1.5° (across track) and 1.5° along track. Assuming an average depth of 38 m and a maximum beam angle of 50°, the average diameter of the beam footprint was calculated at approximately 1.5 × 2.4 m (3.7 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 2002).

Within-cell standard deviations (1-sigma) ranged from 0 to 2.78 m (average 0.19 m). Ninety-five percent of the cell-specific standard deviation values were less than 0.5 m. The average Root Mean Squared uncertainty at the 95th percentile confidence interval (1.96 - sigma) was 0.38 m. Ninety-five percent of these uncertainty values were less than 0.98 m. Uncertainty estimates greater than approximately 0.20 m were constrained to the steep slopes of pockmarks. It is noteworthy that the most stringent National Ocean Service (NOS) standard for this project depth (Special Order 1A) would call for a 95th percentile confidence interval (95% CI) of 0.65 m at the maximum site depth (80.3 m) and 0.38 m at the average site depth (38 m). Performance

Standards for an NOS Order 1A survey at the mean and maximum depths would be 0.7 m and 1.16 m, respectively.

Nadir data from the mainstay and cross-tie transects were compared to further refine the uncertainty assessment. Differences between co-located points occupied on perpendicular transects were tabulated and statistically analyzed to assess and report data quality relative to promulgated USACE performance standards (note that USACE Standards were developed for a maximum depth of 80 ft). The average difference between 125 co-located points at cross-tie intersections was -0.036 m, indicating minimal tide bias. The greatest differences between co-located points was observed on slopes, with a standard deviation of 0.45 m. After elimination of slope points, the standard deviation of these comparisons decreased to 0.23 m. The 95th percentile accuracy estimate for cross-tide comparisons was calculated per USACE (2002) as 0.48 m, further demonstrating data compliance with the promulgated USACE performance standard of 0.61 m in depths greater than 40 ft (12.2 m).

Reduced data were exported in ASCII text format with fields for Easting, Northing, and MLLW Elevation (meters). All data were projected to the Maine State Plane (East), 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. 11.6). Visualizations and data products included

- ASCII databases of all processed soundings including MLLW depths and elevations
- Contours of seabed elevation (50-cm, 1.0-m and 2.0-m intervals) in a geospatial data file (SHP) format suitable for plotting using geographic information system (GIS) and computer-aided design (CAD) software
- 3-dimensional surface maps of the seabed created using 5× vertical exaggeration and artificial illumination to highlight fine-scale features not visible on contour layers delivered in grid and tagged image file (TIF) formats
- an acoustic relief map of the survey area created using 2× vertical exaggeration, delivered in georeferenced TIF format

2.2.4 Backscatter Data Processing

Backscatter data provided an estimation of surficial sediment textures based on sediment surface roughness. 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.

2.2.5 Side-Scan Sonar Data Processing

The side-scan sonar data were processed using both Chesapeake Technology, Inc. SonarWiz software and HYPACK®'s implementation of GeoCoder software. Data were used to produce a seamless mosaic of unfiltered side-scan sonar data. Individual georeferenced TIF images of each sonar file and georeferenced mosaics with resolutions of 0.1 to 0.2 m/pixel were generated.

2.2.6 Acoustic Data Analysis

The processed bathymetric grids were converted to rasters, and bathymetric contour lines and acoustic relief models (three-dimensional visualization of hill-shaded relief) 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 (images and color-coded grids are rendered with sufficient transparency to allow the three-dimensional acoustic relief model to be visible underneath).

2.3 Sediment-Profile and Plan-View Imaging Survey

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

2.3.1 SPI and PV Survey Planning

For the PBSA survey, a total of 30 SPI/PV stations were originally planned. The total number of SPI/PV stations was later doubled to 60 SPI/PV stations, but some stations were planned without replicates (see below). Survey planning included review of 2006 acoustic survey results and preliminary August 2013 acoustic results. A transect sampling approach was developed and applied that featured positioning SPI/PV stations relatively close together (e.g., 50 m apart) along survey lines, or transects. The transect approach was designed to ensure that the sediment characteristics of the flat seafloor and immediately adjacent pockmark were captured in a spatial sequence.

Three transects, identified as Transect 1, 2, and 3 were surveyed with 15 SPI/PV stations along each transect (Figure 2-2). In addition, five stations (with three replicates each) were occupied within one area in the northwest quadrant of the site (denoted NW Quadrant stations) and five stations (with three replicates each) were occupied within each of two potential reference areas (WREF and NREF). SPI/PV actual station replicate locations are provided in Appendix B.

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 as well as the status of the benthic biological community. The technique involves deploying an underwater camera system to photograph a cross section of the sediment-water interface. In the 2013 survey at PBSA, high-resolution SPI images were acquired using a Nikon® D7000 digital single-lens reflex camera mounted inside an Ocean Imaging® Model 3731 pressure housing system. The pressure housing sat atop a wedge-shaped prism with a front faceplate and a back mirror. The mirror was mounted at a 45° angle to reflect the profile of the sediment-water interface. As the prism penetrated the seafloor, a trigger activated a time-delay circuit that fired an internal strobe to obtain a cross-sectional image of the upper 15–20 cm of the sediment column (Figure 2-3).

The camera remained on the seafloor for approximately 20 seconds to ensure that a successful image had been obtained. Details of the camera settings for each digital image are available in the associated parameters file embedded in each electronic image file. For this survey, the ISO-equivalent was set at 640, shutter speed was 1/250, f-stop was f8, and storage was in compressed raw Nikon Electronic Format (NEF) files (approximately 20 MB each). Electronic files were converted to high-resolution JPEG (8-bit) format files (3264 × 4928 pixels) using Nikon Capture® NX2 software (Version 2.2.7).

Test exposures of the Kodak® Color Separation Guide (Publication No. Q-13) were made on deck at the beginning and end of the 2013 survey to verify that all internal electronic systems were working to design specifications and to provide a color standard against which final images could be checked for proper color balance. After deployment of the camera at each station, the frame counter was checked to ensure that the requisite number of replicates had been obtained. In addition, a prism penetration depth indicator on the camera frame was checked to verify that the optical prism had actually penetrated the bottom to a sufficient depth. If images were missed or the penetration depth was insufficient, the camera frame stop collars were adjusted and/or weights were added or removed, and additional replicate images were taken. Changes in prism weight amounts, the presence or absence of mud doors, and frame stop collar positions were recorded for each replicate image.

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

2.3.3 Plan-View Imaging

An Ocean Imaging® Model DSC16000 plan-view underwater camera (PV) system with two Ocean Imaging® Model 400-37 Deep Sea Scaling lasers mounted to the DSC16000 was attached to the sediment-profile camera frame and used to collect plan-view photographs of the seafloor surface. Both SPI and PV images were collected during each "drop" of the system. The PV system consisted of a Nikon D-7000 encased in an aluminum housing, a 24 VDC autonomous power pack, a 500 W strobe, and a bounce trigger. A weight was attached to the bounce trigger with a stainless steel cable so that the weight hung below the camera frame; the scaling lasers projected two red dots that are separated by a constant distance (26 cm) regardless of the field-of-view of the PV system, which can be varied by increasing or decreasing the length of the trigger wire. As the camera apparatus was lowered to the seafloor, the weight attached to the bounce trigger contacted the seafloor prior to the camera frame hitting the bottom and triggered the PV camera (Figure 2-3). 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 200. The additional camera settings used were as follows: shutter speed 1/20, f14, white balance set to flash, color mode set to Adobe RGB, sharpening set to none, noise reduction off, and storage in compressed raw NEF files (approximately 20 MB each). Electronic files were converted to high-resolution JPEG (8-bit) format files (3264 × 4928 pixels) using Nikon Capture® NX2 software.

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

The ability of the PV system to collect usable images was dependent on the clarity of the water column. Water conditions at PBSA were less than optimal, forcing us to use a 1.6-m trigger wire, resulting in an area of bottom visualization approximately 0.5 m × 0.3 m in size. After an initial test lowering at the end of the day on 20 August 2013, we discovered that the aperture in the 20mm lens on the Nikon D7000 inside the DSC16000 housing was frozen. The lens was replaced and tested when we returned to the dock to insure successful image acquisition during camera survey operations that were carried out the following day.

2.3.4 SPI and PV Data Collection

The SPI/PV survey was conducted at PBSA on 21 August 2013 aboard the R/V *Jamie Hanna*. At each station, the vessel was positioned at the selected coordinates and the camera was deployed within a defined station tolerance of 10 m. Three replicate SPI and PV images were collected at each reference area and NW quadrant area station (i.e., three separate lowerings of the camera setup within the defined station tolerance). In each of the three sets of transects, a single replicate SPI and PV image (one lowering of the camera setup) was collected at each station (Appendix B). At stations with three replicates, the three best quality SPI images and the best PV image were chosen for analysis (Appendix C).

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

2.3.5 SPI and PV Data Analysis

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

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

2.3.5.1 SPI Data Analysis

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

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

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

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

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

2.3.5.2 PV Data Analysis

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

2.4 Benthic Grab Sampling Survey

Benthic biology grabs samples were collected by Battelle scientists at twelve stations located throughout PBSA on 20 August 2013. Grab samples of sediment were analyzed for total organic carbon (TOC) and grain size and for benthic community structure. The twelve sampling locations were distributed throughout the study area with six stations located within pockmarks and six stations on the ambient seafloor. The sampling stations were selected such that there were three stations in each quadrant (Transects 1, 2, and 3, and the NW Quadrant). Within each quadrant, a combination of pockmark and ambient seafloor sampling stations locations were selected. Benthic grab sampling locations are provided in Appendix B.

Sediment grab samples were collected using a 0.04-m² Ted Young-modified Van Veen grab sampler. At each station, the vessel was positioned at the target coordinates and grab samples were collected within a defined station tolerance of 30 m. The samples were checked for penetration depth (10 cm was the maximum and 6 cm was the minimum acceptable penetration depth), depth of the apparent redox potential discontinuity (aRPD) layer, sediment texture, odor, and observed biota.

Two grab samples were collected at each station. One grab sample was processed for TOC and grain size analyses, and the other grab sample was processed for infaunal community analysis. For TOC and grain size, grab samples were collected and then the overlying water in the grab sample was removed with a siphon. Next, the entire contents of the grab sample were homogenized until a consistent color and texture was achieved. An aliquot of sediment was then placed into two 125-ml clear glass jars, one for TOC analysis and one for grain size analysis. The TOC and grain size samples were stored on ice and shipped priority overnight to Katahdin Analytical Services (Scarborough, ME) for analysis.

The sediment grab sample for benthic community analysis was washed into a clean 10 liter plastic bucket and sieved through a 0.5 mm mesh screen. The material retained on the sieve was then placed in an appropriate sample container (1 liter or 500 ml) and preserved with 10% formalin and half a tablespoon of borax to buffer the solution. The samples were hand-delivered to AECOM (Woods Hole, MA) on 26 August 2013 for sorting and analysis. AECOM followed standard operating procedures for benthic community analysis of sediment grab samples (AECOM 2010).

2.5 Surface Marker Buoy Observations

DAMOSVision hydrographers captured the GPS locations and type of surface marker buoys used for commercial lobster fishing present in the PBSA during the acoustic survey. This was achieved by visually identifying a marker buoy and saving a GPS location in HYPACK® as the vessel passed each buoy. Acoustic survey transects were positioned 50 m apart, and hyrdographers took care to record each buoy only once and during the closest pass of each marker buoy. As a result, marker buoys were estimated to be within 25 meters of each buoy GPS location saved. A file of marker buoy GPS locations was created and was used to generate a map of surface marker buoy locations throughout the PBSA.

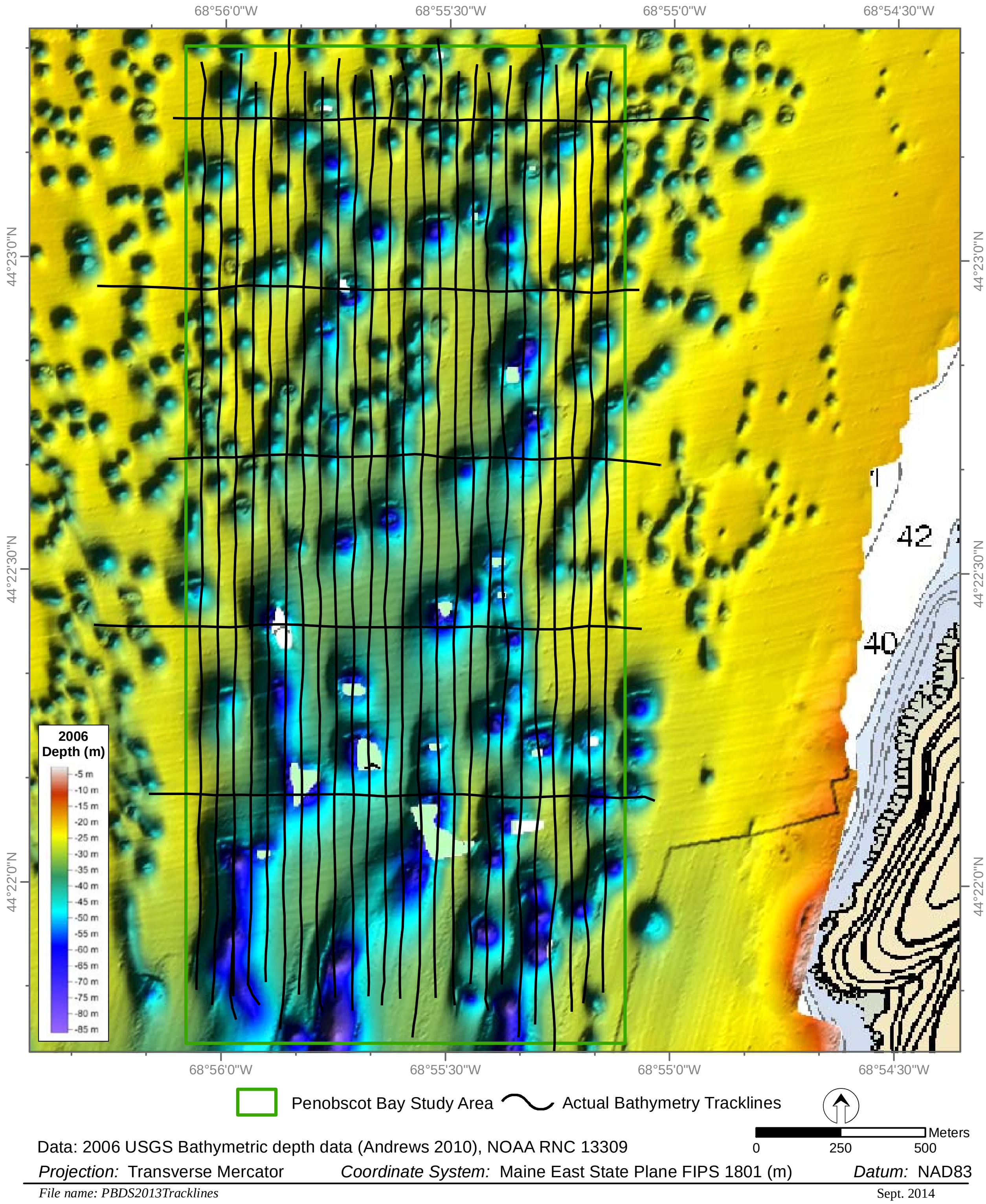


Figure 2-1. Bathymetric survey boundary and actual tracklines at PBSA

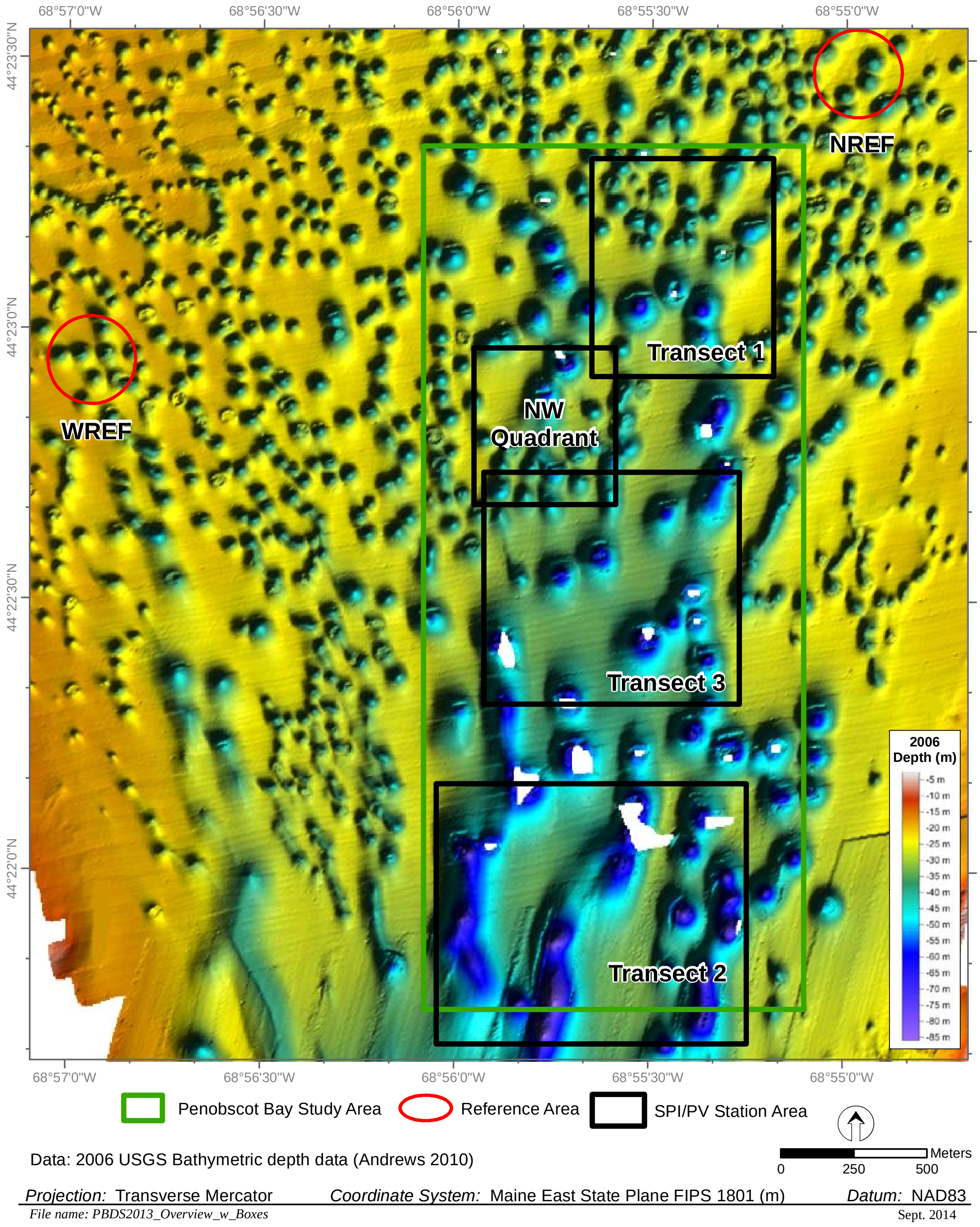


Figure 2-2. PBSA with target SPI/PV station areas indicated

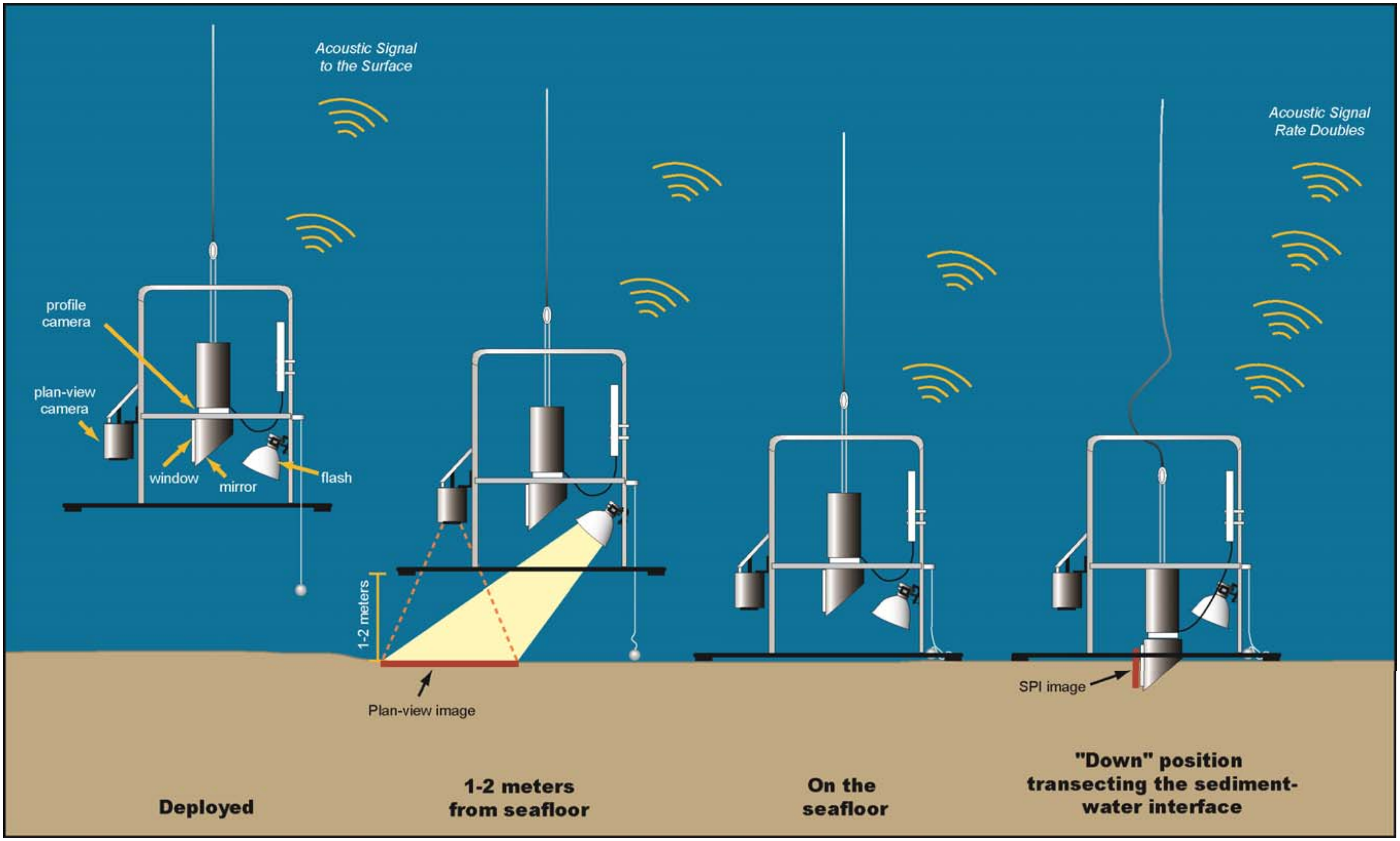


Figure 2-3. Schematic diagram of the SPI/PV camera deployment

3.0 SURVEY RESULTS

3.1 Acoustic Survey Results

An acoustic survey was conducted 19 August 2013 to assess the topography and surficial sediment characteristics at PBSA. Survey results include bathymetric contours, acoustic relief models, and backscatter mosaics. Each type of acoustic data revealed different information that led to insights regarding the topography and surficial sediment in the study area.

3.1.1 Existing Bathymetry

The bathymetry of PBSA as surveyed in 2013 revealed over one hundred pockmarks set into a relatively flat seafloor (Figure 3-1). Non-pockmarked areas were typically between 28 and 32 m deep in the north and deeper (30 to 34 m) toward the south. In the northern portion of the study area, pockmarks were typically individual features and, in some cases, were partially connected to neighboring pockmarks. In the southern portion, the pockmarks tended to be larger in diameter, deeper, and connected together to form north-south oriented troughs.

Given the relatively large size of the survey area (3.0 km^2) and the frequency of pockmarks (more than 100), it was difficult to discern the features of individual pockmarks in the bathymetric map of the entire study area. As a result, two areas were selected for closer analysis; one in the northern portion of the study area representative of smaller pockmarks and the other in the southern portion of representative of larger, more connected pockmarks (Figures 3-1, 3-2, and 3-3).

Bathymetry of the representative northern area revealed changes in water depth from 29 m on the ambient seafloor at the edge of the pockmarks to more than 65 m at the bottom of the larger pockmarks, representing a vertical drop of over 30 m over a horizontal distance of approximately 75 m, representing a vertical:horizontal side slope of approximately 1:2.5 (Figure 3-2). Smaller pockmarks in the area had similar side slopes with bottom depths of approximately 45 m. The pockmarks were identifiable as distinct features, but many tended to be clustered, sharing an adjacent side with neighboring pockmarks.

In the representative southern area, the bathymetry revealed changes in water depth from 30 m on the ambient seafloor to more than 75 meter deep at the bottom of the larger pockmarks (Figure 3-3). Pockmark side slopes were similar to or slightly steeper than those of smaller pockmarks in the northern portion of the study area. Pockmarks in the southern portion of the study area tended to be grouped along north-south oriented troughs. For example, in the series of pockmarks along the southwest side of the study area, water depths were somewhat less over the ridges between the pockmark centers, but were well below the depth of the ambient seafloor for more than 1000 m. The southern trending constriction of the bay in this area (Figure 1-2) is expected to enhance tidal current velocities potentially modifying individual circular pockmarks into conjoined linear features.

Multibeam bathymetric data rendered as an acoustic relief model (grayscale with hillshading) provided a more detailed representation of the surface of the study area (Figure 3-4). The acoustic relief model revealed a surface with relatively smooth sediment in flat portions of the selected northern and southern areas outside of the pockmarks with some fine textural patterns along the slopes of the pockmarks (Figure 3-5 and 3-6).

3.1.2 Acoustic Backscatter and Side-Scan Sonar

Acoustic backscatter data provided an estimate of surficial sediment texture (backscatter is affected by relative hardness as well as surface texture such as grain size and fine-scale surface roughness). A mosaic of unfiltered backscatter data for PBSA (Figure 3-7) generally revealed softer (darker in this image) sediment along the sides of pockmarks and north-south oriented linear streaks of slightly harder or rougher material trailing away from the rim of pockmarks. This pattern was evident in the closer views of representative areas from northern and southern portions of the PBSA (Figures 3-8 and 3-9). The linear features were not observed in the acoustic relief model suggesting that they have little or no surface relief. The linear features appeared to represent tidal-mediated differential sediment transport (slightly finer material has likely been removed by winnowing of fines due to linear vortices setup during tidal exchange). Brothers et al. (2011) have hypothesized that the presence of the pockmarks can perturb the patterns of tidal flow potentially maintaining and modifying the pockmark morphology. The backscatter patterns of the linear features are distinctive, but the lack of surface relief suggests a lack of significant sediment transport. Filtered backscatter and side-scan sonar results showed similar patterns of relatively softer pockmark side slopes and harder linear features on the ambient seafloor adjacent to the pockmarks (Appendix E). Filtering also highlighted the relatively hard bottom (in red) near the center of some of the pockmarks (Figure 3-10), potentially attributed to the depressions bottoming out into a different, harder geologic unit or coarse lag deposits (see Section 3.2.1 below).

3.2 Sediment-Profile and Plan-View Imaging

The sediment-profile and plan-view imaging at PBSA provided further characterization of surficial physical features and allowed for assessment of benthic community status throughout the study area. A transect sampling approach was developed and applied to ensure that the sediment characteristics of both the flat ambient seafloor and the interspersed pockmarks were captured in a spatial sequence. A total of 60 SPI/PV stations were occupied with 15 stations along each of three transects and five stations in each of three specified areas; the northwest quadrant of PBSA (NW Quadrant) and two potential reference areas (WREF and NREF, Figure 3-11). A complete set of image analysis results is presented in Appendix C.

3.2.1 PBSA Transects and NW Quadrant

The locations of the NW Quadrant and Transect 1 stations relative to spatial topography and surficial sediment characteristics are provided in Figures 3-12 and 3-13. Similarly, Transect 2 and 3 stations are provided in the same format in Figure 3-14 and 3-15.

<u>Physical Sediment Characteristics</u>

Surficial sediments in the study area were found to primarily consist of well-sorted, fine silts and clays with high water-content and low bearing strength. The grain size major mode was observed to be uniformly silt/clay (>4 phi) in nearly all of the transect and NW Quadrant stations, except at Stations T2-I and T2-O (located near the bottom of separate pockmarks) where the presence of rocks (cobbles) prevented camera prism penetration (Figures 3-16 through 3-19 and Appendix C).

Camera penetration depth provided a measure of the bearing strength (or bearing capacity) of sediments. At transect and NW Quadrant stations, the sediment was found to have deep camera penetration indicative of extremely low bearing strength (Figures 3-20 through 3-23). The camera was outfitted with mud doors and no weights in the weight carriage (Appendix C) in order to minimize penetration and yet still overpenetrated the soft sediment surface at some stations. Penetration depth tended to be greater on the slopes of pockmarks, indicating softer sediment, and more shallow on the flat ambient seafloor. At stations at or near the bottom of the pockmarks, sediment penetration depths were highly variable from one pockmark to another. Penetration depths ranged from 0 to >21.1 cm (with the high value indicative of overpenetration) at the transect and NW Quadrant stations. Boundary roughness at transect and NW Quadrant stations was observed to range from 0.8 to 5.2 cm (Figures 3-24 through 3-27) and was attributed primarily to biological origins. When reviewing the summary figures and tables, it should be noted that overpenetration of the camera into the sediment precludes capture of the sediment-water interface in the image. Although useful information is still obtained regarding sediment composition and benthic organisms, the surface roughness and aRPD cannot be assessed and are listed as indeterminate.

<u>Biological Characteristics</u>

The aRPD values of all stations within the study area revealed oxygenated sediments (no anoxic conditions) and typically ranged from 2 to 7 cm deep. The aRPD values tended to be deeper at flat ambient seafloor stations and shallower within pockmarks (Figures 3-28 through 3-31 and

Appendix C), but with some exceptions and variability such as the relatively deep aRPD values observed within pockmarks in Transect 2 (at T2-A through T2-D) and at NW Quadrant stations 1 and 3. The deepest aRPD values were observed at pockmark slope station T1-C (15.7 cm) and at rim station T1-K (12.5 cm).

Review of SPI images revealed the presence of biological activity in the form of surface tubes, fecal pellets, burrowing, and feeding voids (Appendix C). In Transect 1, a few polychaetes were observed, and most images had fecal pellets and burrows or tubes. In Transect 2, a few stations showed the presence of high abundances of *Nucula sp.*; one station (T2-F) showed mussels and one station had epifauna on cobbles (T2-I). Polychaetes and *Nucula sp.* were observed in a few of the stations in Transect 3 and the NW Quadrant with fecal pellets, burrows and tubes in most images. No methane or low dissolved oxygen conditions were observed in the images.

The three transects and NW Quadrant stations all had evidence of Stage 3 successional status except some pockmark stations that were indeterminate due to camera overpenetration. All of the Transect 1 stations were 1 on 3 or indeterminate (Figures 3-32 through 3-35 and Appendix C). All of the Transect 2, Transect 3, and NW Quadrant stations were 1 on 3, 2 on 3, or indeterminate, except two pockmark stations in Transect 3 (T3-M and T3-N) that were Stage 3 successional status.

<u>Selected Plan-View and Sediment Profile Image Analysis</u>

General observations of the plan-view and sediment-profile images further supported the findings of SPI metrics and the acoustic survey of soft, fine-grained sediment found throughout the majority of the study area. Transect 1 Stations T1-B, T1-C, and T1-E were positioned on a pockmark rim, slope, and bottom, respectively, and all showed soft, light tan colored sediments. In pockmark Stations T1-C and T1-E suspended fine-grained sediment was visible above the bottom (in right on images, Figure 3-36) as the weight from the trigger wire impacted the bottom. Both of these stations recorded overpenetration of the SPI camera. Plan-view and sediment-profile images of Transect 2 showed fine-grained sediment but with a slightly wider range of characteristics (Figure 3-37). Stations T2-L, T2-M, T2-N were positioned on the ambient flat seafloor, pockmark rim, and pockmark bottom, respectively. Station T2-L had evidence of feeding voids and burrows with light tan sediments. Station T2-M had evidence of small tubes on the surface (note: the disturbed interface in the SPI image due to sediment falling off the camera). Stations T2-N at the bottom of the pockmark was firmer than most with large burrows and a distinct aRPD (Figure 3-37). Selected Transect 3 SPI and PV images from pockmark slope (T3-K) and bottom (T3-L and T3-O) yielded similar observations (Figure 3-38). Station T3-K had very soft disturbed sediment fabric while Stations T3-L and T3-O had evidence of redistribution of material, likely from material displaced down the sidewall (layers of darker and lighter gray material below the aRPD (Figure 3-38).

3.2.2 Potential Reference Areas

SPI and PV image data were collected at five stations in each of two potential reference areas, identified as WREF and NREF in Figure 3-11. The potential reference areas were not included in the 2013 acoustic survey area (Figure 3-11), and topographic reference was provided using 2006 USGS bathymetric data (Figure 3-39). The potential reference areas were located in a similar bathymetric setting as the PBSA; they contained pockmarks set in ambient water depths of 20 to 30 m.

Physical Characteristics
In the potential reference areas, WREF and NREF, all 10 stations sampled had a grain size major mode of silt/clay (Figure 3-40, Appendix C). In the WREF area, the station penetration means ranged from 5.3 to greater than 21.1 cm (Figure 3-41 and Appendix C). The NREF area had similar station penetration mean values ranging from 5.8 to greater than 20.3 cm. In both reference areas, sediments had extremely low bearing strength. Even though the camera was outfitted with mud doors and no weights in the weight carriage, there were individual replicates and stations that still were overpenetrated by the camera. Boundary roughness values ranged from 1.0 to 2.7 cm (Figure 3-42, Appendix C), and similar to PBSA stations, they were mostly of biological origin.

Biological Characteristics

In the WREF area, the average station aRPD values ranged from 2.4 to 3.7 cm deep (Figure 3-43 and Appendix C). The NREF area had average station aRPD values that ranged from a depth of 1.9 to 3.5 cm. Despite the overpenetration at some stations, a successional stage could be assessed in all of the images (Figure 3-44 and Appendix C). Surface tubes, fecal pellets, burrowing, and feeding voids were evident at several reference stations. In the WREF area, polychaetes were visible at several stations. Successional stage at all five stations in the WREF area was 1 on 3. In the NREF area, successional stage varied and included 1 on 3, 2 on 3, and 3. No methane or low dissolved oxygen conditions were observed in the images.

3.3 Benthic Grab Sampling

Sediment grab samples were collected at 12 locations and analyzed for grain size, TOC, and benthic community structure (Figure 3-45). Samples were collected both inside the pockmarks (slopes and bottom) and on the surrounding ambient bottom. The results for grain size, TOC, and benthic community structure were generally similar for all grab samples. All 12 samples consisted of greater than 95 percent fines (Table 3-1). TOC analysis results were similar for all of the sampling locations with measurements ranging from 29 to 35 mg/g (Table 3-1).

Each grab sample yielded an abundance of benthic organisms, with an average of more than 1,000 specimens per sample. The samples contained 59 verified species and a total of 12,140 specimens. Ten species were observed to represent 92% of all specimens (Table 3-2). The top three species were the bivalve, *Nucula annulata*, and the polychaetes, *Cossura longocirrata*, and *Terebellides stroemi*, representing 71% of the entire fauna. These results were very consistent with the SPI/PV results that illustrated patchy high abundances of *Nucula*, a shallow dwelling bivalve, and patchy distribution of slumped oxidized sediments in pockmarks. The results suggested that organisms residing on the pockmark rims and slopes could be episodically transported by sediment slumping downslope into the pockmark and concentrated there. However, this is likely a patchy occurrence as some pockmarks had lower abundances. Benthic species and counts for each sampling location are provided in Appendix F.

3.4 Surface Marker Buoy Observations

A total of 17 lobster trap-style surface marker buoys were observed during the PBSA bathymetric survey on 19 August 2014, and their approximate locations are shown Figure 3-46. The buoys were generally clustered in the northwest, shallower portion of the study area, with 12 of 17 total buoys observed in this area. No marker buoys were observed directly over pockmarks.

3.5 Estimate of Pockmark Volume

To aid in evaluation of the potential use of the PBSA for dredged material placement, the volume of three groups of pockmarks was estimated. The pockmark groups included large to moderate sized pockmarks located in the southern portion of the study area (Figure 3-47). For each group, the pockmark volume below 40 meters depth and below 50 meters depth was estimated using the Surfer® (version 12) GIS-based contouring software.

The 40 meter depth is the contour shown in red in Figure 3-47 and represents the volume up to the ambient seafloor in the immediate vicinity of the Pockmark Groups 1, 2, and 3. Pockmark Group 1 contained five pockmarks with an estimated total volume of approximately 879,000 m^3 below 40 meters depth. Pockmark Group 2 contains three pockmarks with an estimated total volume of approximately 532,000 m^3 and Pockmark Group 3 contains two large pockmarks with an estimated total volume of approximately 766,000 m^3 below 40 meters depth.

The 50 meter depth contour is labeled in black in Figure 3-47 and represents a partial pockmark volume. Pockmark Group 1 contained an estimated total volume of approximately 252,000 m^3 below 50 meters depth. Pockmark Group 2 contains an estimated total volume of approximately

162,000 m^3 and Pockmark Group 3 contains an estimated total volume of approximately 273,000 m^3 below 50 meters depth.

Table 3-1.

PBSA Grab Sampling Results of TOC and Grain Size Analysis

		Grain Size					
Sample ID	**Total Organic Carbon (mg/g)**	**Fines (%)**	**Total Sand (%)**	**Fine Sand (%)**	**Medium Sand (%)**	**Coarse Sand (%)**	**Gravel (%)**
G-001-A	32	95.7	4.3	4.0	0.3	0	0
G-002-A	33	96.1	3.9	2.9	0.8	0.2	0
G-003-A	33	95.7	4.3	3.0	1.3	0	0
G-006-A	31	97.2	2.8	2.3	0.3	0.2	0
G-007-A	32	96.8	3.2	2.0	1.0	0.2	0
G-008-A	34	95.1	4.9	2.3	2.6	0	0
G-011-A	30	97.5	2.5	1.6	0.8	0.1	0
G-012-A	29	96.6	3.4	1.8	1.3	0.3	0
G-014-A	32	97.5	2.5	1.7	0.4	0.4	0
G-016-A	35	98.7	1.3	0.5	0.8	0	0
G-017-A	30	97.8	2.2	1.0	1.2	0	0
G-018-A	30	97.2	2.8	0.9	1.7	0.2	0

Table 3-2.

The Ten Dominant Species from the 12 Benthic Samples

Species	**Total Count**
Nucula annulata	4392
Cossura longocirrata	2941
Terebellides stroemi	1346
Anobothrus gracilis	766
Yoldia sapotilla	737
Levinsenia gracilis	357
Ninoe nigripes	189
Euchone incolor	167
Chaetozone anasimus	155
Nephtys incisa	146
Total	**11,196**

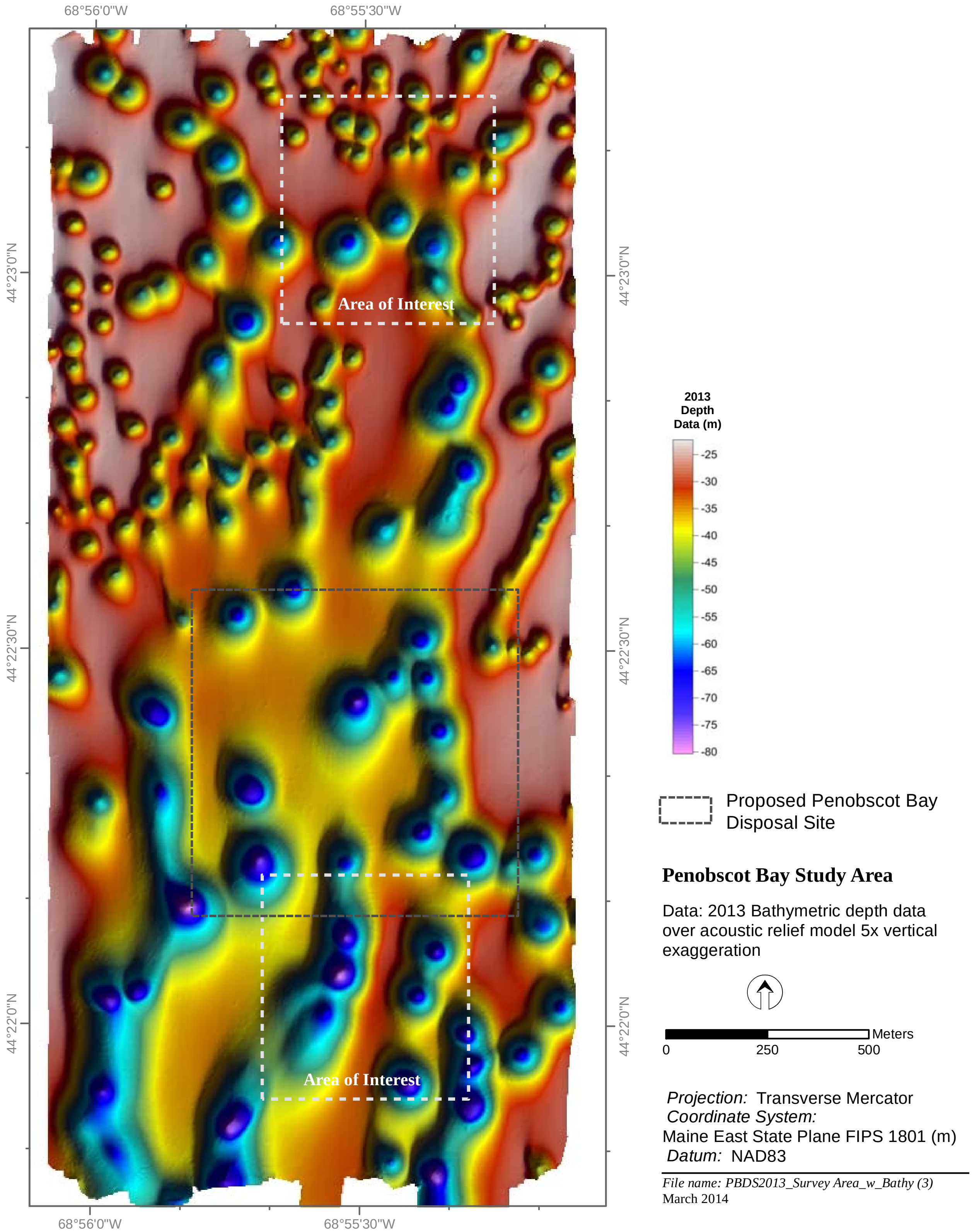


Figure 3-1. Bathymetry of PBSA - August 2013

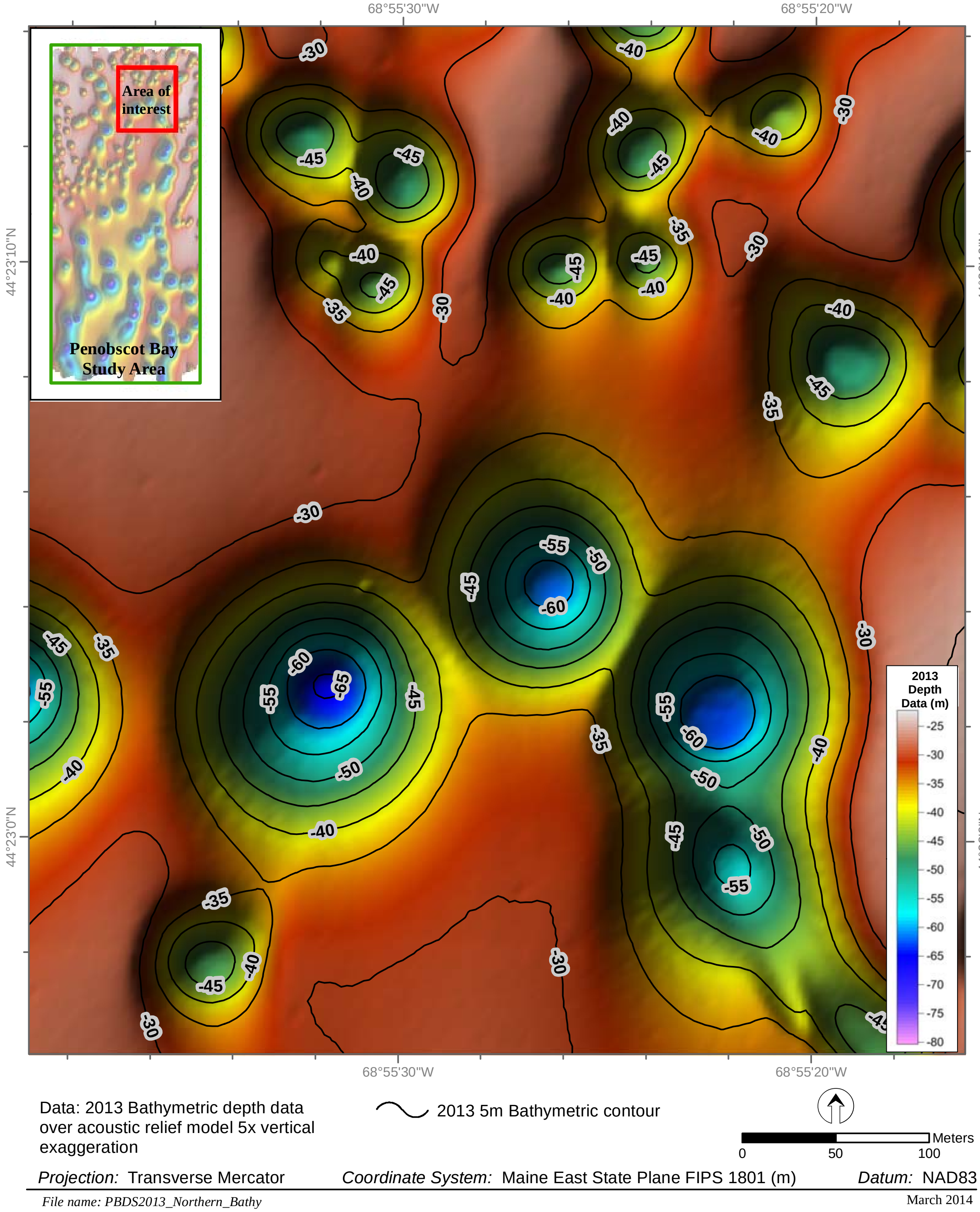


Figure 3-2. Bathymetric contour map of a selected northern area within PBSA

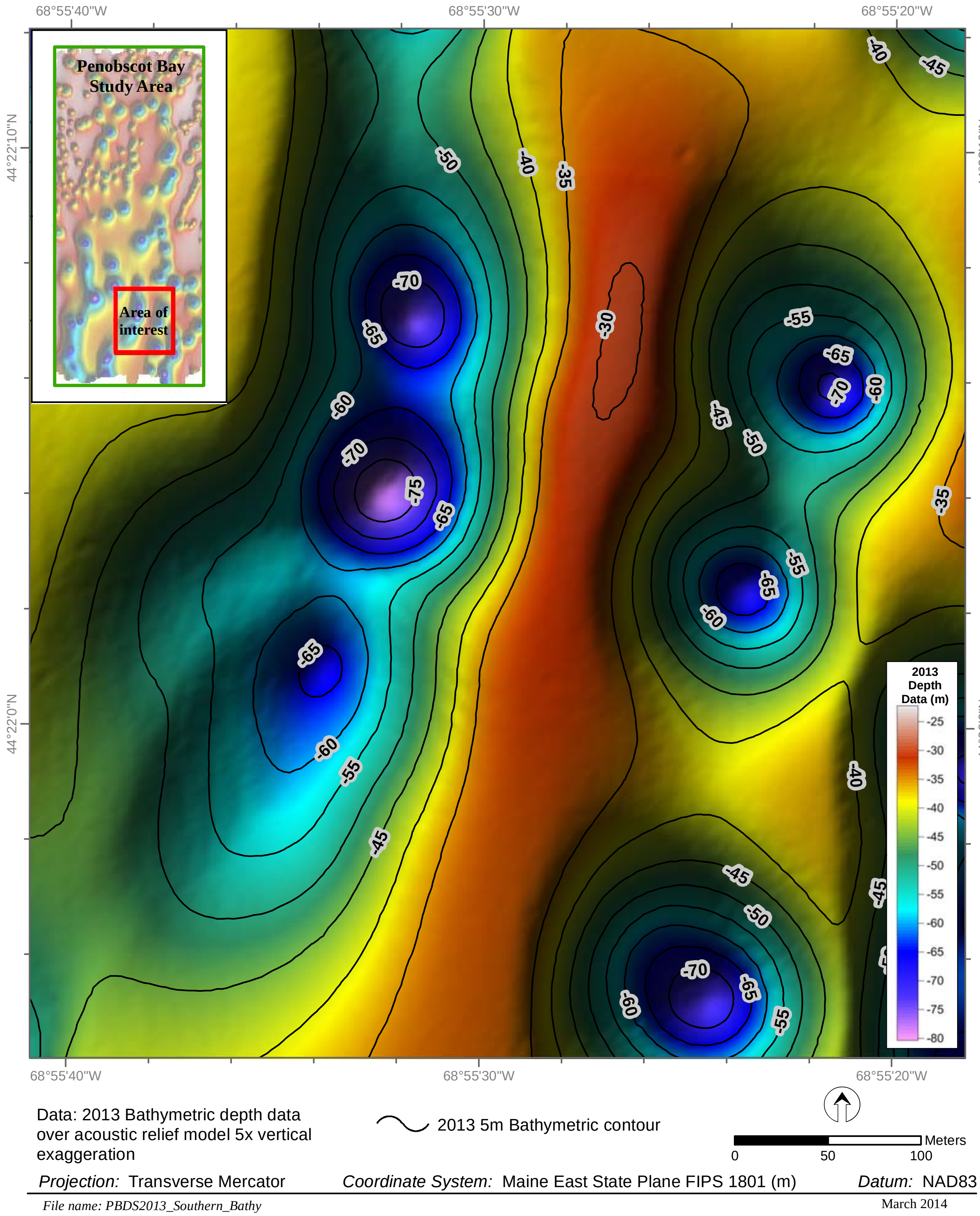


Figure 3-3. Bathymetric contour map of a selected southern area within PBSA

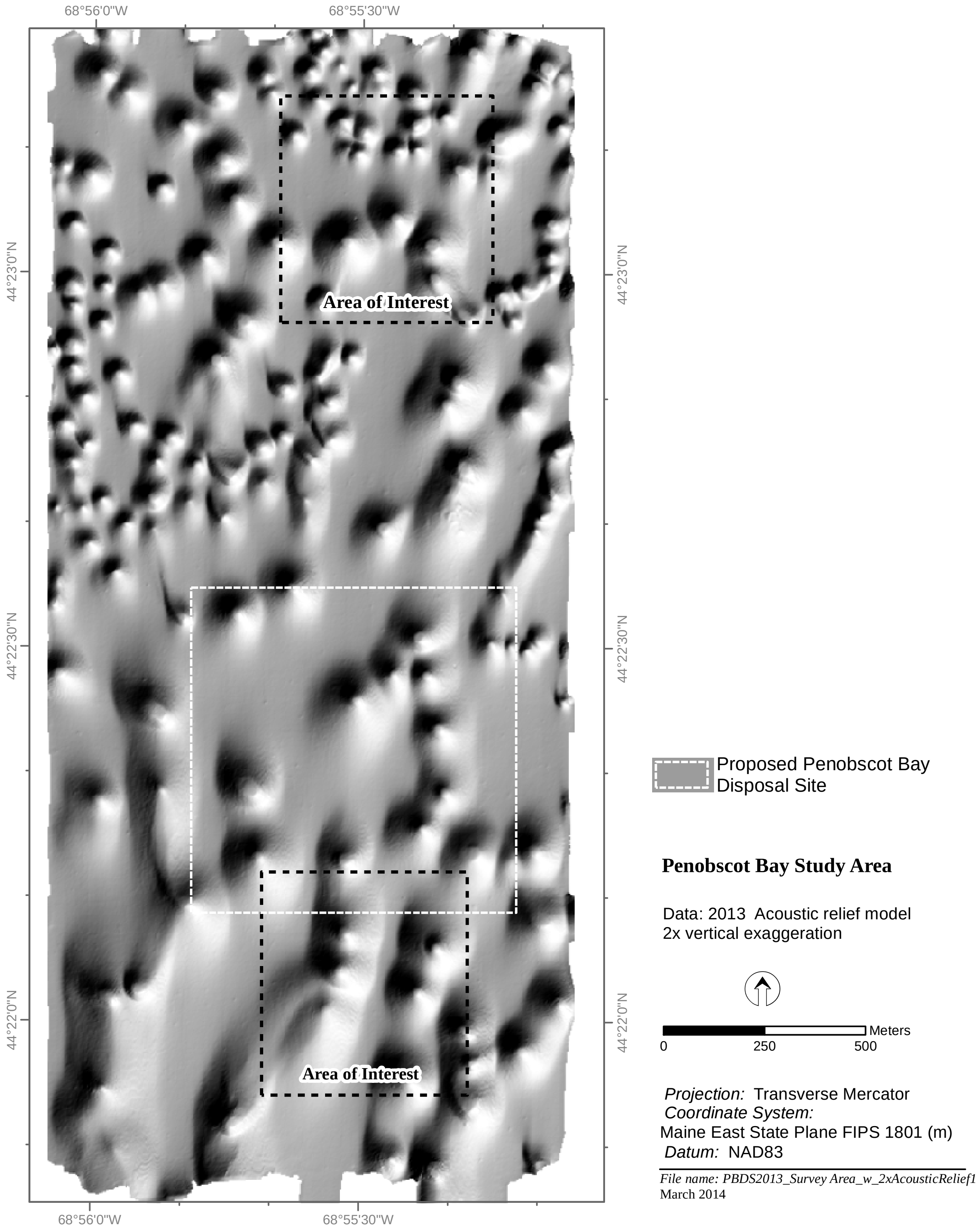


Figure 3-4. Acoustic relief model of PBSA - August 2013

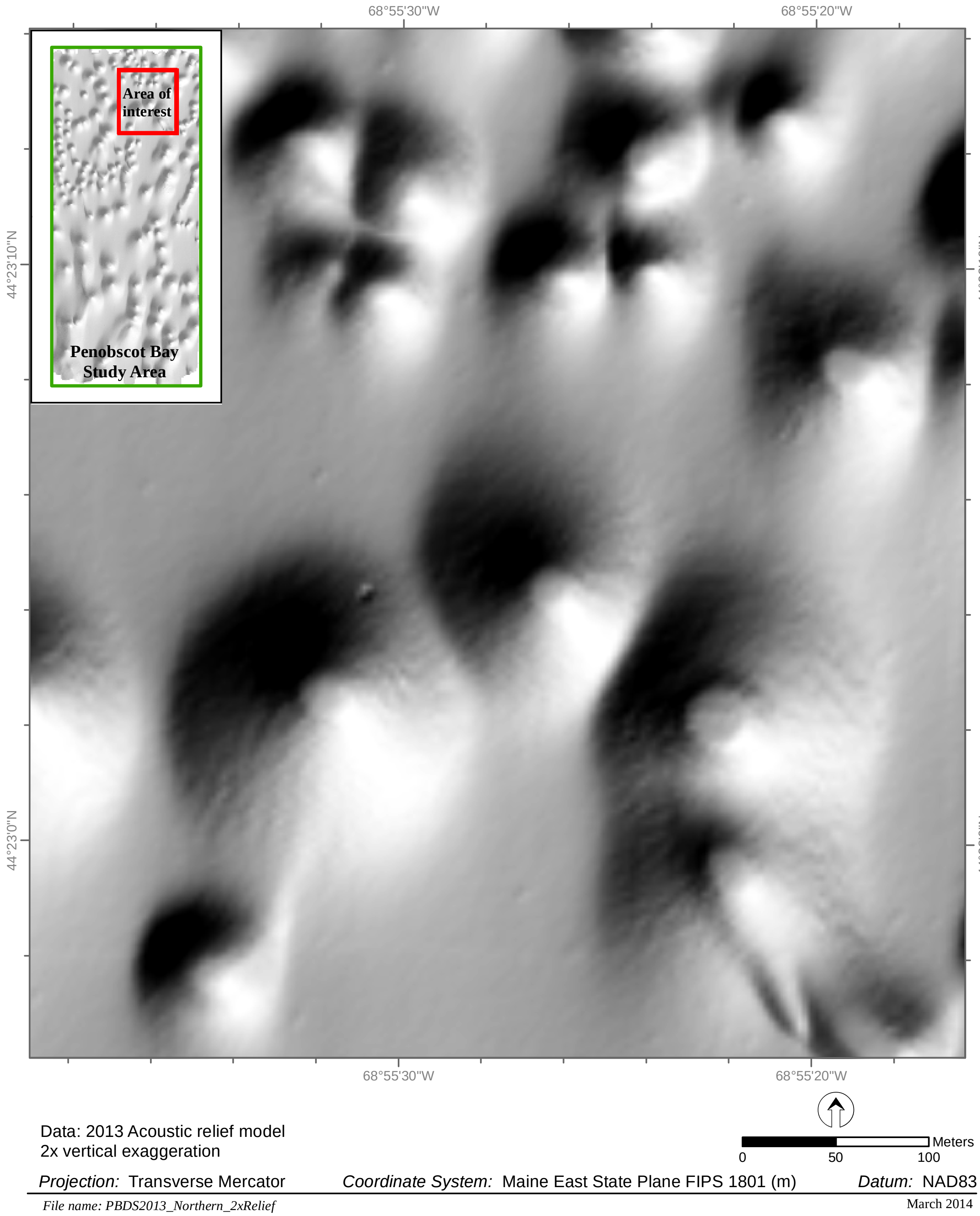


Figure 3-5. Acoustic relief model of a selected northern area within PBSA

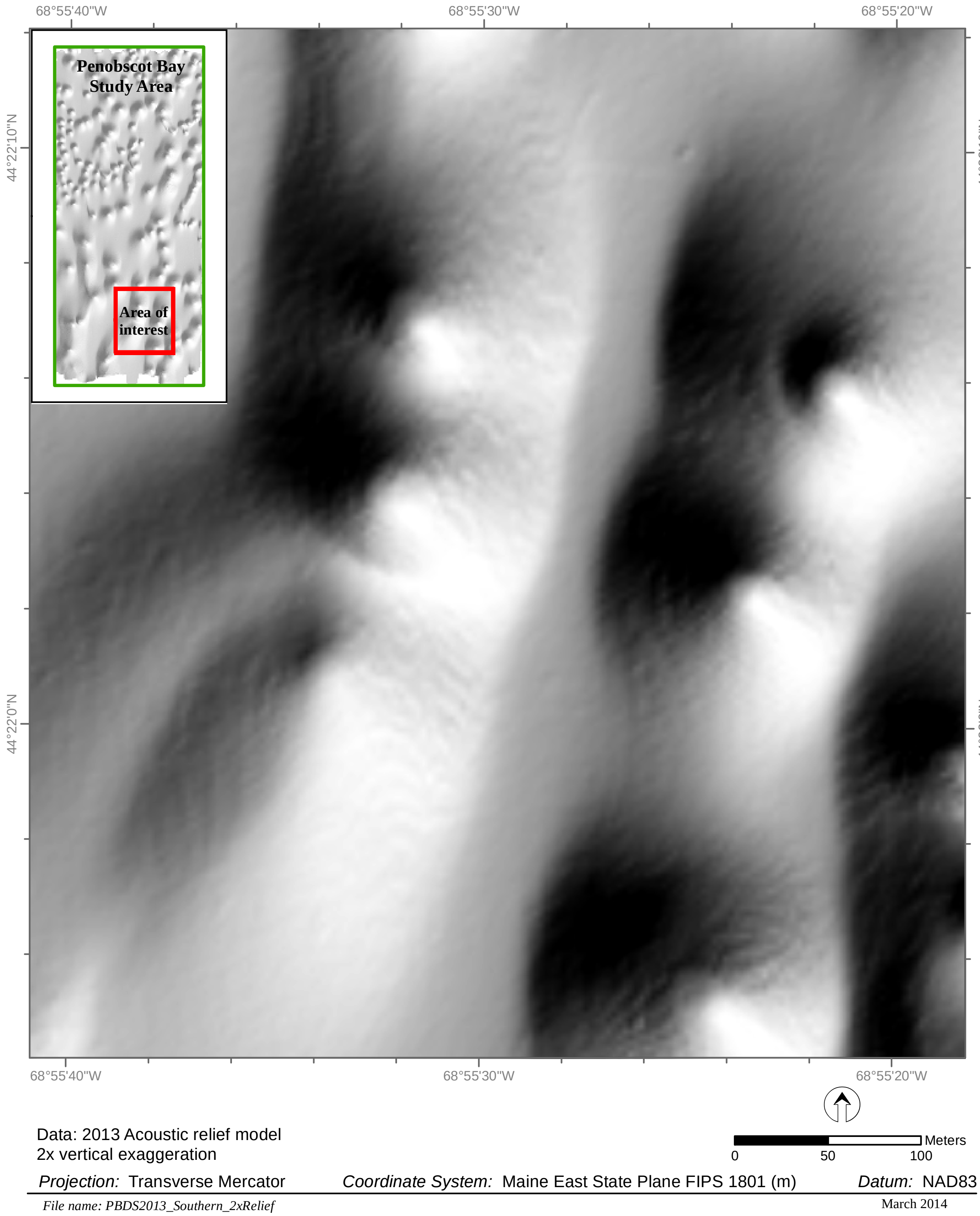


Figure 3-6. Acoustic relief model of a selected southern area within PBSA

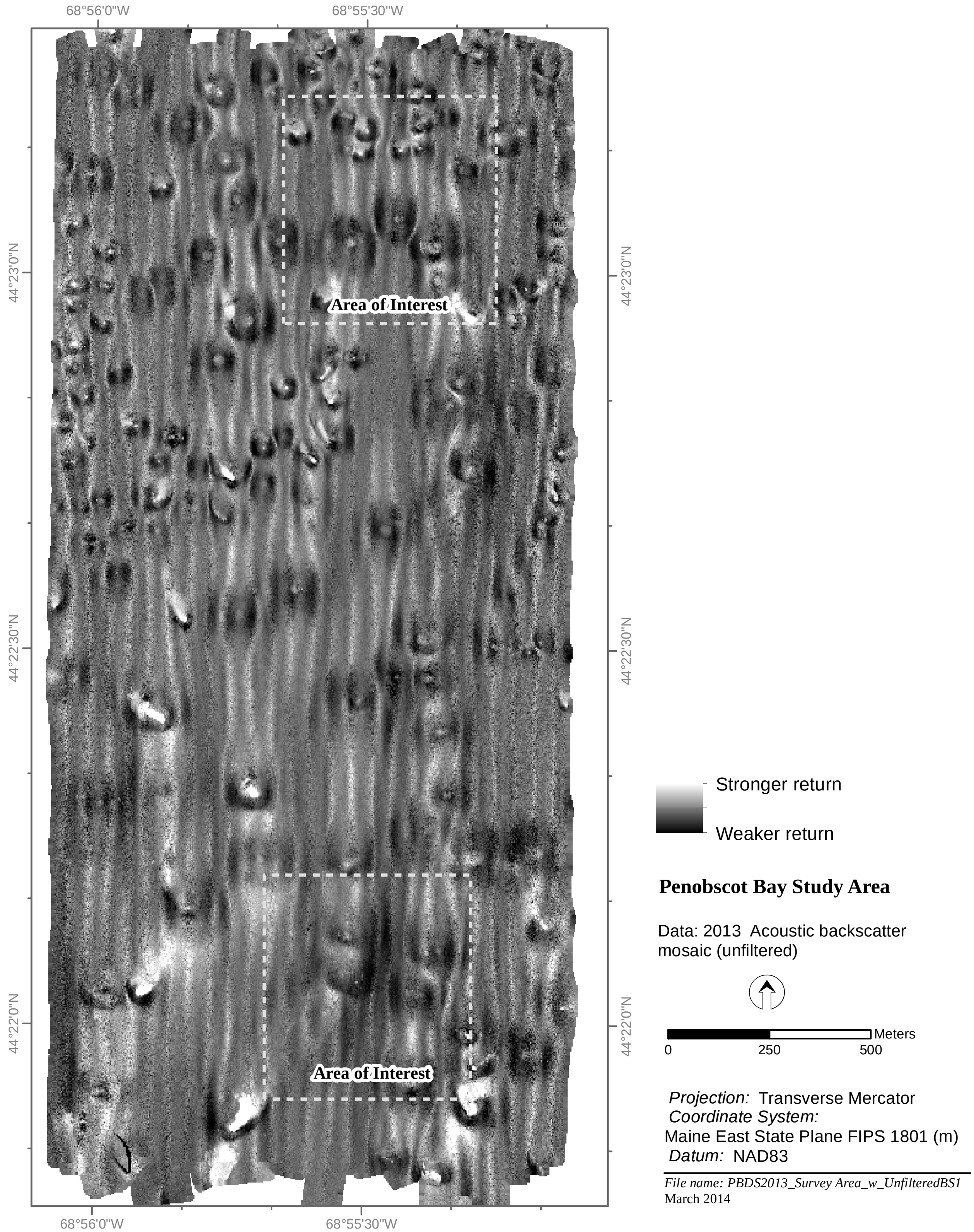


Figure 3-7. Mosaic of unfiltered backscatter data of PBSA - August 2013

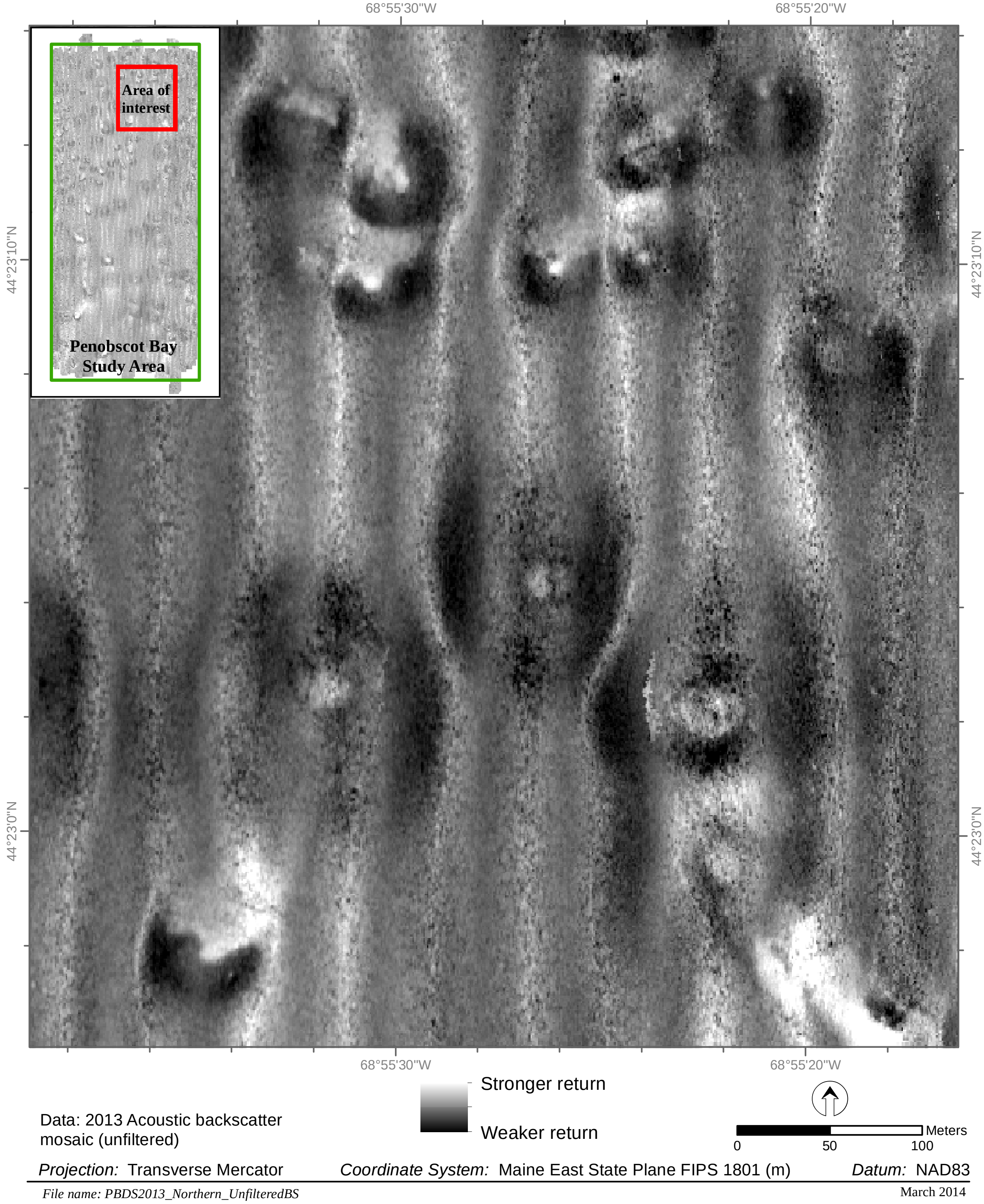


Figure 3-8. Mosaic of unfiltered backscatter data of a selected northern area within PBSA

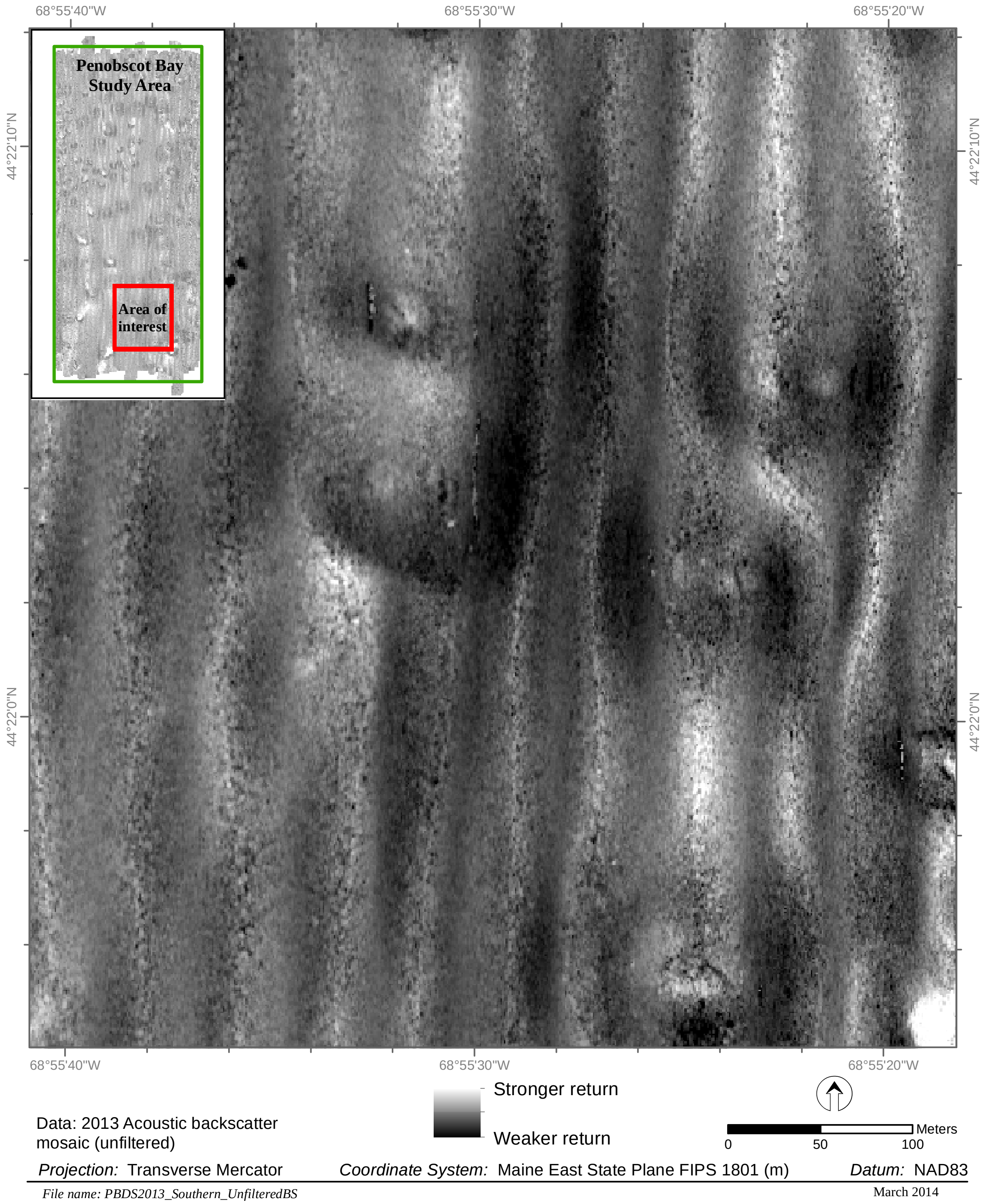


Figure 3-9. Mosaic of unfiltered backscatter data of a selected southern area within PBSA

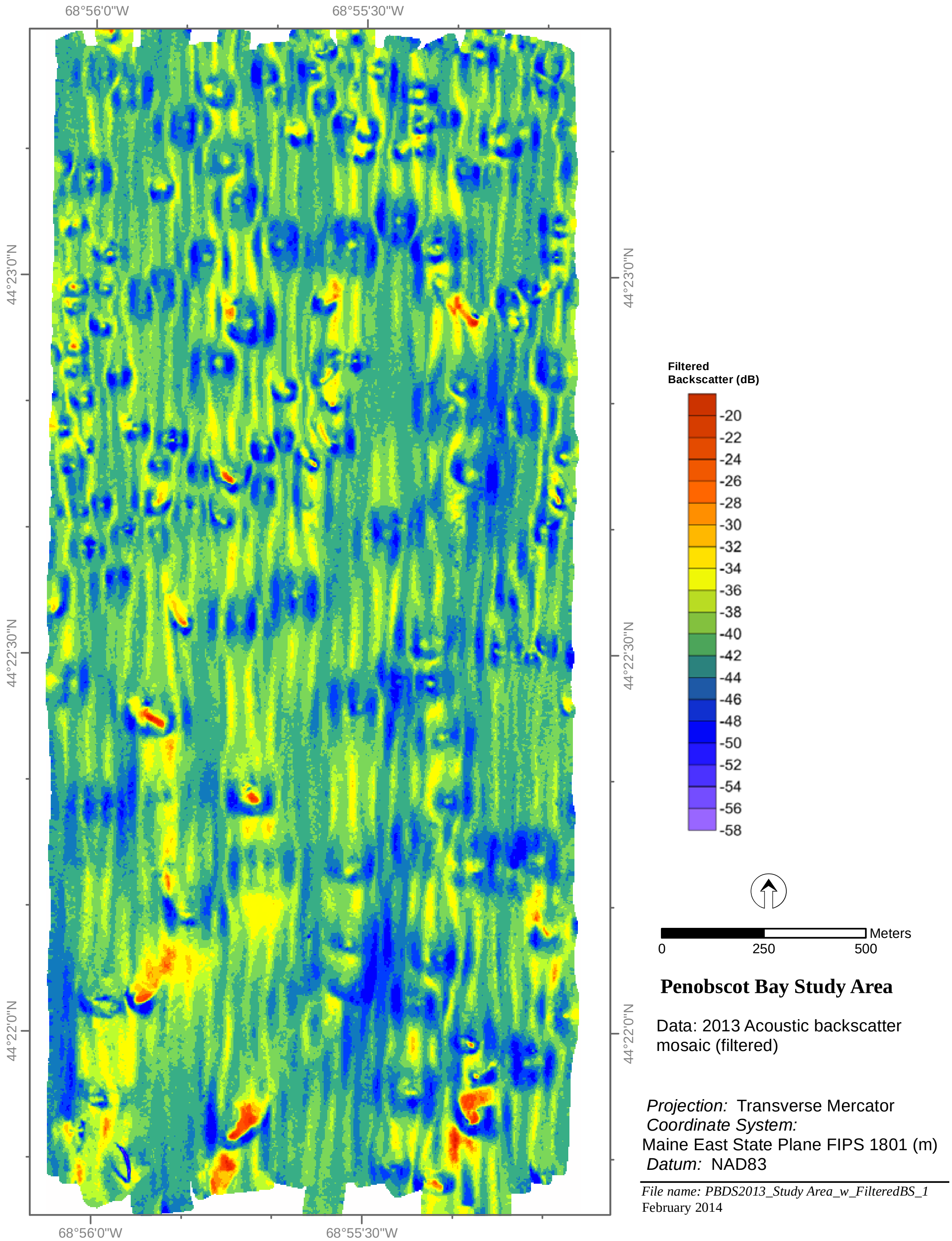


Figure 3-10. Mosaic of filtered backscatter data of PBSA - August 2013

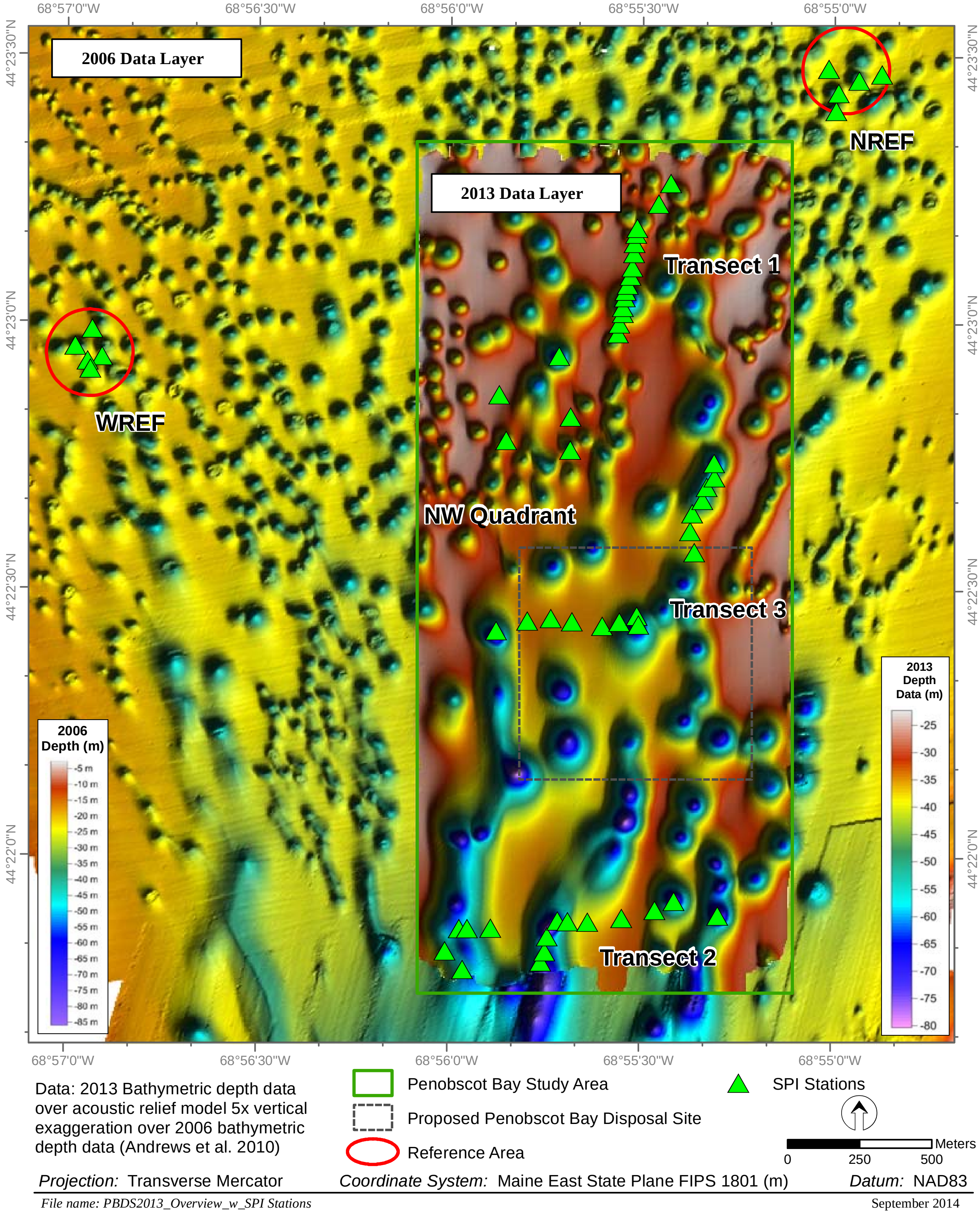


Figure 3-11. SPI/PV station locations at PBSA

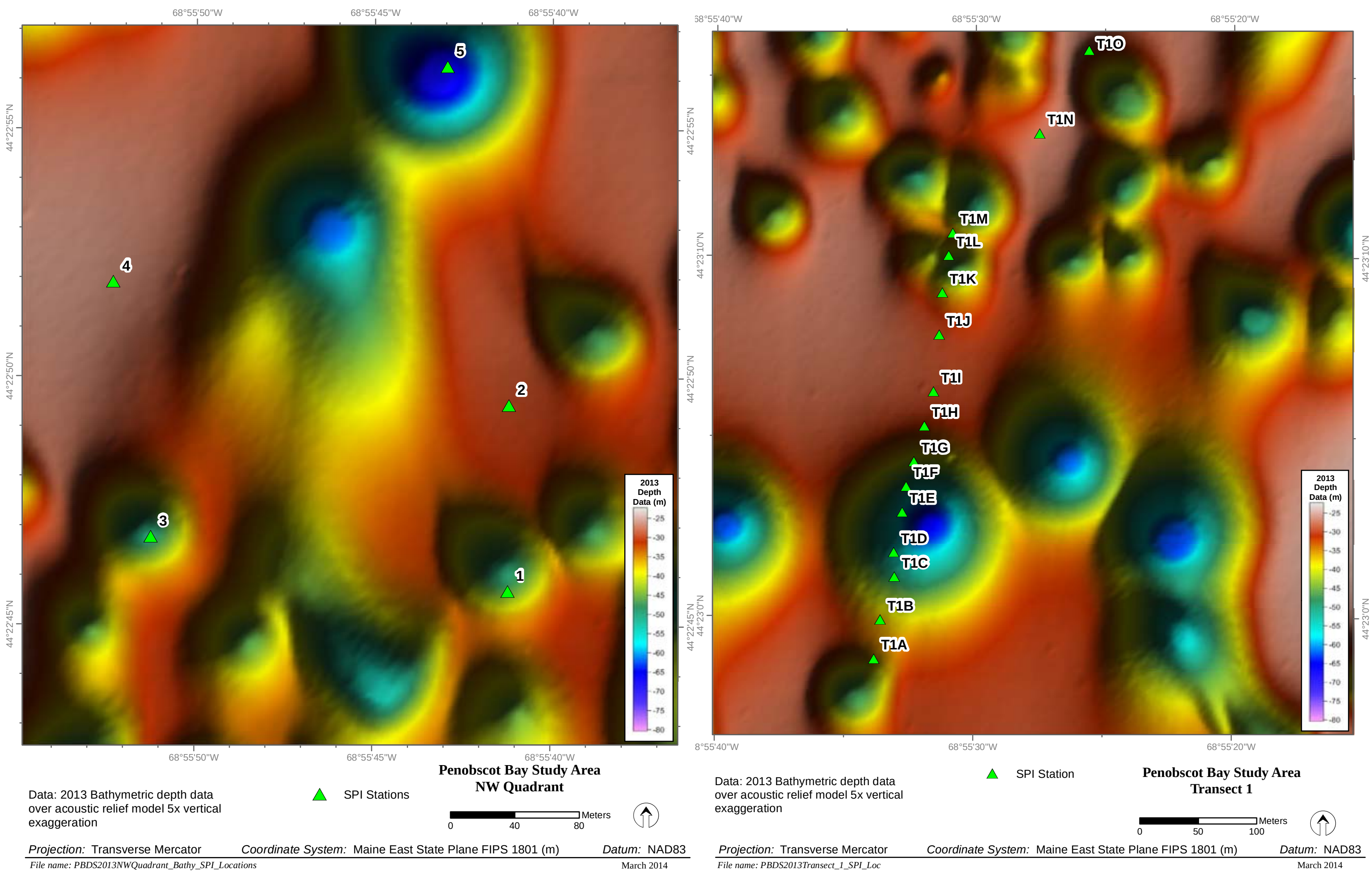


Figure 3-12. PBSA survey areas NW Quadrant and Transect 1 with sediment-profile image stations indicated over bathymetric depth data

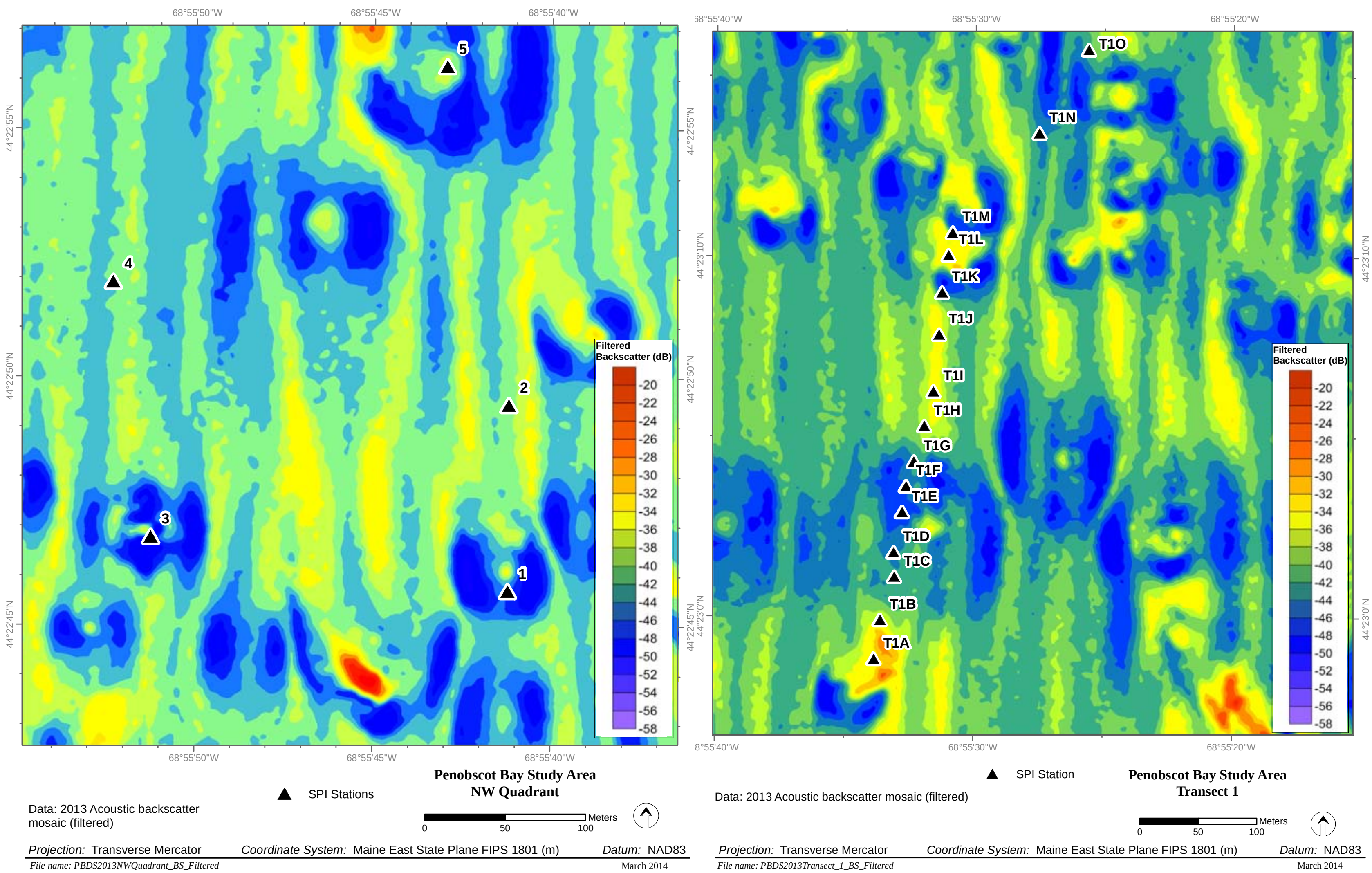


Figure 3-13. PBSA survey areas NW Quadrant and Transect 1 with sediment-profile image stations indicated over filtered backscatter mosaic

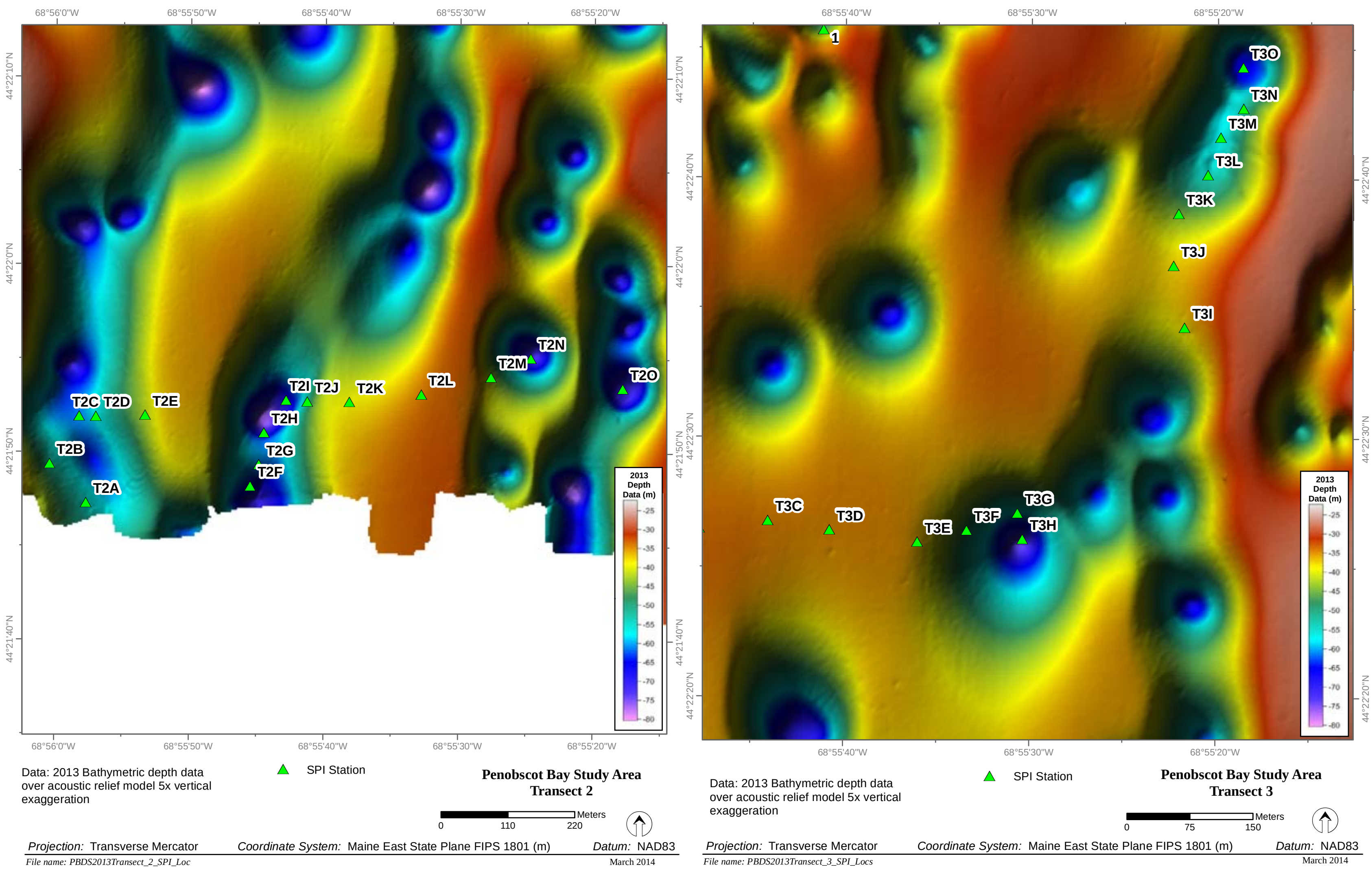


Figure 3-14. PBSA survey areas Transect 2 and Transect 3 with sediment-profile image stations indicated over bathymetric depth data

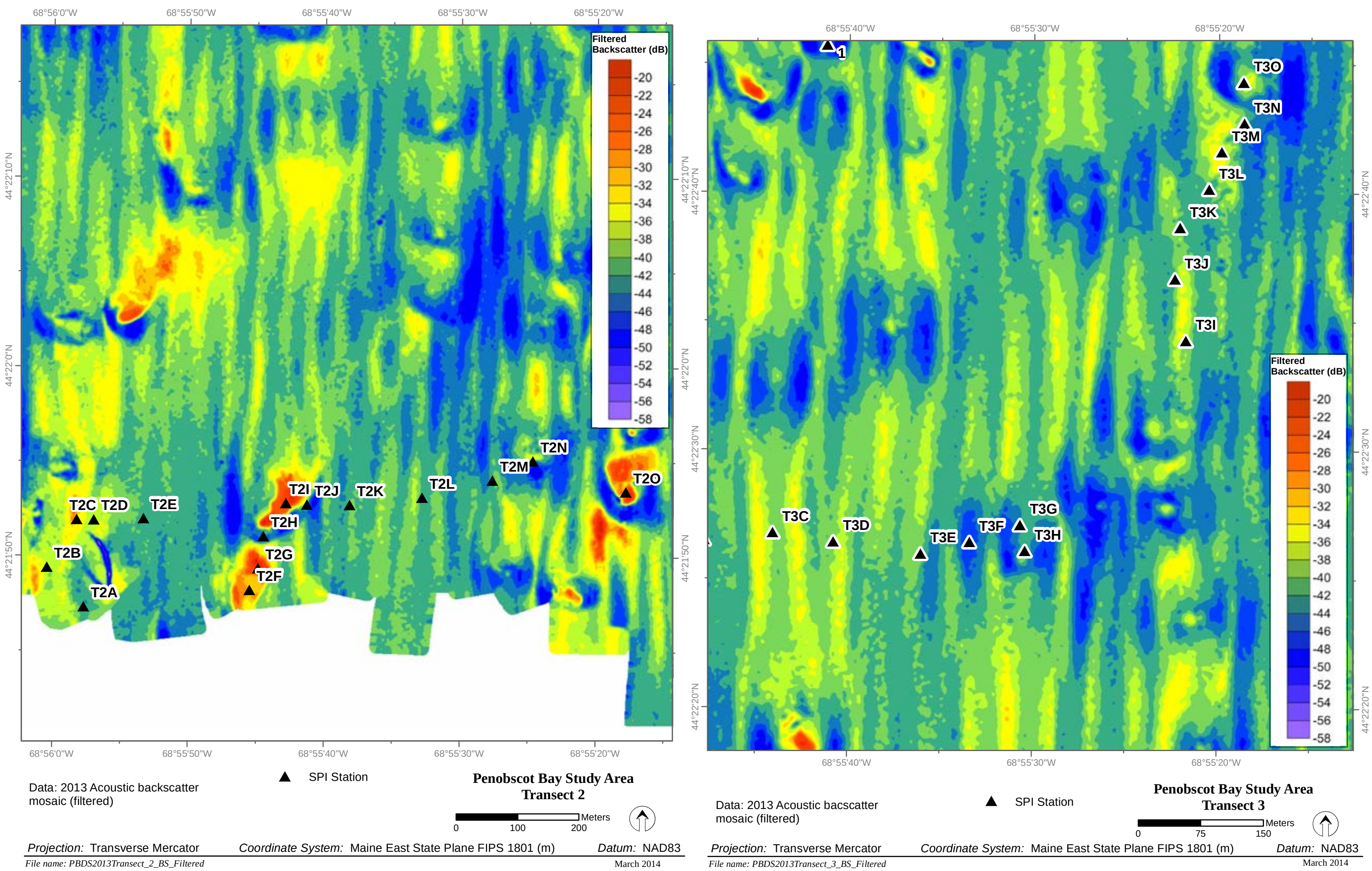
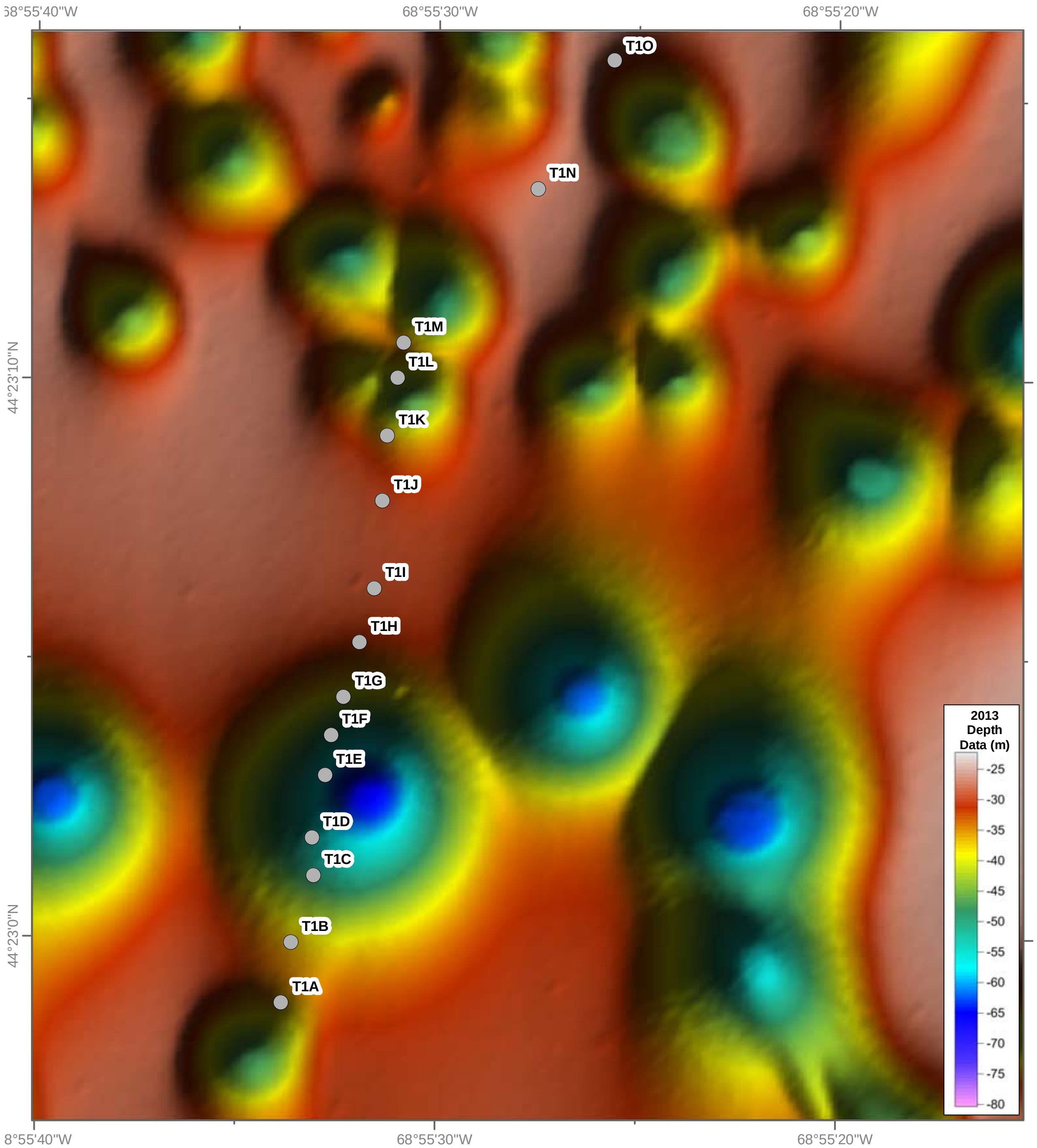


Figure 3-15. PBSA survey areas Transect 2 and Transect 3 with sediment-profile image stations indicated over filtered backscatter mosaic



Data: 2013 Bathymetric depth data over acoustic relief model 5x vertical exaggeration

Sediment Grain Size Major Mode (phi)

silt/clay (>4)

Penobscot Bay Study Area
Transect 1

Meters 0 50 100

Projection: Transverse Mercator *Coordinate System:* Maine East State Plane FIPS 1801 (m) *Datum:* NAD83

File name: PBDS2013Transect_1_Grainsizes March 2014

Figure 3-16. Sediment grain size major mode (phi units) at stations sampled along PBSA Transect 1

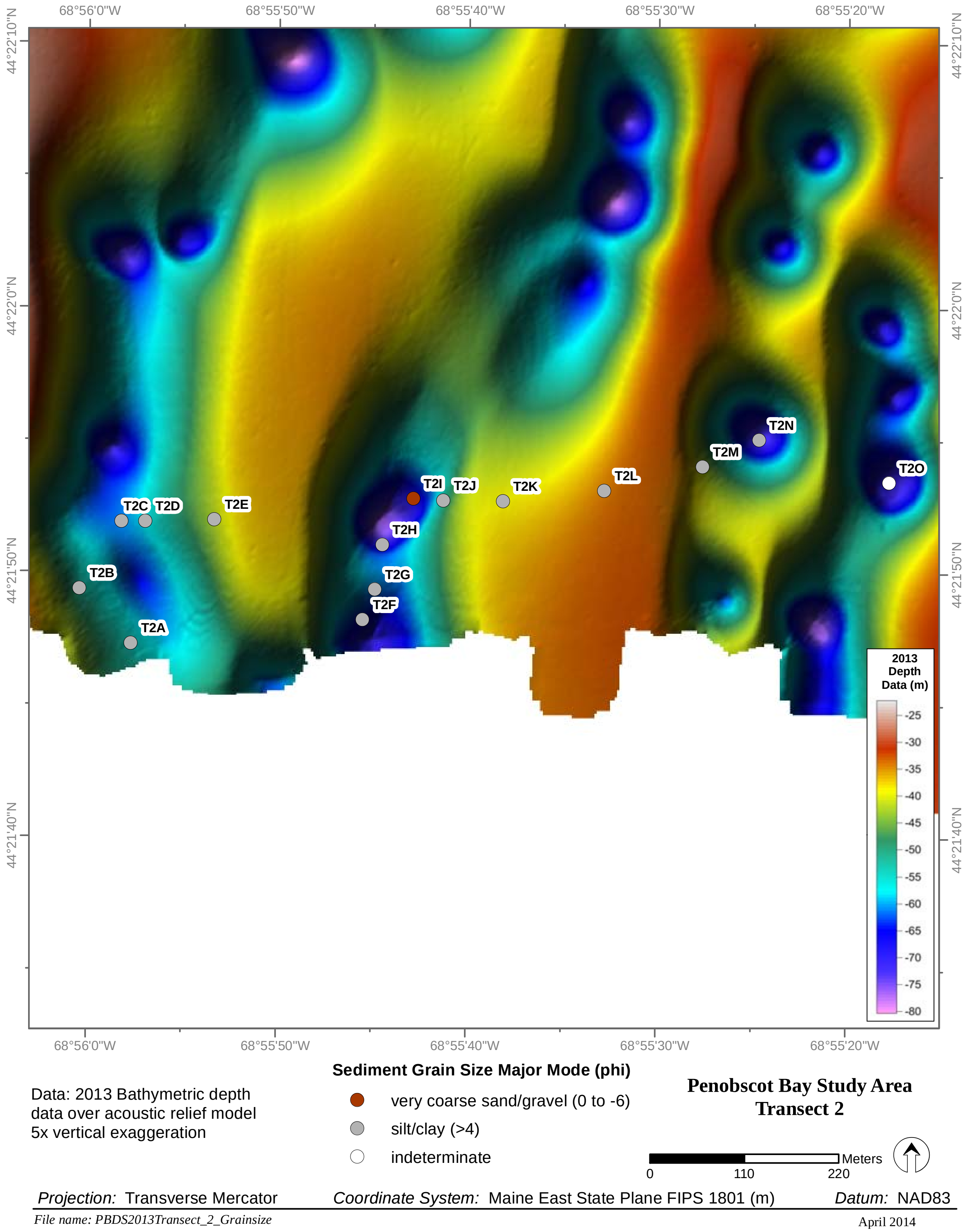


Figure 3-17. Sediment grain size major mode (phi units) at stations sampled along PBSA Transect 2

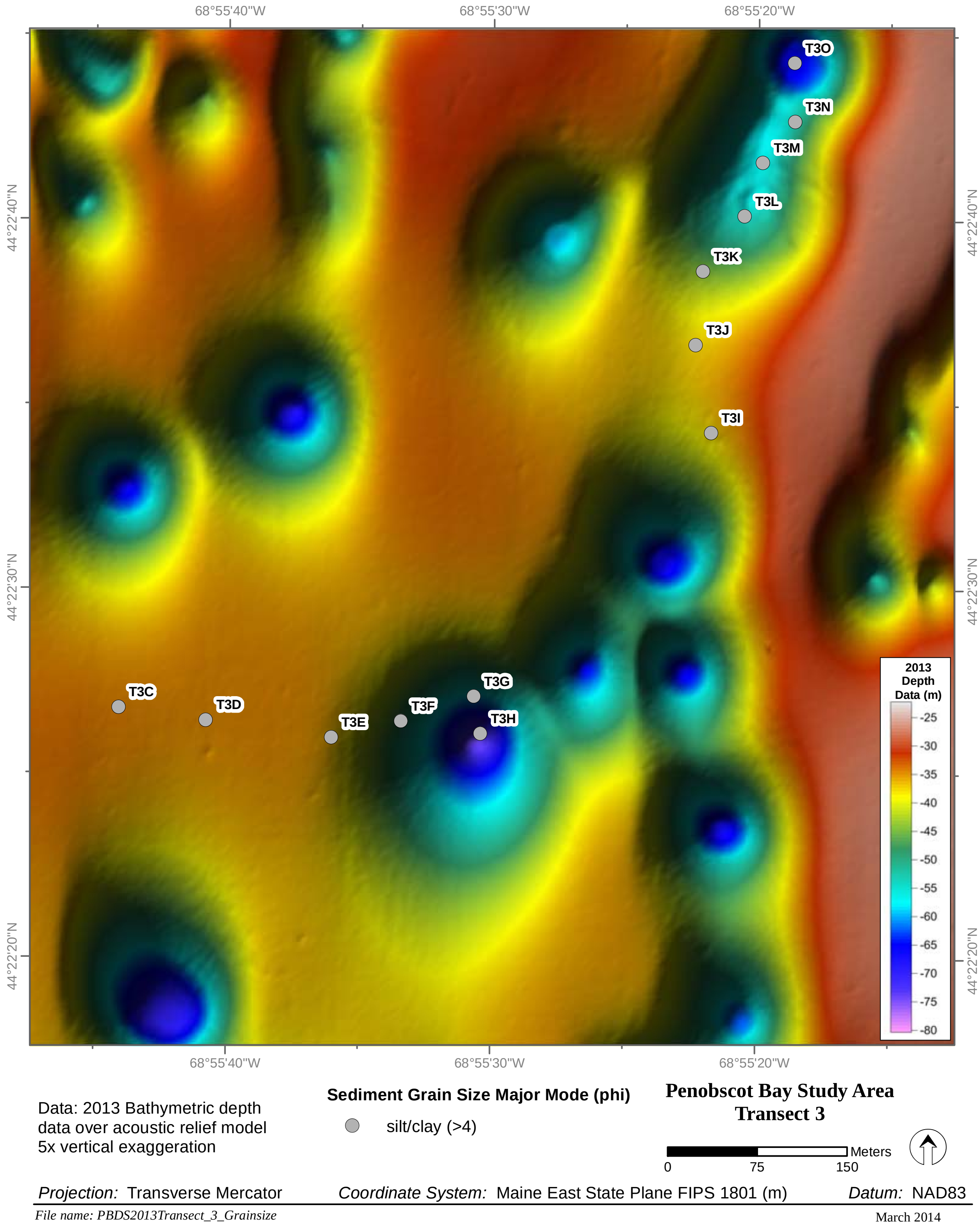


Figure 3-18. Sediment grain size major mode (phi units) at stations sampled along PBSA Transect 3

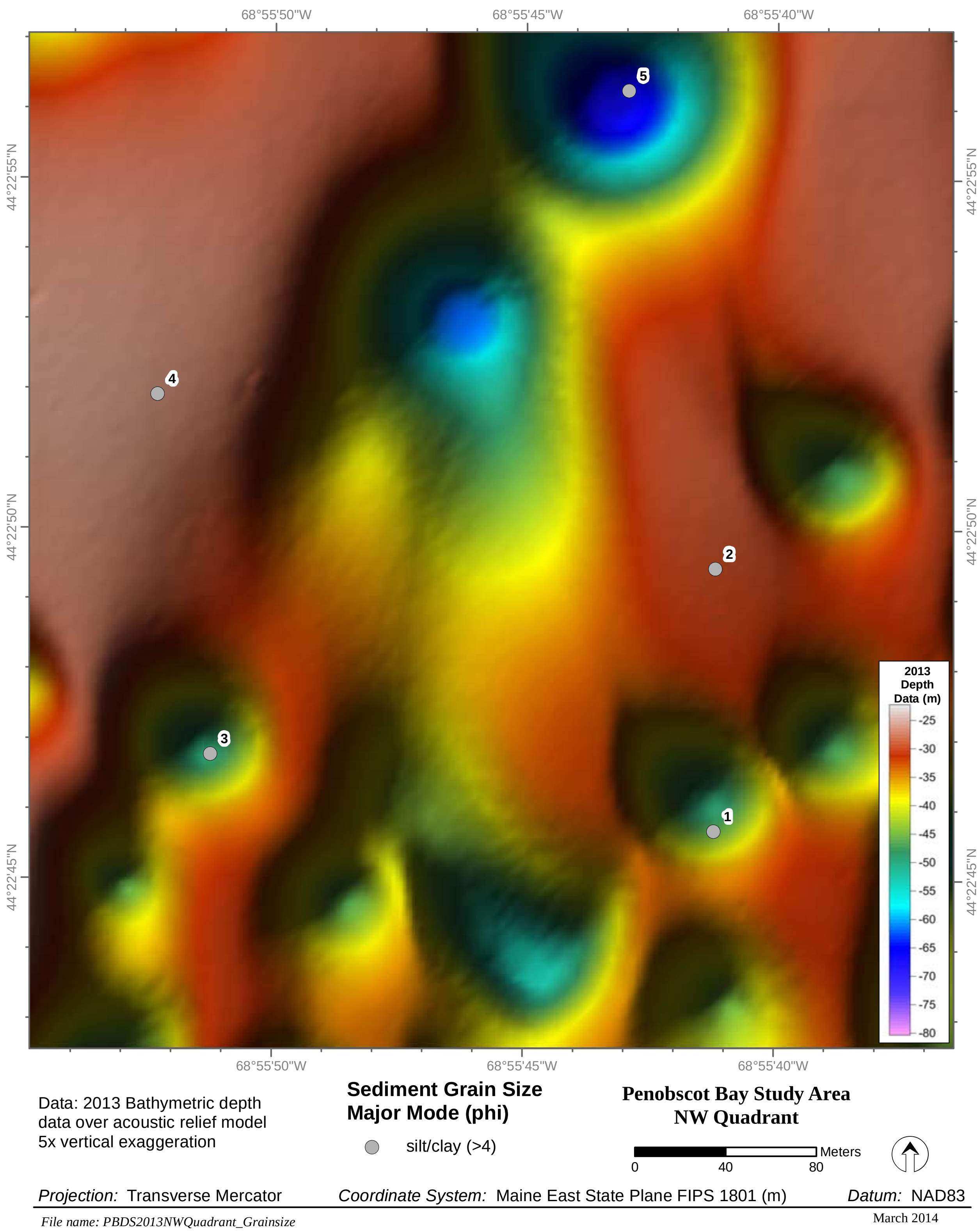


Figure 3-19. Sediment grain size major mode (phi units) at stations sampled within PBSA NW Quadrant

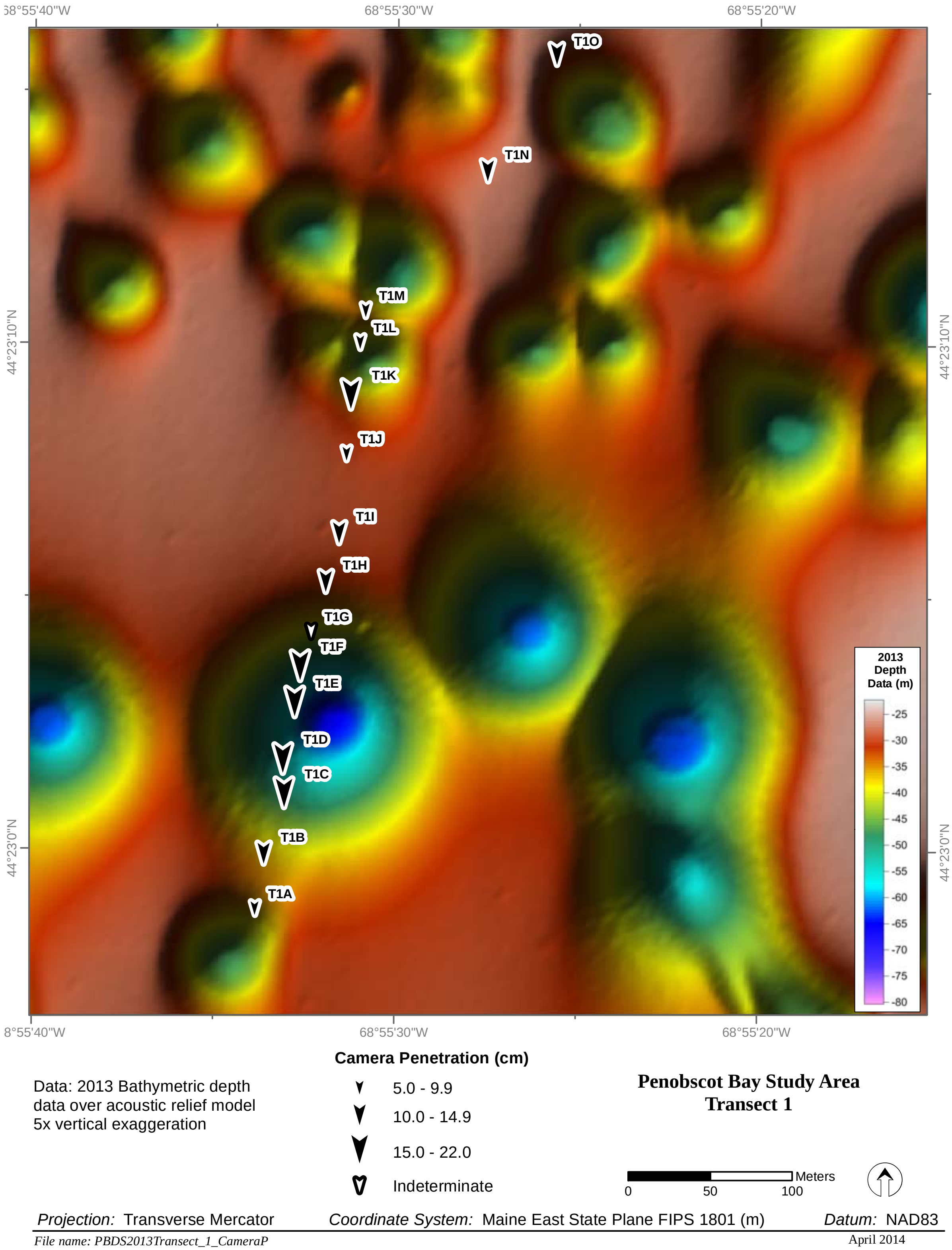


Figure 3-20. Station camera prism penetration depths (cm) at stations sampled along PBSA Transect 1

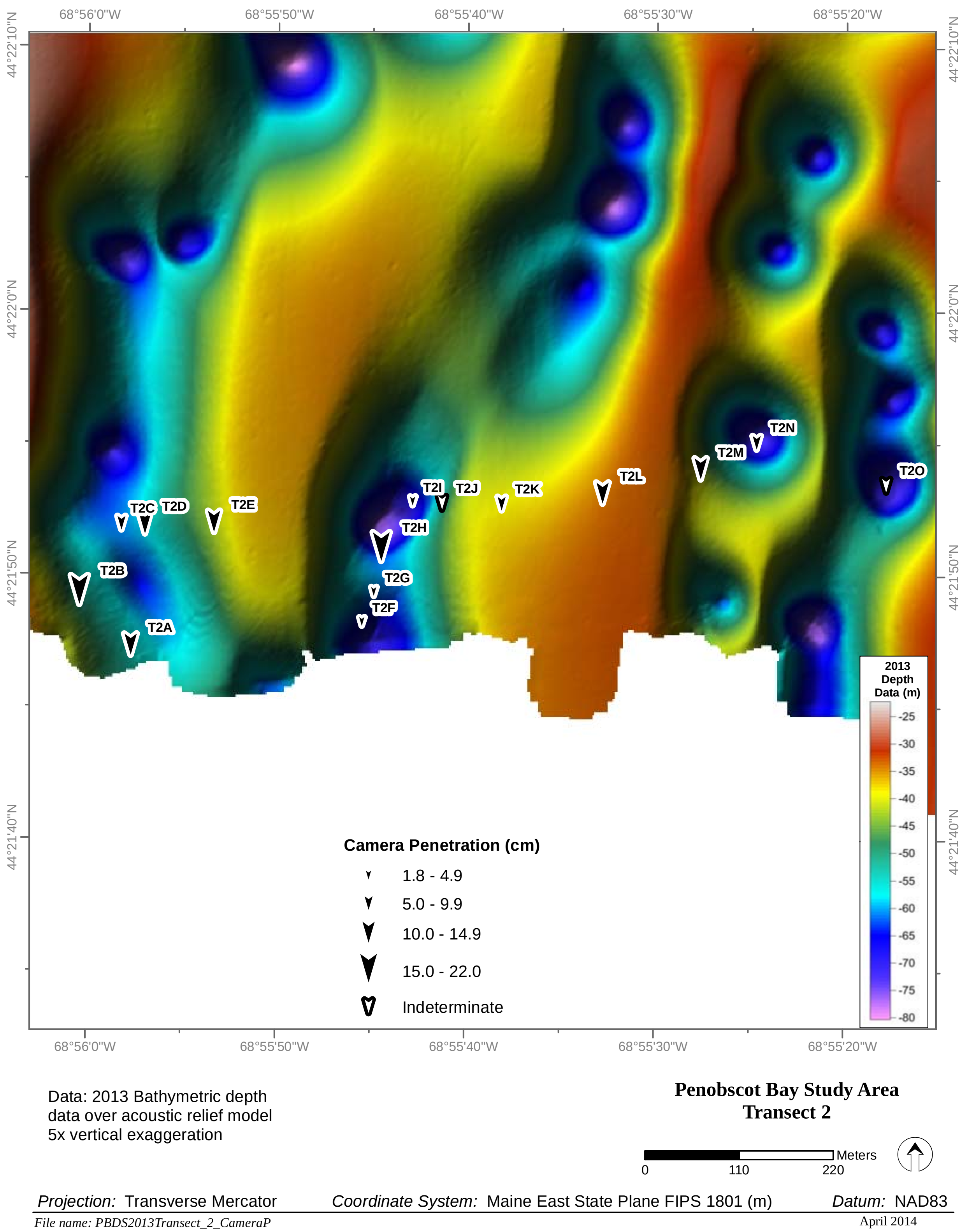


Figure 3-21. Station camera prism penetration depths (cm) at stations sampled along PBSA Transect 2

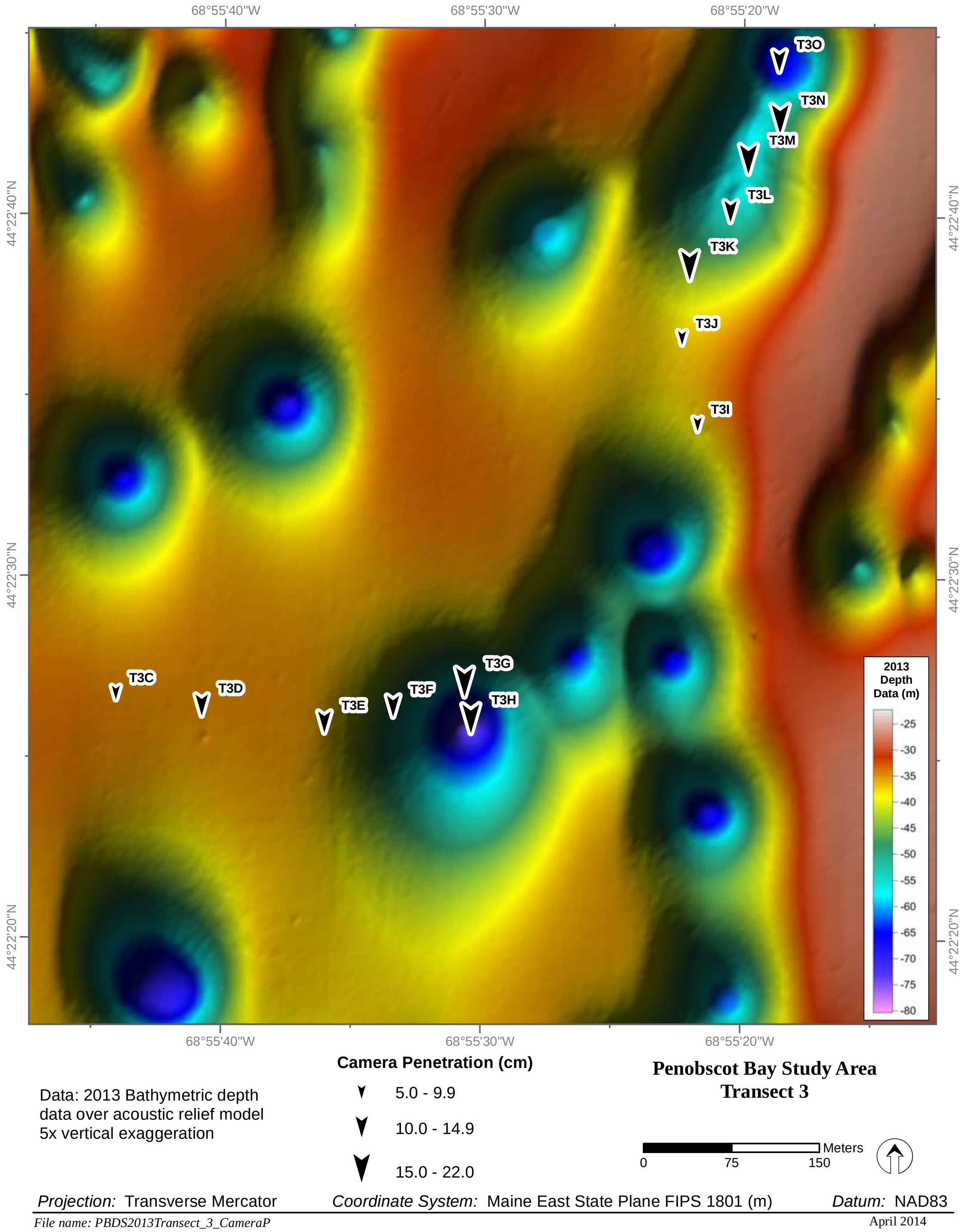


Figure 3-22. Station camera prism penetration depths (cm) at stations sampled along PBSA Transect 3

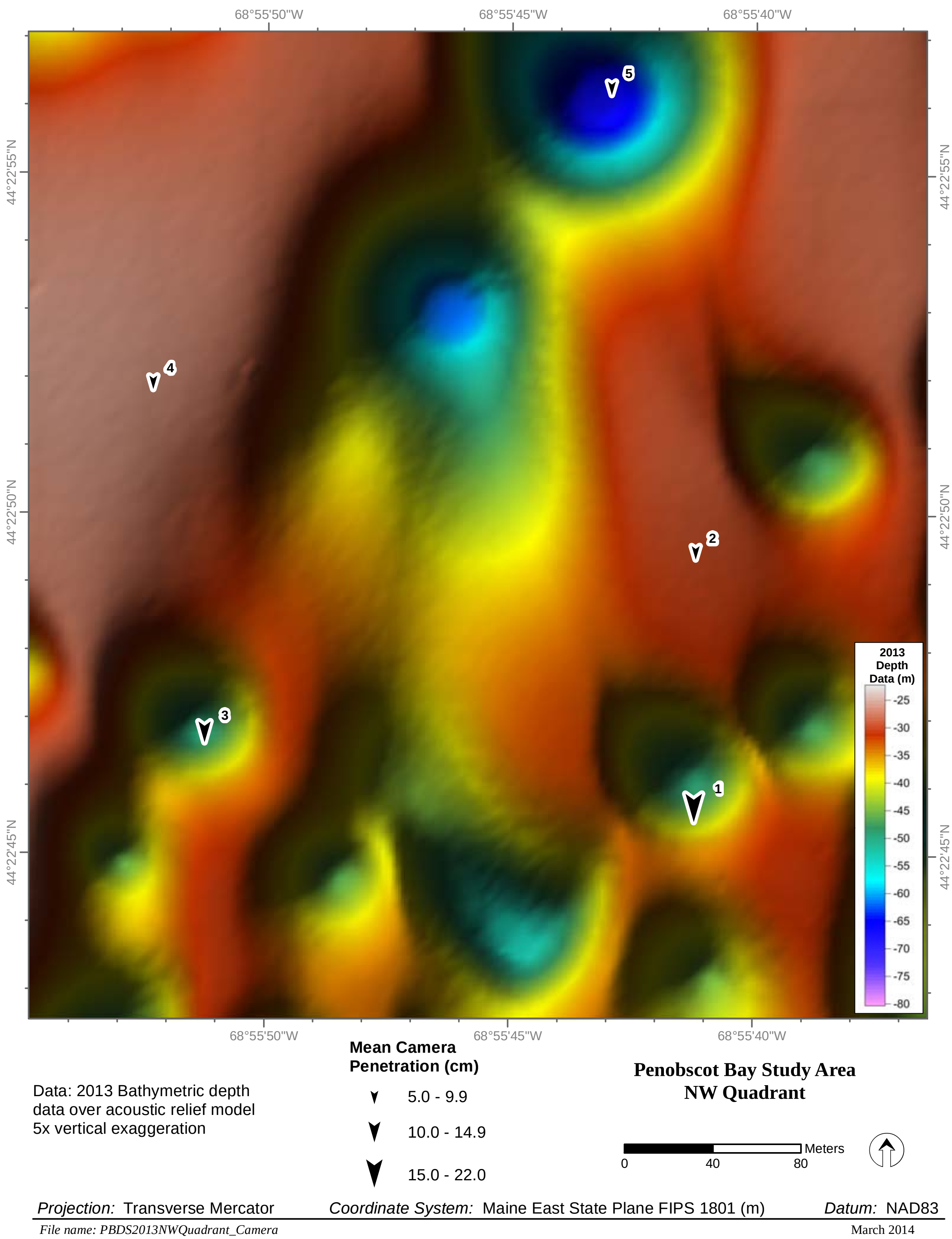


Figure 3-23. Mean station camera prism penetration depths (cm) at stations sampled within PBSA NW Quadrant

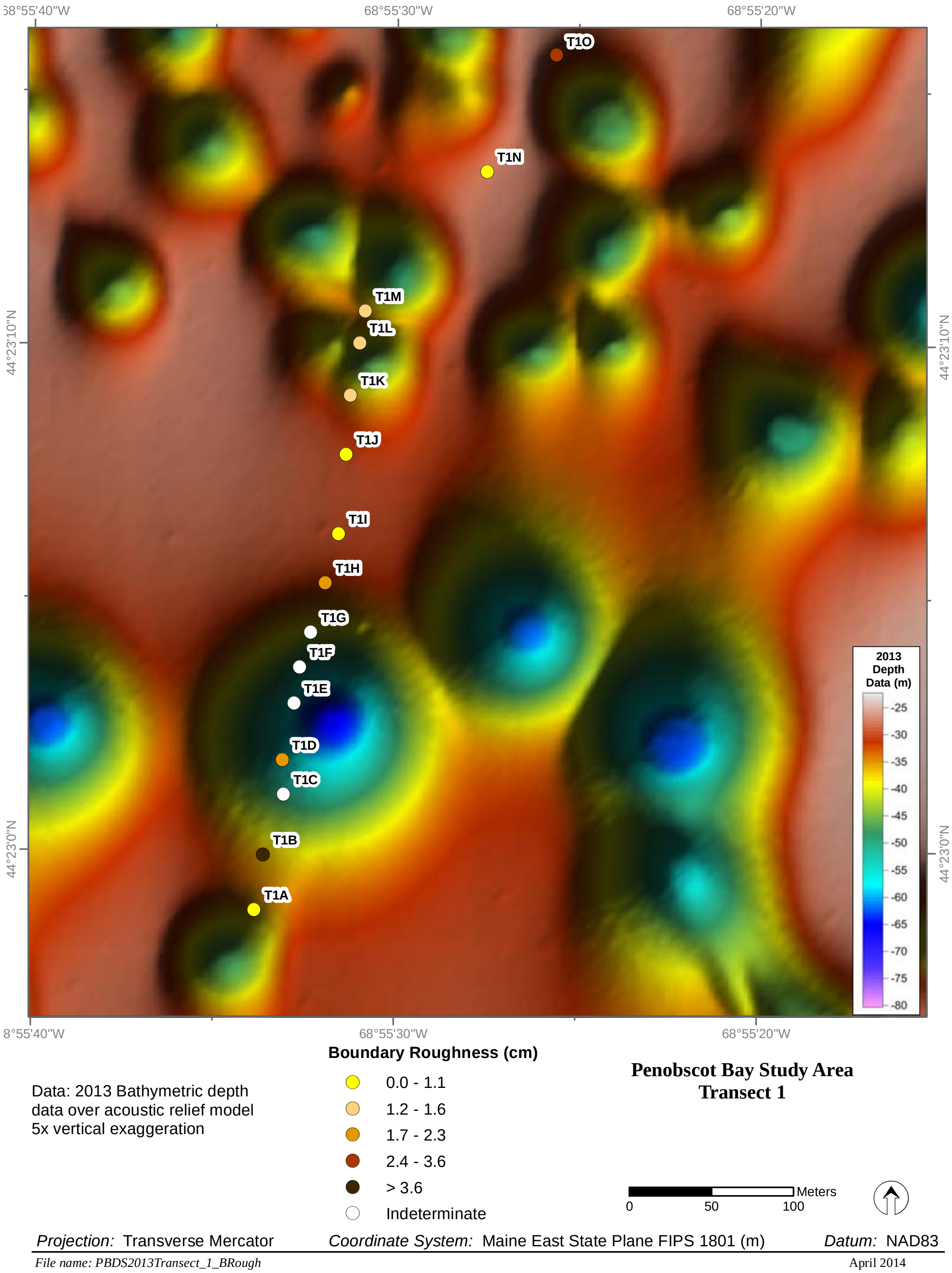


Figure 3-24. Station small-scale boundary roughness values (cm) at stations sampled along PBSA Transect 1

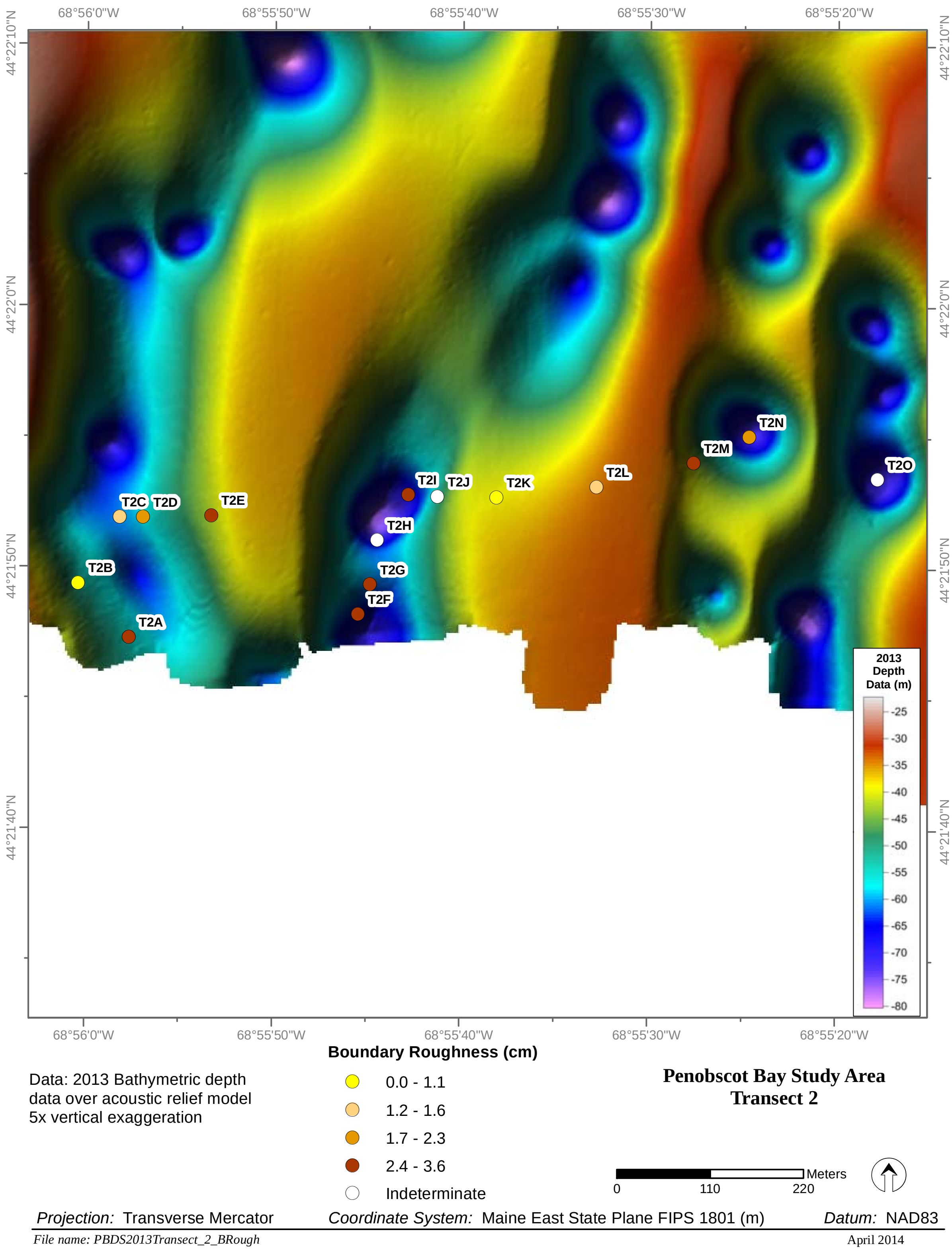


Figure 3-25. Station small-scale boundary roughness values (cm) at stations sampled along PBSA Transect 2

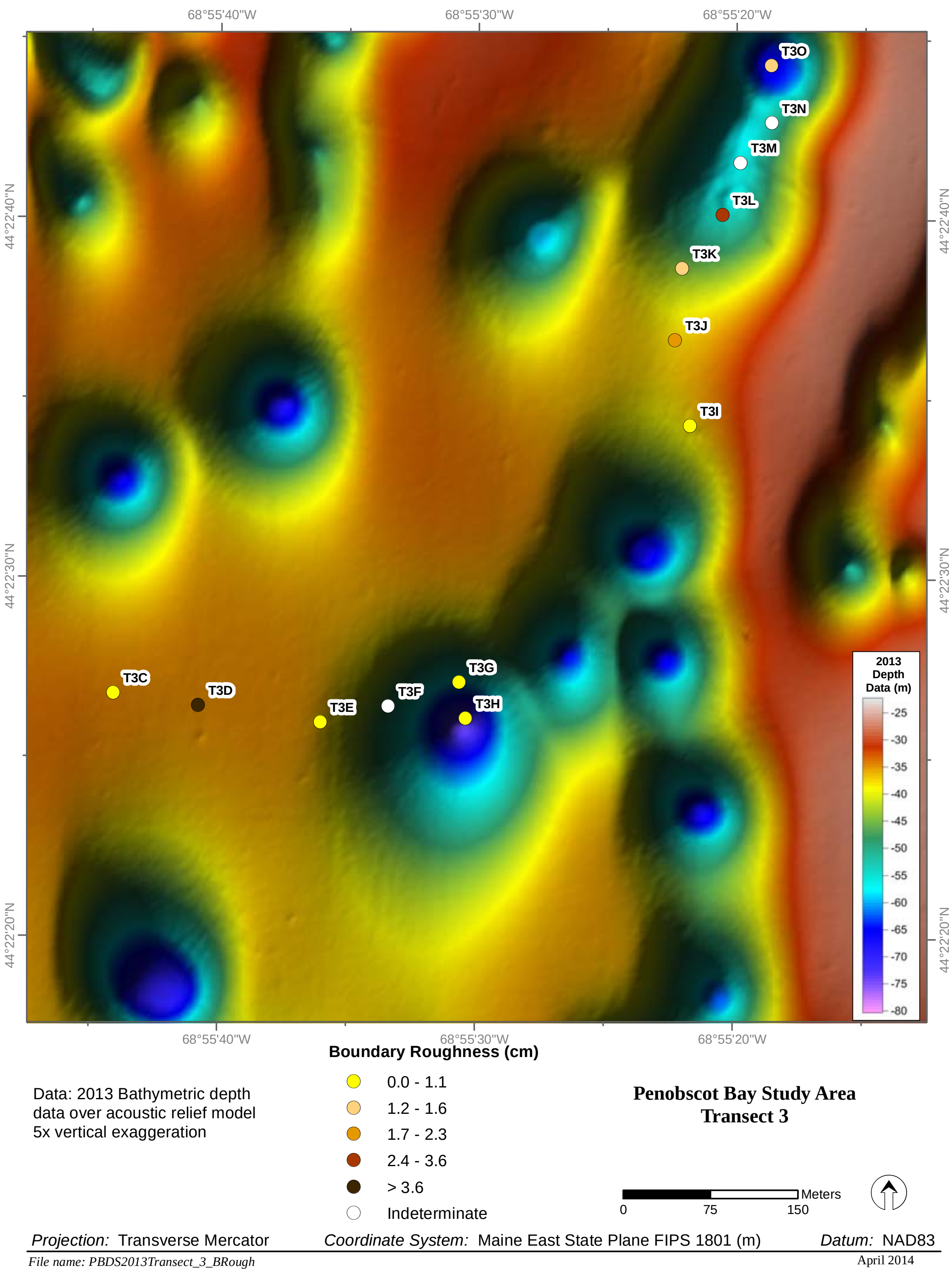


Figure 3-26. Station small-scale boundary roughness values (cm) at stations sampled along PBSA Transect 3

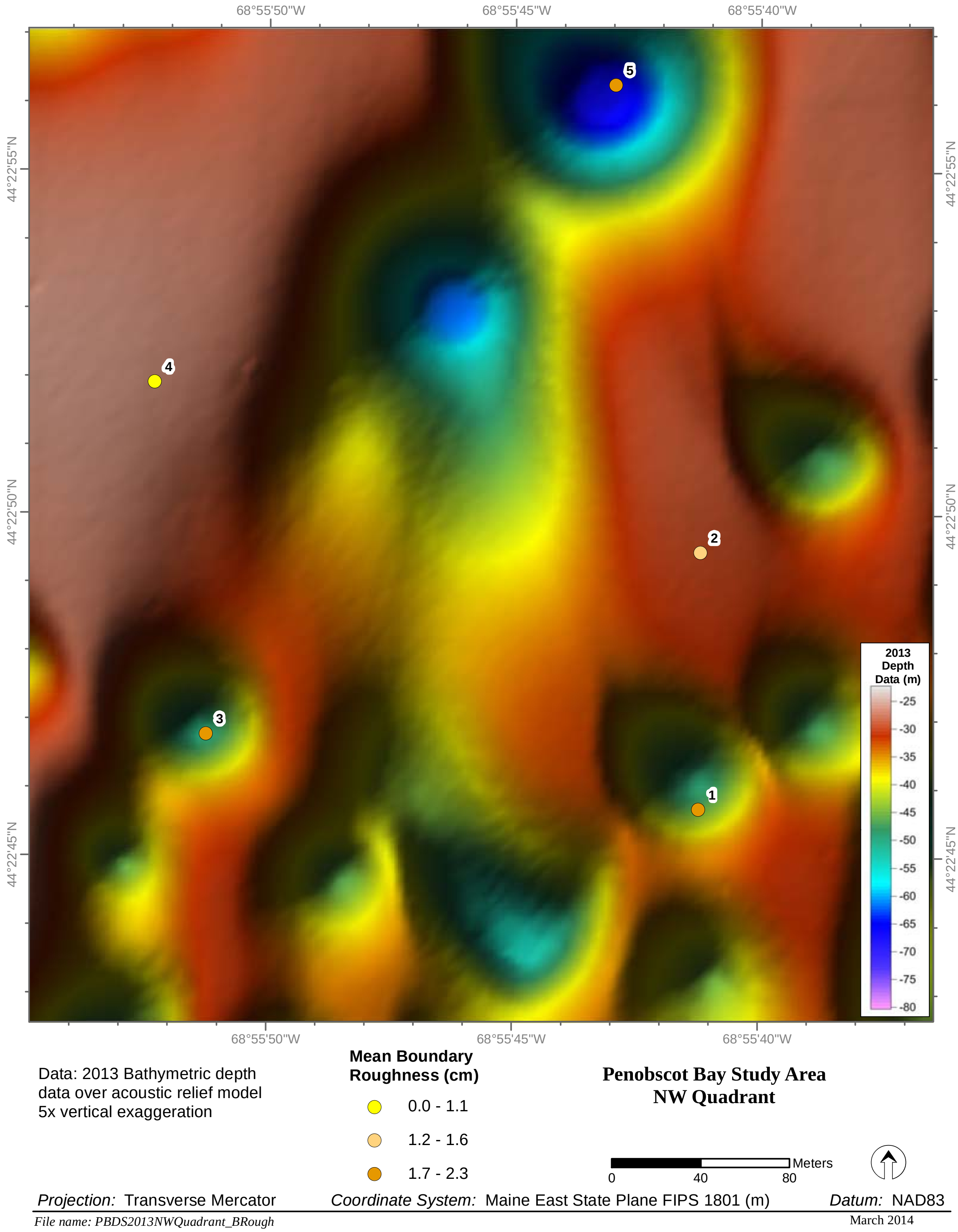


Figure 3-27. Mean station small-scale boundary roughness values (cm) at stations sampled within PBSA NW Quadrant

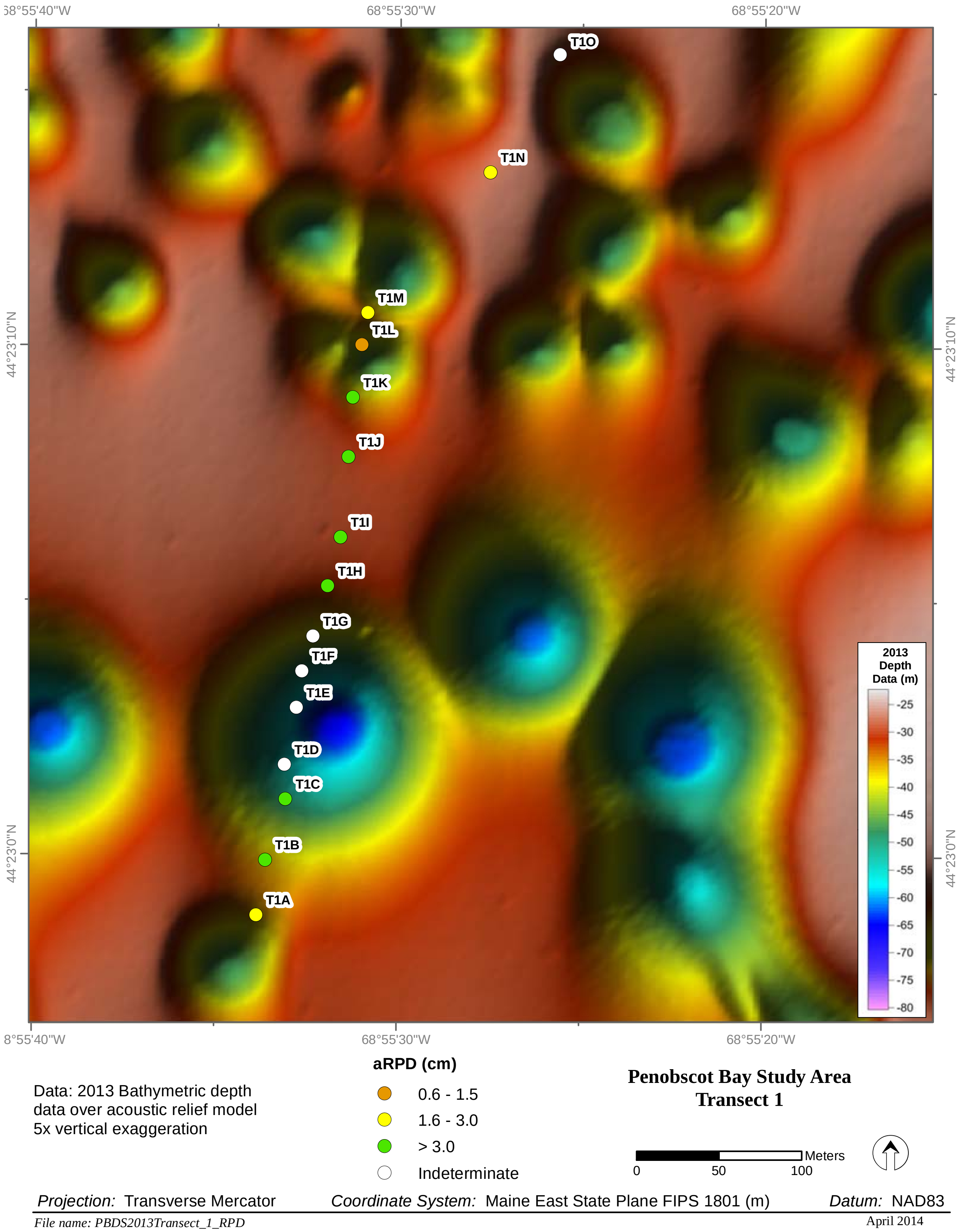


Figure 3-28. Station aRPD depth values (cm) at stations sampled along PBSA Transect 1

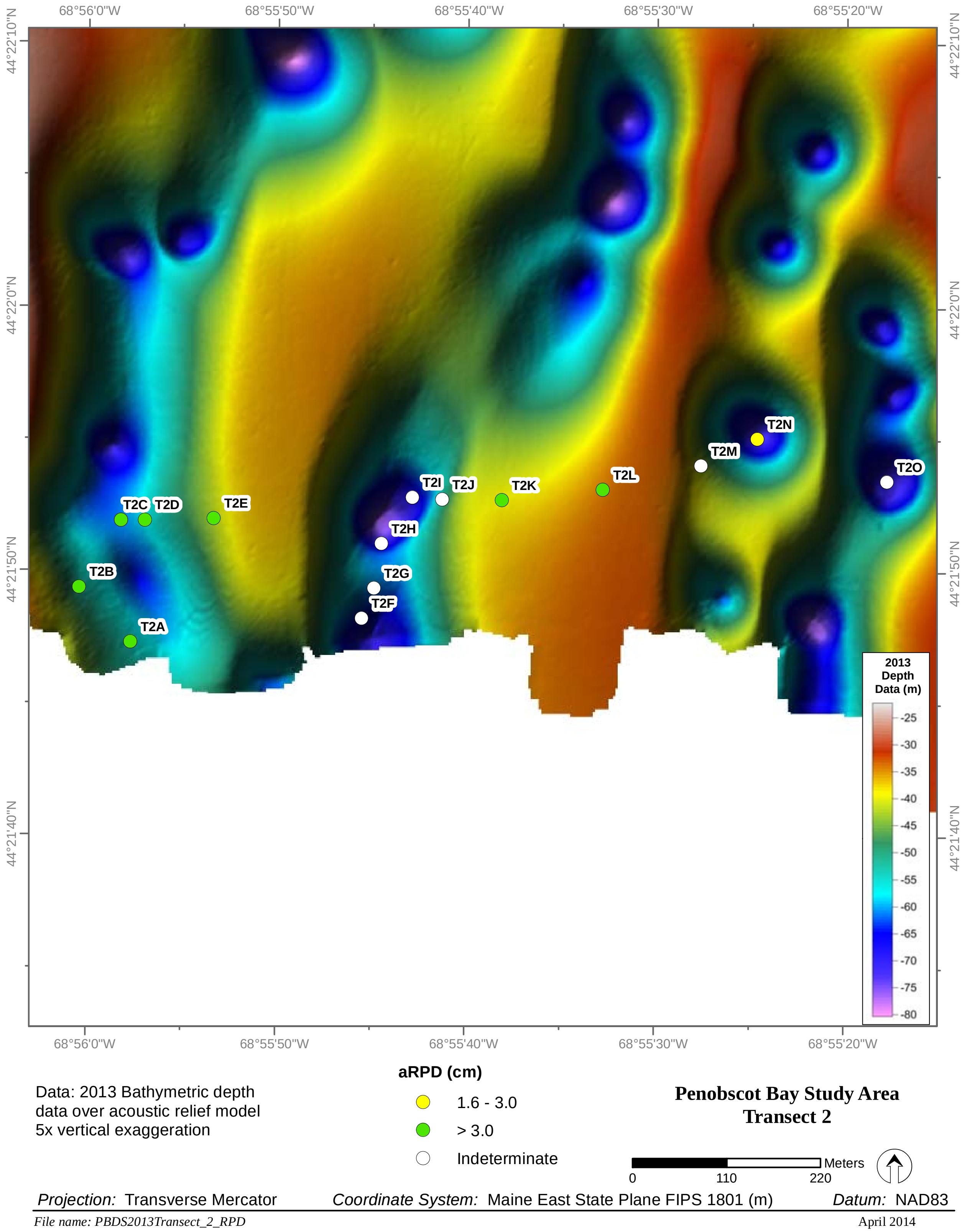


Figure 3-29. Station aRPD depth values (cm) at stations sampled along PBSA Transect 2

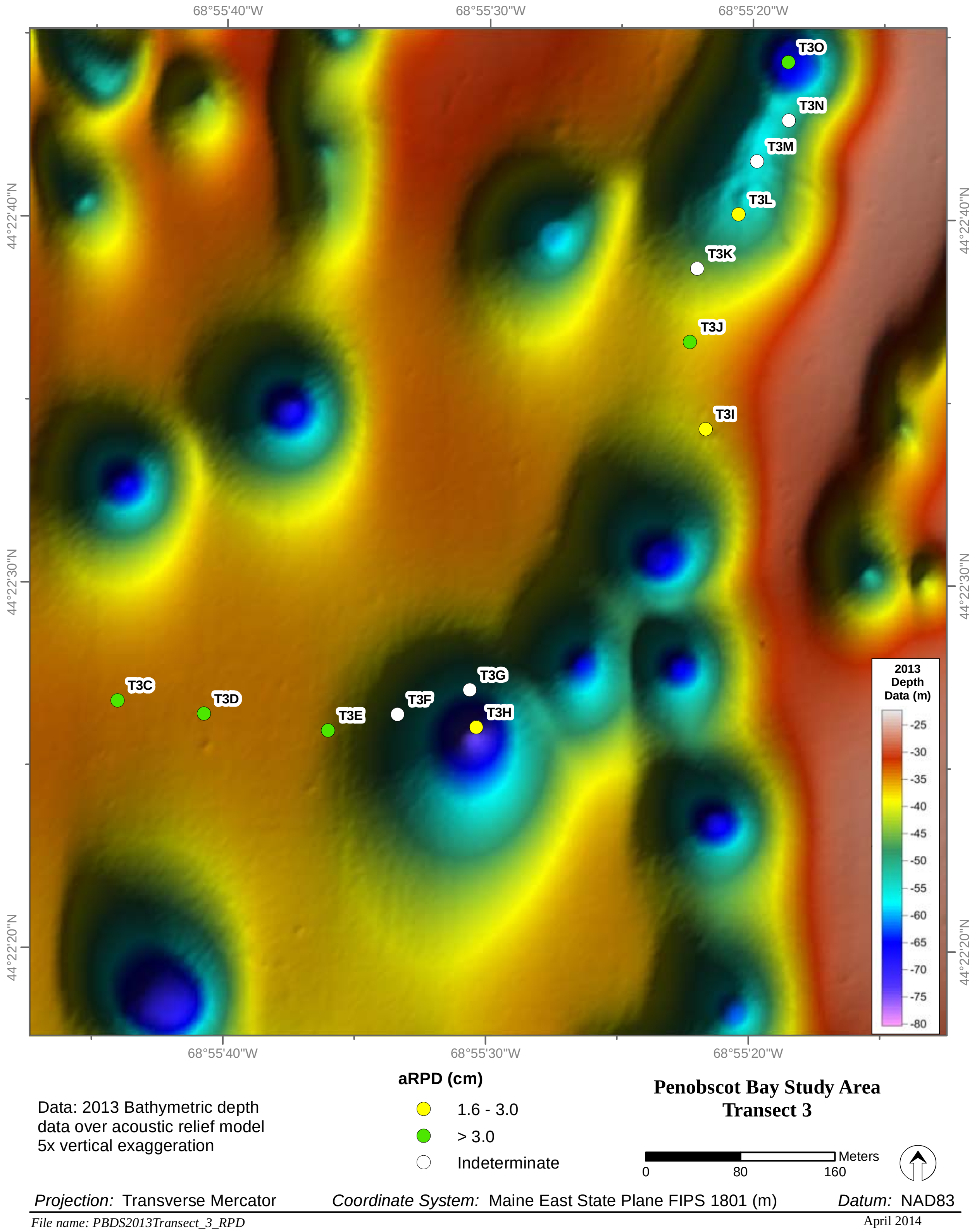


Figure 3-30. Station aRPD depth values (cm) at stations sampled along PBSA Transect 3

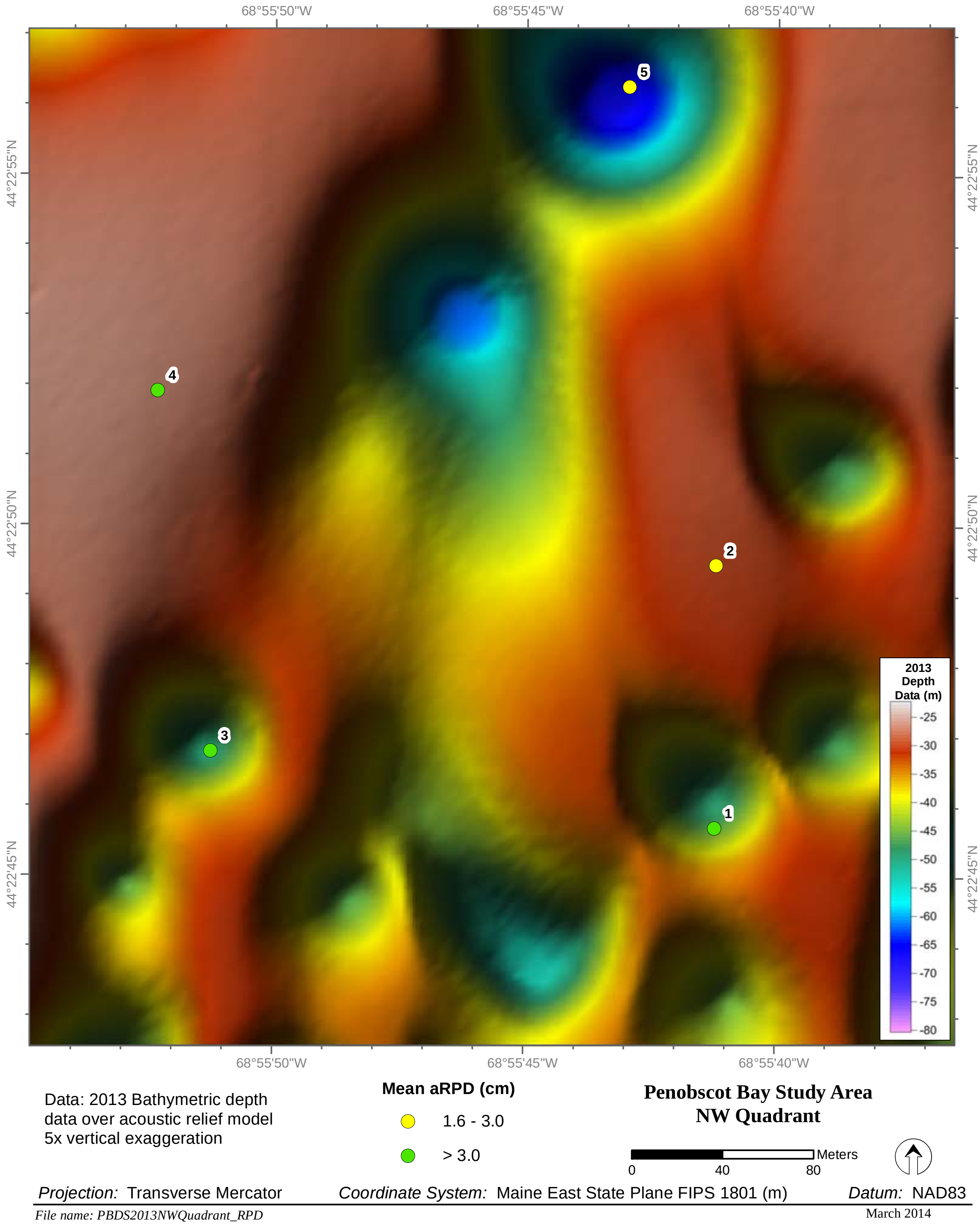


Figure 3-31. Mean station aRPD depth values (cm) at stations sampled within PBSA NW Quadrant

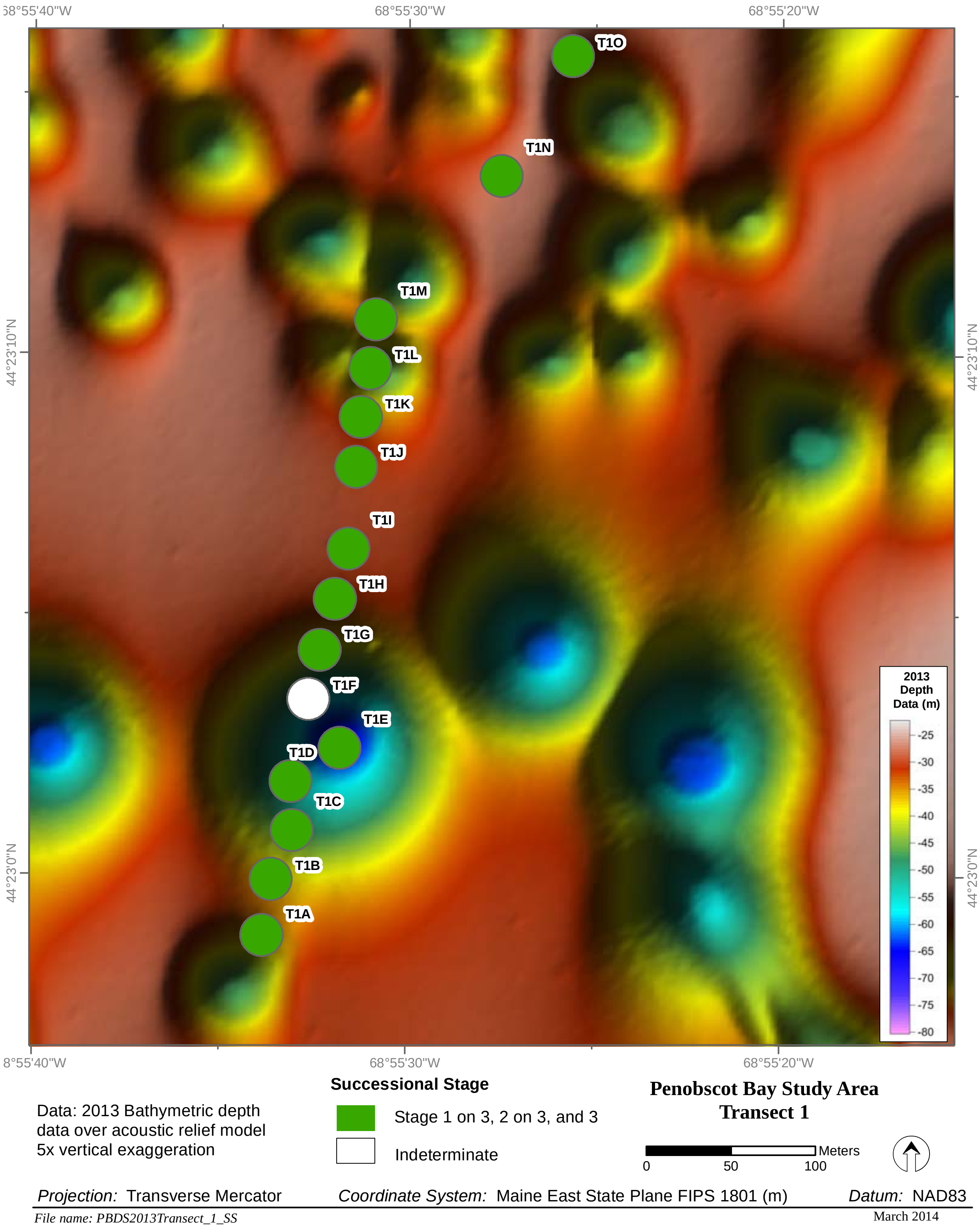


Figure 3-32. Infaunal successional stages found at locations sampled along PBSA Transect 1

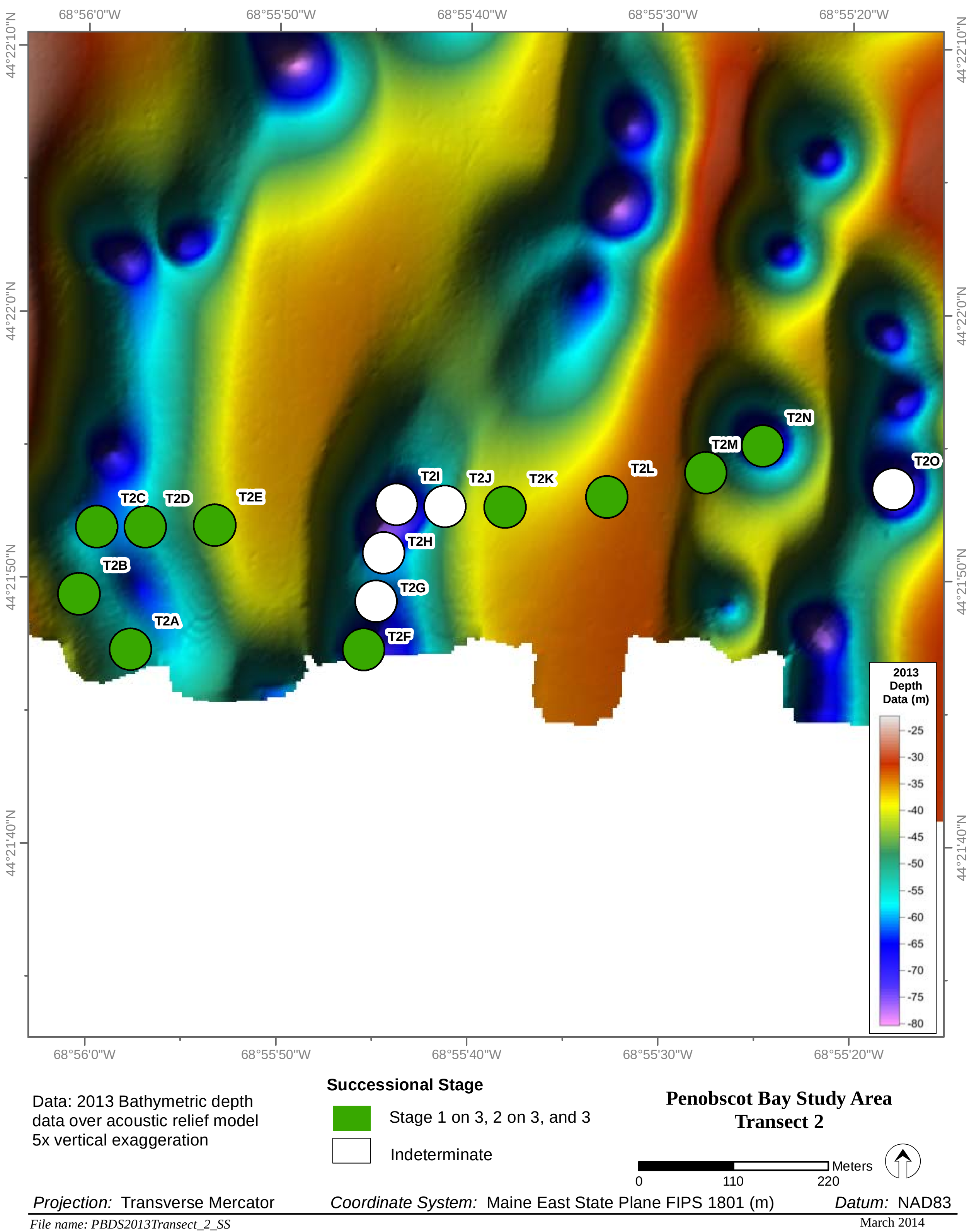


Figure 3-33. Infaunal successional stages found at locations sampled along PBSA Transect 2

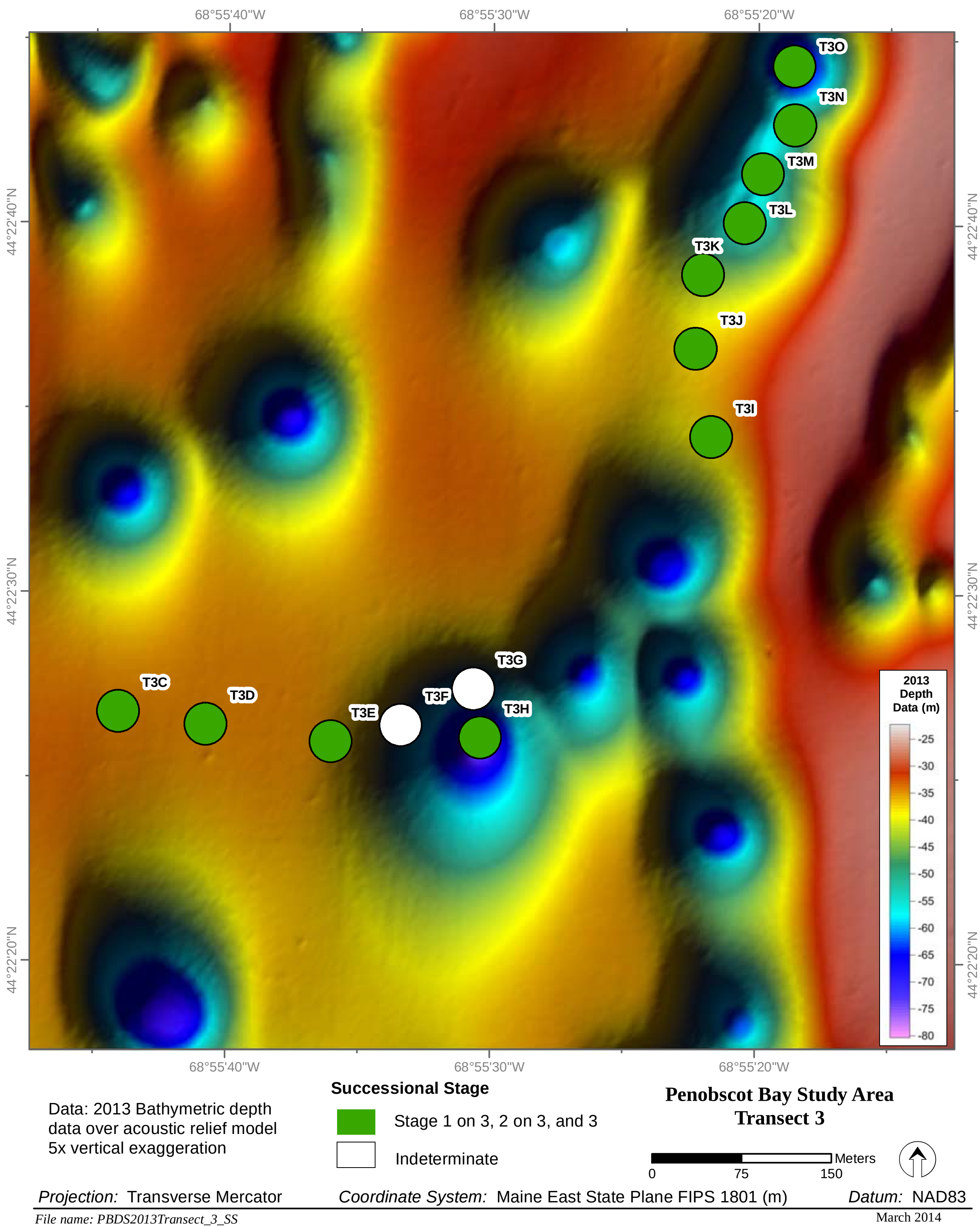


Figure 3-34. Infaunal successional stages found at locations sampled along PBSA Transect 3

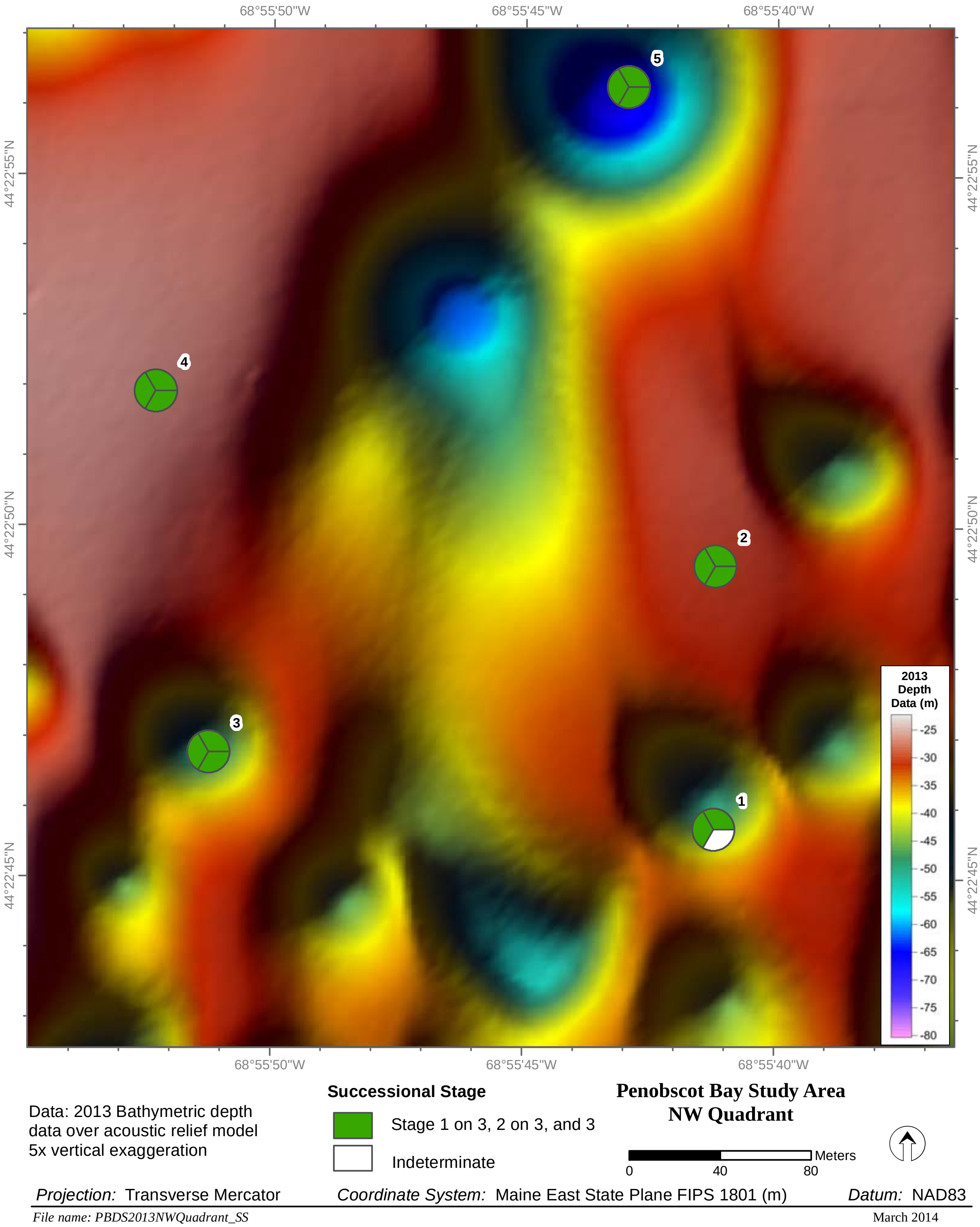


Figure 3-35. Infaunal successional stages found at locations sampled within PBSA NW Quadrant

All profile images are 14.5 cm in width. Plan-view (PV) image widths are provided if known.

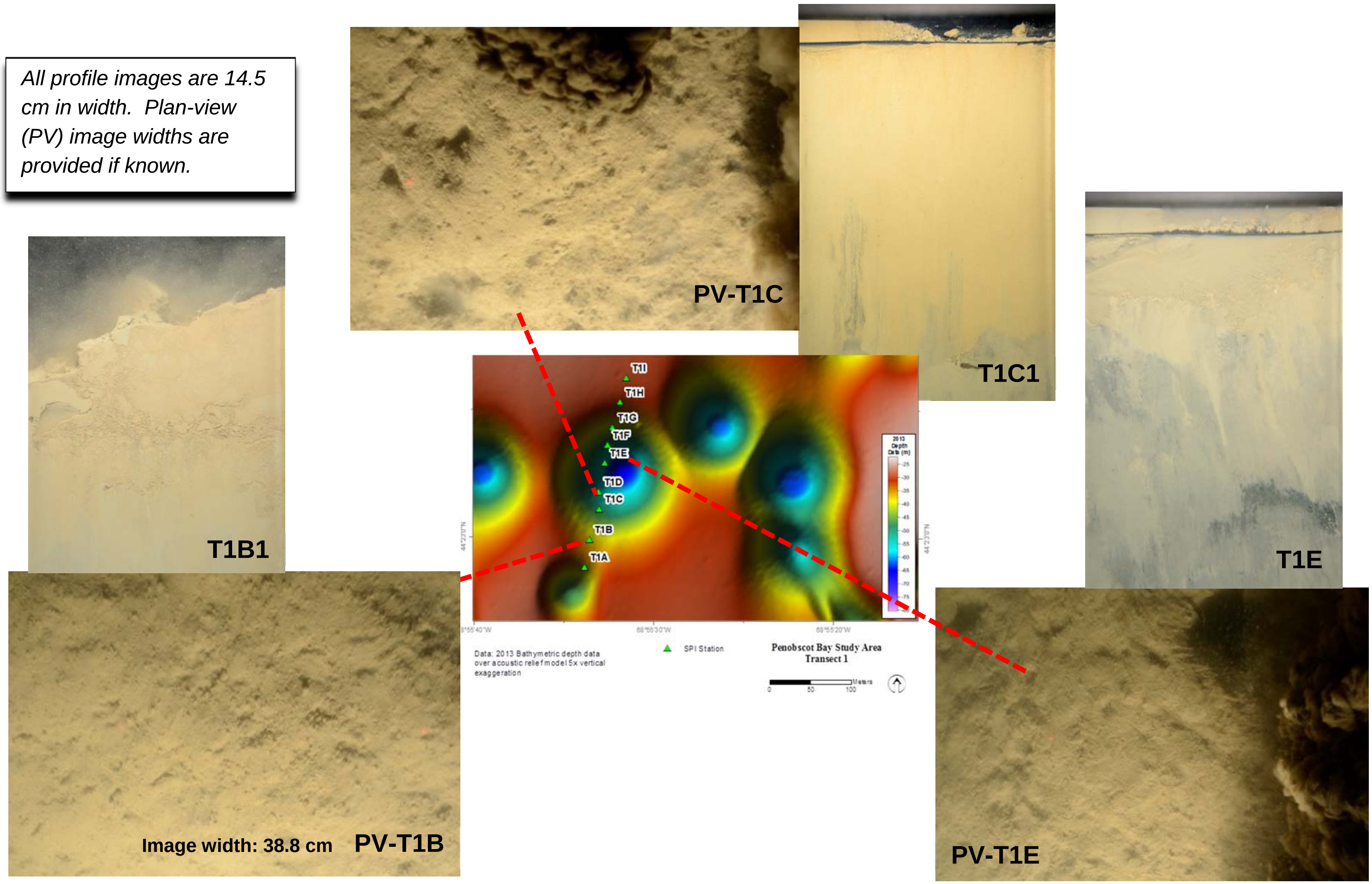


Figure 3-36. Selected sediment-profile and plan-view images of Transect 1

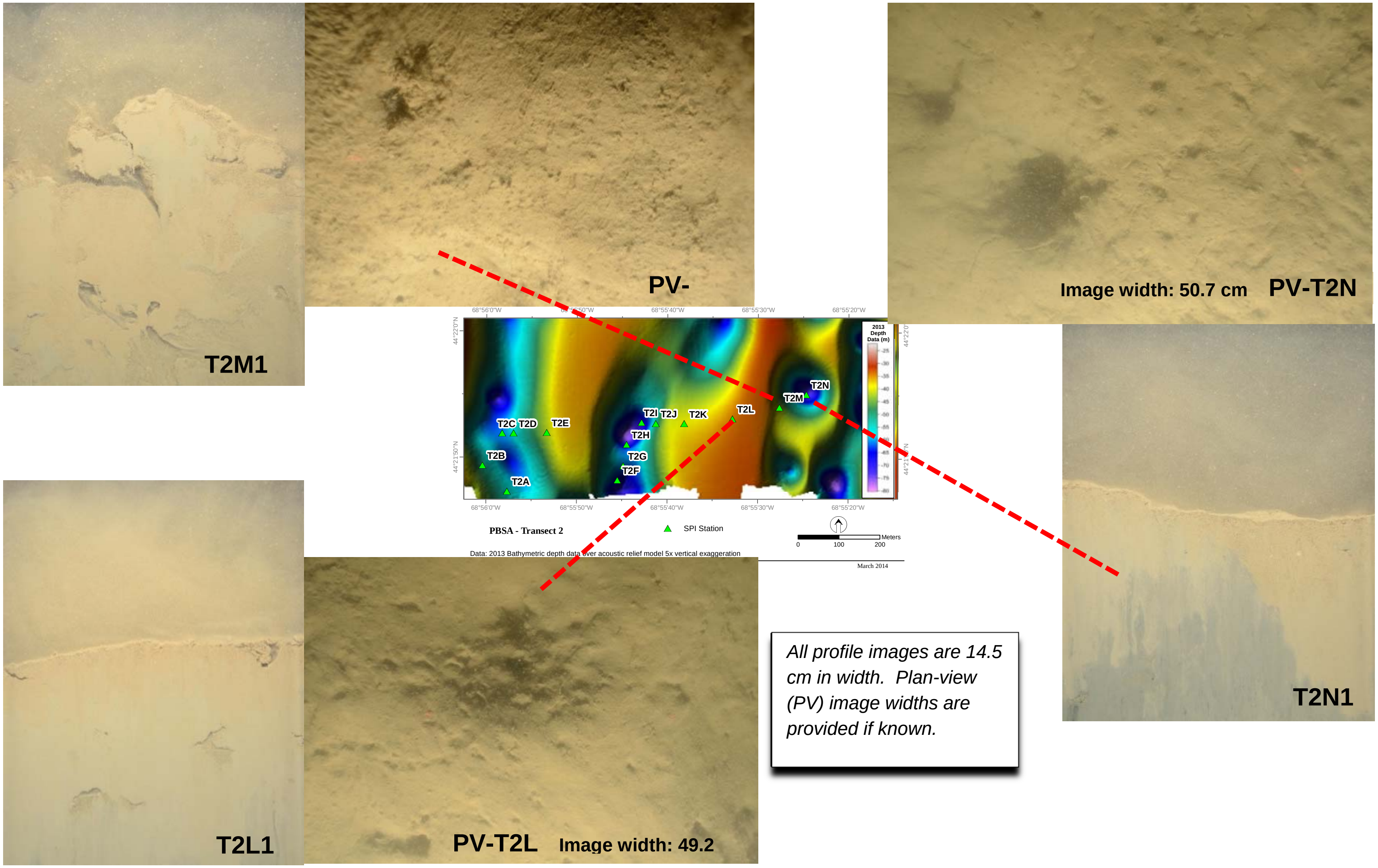


Figure 3-37. Selected sediment-profile and plan-view images of Transect 2

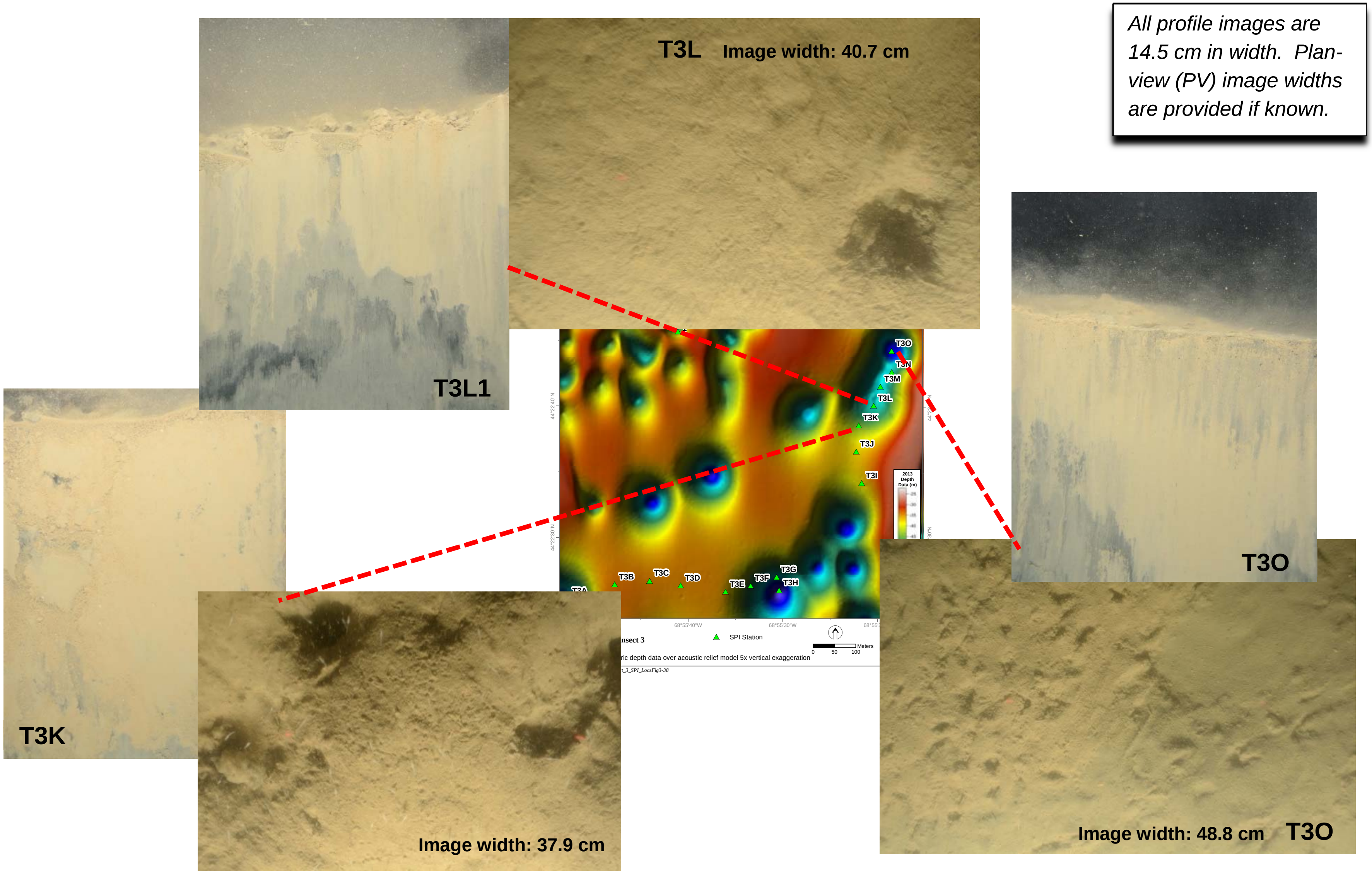


Figure 3-38. Selected sediment-profile and plan-view images of Transect 3

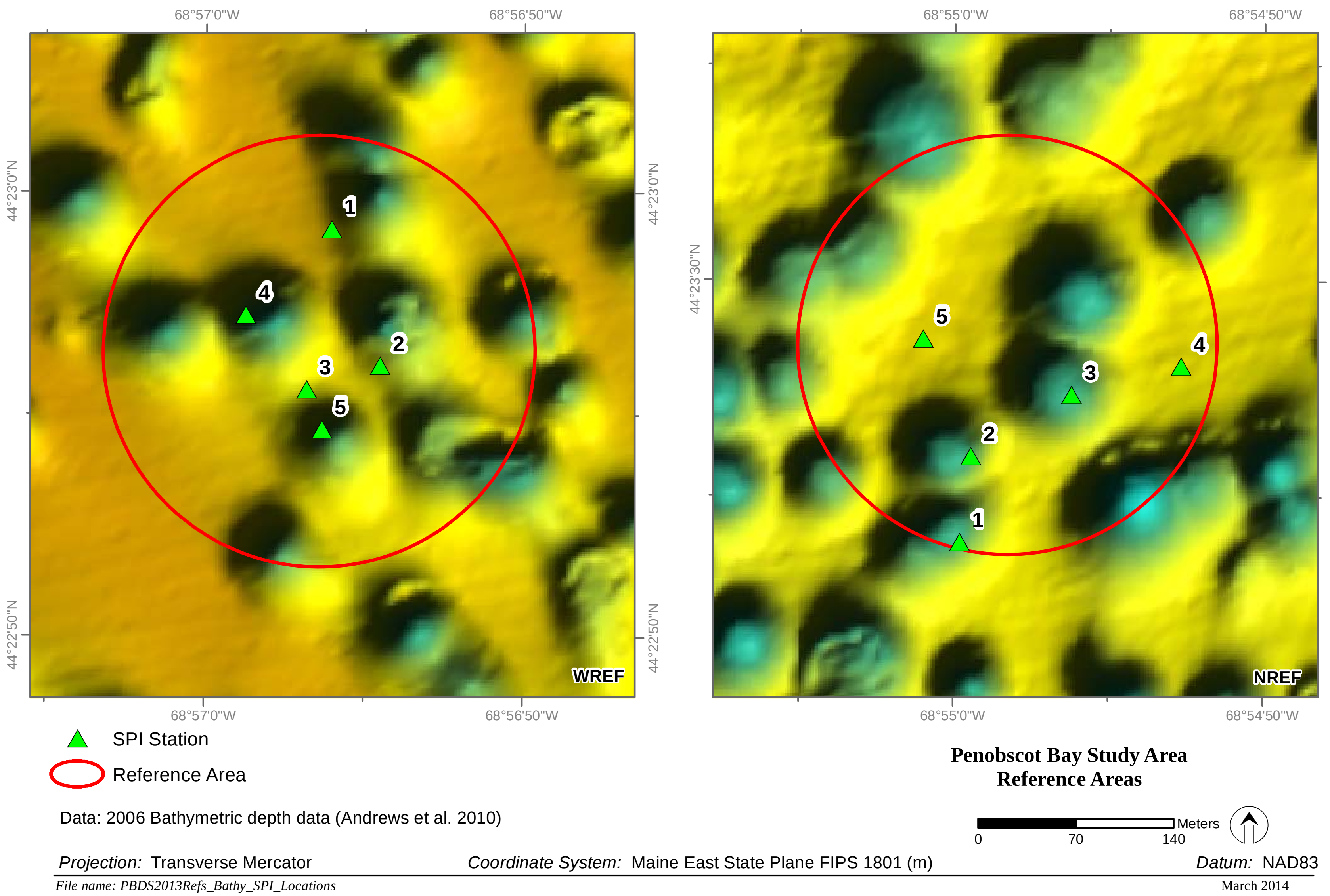


Figure 3-39. PBSA reference areas with sediment-profile image stations indicated over 2006 bathymetric depth data

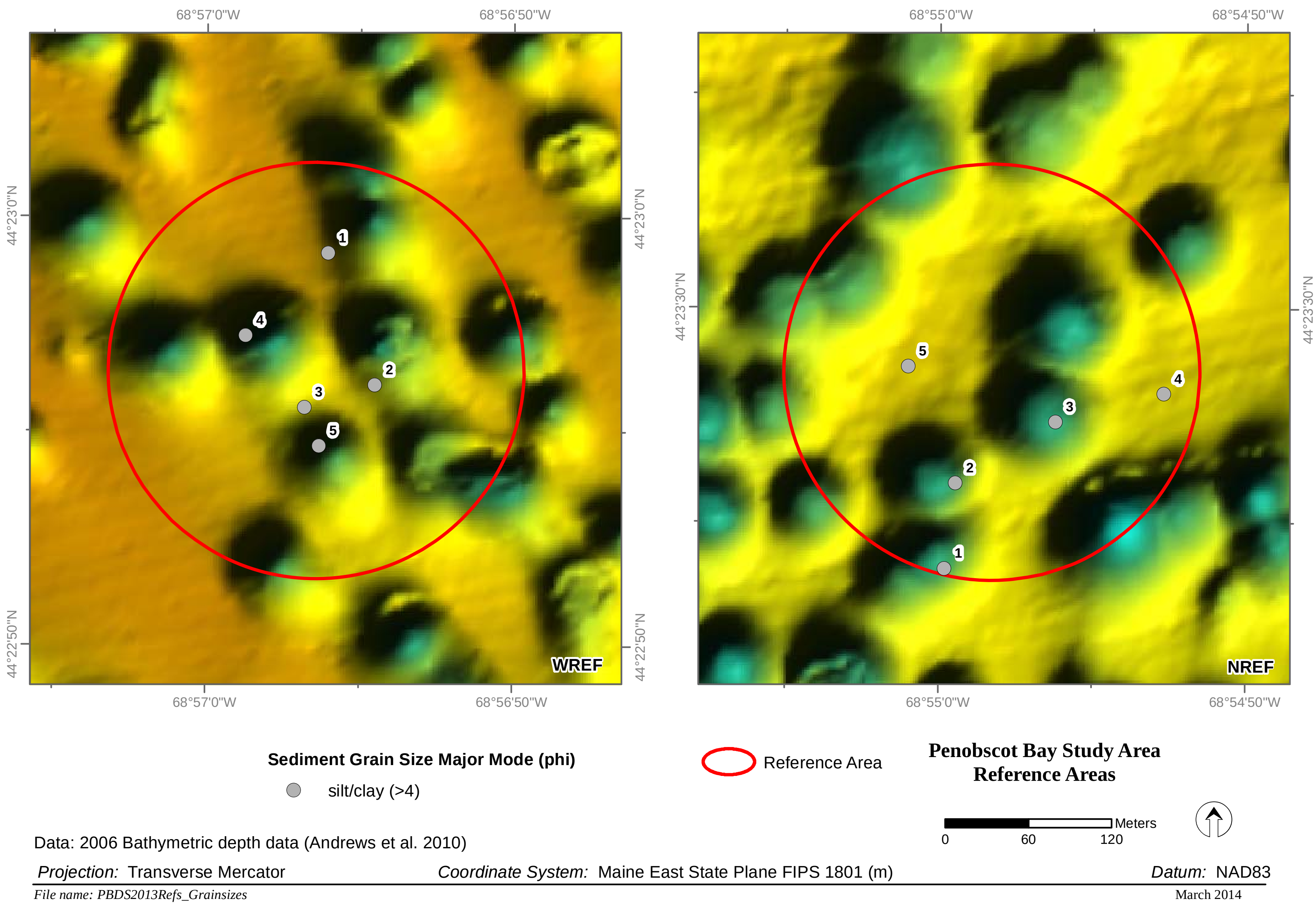


Figure 3-40. Sediment grain size major mode (phi units) at the PBSA reference areas

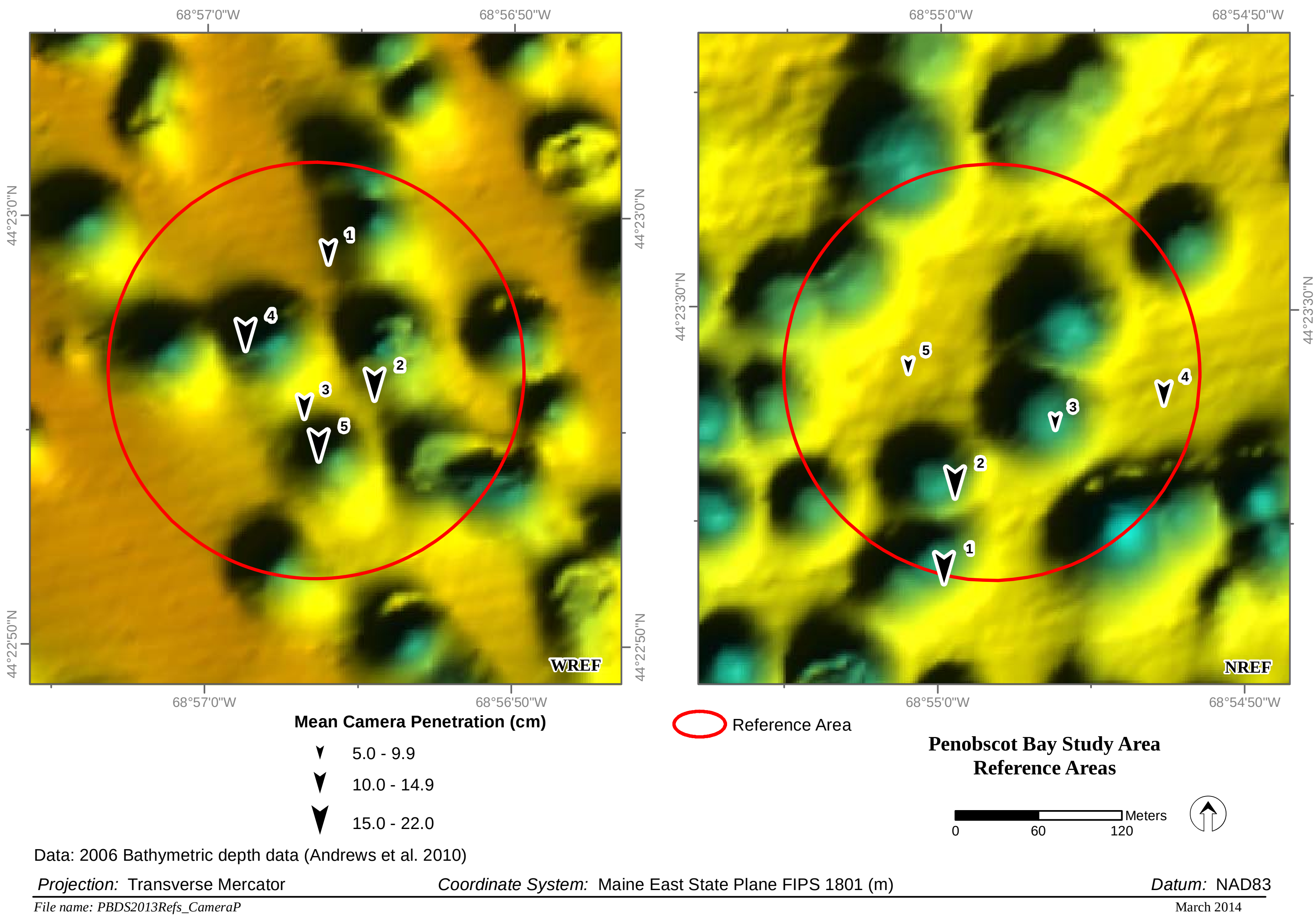


Figure 3-41. Mean station camera prism penetration depths (cm) at the PBSA reference areas

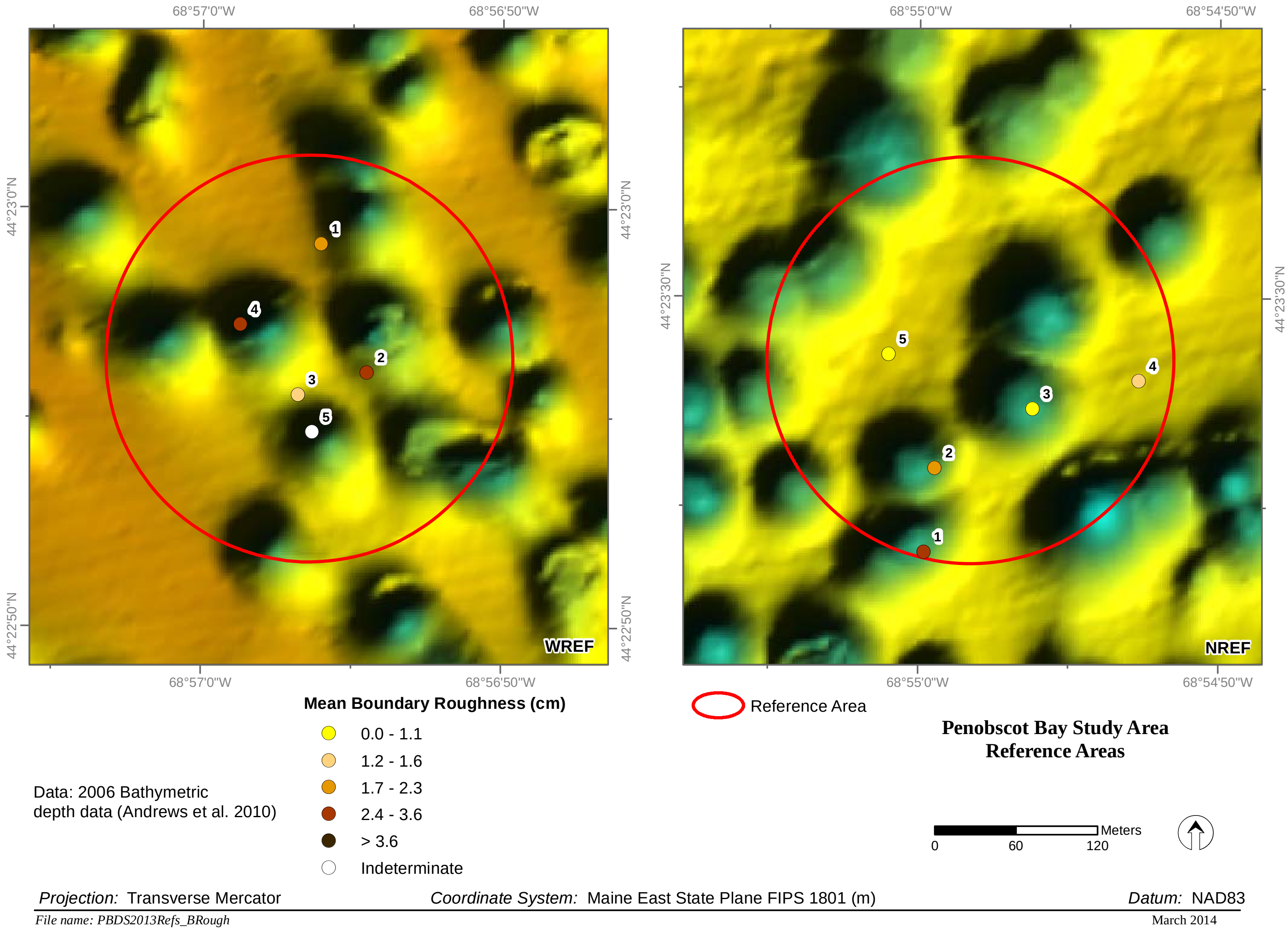


Figure 3-42. Mean station small-scale boundary roughness values (cm) at the PBSA reference areas

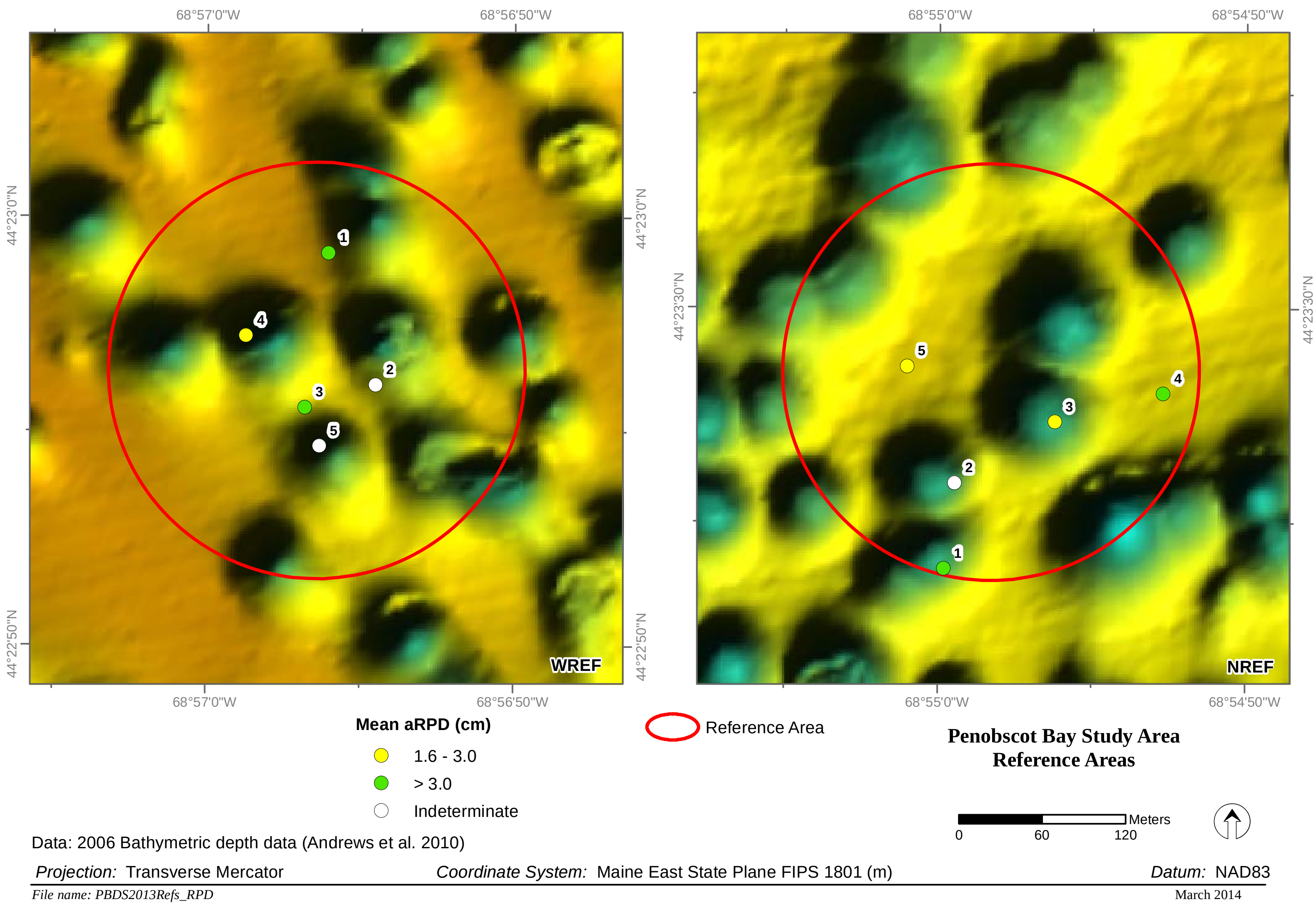


Figure 3-43. Mean station aRPD depth values (cm) at the PBSA reference areas

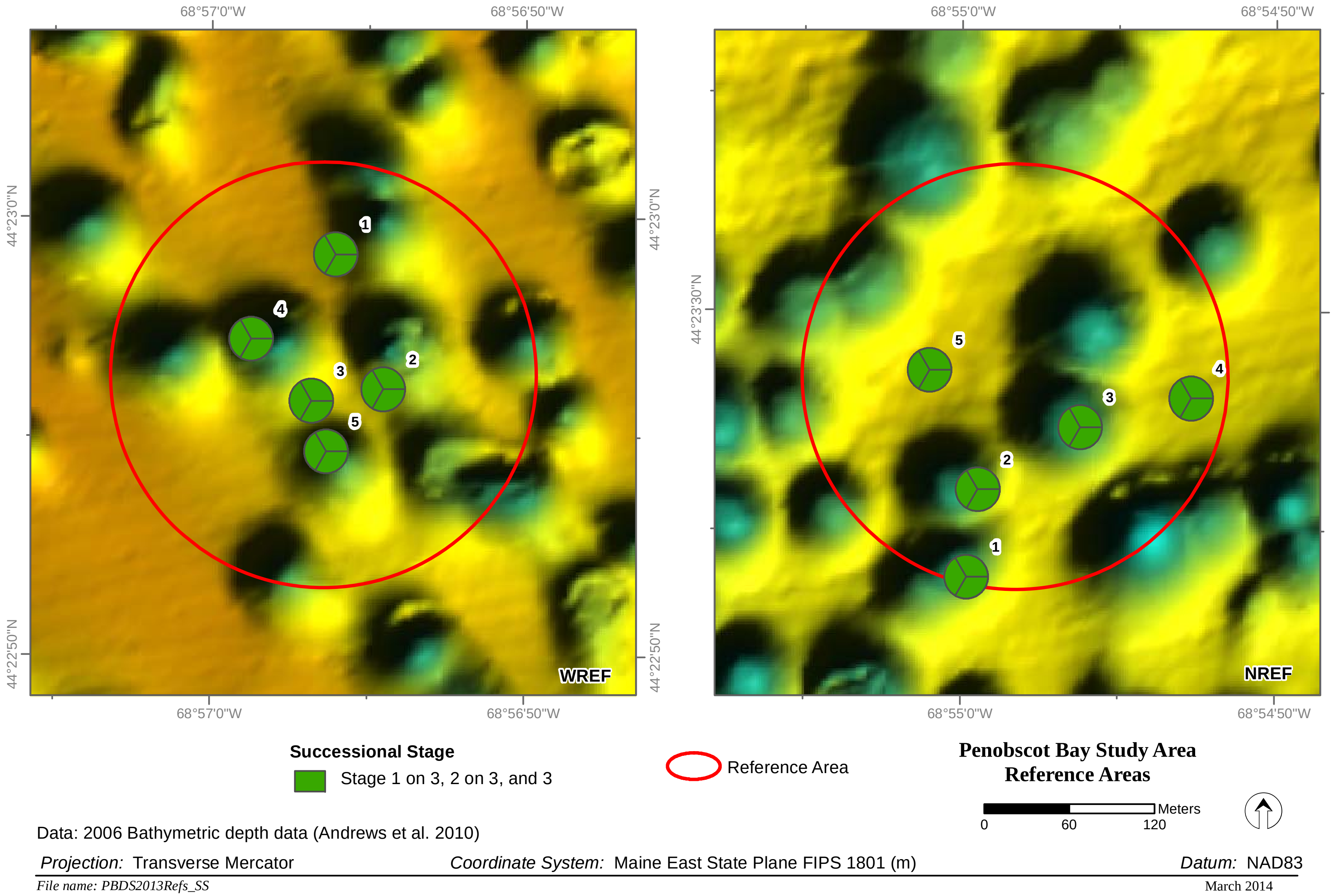


Figure 3-44. Infaunal successional stages found at locations sampled at the PBSA reference areas

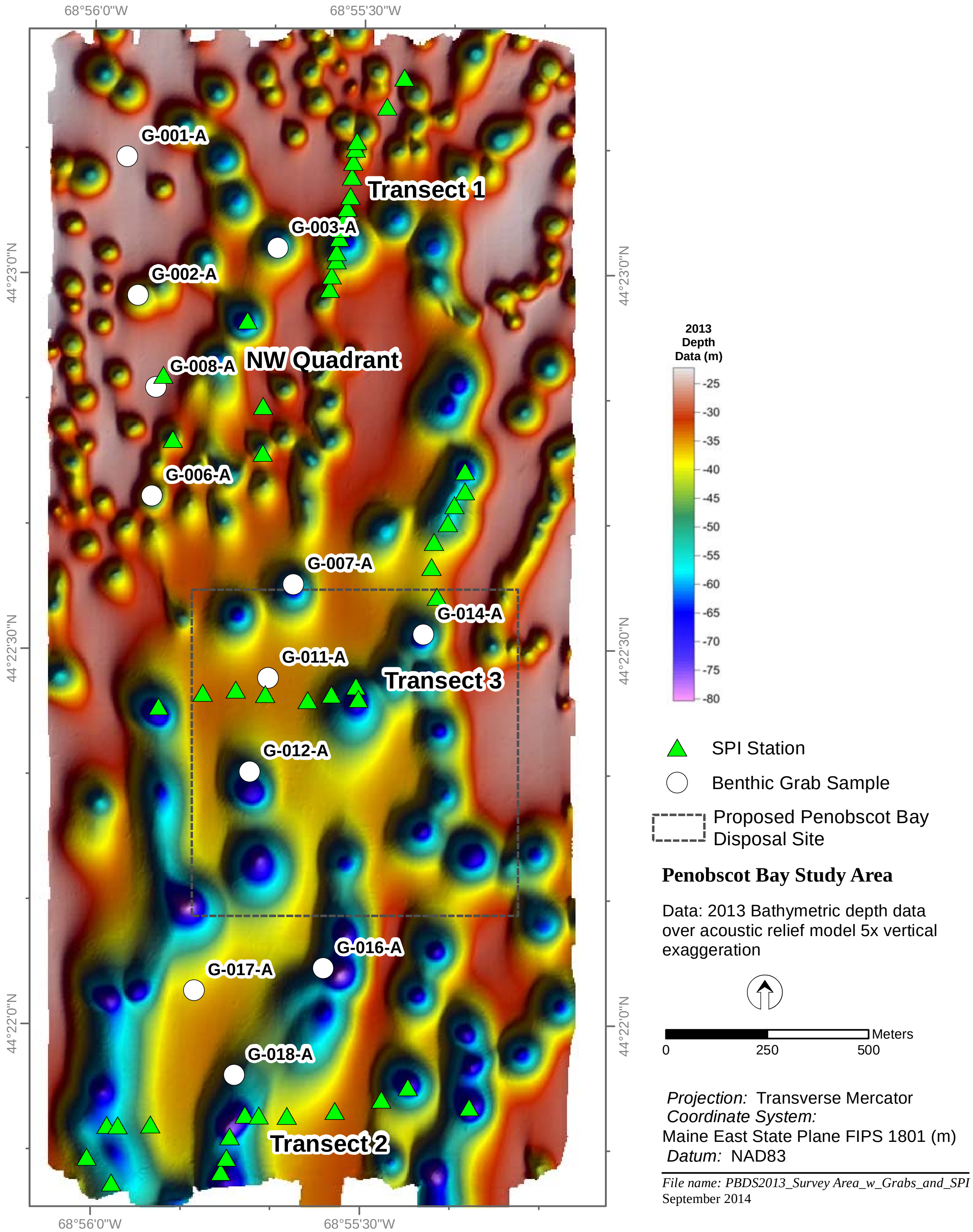


Figure 3-45. Benthic grab sampling locations over bathymetric depth data in PBSA

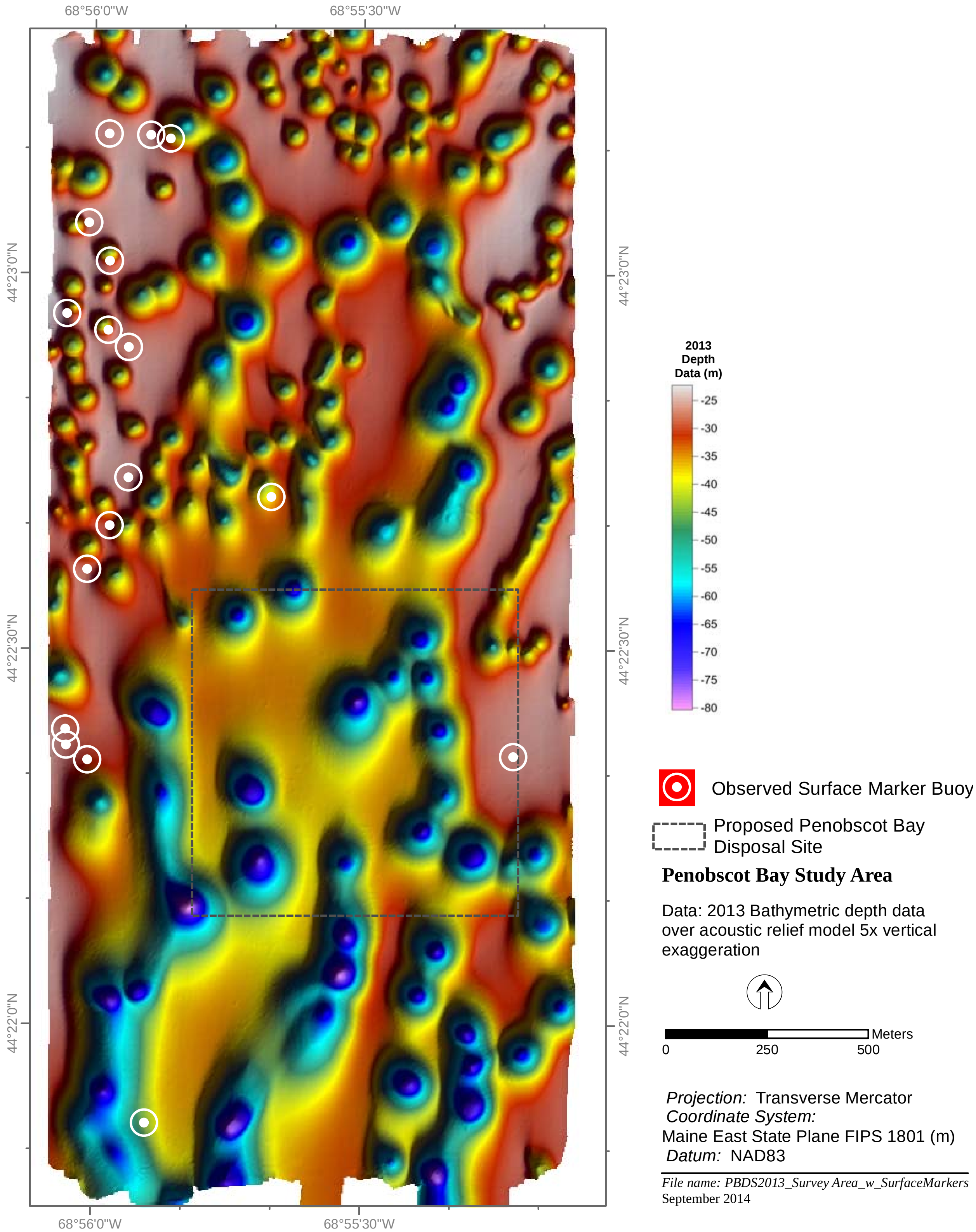


Figure 3-46. Surface marker buoy observations in PBSA

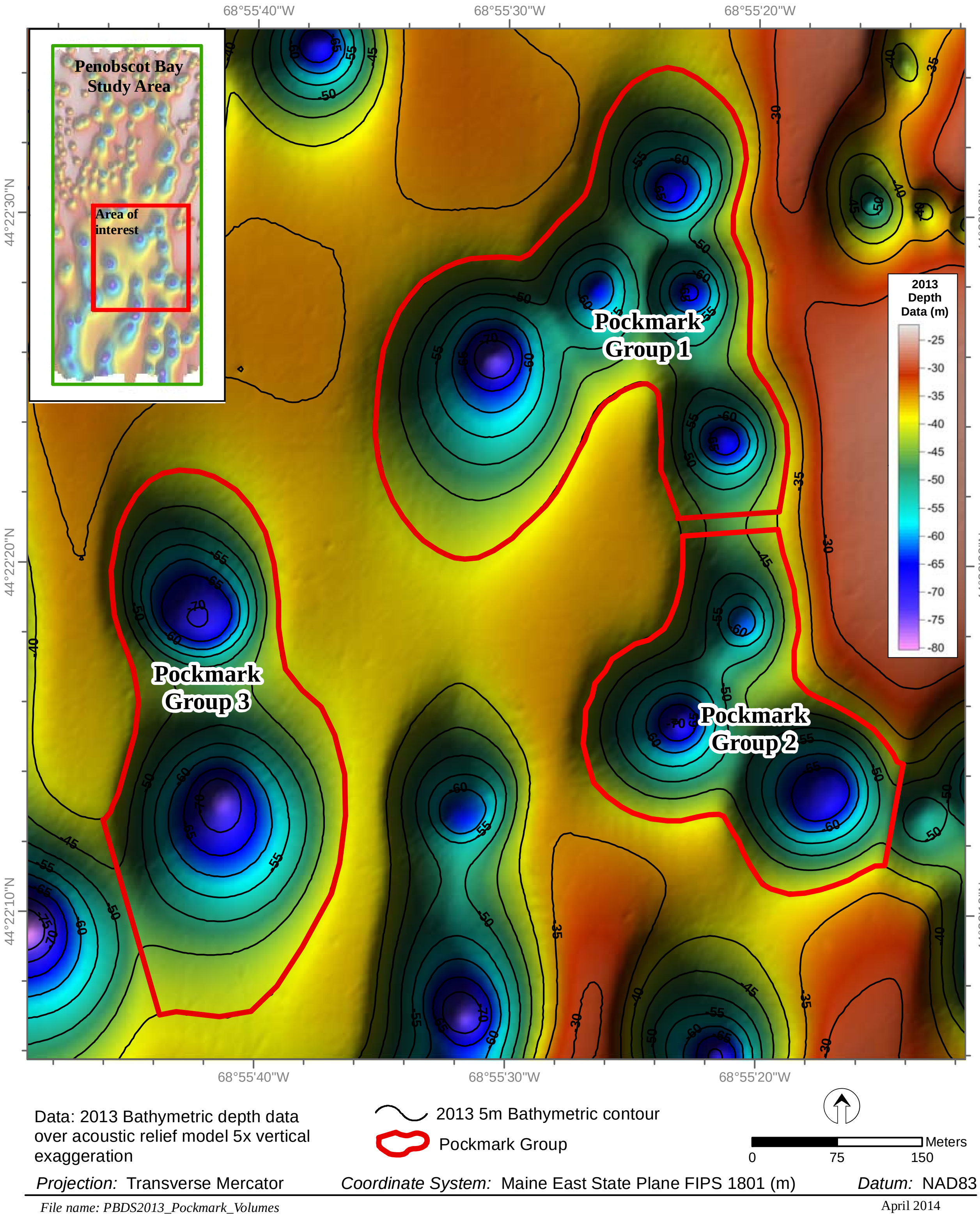


Figure 3-47. Bathymetric contour map with pockmark areas used in volume calculations indicated

4.0 SUMMARY

A survey of a 1,200 × 2,500 m area in the upper portion of Penobscot Bay seafloor was conducted in August 2013 to enhance understanding of physical and biological characteristics to support assessment of the suitability of the area for potentially receiving dredged material. The survey included collection of acoustic data for bathymetric and surficial sediment characterization, sediment-profile imaging (SPI) and plan-view (PV) imaging for further physical and biological characterization, and collection of sediment grabs for physical and biological analyses. The acoustic survey revealed over one hundred pockmarks set into a relatively flat ambient seafloor that ranged from 28 to 34 m deep across the study area. The pockmarks have been attributed to past methane gas release from Holocene sediments (Brothers et al. 2012). Pockmarks were typically crater-shaped, ranging from 60 to 150 m in diameter with depths exceeding 75 m in some cases. Larger and deeper pockmarks tended to be located in the southern portion of the study area. Some pockmarks shared adjacent sides forming north-south oriented troughs that were more prevalent in the southern portion of the study area and potentially attributed to the stronger tidal currents as the bay narrows to the south.

Acoustic data analysis revealed a surface with relatively uniform soft and fine-grained sediment throughout the study area with softer material along the steep slopes of the pockmarks. Along the ambient bottom, north-south oriented linear features of slightly coarser material were observed that bent around the rim of pockmarks. These trails were likely formed by winnowing associated with tidal currents. SPI and PV images supported the acoustic data; surficial sediments in the study area primarily consisted of well-sorted, fine silts and clays with high water-content and low bearing strength. Sediments were observed to be soft, light tan in color and were, at some locations, apparently fluidized at the sediment-water interface. Several SPI images revealed layers with buried interface features and disturbed sediment fabric potentially indicative of sediments that had slumped down the steeply sloped pockmark walls.

Review of SPI and PV images revealed the presence of biological activity in the form of surface tubes, fecal pellets, burrows, and feeding voids at all stations. Abundant polychaetes and small, shallow burrowing bivalves were observed in the benthic samples and SPI images at PBSA stations. No conditions indicative of methane or low dissolved oxygen were observed in the images. SPI and PV image results as well as the benthic grab results confirmed and built upon the findings of the acoustic survey that the sediments in the study area support a healthy benthic community in relatively soft, highly oxygenated sediments.

5.0 REFERENCES

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6.0 DATA TRANSMITTAL

Data transmittal to support this data report will be provided as a separate deliverable for inclusion in a Technical Support Notebook. The data submittal will include:

- Report figures and associated files, including an ArcGIS geo-database
- Raw and adjusted SPI/PV images
- Raw and processed acoustic survey data
- Field notes
- Field pictures
- Pop-up and Pull-out image files

Appendix A

Table of Common Conversions

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

Appendix B

PBSA 2013 Survey

Actual SPI/PV Replicate Locations and Benthic Grab Sampling Locations

PBSA 2013 Survey Actual SPI/PV Replicate Locations

SPI/PV Replicate Locations					
Replicate	**Latitude (N)**	**Longitude (W)**	**Replicate**	**Latitude (N)**	**Longitude (W)**
T1A	44° 22.980'	68° 55.564'	T3A	44° 22.423'	68° 55.878'
T1B	44° 22.998'	68° 55.560'	T3B	44° 22.441'	68° 55.796'
T1C	44° 23.018'	68° 55.551'	T3C	44° 22.446'	68° 55.734'
T1D	44° 23.030'	68° 55.551'	T3D	44° 22.440'	68° 55.679'
T1E	44° 23.048'	68° 55.546'	T3E	44° 22.433'	68° 55.600'
T1F	44° 23.060'	68° 55.543'	T3F	44° 22.440'	68° 55.556'
T1G	44° 23.072'	68° 55.538'	T3G	44° 22.452'	68° 55.511'
T1H	44° 23.088'	68° 55.532'	T3H	44° 22.435'	68° 55.506'
T1I	44° 23.104'	68° 55.526'	T3I	44° 22.571'	68° 55.362'
T1J	44° 23.131'	68° 55.523'	T3J	44° 22.611'	68° 55.372'
T1K	44° 23.150'	68° 55.521'	T3K	44° 22.644'	68° 55.368'
T1L	44° 23.167'	68° 55.517'	T3L	44° 22.669'	68° 55.342'
T1M	44° 23.178'	68° 55.514'	T3M	44° 22.693'	68° 55.330'
T1N	44° 23.224'	68° 55.458'	T3N	44° 22.712'	68° 55.310'
T1O	44° 23.262'	68° 55.427'	T3O	44° 22.738'	68° 55.311'
T2A	44° 21.789'	68° 55.961'	PBDS-1A	44° 22.762'	68° 55.687'
T2B	44° 21.823'	68° 56.007'	PBDS-1B	44° 22.766'	68° 55.690'
T2C	44° 21.865'	68° 55.970'	PBDS-1-C	44° 22.767'	68° 55.686'
T2D	44° 21.865'	68° 55.949'	PBDS-2-A	44° 22.824'	68° 55.686'
T2E	44° 21.866'	68° 55.888'	PBDS-2-B	44° 22.828'	68° 55.690'
T2F	44° 21.804'	68° 55.758'	PBDS-2-C	44° 22.829'	68° 55.693'
T2G	44° 21.823'	68° 55.747'	PBDS-3A	44° 22.780'	68° 55.854'
T2H	44° 21.851'	68° 55.741'	PBDS-3B	44° 22.780'	68° 55.852'
T2I	44° 21.880'	68° 55.714'	PBDS-3C	44° 22.782'	68° 55.849'
T2J	44° 21.879'	68° 55.688'	PBDS-4A	44° 22.865'	68° 55.872'
T2K	44° 21.879'	68° 55.635'	PBDS-4B	44° 22.868'	68° 55.873'
T2L	44° 21.885'	68° 55.547'	PBDS-4C	44° 22.869'	68° 55.873'
T2M	44° 21.901'	68° 55.460'	PBDS-5A	44° 22.938'	68° 55.716'
T2N	44° 21.918'	68° 55.411'	PBDS-5B	44° 22.937'	68° 55.715'
T2O	44° 21.891'	68° 55.297'	PBDS-5C	44° 22.939'	68° 55.718'

PBSA 2013 Survey Actual SPI/PV Replicate Locations (continued)

Reference Replicate Locations			Reference Replicate Locations		
Replicate	**Latitude (N)**	**Longitude (W)**	**Replicate**	**Latitude (N)**	**Longitude (W)**
WREF-1A	44° 22.986'	68° 56.934'	NREF-1A	44° 23.399'	68° 54.997'
WREF-1B	44° 22.984'	68° 56.936'	NREF-1B	44° 23.399'	68° 54.996'
WREF-1C	44° 22.985'	68° 56.937'	NREF-1C	44° 23.400'	68° 54.998'
WREF-2A	44° 22.935'	68° 56.908'	NREF-2A	44° 23.432'	68° 54.991'
WREF-2B	44° 22.936'	68° 56.909'	NREF-2B	44° 23.436'	68° 54.987'
WREF-2C	44° 22.938'	68° 56.909'	NREF-2C	44° 23.434'	68° 54.984'
WREF-4A	44° 22.954'	68° 56.978'	NREF-3A	44° 23.456'	68° 54.936'
WREF-4B	44° 22.956'	68° 56.982'	NREF-3B	44° 23.454'	68° 54.940'
WREF-4C	44° 22.957'	68° 56.983'	NREF-3C	44° 23.459'	68° 54.937'
WREF-3A	44° 22.926'	68° 56.946'	NREF-4A	44° 23.467'	68° 54.878'
WREF-3B	44° 22.930'	68° 56.948'	NREF-4B	44° 23.468'	68° 54.876'
WREF-3C	44° 22.937'	68° 56.951'	NREF-4C	44° 23.467'	68° 54.876'
WREF-5A	44° 22.911'	68° 56.938'	NREF-5A	44° 23.477'	68° 55.017'
WREF-5B	44° 22.899'	68° 56.932'	NREF-5B	44° 23.477'	68° 55.015'
WREF-5C	44° 22.902'	68° 56.935'	NREF-5C	44° 23.481'	68° 55.014'

Notes:
1) Coordinate system NAD83
2) All actual sampling locations are referred to as replicates.
3) PBSA Stations PBDS-1 through 5 are located in the NW Quadrant of the survey area.
4) This table reflects all replicates collected at each station. Fifteen stations each for Transects 1, 2, and 3 were sampled once. Five stations each for NW Quadrant, WREF, and NREF were sampled three times each.

PBSA Benthic Grab Sampling Locations from 20 August 2013

Sample ID	Latitude (N)	Longitude (W)
G-001-A	44° 23.156'	68° 55.940'
G-002-A	44° 22.972'	68° 55.920'
G-003-A	44° 23.035'	68° 55.661'
G-008-A	44° 22.849'	68° 55.885'
G-006-A	44° 22.704'	68° 55.892'
G-007-A	44° 22.587'	68° 55.628'
G-014-A	44° 22.521'	68° 55.386'
G-011-A	44° 22.462'	68° 55.675'
G-012-A	44° 22.338'	68° 55.708'
G-016-A	44° 22.076'	68° 55.569'
G-017-A	44° 22.045'	68° 55.809'
G-018-A	44° 21.933'	68° 55.734'

Note: 1) Coordinate system NAD83

Appendix C

Sediment-Profile and Plan-View Image Analysis Results for PBSA Survey, August 2013

SPI Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRPD Area (sq. cm)	Mean aRPD (cm)
TRANS1	T1A	A1	8/21/2013	11:04:33	10.5 & doors	0	128	14.5	>4	>4	1	86.3	6.0	5.5	6.4	0.9	Biological	35.4	2.4
TRANS1	T1B	B1	8/21/2013	11:07:23	10.5 & doors	0	129	14.5	>4	>4	2	193	13.4	10.6	15.7	5.2	Bio/Physical	90.5	6.2
TRANS1	T1C	C1	8/21/2013	11:10:14	10.5 & doors	0	168	14.5	>4	>4	2	296	20.4	19.8	21.1	ind	ind	218.3	15.1
TRANS1	T1D	D1	8/21/2013	11:12:11	10.5 & doors	0	185	14.5	>4	>4	2	251	17.3	16.3	18.2	1.9	Physical	ind	ind
TRANS1	T1E	E	8/21/2013	11:14:51	10.5 & doors	0	218	14.5	>4	>4	3	298	>21.2	>21.6	>21.6	ind	ind	ind	ind
TRANS1	T1F	F	8/21/2013	11:17:03	10.5 & doors	0	188	14.5	>4	>4	4	>306	>21.2	>21.6	>21.6	ind	ind	ind	ind
TRANS1	T1G	G	8/21/2013	11:18:56	10.5 & doors	0	135	14.5	>4	>4	3	Ind	ind	ind	ind	ind	ind	ind	ind
TRANS1	T1H	H	8/21/2013	11:21:28	10.5 & doors	0	113	14.5	>4	>4	3	186	12.9	11.8	13.8	1.9	Biological	58.2	4.0
TRANS1	T1I	I1	8/21/2013	11:24:10	10.5 & doors	0	107	14.5	>4	>4	2	144	10.0	9.5	10.2	0.7	Biological	54.0	3.7
TRANS1	T1J	J1	8/21/2013	11:29:24	10.5 & doors	0	109	14.5	>4	>4	2	128	8.8	8.3	9.4	1.0	Biological	68.5	4.7
TRANS1	T1K	K1	8/21/2013	11:32:49	10.5 & doors	0	121	14.5	>4	>4	2	271	18.7	18.0	19.1	1.2	Biological	181.0	12.5
TRANS1	T1L	L1	8/21/2013	11:36:16	10.5 & doors	0	156	14.5	>4	>4	2	71.5	4.9	4.2	5.3	1.1	Biological	21.5	1.5
TRANS1	T1M	M1	8/21/2013	11:38:13	10.5 & doors	0	135	14.5	>4	>4	2	142	9.8	9.1	10.3	1.2	Biological	31.7	2.2
TRANS1	T1N	N1	8/21/2013	11:44:34	10.5 & doors	0	98	14.5	>4	>4	2	175	12.1	11.7	12.4	0.8	Biological	26.9	1.9
TRANS1	T1O	O	8/21/2013	11:51:10	10.5 & doors	0	112	14.5	>4	>4	3	169	11.7	10.5	13.1	2.6	Physical	ind	ind
TRANS2	T2A	A1	8/21/2013	13:11:24	10.5 & doors	0	190	14.5	>4	>4	2	190	13.1	11.6	14.3	2.8	Biological	65.6	4.5
TRANS2	T2B	B1	8/21/2013	13:25:49	10.5 & doors	0	180	14.5	>4	>4	2	281	19.4	18.9	19.5	0.6	Biological	105.6	7.3

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Location	Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRPD Area (sq. cm)	Mean aRPD (cm)
TRANS2	T2C	C1	8/21/2013	13:32:08	10.5 & doors	0	206	14.5	>4	>4	2	132	9.1	8.7	9.9	1.2	Biological	47.7	3.3
TRANS2	T2D	D1	8/21/2013	13:35:24	10.5 & doors	0	190	14.5	>4	>4	2	213	14.7	13.4	15.3	2.0	Biological	48.5	3.3
TRANS2	T2E	E1	8/21/2013	13:39:43	10.5 & doors	0	139	14.5	>4	>4	1	204	14.1	13.0	15.7	2.7	Biological	88.7	6.1
TRANS2	T2F	F1	8/21/2013	13:57:39	10.5 & doors	0	223	14.5	>4	>4	2	50.0	3.5	1.7	5.2	3.5	Biological	ind	ind; >5
TRANS2	T2G	G	8/21/2013	14:00:49	10.5 & doors	0	210	14.5	>4	>4	2	32.5	2.2	1.5	3.9	2.5	Biological	ind	ind; >3.9
TRANS2	T2H	H1	8/21/2013	14:05:34	10.5 & doors	0	255	14.5	>4	>4	3	280	19.3	18.8	19.5	ind	ind	ind	ind
TRANS2	T2I	I1	8/21/2013	14:11:32	10.5 & doors	0	213	14.5	-6	>4	-8	26.9	1.9	0.2	3.8	3.5	Physical	ind	ind
TRANS2	T2J	J1	8/21/2013	14:15:53	10.5 & doors	0	150	14.5	>4	>4	3	Ind	ind	ind	ind	ind	ind	ind	ind
TRANS2	T2K	K1	8/21/2013	14:20:05	10.5 & doors	0	132	14.5	>4	>4	2	102	7.0	6.8	7.2	0.3	Biological	46.2	3.2
TRANS2	T2L	L1	8/21/2013	14:26:31	10.5 & doors	0	116	14.5	>4	>4	2	152	10.5	9.6	10.9	1.3	Biological	47.7	3.3
TRANS2	T2M	M	8/21/2013	14:33:55	10.5 & doors	0	147	14.5	>4	>4	2	183	12.6	11.2	14.5	3.3	Physical	ind	ind
TRANS2	T2N	N1	8/21/2013	14:38:18	10.5 & doors	0	236	14.5	>4	>4	2	142	9.8	9.3	11.0	1.7	Biological	32.6	2.2
TRANS2	T2O	O	8/21/2013	14:46:45	10.5 & doors	0	238	14.5	ind	ind	ind	0.0	0.0	0.0	0.0	ind	ind	ind	ind
TRANS3	T3A	A	8/21/2013	15:15:15	10.5 & doors	0	226	14.5	>4	>4	2	129	8.9	8.4	9.7	1.3	Biological	64.9	4.5
TRANS3	T3B	B1	8/21/2013	15:20:42	10.5 & doors	0	113	14.5	>4	>4	2	118	8.1	7.0	8.5	1.5	Biological	54.1	3.7
TRANS3	T3C	C1	8/21/2013	15:25:10	10.5 & doors	0	115	14.5	>4	>4	2	134	9.2	8.8	9.7	0.9	Biological	60.5	4.2
TRANS3	T3D	D1	8/21/2013	15:28:28	10.5 & doors	0	115	14.5	>4	>4	2	144	9.9	8.9	12.7	3.8	Biological	51.5	3.6

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TRANS3	T3E	E1	8/21/2013	15:32:36	10.5 & doors	0	125	14.5	>4	>4	2	187	12.9	12.6	13.2	0.6	Biological	59.8	4.1
TRANS3	T3F	F1	8/21/2013	15:35:55	10.5 & doors	0	165	14.5	>4	>4	2	>208	>14.3	ind	ind	ind	ind	ind	ind
TRANS3	T3G	G1	8/21/2013	15:39:24	10.5 & doors	0	200	14.5	>4	>4	2	222	15.4	14.6	15.5	0.9	Biological	ind	ind
TRANS3	T3H	H1	8/21/2013	15:44:09	10.5 & doors	0	230	14.5	>4	>4	2	218	15.0	14.4	15.4	1.0	Biological	37.9	2.6
TRANS3	T3I	I	8/21/2013	15:57:28	10.5 & doors	0	118	14.5	>4	>4	2	92.8	6.4	6.0	6.8	0.8	Biological	24.7	1.7
TRANS3	T3J	J1	8/21/2013	16:01:58	10.5 & doors	0	124	14.5	>4	>4	2	132	9.1	7.7	9.7	2.0	Biological	60.5	4.2
TRANS3	T3K	K1	8/21/2013	16:05:36	10.5 & doors	0	147	14.5	>4	>4	2	255	17.6	17.2	18.3	1.2	Biological	ind	ind
TRANS3	T3L	L1	8/21/2013	16:09:23	10.5 & doors	0	178	14.5	>4	>4	2	189	13.0	11.7	14.7	3.0	Biological	25.1	1.7
TRANS3	T3M	M1	8/21/2013	16:11:49	10.5 & doors	0	180	14.5	>4	>4	2	290	20.0	19.8	20.1	ind	ind	ind	ind
TRANS3	T3N	N1	8/21/2013	16:13:49	10.5 & doors	0	158	14.5	>4	>4	3	290	20.0	19.8	20.1	ind	ind	ind	ind
TRANS3	T3O	O1	8/21/2013	16:18:01	10.5 & doors	0	200	14.5	>4	>4	2	174	12.0	11.4	12.9	1.5	Biological	51.1	3.5
NW Quad	PBDS-01	A1	8/21/2013	16:43:32	10.5 & doors	0	134	14.5	>4	>4	2	>306	>21.1	>21.1	>21.1	ind	ind	ind	ind
NW Quad	PBDS-01	B1	8/21/2013	16:44:32	10.5 & doors	0	146	14.5	>4	>4	2	257	17.7	16.9	18.7	1.8	Biological	98.2	6.8
NW Quad	PBDS-01	C1	8/21/2013	16:45:35	10.5 & doors	0	143	14.5	>4	>4	2	209	14.4	13.7	15.1	1.5	Biological	63.4	4.4
NW Quad	PBDS-02	A1	8/21/2013	16:50:42	10.5 & doors	0	95	14.5	>4	>4	2	96.4	6.7	6.0	7.5	1.5	Biological	40.1	2.8
NW Quad	PBDS-02	B1	8/21/2013	16:51:38	10.5 & doors	0	95	14.5	>4	>4	2	138	9.5	8.9	9.9	0.9	Biological	38.6	2.7
NW Quad	PBDS-02	C	8/21/2013	16:52:38	10.5 & doors	0	95	14.5	>4	>4	2	113	7.8	7.2	8.1	0.9	Biological	30.8	2.1

SPI Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRPD Area (sq. cm)	Mean aRPD (cm)
NW Quad	PBDS-03	A1	8/21/2013	16:59:33	10.5 & doors	0	144	14.5	>4	>4	3	196	13.5	12.9	14.1	1.2	Biological	ind	ind
NW Quad	PBDS-03	B1	8/21/2013	17:00:46	10.5 & doors	0	137	14.5	>4	>4	3	188	13.0	12.2	13.4	1.2	Biological	ind	ind
NW Quad	PBDS-03	C1	8/21/2013	17:01:57	10.5 & doors	0	134	14.5	>4	>4	2	258	17.8	16.6	19.3	2.7	Physical	110.4	7.6
NW Quad	PBDS-04	A1	8/21/2013	17:07:13	10.5 & doors	0	85	14.5	>4	>4	2	132	9.1	8.1	9.5	1.4	Biological	55.2	3.8
NW Quad	PBDS-04	B1	8/21/2013	17:08:11	10.5 & doors	0	85	14.5	>4	>4	2	95.3	6.6	6.3	6.8	0.4	Biological	42.3	2.9
NW Quad	PBDS-04	C1	8/21/2013	17:09:39	10.5 & doors	0	85	14.5	>4	>4	2	141	9.7	9.4	10.0	0.6	Biological	37.8	2.6
NW Quad	PBDS-05	A1	8/21/2013	17:16:24	10.5 & doors	0	203	14.5	>4	>4	2	120	8.3	8.0	8.6	0.6	Biological	19.6	1.4
NW Quad	PBDS-05	B	8/21/2013	17:17:18	10.5 & doors	0	206	14.5	>4	>4	2	137	9.5	8.0	11.5	3.5	Physical	ind	ind
NW Quad	PBDS-05	C1	8/21/2013	17:18:26	10.5 & doors	0	197	14.5	>4	>4	2	89.8	6.2	5.7	6.6	0.8	Biological	38.9	2.7
WREF	WREF-01	A1	8/21/2013	8:17:40	12	0	85	14.5	>4	>4	2	168	11.6	11.3	11.9	0.6	Biological	59.6	4.1
WREF	WREF-01	B1	8/21/2013	8:18:28	12	0	85	14.5	>4	>4	2	193	13.3	12.4	14.8	2.4	Biological	52.3	3.6
WREF	WREF-01	C1	8/21/2013	8:19:24	12	0	85	14.5	>4	>4	2	77.3	5.3	4.4	6.3	1.9	Biological	22.2	1.5
WREF	WREF-02	A1	8/21/2013	9:43:17	13	0	85	14.5	>4	>4	2	>305	>21.1	>21.0	>21.0	ind	ind	ind	ind
WREF	WREF-02	B1	8/21/2013	9:44:17	13	0	85	14.5	>4	>4	2	>305	>21.1	>21.0	>21.0	ind	ind	ind	ind
WREF	WREF-02	C1	8/21/2013	9:45:24	13	0	85	14.5	>4	>4	2	282	19.4	17.8	20.5	2.7	Biological	ind	ind
WREF	WREF-03	A1	8/21/2013	10:16:47	11.5 & doors	0	92	14.5	>4	>4	2	176	12.2	11.9	12.5	0.6	Biological	53.6	3.7
WREF	WREF-03	B1	8/21/2013	10:17:46	11.5 & doors	0	95	14.5	>4	>4	2	158	10.9	10.6	11.6	1.0	Biological	51.0	3.5
WREF	WREF-03	C	8/21/2013	10:18:55	11.5 & doors	0	103	14.5	>4	>4	2	279	19.3	18.5	20.3	1.7	Biological	54.4	3.8
WREF	WREF-04	A1	8/21/2013	10:09:01	11.5 & doors	0	105	14.5	>4	>4	3	202	14.0	12.6	14.7	2.1	Biological	ind	ind

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Location	Station	Replicate	Date	Time	Stop Collar Setting (in)	# of Weights (per side)	Water Depth (ft)	Calibration Constant	Grain Size Major Mode (phi)	Grain Size Maximum (phi)	Grain Size Minimum (phi)	Penetration Area (sq. cm)	Penetration Mean (cm)	Penetration Minimum (cm)	Penetration Maximum (cm)	Boundary Roughness (cm)	Boundary Roughness Type	aRPD Area (sq. cm)	Mean aRPD (cm)
WREF	WREF-04	B1	8/21/2013	10:10:11	11.5 & doors	0	90	14.5	>4	>4	3	247	17.1	14.7	19.1	4.4	Biological	ind	ind
WREF	WREF-04	C	8/21/2013	10:10:54	11.5 & doors	0	87	14.5	>4	>4	2	286	19.8	19.1	20.4	1.3	Biological	34.5	2.4
WREF	WREF-05	A	8/21/2013	10:27:50	11.5 & doors	0	124	14.5	>4	>4	2	305	>21.1	>21.0	>21.0	ind	ind	ind	ind
WREF	WREF-05	B	8/21/2013	10:30:29	11.5 & doors	0	122	14.5	>4	>4	3	>305	>21.1	>21.0	>21.0	ind	ind	ind	ind
WREF	WREF-05	C	8/21/2013	10:31:27	11.5 & doors	0	116	14.5	>4	>4	3	>305	>21.1	>21.0	>21.0	ind	ind	ind	ind
NREF	NREF-01	A1	8/21/2013	17:37:53	10.5 & doors	0	113	14.5	>4	>4	3	241	16.6	15.9	17.2	1.3	Physical	ind	ind
NREF	NREF-01	B1	8/21/2013	17:38:57	10.5 & doors	0	107	14.5	>4	>4	2	223	15.4	13.5	15.9	2.4	Physical	43.6	3.0
NREF	NREF-01	C1	8/21/2013	17:40:02	10.5 & doors	0	106	14.5	>4	>4	2	208	14.3	12.1	16.3	4.2	Physical	51.2	3.5
NREF	NREF-02	A	8/21/2013	17:46:00	10.5 & doors	0	96	14.5	>4	>4	2	>281	>19.5	>19.5	>19.5	ind	ind	ind	ind
NREF	NREF-02	B	8/21/2013	17:46:59	10.5 & doors	0	88	14.5	>4	>4	2	188	13.0	11.7	13.6	1.9	Physical	ind	ind
NREF	NREF-02	C1	8/21/2013	17:47:55	10.5 & doors	0	84	14.5	>4	>4	2	>293	>20.3	>20.3	>20.3	ind	ind	ind	ind
NREF	NREF-03	A1	8/21/2013	17:50:48	10.5 & doors	0	114	14.5	>4	>4	2	145	10.0	9.8	10.2	0.4	Biological	24.9	1.7
NREF	NREF-03	B1	8/21/2013	17:51:52	10.5 & doors	0	118	14.5	>4	>4	2	139	9.6	9.1	10.3	1.2	Biological	29.4	2.0
NREF	NREF-03	C1	8/21/2013	17:52:57	10.5 & doors	0	119	14.5	>4	>4	2	139	9.6	9.0	10.4	1.5	Biological	28.1	1.9
NREF	NREF-04	A	8/21/2013	17:55:23	10.5 & doors	0	75	14.5	>4	>4	2	186	12.9	11.5	13.7	2.2	Biological	73.3	5.1
NREF	NREF-04	B1	8/21/2013	17:56:37	10.5 & doors	0	75	14.5	>4	>4	2	130	9.0	8.9	9.1	0.2	Biological	46.4	3.2
NREF	NREF-04	C1	8/21/2013	17:57:37	10.5 & doors	0	75	14.5	>4	>4	2	126	8.7	8.1	9.4	1.2	Biological	32.8	2.3

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NREF	NREF-05	A1	8/21/2013	18:02:32	10.5 & doors	0	73	14.5	>4	>4	2	146	10.1	10.0	10.3	0.3	Biological	37.0	2.6
NREF	NREF-05	B1	8/21/2013	18:03:27	10.5 & doors	0	71	14.5	>4	>4	2	83.6	5.8	4.6	6.5	1.9	Biological	29.1	2.0
NREF	NREF-05	C1	8/21/2013	18:04:21	10.5 & doors	0	71	14.5	>4	>4	2	150	10.3	9.8	10.6	0.8	Biological	33.2	2.3

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

SPI Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Mud Clast Number	Mud Clast State	Methane?	Low DO?	Comment	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
TRANS1	T1A	A1	0	-	n	n	Consolidated silt/clay with blue clay inclusion at depth; tubes at SWI and in background; burrowing in upper cm; filled voids at depth	0	-	-	-	1 on 3
TRANS1	T1B	B1	4	oxidized	n	n	Silt/clay with chunks and large mud clasts on surface in background from camera door artifact; tubes at SWI; few thin polychaetes at depth; disturbed profile, large void on left just below surface	2	1.5	8.3	4.9	1 on 3
TRANS1	T1C	C1	ind	ind	n	n	High-water content silt/clay, overpenetrated, voids at depth, PV image confirms succ. Stage	2	17.9	>20.0	~19.0	1 on 3
TRANS1	T1D	D1	0	-	n	n	High water content silt/clay, camera moved after penetrated because of low shear strength seds; burrowing at depth	1	14.0	14.9	14.5	1 on 3
TRANS1	T1E	E	ind	ind	n	n	High-water content silt/clay, overpenetrated, voids at depth, PV image confirms succ. Stage, disturbed profile, low bearing strength sediments	0	-	-	-	1 on 3
TRANS1	T1F	F	ind	-	n	n	Completely fluidized silt/clay	0	-	-	-	ind
TRANS1	T1G	G	ind	-	n	n	Completely fluidized silt/clay; succ stage based on PV image	0	-	-	-	1 on 3
TRANS1	T1H	H	6	both	n	n	Silt/clay with mud clast artifacts from camera doors, tubes at SWI, burrowing through aRPD; one large, one small void at depth;	2	7.3	9.2	8.2	1 on 3
TRANS1	T1I	I1	0	-	n	n	Silt/clay with tubes @ SWI; burrowing in upper cms, thru aRPD, and evidence of deeper burrowers just below base of aRPD; void at depth; very thin polychaete at depth to left	1	8.5	1.1	4.8	1 on 3
TRANS1	T1J	J1	0	-	n	n	Silt/clay with tubes at SWI and in background; burrowing in aRPD; voids at depth	2	4.0	6.9	5.4	1 on 3
TRANS1	T1K	K1	0	-	n	n	Silt/clay with high water content, looks like depositional aRPD, evidence of burrowing at depth, succ stage confirmed by PV image structures	0	-	-	-	1 on 3
TRANS1	T1L	L1	0	-	n	n	Silt/clay with tubes in background; burrowing through aRPD; void at depth	1	3.6	5.3	4.4	1 on 3
TRANS1	T1M	M1	0	-	n	n	Silt/clay with small tubes @ SWI; shallow burrowing; voids below aRPD to depth	4	10.4	8.3	9.4	1 on 3
TRANS1	T1N	N1	10+	oxidized	n	n	Silt/clay with mud clast artifacts from camera at SWI, small tubes and one med tube at SWI; burrowing through aRPD; thin polychaete at depth on right, burrowing to depth of profile	7	4.1	10.7	7.4	1 on 3

SPI Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Mud Clast Number	Mud Clast State	Methane?	Low DO?	Comment	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
TRANS1	T1O	O	10+	both	n	n	Silt/clay with disturbed profile from camera sliding; evidence of burrowing at depth as well as small tubes @ SWI	1	10.8	11.4	11.1	1 on 3
TRANS2	T2A	A1	0	-	n	n	Silt/clay with fecal pellets, small tubes at SWI; burrowing through aRPD, evidence of deeper burrowers near base of aRPD (transected burrow)	0	-	-	-	1 on 3
TRANS2	T2B	B1	0	-	n	n	Silt/clay with tubes visible at center; burrowing in upper cms; voids near base of deep aRPD; voids at depth; wiper blade against surface	1	15.8	16.8	16.3	1 on 3
TRANS2	T2C	C1	10+	oxy	n	n	Silt/clay with abundant Nucula on sediment surface and on wiper blade, bioturbation greater than prism penetration depth.	5	2.4	8.9	5.6	2 on 3
TRANS2	T2D	D1	0	-	n	n	Silt/clay with Nucula in upper few cm, small tubes at SWI and in background; burrowing in through aRPD; voids at depth	6	8.8	14.3	11.6	2 on 3
TRANS2	T2E	E1	2	oxidized	n	n	Silt/clay with small tubes at SWI and in background; small voids just below aRPD, other filled voids at depth, bioturbation depth exceeds prism penetration depth.	4	4.3	5.1	4.7	1 on 3
TRANS2	T2F	F1	2	oxidized	n	n	Silt/clay with minimal penetration because of presence of mussels on bottom (see corresponding PV image), aRPD extends past penetration depth in parts; one void connected to surface at left, successional stage confirmed by PV image	2	1.9	16.7	9.3	1 on 3
TRANS2	T2G	G	0	-	n	n	Silt clay, penetration too shallow to determine stage	0	-	-	-	ind
TRANS2	T2H	H1	ind	-	n	n	Low bearing strength silt/clay; over-penetrated, SWI disturbed by wiper blade.	ind	-	-	-	ind
TRANS2	T2I	I1	0	-	n	n	Rocky bottom with silt detrital mantle, fouling community growing on rock surfaces	ind	-	-	-	ind
TRANS2	T2J	J1	ind	-	n	n	Over-penetration. High water content silt/clay; voids present but profile and interface disturbed	ind	-	-	-	ind
TRANS2	T2K	K1	0	-	n	n	Silt/clay with small tubes @ SWI; shallow burrowing; voids below aRPD to depth	5	3.5	7.0	5.3	1 on 3
TRANS2	T2L	L1	0	-	n	n	Silt/clay with fecal pellets and burrowing in upper cms; few thin polychaetes; voids below aRPD and at depth	5	3.9	7.6	5.7	1 on 3

SPI Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Mud Clast Number	Mud Clast State	Methane?	Low DO?	Comment	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
TRANS2	T2M	M	10+	both	n	n	Silt/clay with uneven surface and large sed chunks caused by camera sledding down slope; evidence of burrowing throughout profile. Succ Stage based on combo of SPI and PV information	0	-	-	-	1 on 3
TRANS2	T2N	N1	0	-	n	n	Silt -clay with small tubes @ SWI as well as Nucula in top few cm; indication of deeper burrowers at base of aRPD, void at depth	1	9.8	10.0	9.9	2 on 3
TRANS2	T2O	O	ind	-	ind	ind	No penetration. PV shows detritus covered rocks	-	-	-	-	ind
TRANS3	T3A	A	0	-	n	n	Silt/clay with fecal pellet layer at surface; burrowing through aRPD, one void at base of aRPD, others in relict aRPD; small polychaete at depth to left of center at center	3	2.6	5.8	4.2	2 on 3
TRANS3	T3B	B1	10+	oxidized	n	n	Silt/clay with mud clast artifacts from camera on sediment surface; tubes @ SWI and in background; small void at base of aRPD on left; few small thin polychaetes against faceplate	1	2.4	2.9	2.7	1 on 3
TRANS3	T3C	C1	0	-	n	n	Silt/clay with few tubes on surface; small bivalve just below SWI to left; burrowing in upper cms; small voids at base of aRPD	5	3.6	7.4	5.5	1 on 3
TRANS3	T3D	D1	0	-	n	n	Silt/clay with biogenic mounding (see PV) and surface disturbed by mud door bow wave; very thin polychaete at depth on left	2	6.2	9.3	7.7	2 on 3
TRANS3	T3E	E1	10+	oxidized	n	n	Silt/clay with small mud clast artifacts on surface and in background; burrowing through aRPD, burrow openings visible in associated PV image	0	-	-	-	1 on 3
TRANS3	T3F	F1	ind		n	n	Silt/clay with smearing because camera is sliding down slope, obscuring almost all of SWI; some signs of small polychaetes and burrowing in aRPD	0	-	-	-	ind
TRANS3	T3G	G1	ind		n	n	High water content, low shear strength silt/clay with disturbed interface due to thixotropic nature of sediment. Evidence of burrowing in aRPD; thin polychaete at depth; backfilled voids at depth	0	-	-	-	ind
TRANS3	T3H	H1	10+	oxidized	n	n	Silt clay with small to med mud clast artifacts on surface; few small tubes at SWI; small void below aRPD on right, Nucula present in top few cm and on wiper blade too	1	3.9	4.0	3.9	2 on 3
TRANS3	T3I	I	10+	oxidized	n	n	Silt/clay with small mud clast artifacts at SWI; burrowing through aRPD; voids below aRPD and at depth; polychaete to right of shallower void	2	3.6	6.5	5.1	1 on 3

SPI Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Mud Clast Number	Mud Clast State	Methane?	Low DO?	Comment	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
TRANS3	T3J	J1	4	both	n	n	Silt/clay with a few mud clast artifacts and dense tubes on surface; one void near base of aRPD;	4	1.7	8.2	5.0	1 on 3
TRANS3	T3K	K1	ind		n	n	Silt/clay with smearing because of downslope travel by camera base; deposit feeders at depth, tubes visible on surface in PV image.	0	-	-	-	1 on 3
TRANS3	T3L	L1	10+	oxidized	n	n	Silt/clay with surface disturbed by mud door bow wave, uneven patches of fecal pellets, tubes, large mud clasts at SWI; small void below aRPD	1	7.3	7.5	7.4	1 on 3
TRANS3	T3M	M1	ind		n	n	High water content mud; camera overpenetrated, no detail at SWI; obvious deposit feeders present at depth, large burrow openings in associated PV image.	4	15.0	18.3	16.7	3
TRANS3	T3N	N1	ind		n	n	High water content mud; camera overpenetrated, no detail at SWI; obvious deposit feeders present at depth	1	3.7	5.2	4.4	3
TRANS3	T3O	O1	2	oxidized	n	n	Silt/clay with some mud clast artifacts from base sled doors; tubes at surface and in background; small void at depth on left	1	11.7	12.0	11.9	1 on 3
NW Quad	PBDS-01	A1	ind	ind	n	n	Over-penetration. Silt/clay with low bearing strength & high water content; evidence of deposit feeders present	0	-	-	-	ind
NW Quad	PBDS-01	B1	8	both	n	n	Silt/clay with high water content; evidence of deeper burrows toward base of aRPD, transected burrows at depth	0	-	-	-	1 on 3
NW Quad	PBDS-01	C1	0	-	n	n	Silt/clay with fecal pellet layer, shallow burrows, and small tubes at SWI; burrowing through aRPD; evidence of larger burrower near base of aRPD on left	0	-	-	-	1 on 3
NW Quad	PBDS-02	A1	10+	oxidized	n	n	Silt clay with small to med mud clasts across SWI from camera doors, fecal pellets; evidence of burrowing at depth, Stage 1 tubes visible in PV image	2	3.9	5.6	4.7	1 on 3
NW Quad	PBDS-02	B1	10+	oxidized	n	n	Silt/clay with small mud clasts and fecal pellets; burrowing through aRPD; one void is at base of aRPD on right	5	2.1	8.9	5.5	1 on 3
NW Quad	PBDS-02	C	10+	oxidized	n	n	Silt/clay covered with small mud clasts; long thin polychaete at depth; one void connected to SWI by visible burrow	8	2.1	6.8	4.4	1 on 3
NW Quad	PBDS-03	A1	10+	both	n	n	Silt/clay with indeterminate aRPD because of disturbed fabric; fecal pellets in upper cm; med-large clasts on surface; PV shows Stage 1 on 3 clearly	0	-	-	-	1 on 3

SPI Image Analysis Results for PBSA Survey, August 2013

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NW Quad	PBDS-03	B1	10+	both	n	n	Silt/clay with indeterminate aRPD because of disturbed fabric; fecal pellets in upper cm; med-large clasts on surface; PV shows Stage 1 on 3 clearly; camera on slope in this rep & last because of diagonal smearing (base is sliding downhill)	0	-	-	-	1 on 3
NW Quad	PBDS-03	C1	10+	oxidized	n	n	Silt/clay, camera on slope, oxidized layer is turbidite flow deposit, sharp contact boundary with underlying consolidated clay; Stage 1 on 3 visible in PV image; polychaete in U-burrow near divide between light/dark sed	0	-	-	-	1 on 3
NW Quad	PBDS-04	A1	10+	oxidized	n	n	Silt/clay with layer of fecal pellets and mud clasts on surface; burrowing through aRPD, evidence of larger burrows below aRPD, voids at depth	5	3.6	8.7	6.2	1 on 3
NW Quad	PBDS-04	B1	10+	oxidized	n	n	Silt/clay with small tubes at SWI, one larger burrow at right, burrow openings visible in PV image	0	-	-	-	1 on 3
NW Quad	PBDS-04	C1	10+	oxidized	n	n	Silt/clay with layer of small tubes and fecal pellets at SWI, burrowing through aRPD; voids at depth	6	4.3	7.1	5.7	1 on 3
NW Quad	PBDS-05	A1	10+	oxidized	n	n	Silt/clay, high density of Nucula present (as evidenced by those on wiper blade), evidence of burrowing throughout profile.	1	3.7	3.8	3.8	2 on 3
NW Quad	PBDS-05	B	10+	both	n	n	Silt/clay; surface disturbed and breaking up from camera movement, high density of Nucula present as in previous rep.	5	3.7	7.9	5.8	2 on 3
NW Quad	PBDS-05	C1	4	both	n	n	Silt/clay with many tubes at SWI and in background; burrowing through aRPD, thin polychaete below aRPD to right of center, evidence of burrowing throughout profile.	3	2.8	5.7	4.2	1 on 3
WREF	WREF-01	A1	10	both	n	n	Silt/clay with tubes @ SWI, evidence of burrowing in aRPD, very thin polychaete ~2cm below SWI; voids at base of aRPD and at depth	6	4.2	10.4	7.3	1 on 3
WREF	WREF-01	B1	9	both	n	n	Silt/clay with small tubes in background; few large mud clasts on surface (camera artifact); burrowing in aRPD ; voids are large with reworked sed; polychaete against faceplate at left at depth	4	4.0	7.5	5.8	1 on 3
WREF	WREF-01	C1	10+	both	n	n	Consolidated silt/clay with mud clasts across SWI; burrowing in upper 2 cms, voids are small	3	2.0	4.6	3.3	1 on 3
WREF	WREF-02	A1	ind	ind	n	n	Over-penetration. Silt clay with infaunal deposit feeders; PV image shows tubes @ SWI	0	-	-	-	1 on 3

SPI Image Analysis Results for PBSA Survey, August 2013

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WREF	WREF-02	B1	ind	ind	n	n	Over-penetration. Silt clay with infaunal deposit feeders; PV image shows tubes @ SWI	0	-	-	-	1 on 3
WREF	WREF-02	C1	10+	both	n	n	High-water content silt/clay, interface disturbed by camera movement, aRPD indeterminate; tubes on surface, burrowing at depth.	0	-	-	-	1 on 3
WREF	WREF-03	A1	10+	oxidized	n	n	Silt/clay with tubes at SWI, burrowing through aRPD; voids at base of aRPD and at depth	3	5.1	12.0	8.5	1 on 3
WREF	WREF-03	B1	0	-	n	n	Silt/clay with burrowing through aRPD; long burrow connected to void at base of aRPD at center	3	2.3	11.3	6.8	1 on 3
WREF	WREF-03	C	4	oxidized	n	n	Silt/clay with small mud clasts on surface; evidence of burrowing at depth, PV shows classic 1 on 3 taxa	0	-	-	-	1 on 3
WREF	WREF-04	A1	0	-	n	n	Silt/clay with disturbed interface, aRPD indeterminate; evidence of burrowing throughout profile, PV shows 1 on 3 taxa	0	-	-	-	1 on 3
WREF	WREF-04	B1	6	both	n	n	Silt/clay with disturbed interface, aRPD indeterminate; evidence of burrowing throughout profile.	0	-	-	-	1 on 3
WREF	WREF-04	C	5	both	n	n	Silt/clay with fecal pellet surface layer; burrowing in upper 1-2cm; small polychaete at base of aRPD on right and at depth on left; transected burrows at depth	1	4.5	6.1	5.3	1 on 3
WREF	WREF-05	A	ind	ind	n	n	Over-penetration. High water content silt/clay; voids present and burrow openings in associated PV image	0	-	-	-	1 on 3
WREF	WREF-05	B	ind	ind	n	n	Over-penetration. High water content silt/clay; voids present and burrow openings in associated PV image	0	-	-	-	1 on 3
WREF	WREF-05	C	ind	ind	n	n	Over-penetration. High water content silt/clay; voids present and burrow openings in associated PV image	0	-	-	-	1 on 3
NREF	NREF-01	A1	0	-	n	n	Silt with voids in lower 5 cm; silt mixed with disturbed sed- mixed of compact and loose, old tubes and mud clasts, surface disturbed by sampling, aRPD impossible to measure	6	11.2	16.4	13.8	1 on 3
NREF	NREF-01	B1	10+	both	n	n	Silt/clay; surface covered with small- medium mud clasts that are artifacts from camera; sediment with some chaotic/shifted texture at depth; one void mostly filled, low bearing strength sediments	2	10.4	14.5	12.4	3

SPI Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Mud Clast Number	Mud Clast State	Methane?	Low DO?	Comment	# of Feeding Voids	Void Minimum Depth (cm)	Void Maximum Depth (cm)	Void Average Depth (cm)	Successional Stage
NREF	NREF-01	C1	10+	both	n	n	Silt/clay; surface covered with small- medium mud clasts that are artifacts from camera; a few tubes; evidence of shallow burrowing in aRPD	2	5.3	11.3	8.3	1 on 3
NREF	NREF-02	A	ind	ind	n	n	Over-penetration. High water content silt/clay; voids present and burrow openings in associated PV image	0	-	-	-	3
NREF	NREF-02	B	0	-	n	n	Silt/clay with high-water content sediment; oxidized surface layer blown away by sampling disturbance	2	9.0	11.9	10.4	3
NREF	NREF-02	C1	ind	ind	n	n	Over-penetration. Filled void near top of image, others at depth; low bearing strength sediments, disturbed profile	5	>12.0	>20.3	>16.0	3
NREF	NREF-03	A1	4	both	n	n	Silt/clay with layer of reduced fecal pellets; tubes in background; open burrow from SWI; few small voids at depth, Nucula visible against faceplate	4	5.4	8.8	7.1	2 on 3
NREF	NREF-03	B1	0	-	n	n	Silt/clay with fecal pellets and shallow burrowing; void just below aRPD	2	2.7	6.2	4.5	1 on 3
NREF	NREF-03	C1	9	both	n	n	Silt/clay with many tubes on surface in background; mud clasts on surface are artifacts from camera sled; evidence of burrowing through aRPD	6	3.0	6.3	4.7	1 on 3
NREF	NREF-04	A	0	-	n	n	Silt/clay with small tubes in upper cms; evidence of burrowing through aRPD; two voids below	2	5.7	7.9	6.8	1 on 3
NREF	NREF-04	B1	10+	both	n	n	Silt/clay, surface covered with small mud clasts from camera artifact; evidence of burrowing through aRPD; small void at base of aRPD; others at depth. Stage 1 tubes visible in PV image	3	2.5	8.9	5.7	1 on 3
NREF	NREF-04	C1	10+	both	n	n	Silt/clay, surface covered with small mud clasts- camera artifact; burrowing through aRPD, small burrows near base of aRPD, others at depth	5	2.6	7.9	5.3	1 on 3
NREF	NREF-05	A1	0	-	n	n	Silt/clay with high water content; some small mud clasts from sled door artifacts, small tubes @ SWI	4	3.5	8.8	6.1	1 on 3
NREF	NREF-05	B1	0	-	n	n	Firmer silt/clay with surface layer of fecal pellets, indication of larger burrows near base of aRPD on right, burrow openings and Stage 1 tubes visible in corresponding PV image	0	-	-	-	1 on 3
NREF	NREF-05	C1	10+	both	n	n	Silt/clay, surface covered with small mud clasts- camera artifact; burrowing through aRPD, voids at depth	7	1.6	7.9	4.7	1 on 3

PV Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Epifauna	Mud Clasts	Debris	Comment
TRANS1	T1-A	A	8/21/2013	11:04:48	71.6	47.4	0.3	mud	n	y	y	y	n	n	n	mud; many small burrows, large burrows; tubes; short tracks; slopes downward to upper right
TRANS1	T1-B	B	8/21/2013	11:07:28	38.8	25.7	0.1	mud	n	y	y	n	n	n	n	mud; tubes and burrow openings; photo snapped close to surface, appears to be sloping downward to left lower corner
TRANS1	T1-C	C	8/21/2013	11:10:18	ind	ind	ind	mud	n	y	y	n	n	n	n	mud; tubes and burrows; very close to sed, sus sed cloud
TRANS1	T1-D	D	8/21/2013	11:12:15	ind	ind	ind	mud	n	y	y	n	n	n	n	soft mud; small to large burrows; tubes, slopes downward to right of image
TRANS1	T1-E	E	8/21/2013	11:15:00	ind	ind	ind	mud	n	y	y	y	n	n	n	soft mud; right 1/3 of image obscured by cloud of sus sed; small to large burrows; tubes, slopes downward to right
TRANS1	T1-F	F	8/21/2013	11:16:59	80.9	53.6	0.4	mud	n	y	y	y	y	n	n	mud; burrows; bottom fish; level surface
TRANS1	T1-G	G	8/21/2013	11:19:07	ind	ind	ind	mud	n	y	y	y	n	n	n	mud; small burrows, tubes, flat bottom
TRANS1	T1-H	H	8/21/2013	11:21:42	ind	ind	ind	mud	n	y	y	y	y	n	n	mud; small to med/large burrows, tubes, 2 shrimp, flat bottom
TRANS1	T1-I	I	8/21/2013	11:24:16	54.4	36.0	0.2	mud	n	y	y	n	n	n	n	mud; small to large burrows, tubes, close image, good resolution, flat bottom
TRANS1	T1-J	J	8/21/2013	11:29:28	ind	ind	ind	mud	n	y	y	n	n	n	n	soft mud; small burrows, tubes, large burrow opening in upper right corner of image
TRANS1	T1-K	K	8/21/2013	11:32:51	ind	ind	ind	mud	n	y	y	y	n	n	n	soft mud; small to med burrows, track in upper left, most of image is obscured by sed cloud
TRANS1	T1-L	L	8/21/2013	11:36:18	ind	ind	ind	mud	n	y	y	y	y	n	n	mud; small to large burrows; tubes, some fan-like; shrimp- good resolution, flat bottom
TRANS1	T1-M	M	8/21/2013	11:38:17	ind	ind	ind	mud	n	y	y	y	y	n	n	mud; small to med burrows, tubes, shrimp- flat bottom

PV Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Epifauna	Mud Clasts	Debris	Comment
TRANS1	T1-N	N	8/21/2013	11:44:39	ind	ind	ind	mud	n	y	y	n	n	n	n	mud; small to med burrows; large foraging pit or start of slope in upper right quadrant of image
TRANS1	T1-O	O	8/21/2013	11:51:24	ind	ind	ind	mud	n	y	y	y	y	n	n	soft mud; small burrows; long track in upper left; small tubes, shrimp, downward slope to lower right quadrant
TRANS2	T2-A	A	8/21/2013	13:11:30	77.2	51.1	0.4	mud	n	y	y	y	y	n	n	mud; sed 'ridge' on left and in upper left corner with downward slope to lower right; small to med burrows; short tracks; some fauna coming out of a burrow in lower right
TRANS2	T2-B	B	8/21/2013	13:25:54	53.7	35.5	0.2	mud	n	y	y	n	n	n	n	soft mud; small to large burrows; tubes
TRANS2	T2-C	C	8/21/2013	13:32:14	47.7	31.6	0.2	mud	n	y	y	y	y	n	n	mud; small burrows; tubes; small fauna near center; tracks; depression or slope to lower right corner
TRANS2	T2-D	D	8/21/2013	13:35:28	64.2	42.5	0.3	mud	y	y	y	y	n	n	n	soft mud; sed 'ridge' on length of image bottom to top; small burrows; tubes, foraging tracks
TRANS2	T2-E	E	8/21/2013	13:39:48	48.9	32.4	0.2	mud	n	y	y	y	n	n	n	soft mud; small to med/large burrows; tubes
TRANS2	T2-F	F	8/21/2013	13:57:43	72.0	47.7	0.3	mud	n	y	y	y	y	n	n	soft mud; small burrows; choppy tracks; brittle star arms in upper left; small and med mounds, small rocks with hydroids on them, downward slope to lower right corner
TRANS2	T2-G	G	8/21/2013	14:01:04	62.0	41.0	0.3	mud	n	y	y	y	n	n	n	soft mud; small to med burrows; short/fat tracks; partially withdrawn ceriantheid
TRANS2	T2-I	I	8/21/2013	14:11:37	ind	ind	ind	mud	n	y	y	n	y	n	n	soft mud; small to med burrows; tubes; few mud clasts; amphipod on stalk in upper center, extensive hydroids
TRANS2	T2-K	K	8/21/2013	14:20:09	50.1	33.2	0.2	mud	n	y	y	n	n	n	n	soft mud; small to medium burrows; tubes, relatively flat bottom

PV Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Epifauna	Mud Clasts	Debris	Comment
TRANS2	T2-L	L	8/21/2013	14:26:35	49.2	32.6	0.2	mud	n	y	y	n	n	n	n	soft mud; small to med/large burrows; tubes, a few large ones clearly visible at center; downward slope to lower right corner of image
TRANS2	T2-M	M	8/21/2013	14:34:08	ind	ind	ind	mud	n	y	y	n	n	n	n	soft mud; small burrows; tubes; mud clasts-photo taken close to bottom and slightly out of focus
TRANS2	T2-N	N	8/21/2013	14:38:22	50.7	33.6	0.2	mud	n	y	y	y	y	n	n	soft mud; small to v large burrows; tubes, 2 shrimp
TRANS2	T2-O	O	8/21/2013	14:46:59	52.4	34.7	0.2	mud	n	y	y	y	y	n	n	soft mud; small to med burrows; some tubes, mud clasts; track; epifauna- tunicate(?) at upper edge of image; hydroids
TRANS3	T3-A	A	8/21/2013	15:15:29	39.3	26.0	0.1	mud	n	y	y	y	n	n	n	soft mud; small to med burrows; tubes, thin tracks
TRANS3	T3-B	B	8/21/2013	15:20:47	49.9	33.0	0.2	mud	n	y	y	n	n	n	n	soft mud; small to med burrows; tubes, flat bottom
TRANS3	T3-C	C	8/21/2013	15:25:15	44.8	29.7	0.1	mud	n	y	y	n	n	n	n	mud; small burrows; tubes, including one cluster of many tubes; sloping downward on left
TRANS3	T3-D	D	8/21/2013	15:28:33	47.1	31.2	0.1	mud	n	y	y	n	y	n	n	soft mud; small to med/large burrows; tubes, shrimp, sloping downward on left
TRANS3	T3-E	E	8/21/2013	15:32:40	47.7	31.6	0.2	mud	n	y	y	n	n	n	n	mud; small to large burrows; tubes; slight start of downward slope on left edge of image
TRANS3	T3-F	F	8/21/2013	15:35:58	ind	ind	ind	mud	n	y	y	n	y	n	n	mud; small to large burrows, some tubes and shrimp
TRANS3	T3-G	G	8/21/2013	15:39:21	60.1	39.8	0.2	mud	n	y	y	y	n	n	n	mud; small burrows; tubes, few thin tracks, flat bottom

PV Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Epifauna	Mud Clasts	Debris	Comment
TRANS3	T3-I	I	8/21/2013	15:57:43	38.3	25.4	0.1	mud	n	y	y	n	y	n	n	mud; small burrows, few tubes and mud clasts; few shrimp- bottom is sloped downward to lower right corner
TRANS3	T3-J	J	8/21/2013	16:02:04	39.7	26.3	0.1	mud	n	y	y	n	n	n	n	mud; small burrows; few tubes; steeply sloping seafloor
TRANS3	T3-K	K	8/21/2013	16:05:40	37.9	25.1	0.1	mud	n	y	y	n	y	n	n	mud; small to large burrows; tubes; lots of small shrimp; seafloor is sloping downward toward bottom of image
TRANS3	T3-L	L	8/21/2013	16:09:28	40.7	27.0	0.1	mud	n	y	y	n	n	n	n	mud; small to v large burrows; flat bottom
TRANS3	T3-M	M	8/21/2013	16:11:53	55.6	36.8	0.2	mud	n	y	y	y	y	n	n	silt/clay; small to v large burrows; few thin short tracks; couple small shrimp
TRANS3	T3-N	N	8/21/2013	16:13:53	36.4	24.1	0.1	mud	n	y	y	ind	n	n	n	silt/clay; small to med burrows, - most of image is not visible, not illuminated
TRANS3	T3-O	O	8/21/2013	16:18:06	48.8	32.3	0.2	mud	n	y	y	n	y	n	n	soft mud; small to med/large burrows; two "flat" smoother areas (no med burrows); small shrimp and other unidentified epifauna (possibly small holothurians)
NW Quad	PBDS-02	A	8/21/2013	16:50:47	49.1	32.5	0.2	mud	n	y	y	n	y	n	n	soft mud; v small burrows, tubes and shrimp
NW Quad	PBDS-02	B	8/21/2013	16:51:43	47.8	31.7	0.2	mud	n	y	y	n	y	n	n	soft mud; small and 2 large burrows, tubes and shrimp
NW Quad	PBDS-02	C	8/21/2013	16:52:54	51.8	34.3	0.2	mud	n	y	y	y	n	n	n	soft mud; small and 2 med burrows, tubes and few short tracks
NW Quad	PBDS-03	A	8/21/2013	16:59:37	49.6	32.8	0.2	mud	n	y	y	y	n	n	n	soft mud; small burrows throughout, tubes, tracks, and appears to be sloping downward to left of image
NW Quad	PBDS-03	B	8/21/2013	17:00:49	43.2	28.6	0.1	mud	n	y	y	y	n	n	n	soft mud; small burrows, one large burrow, tubes, on slope
NW Quad	PBDS-04	A	8/21/2013	17:07:18	48.4	32.0	0.2	mud	n	y	y	y	n	n	n	soft mud; small burrows; tubes... good image clarity

PV Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Epifauna	Mud Clasts	Debris	Comment
NW Quad	PBDS-04	B	8/21/2013	17:08:17	43.2	28.6	0.1	mud	n	y	y	y	n	n	n	soft mud; small burrows; tubes... good image clarity
NW Quad	PBDS-04	C	8/21/2013	17:09:45	48.6	32.2	0.2	mud	n	y	y	y	n	n	n	soft mud; small burrows and 1 large one, tubes and faint tracks
NW Quad	PBDS-05	A	8/21/2013	17:16:29	46.4	30.7	0.1	mud	n	y	y	y	n	n	n	soft mud; small to large burrows, tubes, short tracks
NW Quad	PBDS-05	B	8/21/2013	17:17:32	44.5	29.4	0.1	mud	n	y	y	y	n	n	n	soft mud; sus sed obscures some of image; small to med burrows; mud clasts- two large red ones; short tracks
NW Quad	PBDS-05	C	8/21/2013	17:18:31	44.3	29.3	0.1	mud	n	y	y	n	y	n	n	soft mud; small to med burrows; tubes; small shrimp- good image clarity
WREF	WREF-01	A	8/21/2013	8:17:45	118.2	78.3	0.9	mud	n	y	ind	y	n	n	n	soft mud; small to large burrows; low resolution
WREF	WREF-02	A	8/21/2013	9:43:23	ind	ind	ind	mud	n	y	y	y	n	n	n	soft mud; burrows, tubes, mud clasts; photo taken very close to sed surface
WREF	WREF-03	A	8/21/2013	10:16:53	48.0	31.8	0.2	mud	n	y	y	y	n	n	n	mud; small to med burrows, tubes, small track in upper left corner
WREF	WREF-03	C	8/21/2013	10:19:10	47.6	31.5	0.2	mud	n	y	y	n	n	n	n	mud; small to med burrows, tubes, flat surface
WREF	WREF-04	A	8/21/2013	10:09:05	54.6	36.1	0.2	mud	n	y	y	n	n	n	n	mud; small burrows; tubes throughout; downward slope to upper left
WREF	WREF-05	B	8/21/2013	10:30:43	68.3	45.2	0.3	mud	n	y	y	y	n	n	n	mud; small to med/large burrows; tubes and many short tracks; flat surface
WREF	WREF-05	C	8/21/2013	10:31:40	68.3	45.2	0.3	mud	n	y	y	y	n	n	n	mud; small to med/large burrows; tubes and short tracks; upper left obscured by suspended sediment
NREF	NREF-01	A	8/21/2013	17:37:58	36.9	24.4	0.1	mud	n	y	y	y	y	n	n	silt/clay; small-med burrows, few tubes, small tracks, transparent shrimp to left at center
NREF	NREF-02	B	8/21/2013	17:47:08	ind	ind	ind	mud	n	n	y	y	y	n	n	silt/clay; few small shrimp; lobster trawl rope visible with tunicates

PV Image Analysis Results for PBSA Survey, August 2013

Location	Station	Replicate	Date	Time	Image Width (cm)	Image Height (cm)	Field-of-View imaged (m^2)	Sediment Type	Bedforms	Burrows	Tubes	Tracks	Epifauna	Mud Clasts	Debris	Comment
NREF	NREF-03	C	8/21/2013	17:53:02	ind	ind	ind	mud	n	y	y	n	n	y	n	silt/clay; tubes, mud clasts on surface
NREF	NREF-04	A	8/21/2013	17:55:40	45.2	29.9	0.1	mud	n	y	y	y	n	n	n	soft mud; small to med burrows, small tracks, higher density of tubes on right side of image
NREF	NREF-05	A	8/21/2013	18:02:39	49.3	32.6	0.2	mud	n	y	y	y	n	n	n	silt/clay; small burrows, tubes on surface, small narrow tracks
NREF	NREF-05	B	8/21/2013	18:03:33	47.4	31.4	0.1	mud	n	y	y	n	n	n	n	silt/clay; small-med burrows, tubes and crab tracks

Note: 1) “ind” indicates that the sample result was indeterminate

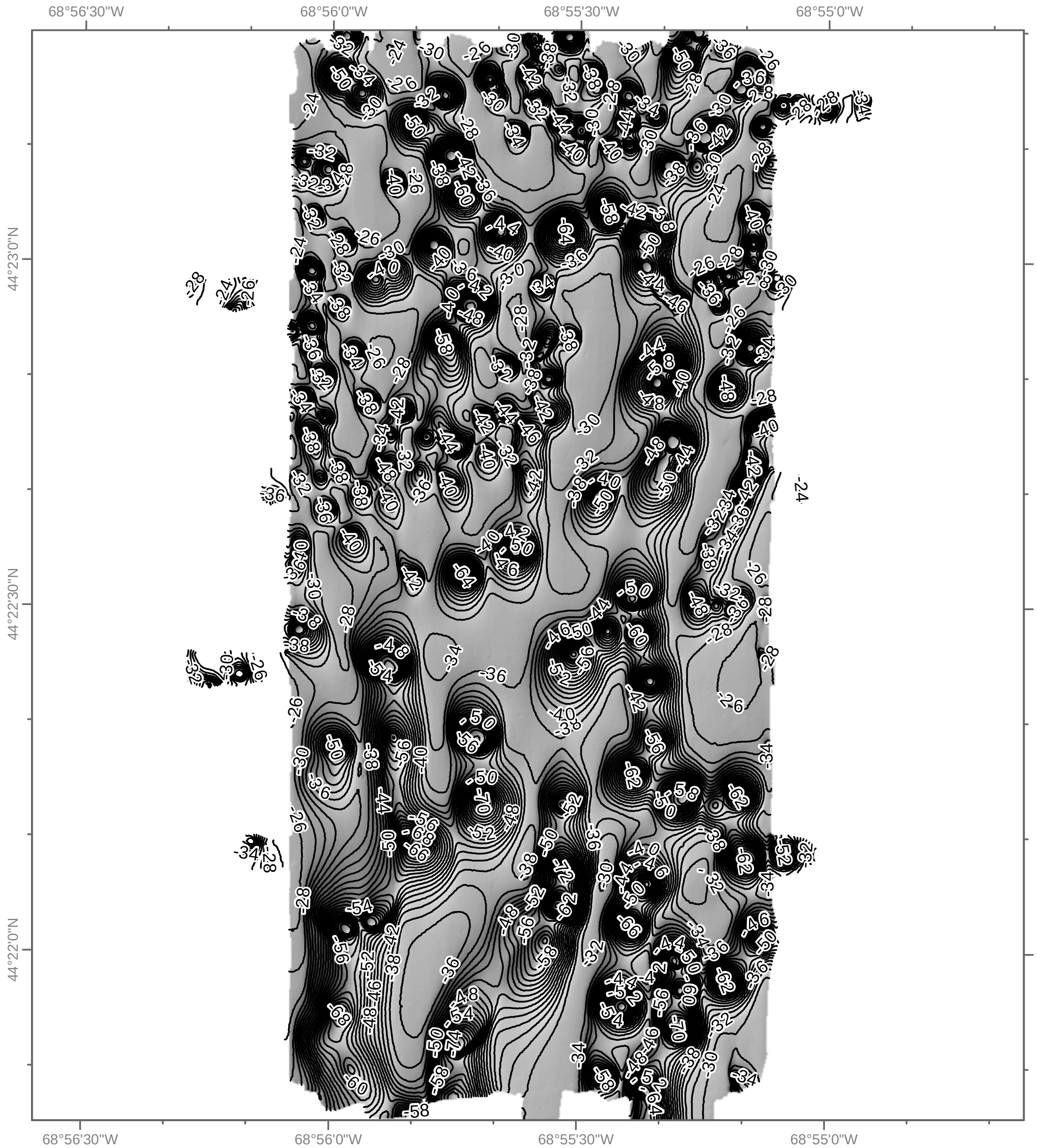
Appendix D

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 E

Additional Figures



Data: 2013 2-m contour data over acoustic relief model 2x vertical exaggeration

2 m Contour MLLW

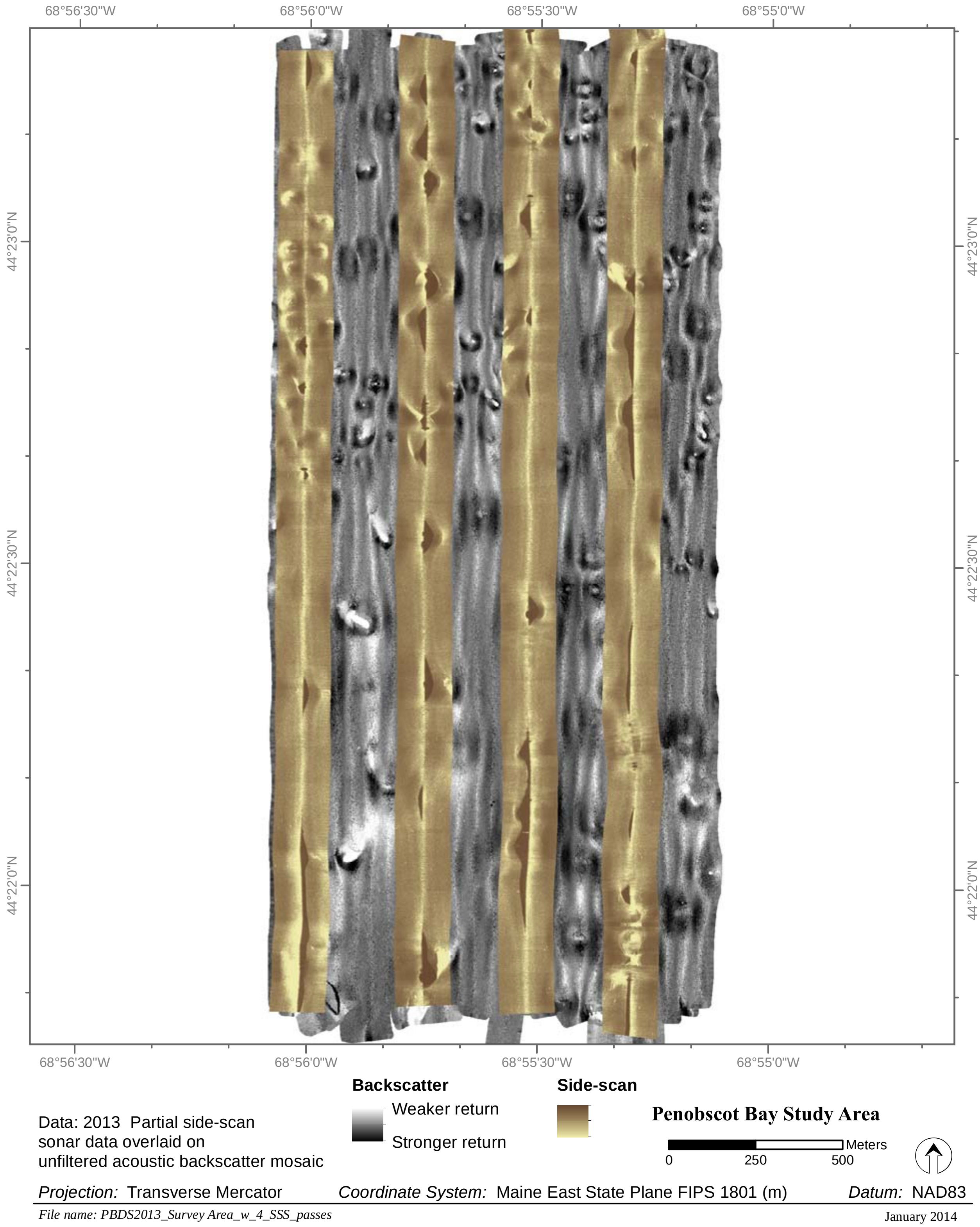
Penobscot Bay Study Area

0 250 500 Meters

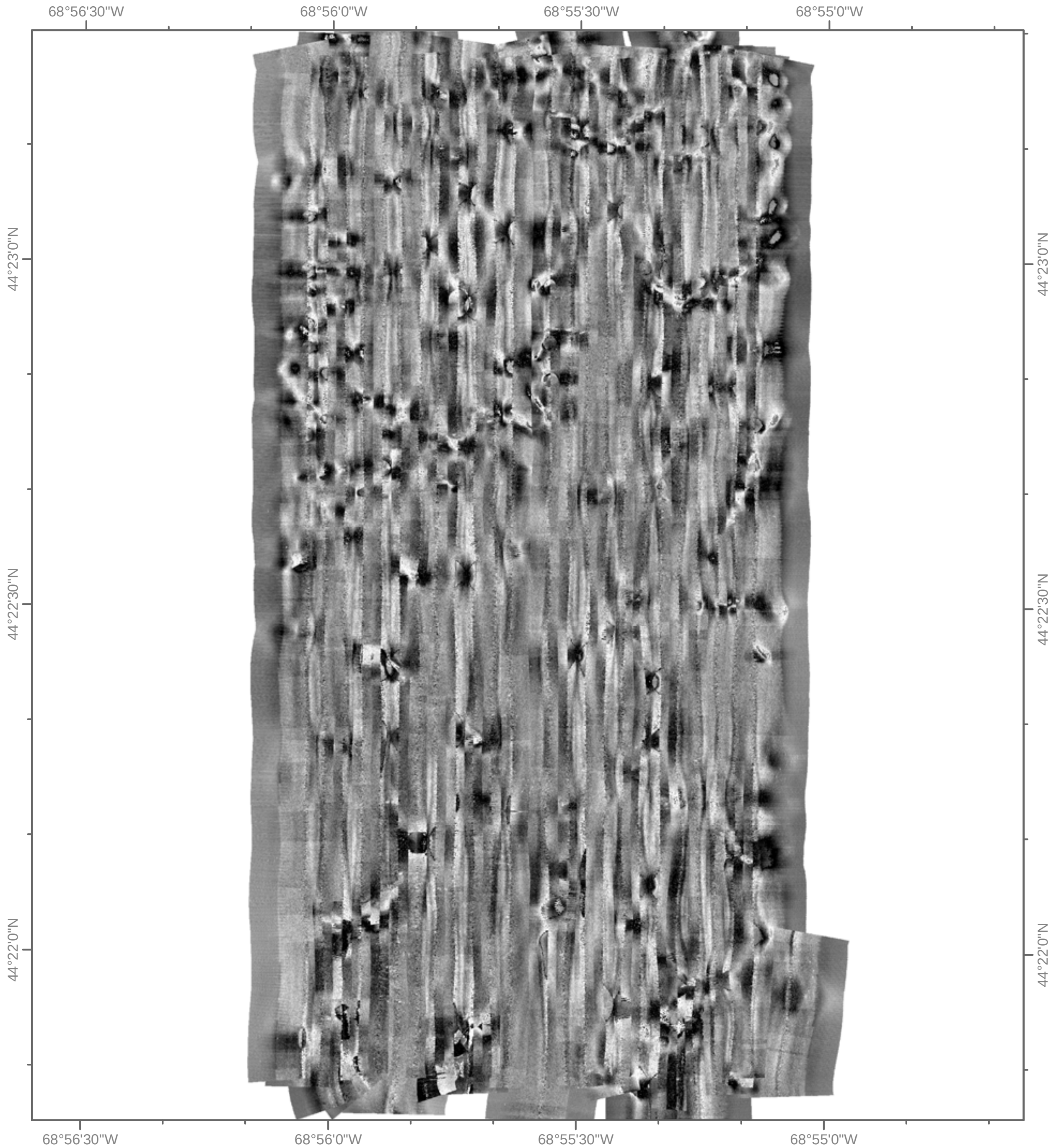
Projection: Transverse Mercator *Coordinate System:* Maine East State Plane FIPS 1801 (m) *Datum:* NAD83

File name: PBDS2013_Survey Area_w_Contour January 2014

Bathymetric contour map of the Penobscot Bay study area - August 2013



Partial side-scan sonar mosaic of the Penobscot Bay study area over unfiltered backscatter - August 2013.



Penobscot Bay Study Area

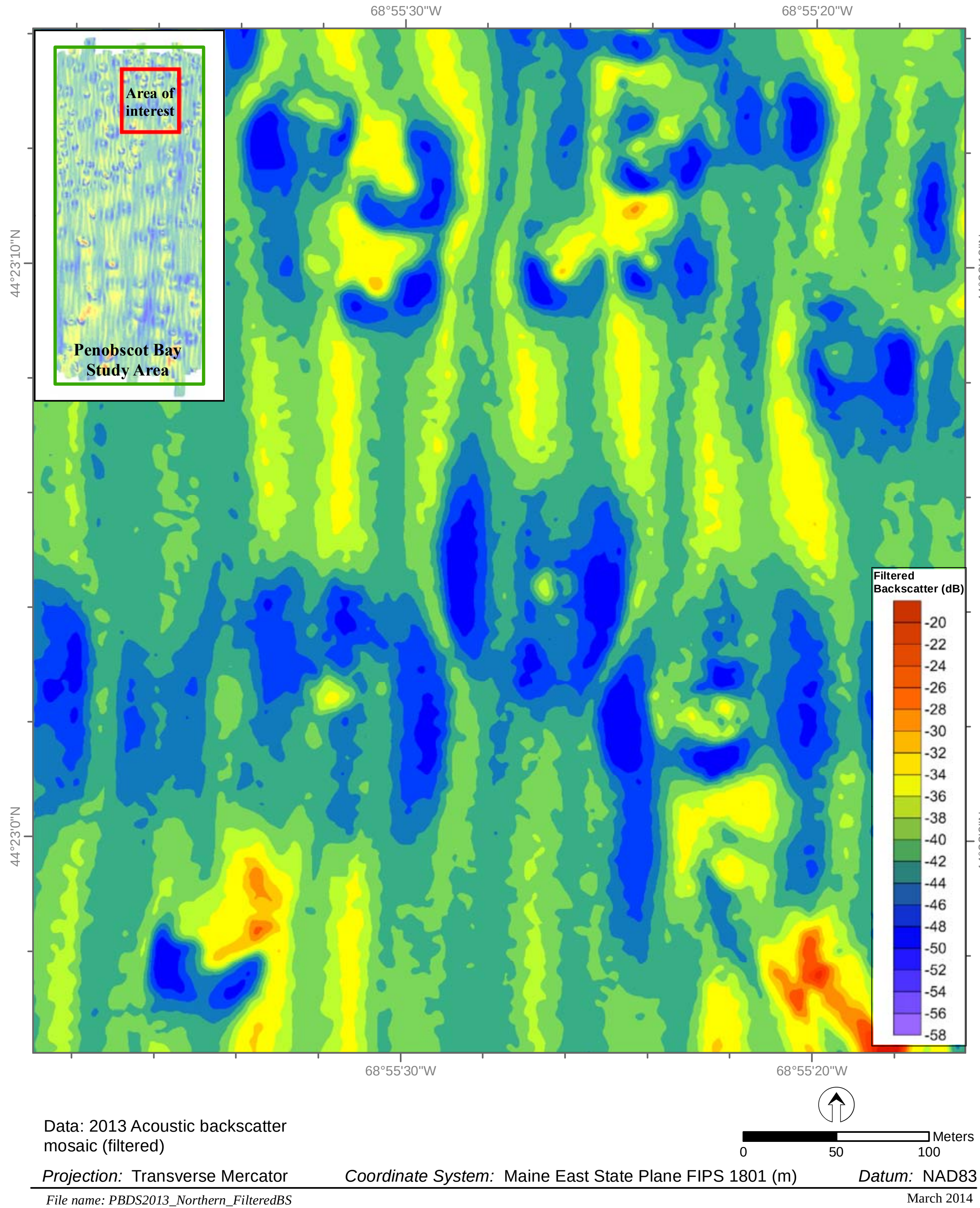
Data: 2013 Side-scan sonar mosaic

0 250 500 Meters

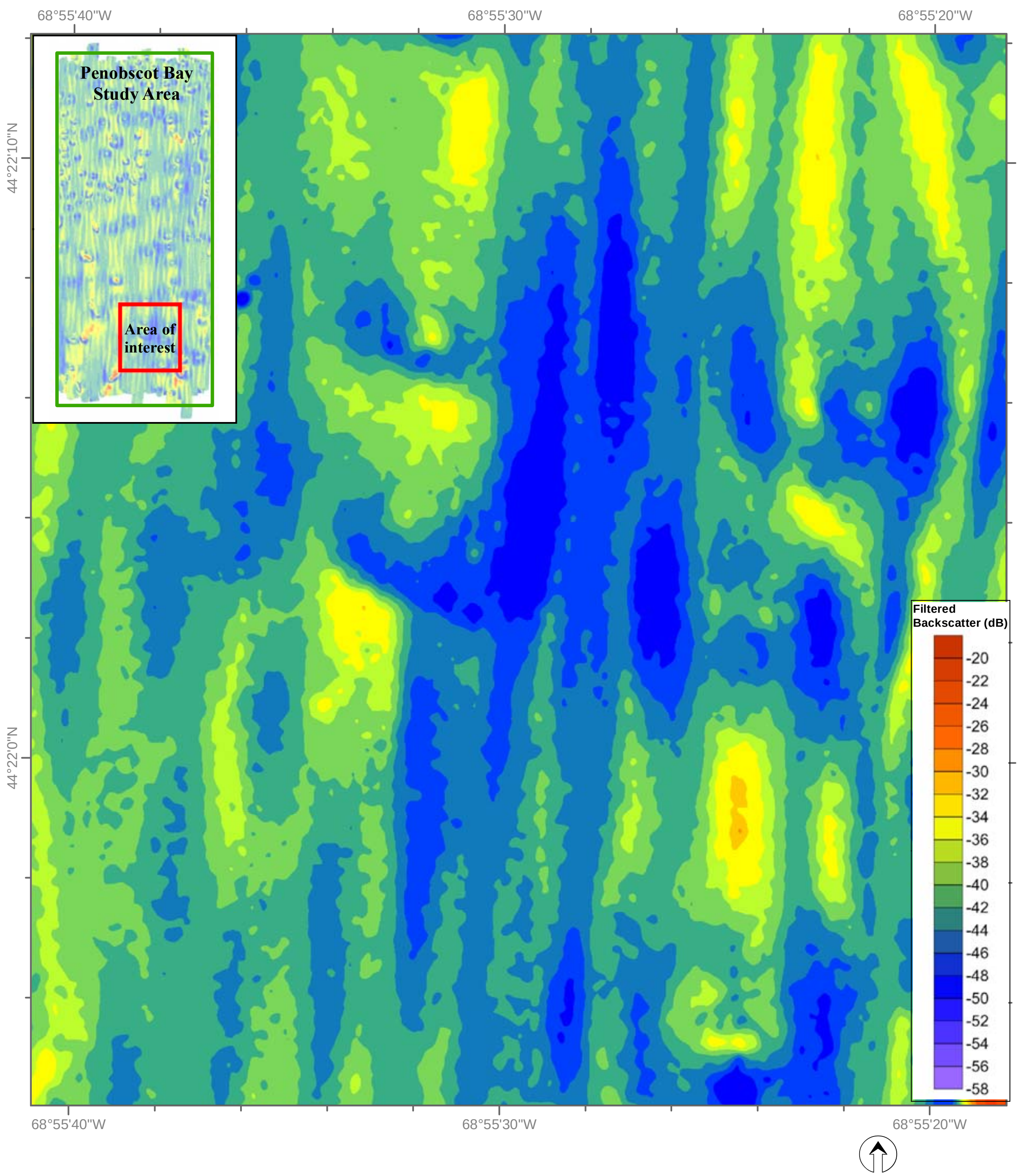
Projection: Transverse Mercator *Coordinate System:* Maine East State Plane FIPS 1801 (m) *Datum:* NAD83

File name: PBDS2013_Survey Area_SSS January 2014

Side-scan sonar mosaic of the Penobscot Bay study area - August 2013



Mosaic of filtered backscatter data of a selected northern area within PBSA



Data: 2013 Acoustic backscatter mosaic (filtered)

Meters 0 50 100

Projection: Transverse Mercator *Coordinate System:* Maine East State Plane FIPS 1801 (m) *Datum:* NAD83

File name: PBDS2013_Southern_FilteredBS March 2014

Mosaic of filtered backscatter data of a selected southern area within PBSA

Appendix F

Benthic Infaunal Data from Samples Collected in Penobscot Bay

Species/Stations	G-001-A	G-002-A	G-003-A	G-006-A	G-007-A	G-008-A	G-011-A	G-012A	G-014-A	G-016A	G-017-A	G-018A
Admete viridula	0	0	0	0	0	0	1	0	0	0	0	0
Anobothrus gracilis	32	31	71	65	31	125	32	39	118	84	114	24
Aphelochaeta nr. monilaris	0	1	1	1	0	0	1	0	4	1	0	0
Apistobranchus tullbergi	0	0	0	0	0	0	0	0	1	0	0	0
Arctica islandica	5	3	3	8	8	33	21	4	4	2	70	39
Aricidea minuta	16	4	4	0	0	6	10	6	1	1	8	1
Aricidea quadrilobata	3	8	23	7	3	18	2	2	27	10	9	4
Brada villosa	0	0	1	4	0	1	0	0	0	0	0	0
Capitella spp. complex	0	0	0	0	0	0	0	0	0	3	0	0
Caudina arenata	0	0	0	2	6	1	0	0	24	0	0	0
Cerebratulus sp. 1	1	2	2	0	0	0	0	1	6	1	1	0
Chaetoderma nitidulum	2	1	2	0	4	0	3	1	15	1	1	1
Chaetozone anasimus	5	18	10	3	12	9	4	1	67	21	3	2
Cnidaria sp. 1	0	1	0	1	0	0	0	0	2	0	0	0
Cossura longocirrata	41	512	71	33	88	493	28	51	941	483	108	92
Deflexilodes tesselatus	0	1	0	0	0	0	0	0	0	0	0	0
Dyopedos monacanthus	0	0	0	0	0	0	1	0	0	0	1	0
Erythrops erythrophthalma	0	0	1	0	0	2	0	0	0	2	0	0
Eteone longa	0	9	9	3	6	0	2	1	15	9	0	0
Euchone incolor	0	6	16	10	12	18	7	0	66	29	2	1

Species/Stations	G-001-A	G-002-A	G-003-A	G-006-A	G-007-A	G-008-A	G-011-A	G-012A	G-014-A	G-016A	G-017-A	G-018A
Eudorella hispida	0	0	1	0	0	1	3	0	0	0	4	1
Eudorella pusilla	0	0	0	0	0	1	0	0	0	0	3	0
Frigidoalvania pelagica	0	0	0	1	0	2	0	0	0	0	1	2
Harmothoe extenuata	1	0	0	1	0	0	0	0	0	0	0	0
Harpinia propinqua	8	0	0	0	0	9	3	1	0	0	5	0
Leptostylis longimana	1	0	0	0	0	0	3	0	0	0	0	1
Levinsenia gracilis	16	4	9	5	3	58	72	23	17	15	88	47
Mediomastus californiensis	0	4	2	1	0	1	0	0	0	16	1	0
Micrura affinis	4	1	2	2	4	3	4	0	12	1	2	0
Mya arenaria	2	0	2	2	5	10	10	0	3	2	4	0
Nemertea sp. 1	0	0	0	0	0	0	0	0	7	1	0	0
Nemertea sp. 2	0	0	0	0	2	0	0	0	0	0	0	0
Nemertea sp. A (Carinomella)	1	0	0	0	0	0	0	0	0	2	0	0
Nephtys incisa	5	12	18	13	16	13	10	7	34	3	9	6
Ninoe nigripes	11	10	23	7	13	14	10	4	61	20	11	5
Nucula annulata	105	151	507	612	463	134	22	13	1816	207	229	133
Nuculana pernula	0	0	0	0	0	0	0	0	0	0	0	1
Pandora gouldiana	0	0	0	0	0	0	0	0	0	0	0	1
Paracaprella tenuis	0	0	2	2	3	0	4	0	0	0	1	2
Parvicardium pinnulatum	0	1	1	0	1	3	4	0	0	0	6	2

Species/Stations	**G-001-A**	**G-002-A**	**G-003-A**	**G-006-A**	**G-007-A**	**G-008-A**	**G-011-A**	**G-012A**	**G-014-A**	**G-016A**	**G-017-A**	**G-018A**
Periploma papyratium	0	2	4	6	4	9	3	0	8	1	7	6
Pherusa plumosa	1	0	2	9	3	1	1	0	14	1	1	0
Phoronis psammophila	0	0	0	0	1	2	0	0	6	1	0	1
Photis pollex	0	0	0	0	0	0	1	0	0	0	0	0
Phyllodoce mucosa	0	0	0	0	1	0	0	0	0	0	0	0
Pista elongata	0	0	0	1	0	0	0	0	0	0	0	0
Pitar morrhuanus	1	1	0	0	1	2	3	0	0	0	11	1
Pleurogonium rubicundum	0	1	0	0	0	0	0	0	0	0	0	0
Polycirrus medusa	0	0	1	1	4	0	0	0	3	0	0	0
Prionospio steenstrupi	0	0	0	0	0	0	0	0	2	1	0	0
Sphaerodoropsis minuta	0	0	0	0	0	2	0	0	2	0	0	1
Stenopleustes inermis	0	0	0	0	0	0	0	0	0	0	1	0
Terebellides stroemi	92	126	112	246	106	255	89	16	65	36	157	46
Tharyx acutus	0	0	0	1	0	0	0	1	0	1	0	1
Thyasira gouldi	10	2	2	7	3	10	10	1	4	1	7	4
Turbellaria sp. 1	0	0	1	0	0	0	0	2	2	0	1	0
Yoldia sapotilla	59	28	29	97	96	83	58	13	88	36	84	66

Note: 1) Number of each species counted in the sample collected from each station provided