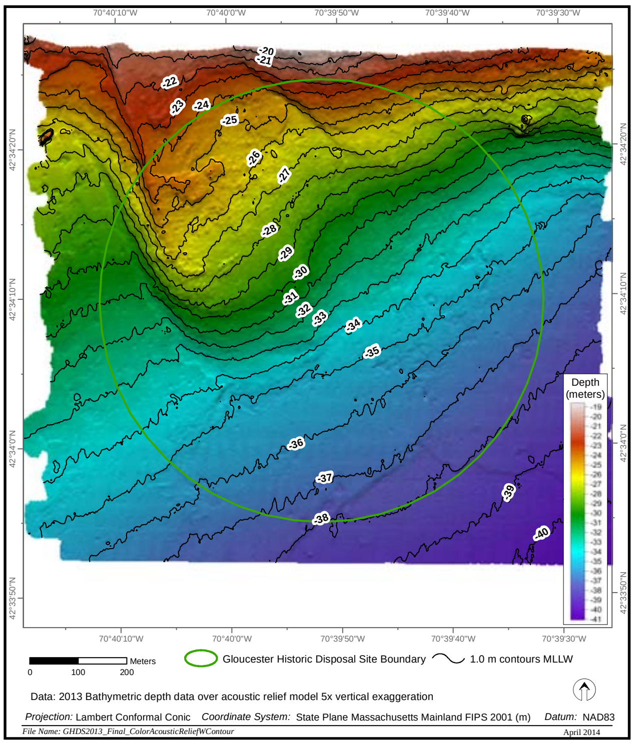
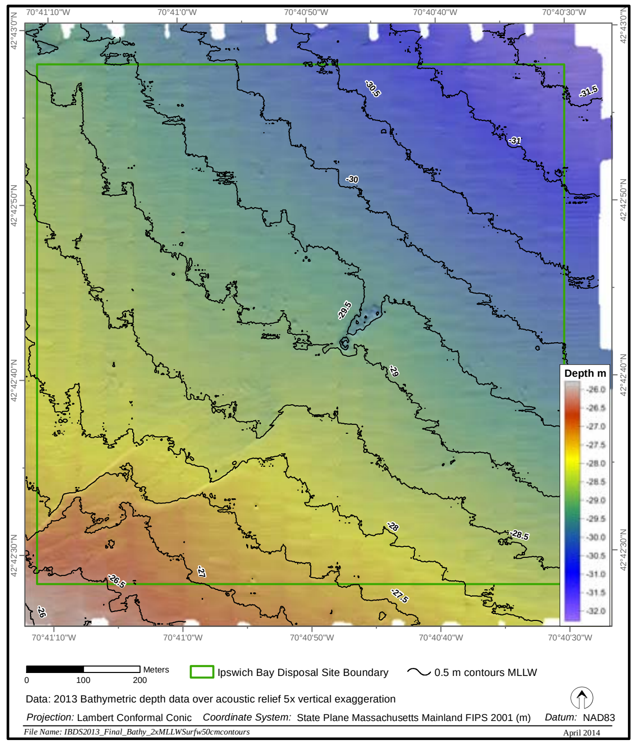
Data Summary Report of the Gloucester Historic and Ipswich Bay Disposal Sites August 2013 Monitoring Survey

Disposal Area Monitoring System DAMOS





D A M O S

DISPOSAL AREA MONITORING SYSTEM

Data Summary Report 2013-03

September 2014

US Army Corps of Engineers®
New England District

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

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1.0 INTRODUCTION

Two monitoring surveys were conducted near Cape Ann off the northern shore of Massachusetts in August 2013 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS) Program. Surveys were conducted at the long-inactive Gloucester Historic Disposal Site (GHDS) and Ipswich Bay Disposal Site (IBDS) to support evaluation of the potential suitability of these sites to receive dredged material from a planned future dredging project in the Annisquam River (Figure 1-1). An introduction to the DAMOS Program and the two survey areas is provided below.

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 objectives related to NAE's dredging and disposal operations. The 2013 GHDS and IBDS surveys were special DAMOS studies designed to support assessment of the study areas 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 measurements, and side-scan sonar) 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 can also be performed to provide further physical characterization of the seafloor and to support evaluation of seafloor (benthic) habitat conditions. Special DAMOS monitoring surveys may also feature additional types of data collection activities as deemed appropriate to achieve specific survey objectives, such as sediment grab sampling to support sediment characterization.

1.2 Introduction to the Gloucester Historic Disposal Site

The Gloucester Historic Disposal Site (GHDS) lies outside Gloucester Harbor, 1.1 km (0.7 miles) south of Eastern Point (Figure 1-2). GHDS is depicted as a circular area approximately 0.9 km (0.6 miles) in diameter on NOAA charts in approximately 24 to 38 meter (80 to 120 foot) waters. Placement of dredged material has not occurred at this site since the start of the DAMOS Program in 1977 and there are no specific site disposal records available prior to this date.

1.3 Introduction to the Ipswich Bay Disposal Site

The Ipswich Bay Disposal Site (IBDS) is a potential site located north of Ipswich Bay and 4.6 km (2.9 miles) northwest of Halibut Point. IBDS is defined as an area consisting of an approximately 900 × 900 meter (3,000 × 3,000 foot) square in 27 to 31 meter (90 to 100 foot) waters (Figure 1-3). There is no record of previous placement at this location since the start of the DAMOS Program in 1977 and no indications on NOAA charts of a historic disposal area.

1.4 Survey Objective

The objective of these surveys was to characterize the seafloor topography and surficial sediment features of GHDS and IBDS by completing high-resolution acoustic surveys with supplemental grab sampling of sediment for visual observation.

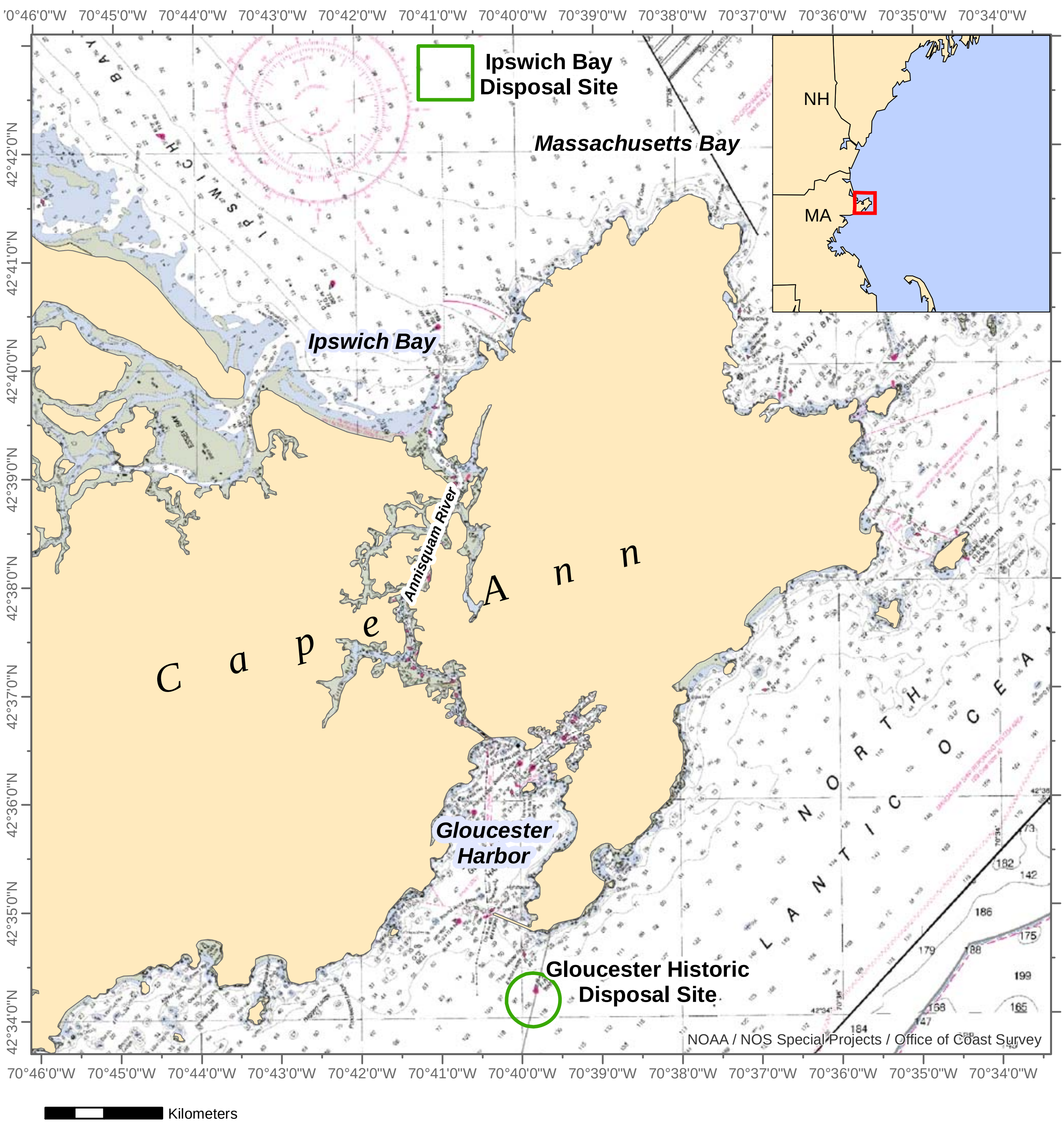

Figure 1-1. Location of the Cape Ann study area

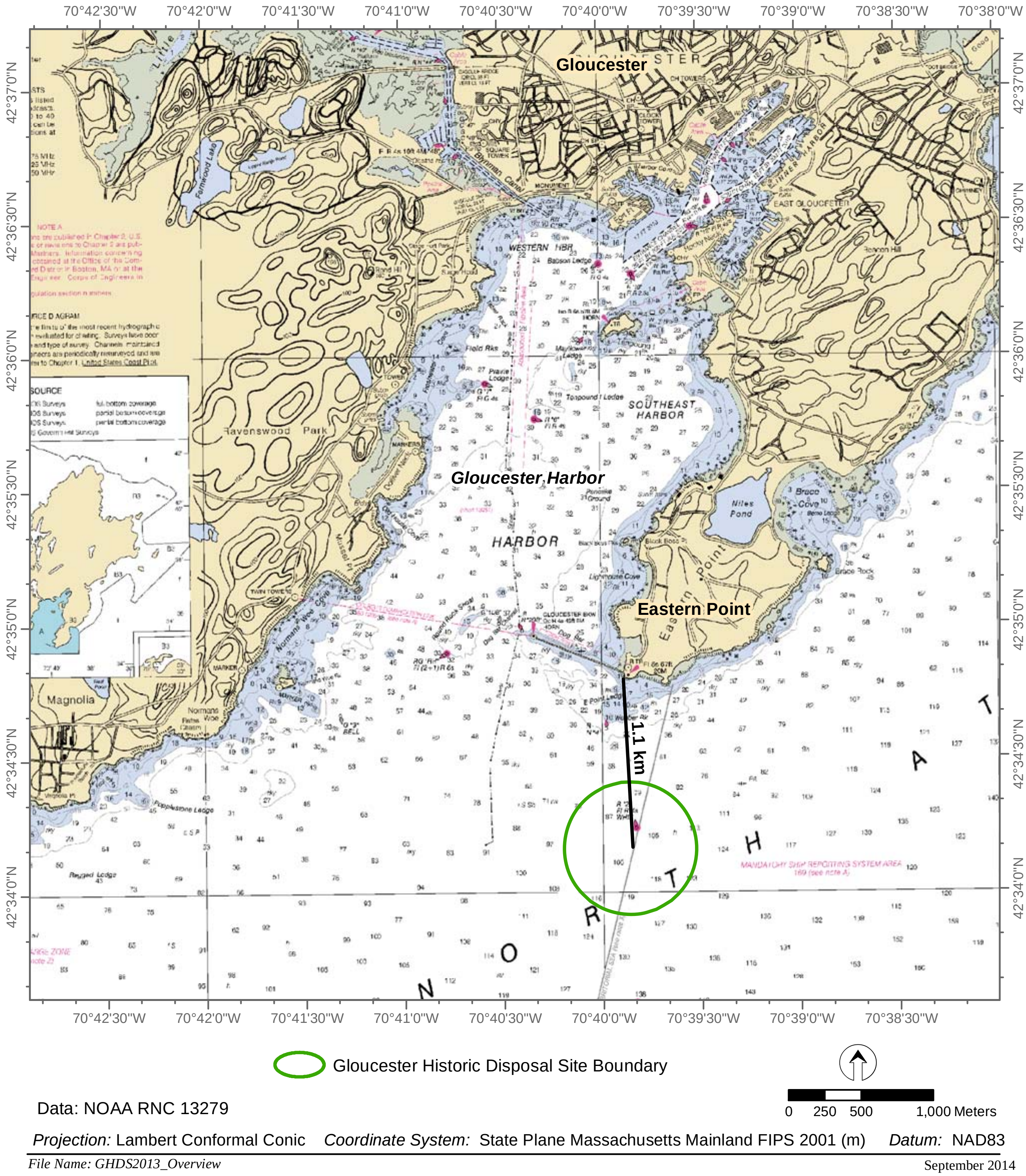

Figure 1-2. Location of Gloucester Historic Disposal Site (GHDS)

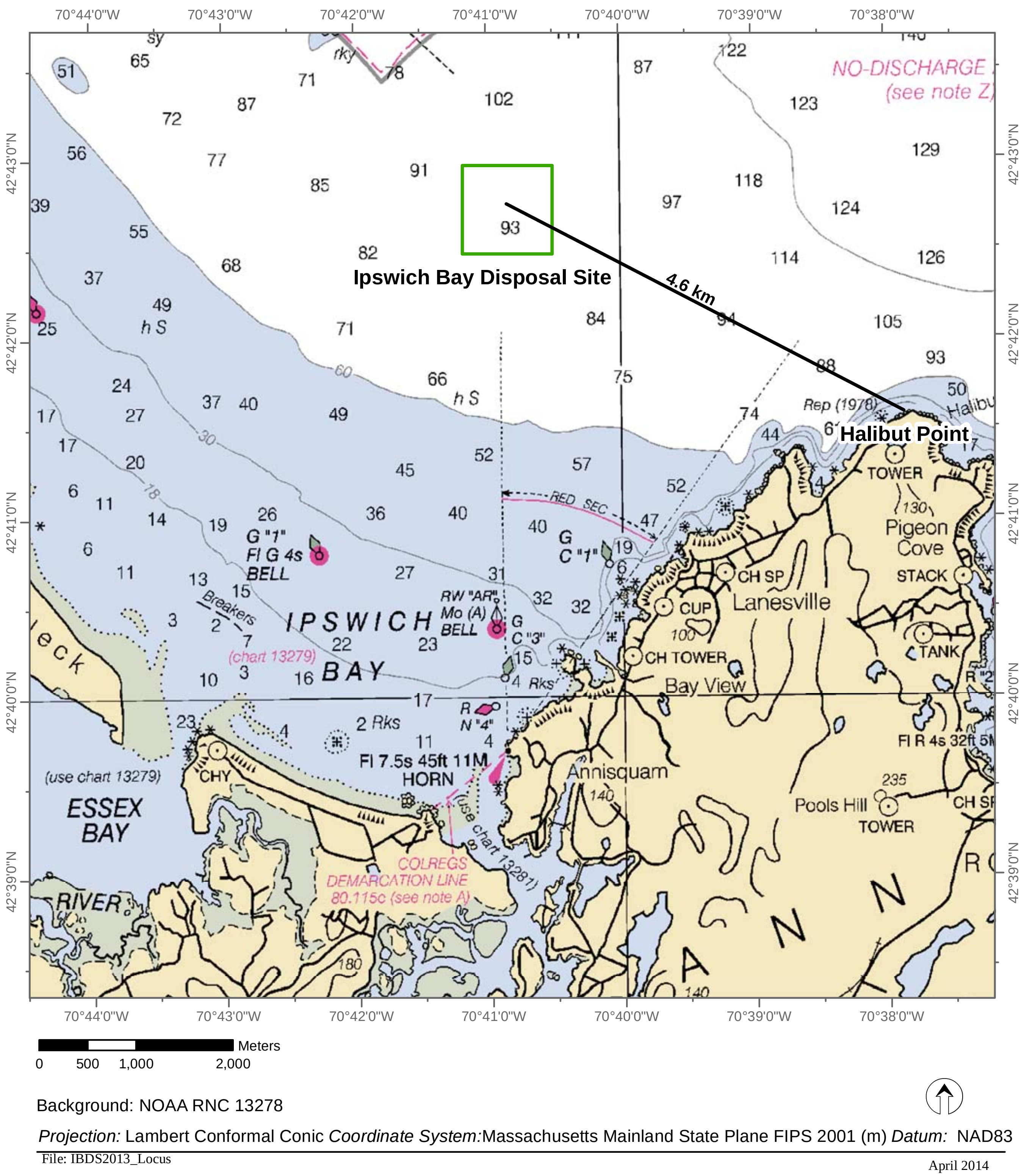

Figure 1-3. Location of Ipswich Bay Disposal Site (IBDS)

2.0 METHODS

The August 2013 surveys at GHDS and IBDS were conducted by a team of investigators from DAMOSVision (CR Environmental) and the USACE aboard the 55-foot R/V *Jamie Hanna*. The GHDS acoustic survey with supplemental grab sampling for visual characterization was conduct on 14 August 2013 and the IBDS acoustic survey with supplemental visual grab sampling was conducted on 15 August 2013. A qualitative assessment of the presence of surface marker buoys was also conducted simultaneously with the acoustic survey at both sites.

As part of the characterization of GHDS and IBDS, results from benthic grab sampling performed in 2012 as part of a regional benthic characterization performed by Massachusetts Coastal Zone Management were summarized for stations in proximity to GHDS and IBDS (AECOM 2013). The results of that survey were reviewed and summarized to support GHDS and IBDS survey objectives.

2.1 Navigation and On-Board Data Acquisition for GHDS and IBDS

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

2.2 GHDS 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 GHDS Survey Planning

The acoustic survey featured a high spatial resolution survey of GHDS. DAMOSVision hydrographers coordinated with USACE NAE scientists and reviewed alternative survey designs. For GHDS, a 1,000 × 1,000 m area was selected with a series of survey lines spaced 45 m apart and cross-tie lines spaced 250 m apart (Figure 2-1). The survey was designed to cover GHDS entirely and provide greater than 100-percent coverage of the seafloor within the survey area. Hydrographers obtained site coordinates, imported them to ArcView GIS software, and created planning maps. The proposed survey area encompassing the entire site was then reviewed and approved by NAE scientists.

2.2.2 GHDS Acoustic Data Collection

The 2013 multibeam bathymetric survey of GHDS was conducted on 14 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 GHDS Bathymetric Data Processing

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

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

Tidal adjustments were accomplished using a Tide Zoning Model (TZM) calculated by the National Oceanic and Atmospheric Administration's (NOAA's) Center for Operational Oceanographic Products and Services (CO-OPS) specifically for this survey area. The model applied a time correction of -6 minutes and a range correction of 0.92 to the six-minute Mean Lower Low Water (MLLW) data series acquired at NOAA's Boston Tide Station (#8443970). Bathymetric data processed using the TZM displayed elevated uncertainty along cross-tie lines when compared to data processed using tide data recorded using a digital water level sensor installed in Gloucester Inner Harbor during the survey. The mean difference between the Boston and Gloucester records was -0.007 m. The tide range difference between the Boston and Gloucester tide records was -0.11 to – 0.14 m (Standard Deviation = 0.063m). To minimize tide bias, the TZM MLLW water surface elevation at low tide was used to calculate the in-situ sensor elevation. Data from the Gloucester Inner Harbor gage 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 (Figure 2-2). The water column was strongly stratified during the survey and data artifacts associated with refraction remain in the bathymetric surface model at a relatively fine scale (generally less than five to 10 cm) relative to the survey depth. Bathymetric data were filtered to accept only beams falling within an angular limit of 45° to minimize refraction artifacts. Spurious sounding solutions were 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 32 m and a maximum beam angle of 45°, the average diameter of the beam footprint was calculated at approximately 1.7 × 1.2 m (2.0 m^2). Data were reduced to a cell (grid) size of 2.0 × 2.0 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 2.69 m (average 0.052 m). Ninety-five percent of the cell-specific standard deviation values were less than 0.11 m. The average Root Mean Squared uncertainty at the 95th percentile confidence interval (1.96 - sigma) was 0.10 m. Ninety-five percent of these uncertainty values were less than 0.22 m. Uncertainty estimates greater than approximately 0.10 m were associated with refraction of mid-outer portions of the swath, with a wreck located in the northwestern portion of the survey area and with steep slopes relative to the cell diameter. 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 0.40 m at the maximum site depth (41 m) and 0.35 m at the mean site depth (32 m). Performance Standards for an NOS Order 1A survey at the mean and maximum depths would be 0.65 m and 0.73 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 cross-tie intersections was 0.018 m (SD 0.08 m), indicating minimal tide bias. The 95th percentile accuracy estimate for cross-tie comparisons was calculated per USACE (2002) as 0.12 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 Massachusetts State Plane (Mainland), 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 (25-cm, 50-cm, and 1.0-m intervals) in SHP format suitable for plotting using GIS and CAD software
- 3-dimensional surface maps of the seabed created using 5× vertical exaggeration and artificial illumination to highlight fine-scale features not visible on contour layers (delivered in grid and TIF formats), and

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

2.2.4 GHDS 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 GHDS Side-Scan Sonar Data Processing

The side-scan sonar data were processed using HYPACK®'s implementation of GeoCoder software. Data were used to produce a seamless mosaic of unfiltered side-scan sonar data with a resolution of 0.2 m/pixel.

2.2.6 GHDS 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 three-dimensional acoustic relief model to be visible underneath).

2.3 IBDS 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.

2.3.1 IBDS Survey Planning

The acoustic survey featured a high spatial resolution survey of IBDS. DAMOSVision hydrographers coordinated with USACE NAE scientists and reviewed alternative survey designs. For IBDS, a 1,000 × 1,000 m area was selected with a series of survey lines spaced 45 m apart and cross-tie lines spaced 200 m apart (Figure 2-3). The survey was designed to cover the entire IBDS and provide greater than 100-percent coverage of the seafloor within the survey area. Hydrographers obtained site coordinates, imported them to ArcView GIS software, and created planning maps. The proposed survey area encompassing the entire site was then reviewed and approved by NAE scientists.

2.3.2 IBDS Acoustic Data Collection

The 2013 multibeam bathymetric survey of IBDS was conducted on 15 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.

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- Development of a grid surface representing depth solutions
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Tidal adjustments were accomplished using a Tide Zoning Model (TZM) calculated by the National Oceanic and Atmospheric Administration's (NOAA's) Center for Operational Oceanographic Products and Services (CO-OPS) specifically for this survey area. The model applied corrections of 6 minutes to the 6-minute Mean Lower Low Water (MLLW) data series acquired at NOAA's Fort Point NH Tide Station (#8423898). Bathymetric data processed using the TZM displayed elevated uncertainty along cross-tie lines when compared to data processed using the same data with a 12-minute offset. Data from Station # 8423898 with a 12 minute offset 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 (Figure 2-4). The water column was strongly stratified during the survey and data artifacts associated with refraction remain in the bathymetric surface model at a relatively fine scale (generally less than five to 10 cm) relative to the survey depth. Bathymetric data were filtered to accept only beams falling within an angular limit of 45° to minimize refraction artifacts. Spurious sounding solutions were flagged or rejected based on the careful examination of data on a sweep-specific basis.

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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 cross-tie intersections was 0.002 m (SD 0.04 m), indicating minimal tide bias. The 95th percentile accuracy estimate for cross-tide comparisons was calculated per USACE (2002) as 0.086 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 Massachusetts State Plane (Mainland), 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).

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2.3.5 IBDS Side-Scan Sonar Data Processing

The side-scan sonar data were processed using HYPACK®'s implementation of GeoCoder software. Data were used to produce a seamless mosaic of unfiltered side-scan sonar data with a resolution of 0.5 m/pixel.

2.3.6 IBDS Acoustic Data Analysis

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2.4 Analysis of Previously Collected Benthic Grab Sampling Data

To enhance understanding of the physical and biological characteristics of the GHDS and IBDS study areas, recently collected benthic sampling data were analyzed. Benthic grab samples were collected at locations around the GHDS and IBDS study areas by AECOM in 2012 in support of regional benthic characterization for Massachusetts Coastal Zone Management. A brief summary of methods of analysis is provided below. Detailed descriptions of sampling methods, laboratory analysis, and statistical analysis are provided in the 2012 benthic analysis report (AECOM 2013).

The 2012 survey activities had a broad purpose to characterize the seafloor habitats within Massachusetts state waters and consisted of 350 stations in Massachusetts and Ipswich Bays of which 207 infaunal samples were obtained and analyzed (Figure 2-5). The 2012 benthic sampling regime was a nonrandom, directed sampling program designed to acquire a surficial sediment grab density of at least one grab per square kilometer (AECOM 2013).

To support the habitat mapping efforts, the relationship of three environmental factors of interest, a derivative of depth (the BPI, Lundblad et al. 2006), sediment type (using a Barnhardt classification, Barnhardt et al. 1998), and Ecological Marine Units (EMUs) to faunal assemblages was characterized during the analysis. EMUs are a habitat mapping classification tool developed by Massachusetts Coastal Zone Management (MACZM). The benthic results from this study provide a broad indication of the distribution of benthic communities in the vicinity of each potential disposal site. The statistical analyses of the 2012 results (descriptive univariate statistics, Bray-Curtis similarity analysis, and non-metric multidimensional scaling analysis) were applied in the MACZM study to examine relationships to habitat groupings (depth, sediment type, EMU). The study defined eleven infaunal cluster groups that shared similar characteristics and examined the distribution of these infaunal groups (AECOM 2013).

For the purposes of this study, these broad relationships helped to characterize the conditions at the potential disposal sites and place them in the regional context. The sediment grain size results of the 2012 benthic grab stations were reclassified herein according to the Folk Sediment Classification for consistency with an extensive grain size dataset revised by Ford and Voss (2010) and recently updated (2014).

2.5 Visual Grab Sampling at GHDS and IBDS

Sediment grab samples were collected at GHDS and IBDS on 14 and 15 August 2013 for visual inspection of sediment characteristics. Sediment grab samples were collected using a 0.04-m^2 Ted Young-modified Van Veen grab sampler. The contents of each grab sampling event were laid on deck, photographed, and evaluated for color, odor and texture.

2.6 Surface Marker Buoy Observations at GHDS and IBDS

At GHDS, DAMOSVision hydrographers captured the GPS locations and type of surface marker buoys typically used for commercial lobster fishing that were present in GHDS 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 45 m apart, and hydrographer 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 approximately 23 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 GHDS.

At IBDS, a qualitative assessment of surface marker buoys was made on 15 August 2013 by USACE staff during the acoustic survey. The observed surface marker positions were approximated based on vessel position along track line on navigational screen.

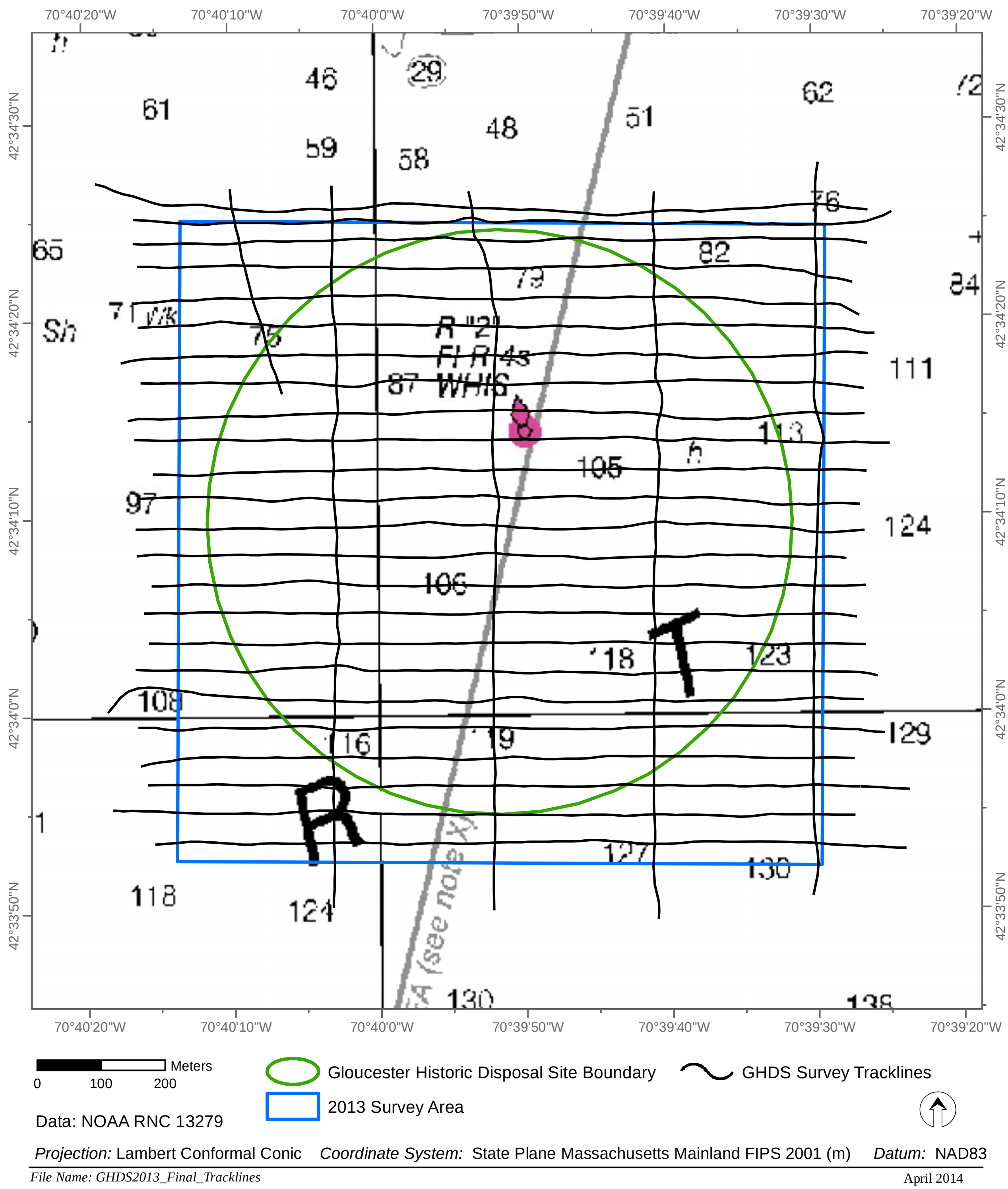

Figure 2-1. Bathymetric survey boundary and actual tracklines at GHDS

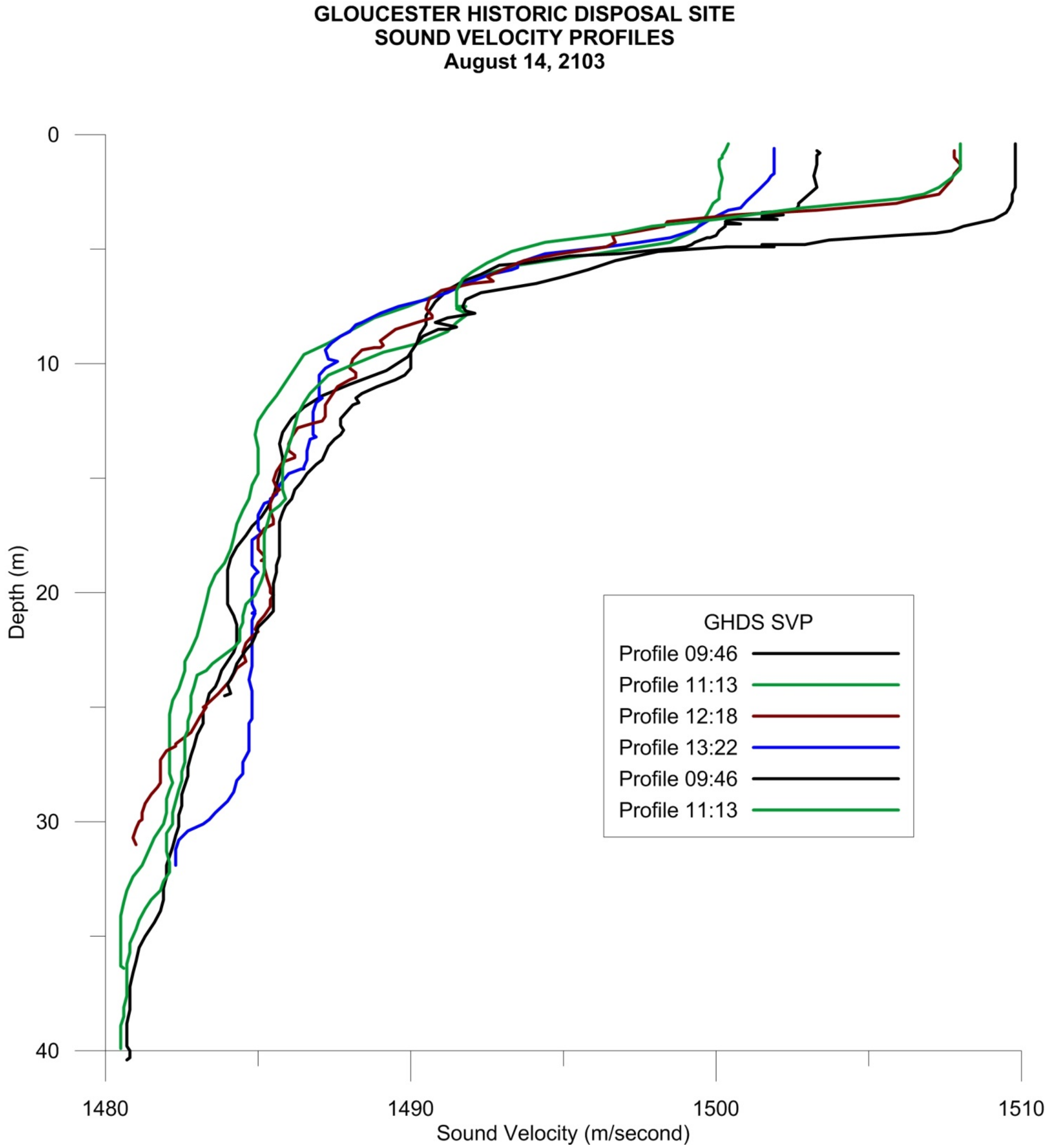

Figure 2-2. Sound velocity profiles (SVP) from 14 August 2013 at GHDS

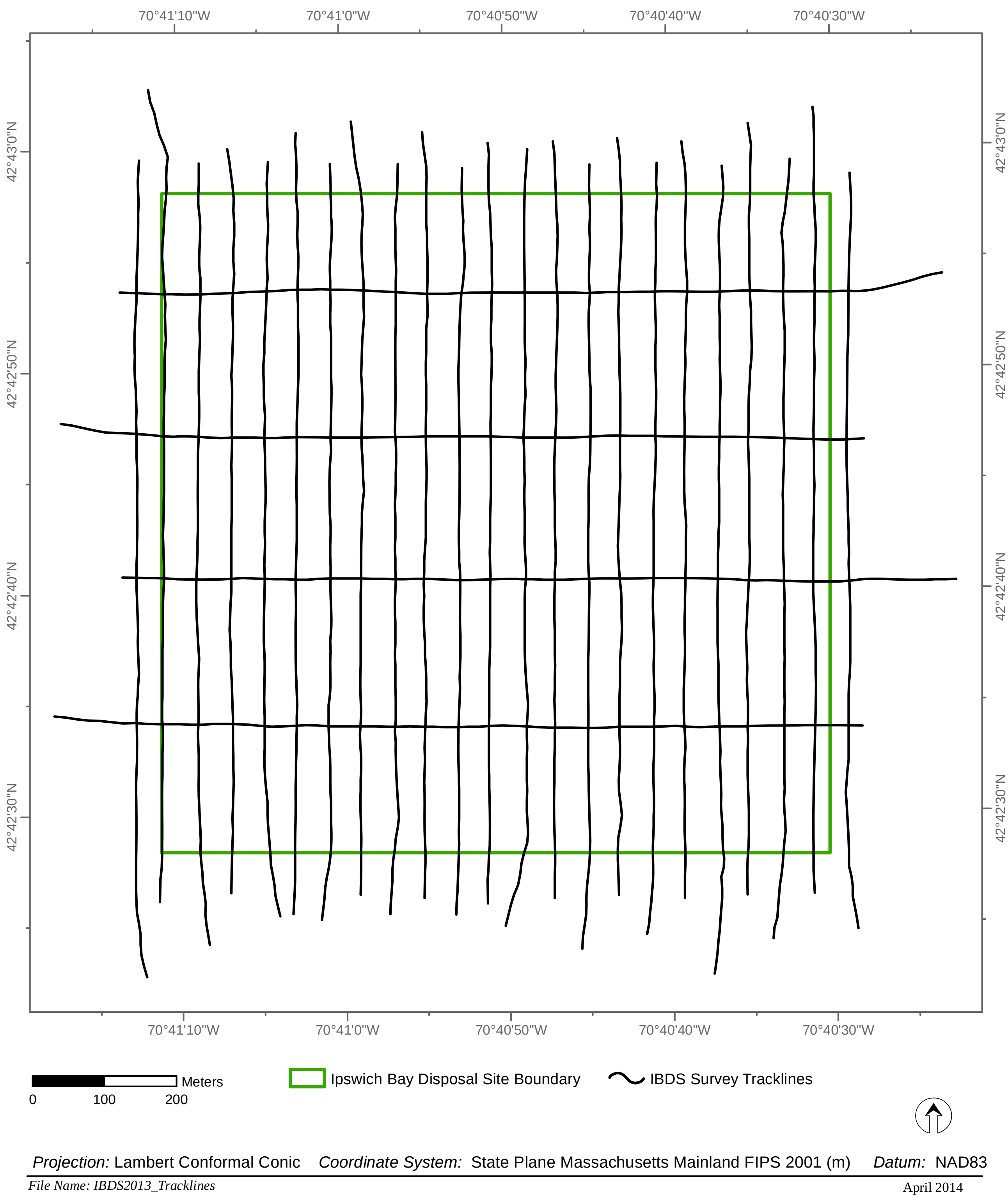

Figure 2-3. Bathymetric survey boundary and actual tracklines at IBDS

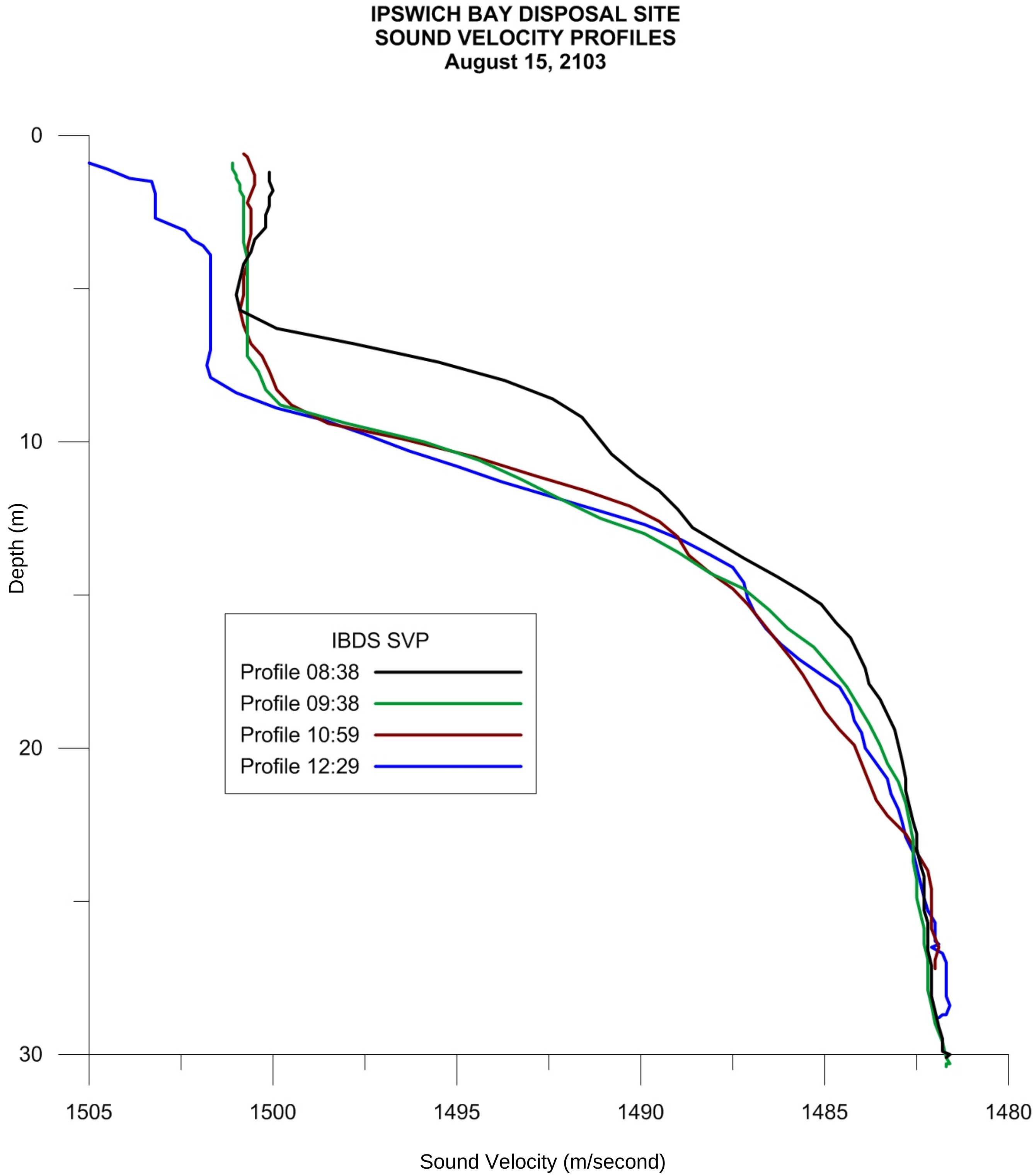

Figure 2-4. Sound velocity profiles (SVP) from 15 August 2013 at IBDS

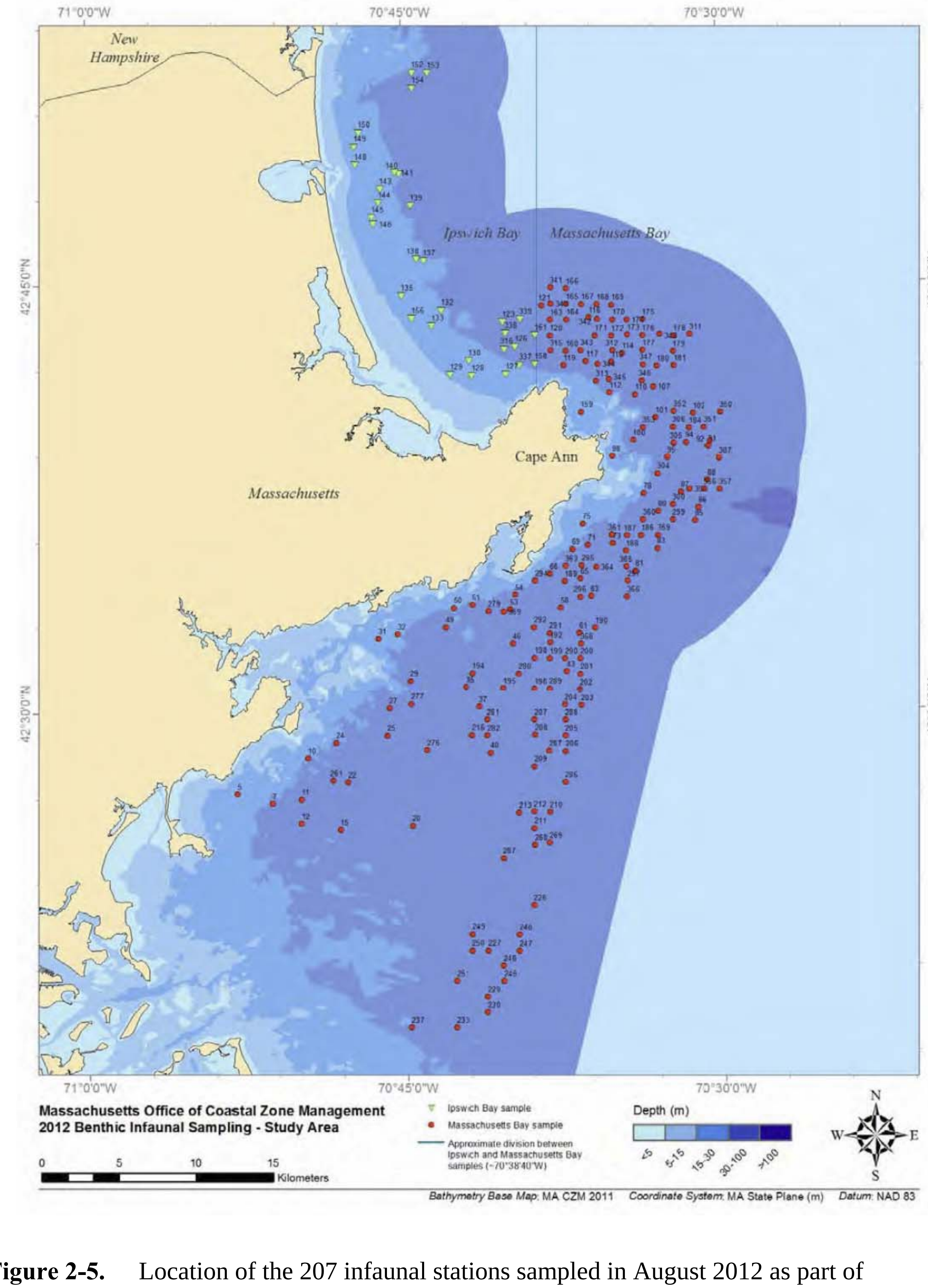

Figure 2-5. Location of the 207 infaunal stations sampled in August 2012 as part of Massachusetts Coastal Zone Management study (AECOM 2013)

3.0 SURVEY RESULTS

3.1 GHDS Acoustic Survey Results

An acoustic survey was conducted in August 2013 to assess the topography and surficial sediment characteristics at GHDS. Survey results included 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 GHDS Bathymetry

The bathymetry of GHDS as surveyed in 2013 revealed variable topography with a submerged rock platform (22 to 27 m deep) in the northwest, bordered by a relatively steep slope near the center of the site that drops approximately 5 m (27 to 33 m) to a more gently sloping bottom in deeper water (33 m to 38 m) to the south and southeast (Figure 3-1).

Multibeam bathymetric data rendered as an acoustic relief model (grayscale with hillshading) provided a more detailed representation of the surface of GHDS (Figure 3-2). Most of GHDS appears to consist of smooth sediment although ridges of a rocky outcrop were observed on most of the relatively steep slope to the west. Some evidence of scouring of sediment was evident at the base of the western facing steep slope and southern toe of the rock platform. A distinctive scarp feature was visible at the southern boundary of the site where seafloor slope increased slightly and then evened out to the north. Clear acoustic evidence of dredged material placement activity was detectable at many locations throughout the site, particularly in the deeper area to the east-southeast. Within the site, many impact craters and other features were revealed that are indicative of dredged material placement (Figure 3-2).

3.1.2 GHDS Acoustic Backscatter and Side-Scan Sonar

Acoustic backscatter data provided an estimate of surficial sediment texture (hard, soft, rough, and smooth). A mosaic of unfiltered backscatter data for GHDS (Figure 3-3) generally revealed the shallower areas as harder surfaces having a stronger acoustic return (lighter gray in Figure 3-3) and deeper areas as soft sediment having a weaker acoustic return (darker gray). The margin of the shallower areas had a distinctive scalloped appearance of alternating strong and weak backscatter suggestive of sand waves along the scoured region observed in the topography. A harder surface was also observed to the far south-southeast that extended south of the disposal site coincident with the edge of the scarp visible in bathymetry.

Dredged material placement activities were clearly detectable in the patterns of backscatter within portions of the disposal site. The backscatter image revealed circular patterns of increased backscatter appearing as small white dots on the relatively flat southeastern region. Filtered backscatter and side-scan sonar mosaics showed similar patterns of hard surfaces and soft sediment throughout the survey area, but the difference in resolution helped to illuminate the patterns of sand waves (compare Figures 3-4 and 3-5).

The filtered backscatter revealed a regular pattern of stronger and weaker backscatter along the western margin of the rock platform but no distinct pattern on the southern margin (Figure 3-4). The side-scan sonar mosaic revealed detailed sand wave features (wavelength about 5 m) along the southern margin of the rock platform and in parts of the flat sediment deposits (Figure 3-5). The patterns along the western margin of the rocky platform are less clear but the surface of the rocky platform has a large number of hard targets consistent with boulders, many as large as 3-5 m (Figure 3-5).

3.2 IBDS Acoustic Survey Results

An acoustic survey was conducted in August 2013 to assess the topography and surficial sediment characteristics at IBDS. Survey results included 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.

3.2.1 Existing IBDS Bathymetry

The bathymetry of IBDS as surveyed in 2013 revealed a relatively smooth topography that gently sloped from 26.5 m deep in the southwest to 31.5 m in the northeast (Figure 3-6). An isolated rock ridge and a slightly shallower area with some evidence of sediment transport ran diagonally through the site from the southwest to northeast perpendicular to the slope.

Multibeam bathymetric data rendered as an acoustic relief model (grayscale with hillshading) provided a more detailed representation of the surface of IBDS (Figure 3-7). Most of IBDS appears to consist of smooth sediment although a narrow ridge of rock was observed in the center of the site. Some evidence of scouring of sediment was apparent around the rock material and along a ridge in the southwest. Acoustic evidence of potential historic dredged material placement activity was detectable with several circular patterns consistent with dredged material impact craters (Figure 3-7).

3.2.2 IBDS Acoustic Backscatter and Side-Scan Sonar

Acoustic backscatter data provided an estimate of surficial sediment texture (hard, soft, rough, and smooth). A mosaic of unfiltered backscatter data for IBDS (Figure 3-8) generally revealed the shallower areas as having linear deposits of harder (or rougher) surfaces with a stronger acoustic return (lighter gray in Figure 3-8) and deeper areas as soft sediment with a weaker acoustic return (darker gray).

Dredged material placement activities were clearly detectable in the patterns of backscatter in only one location in the disposal site (southeast of the rock material). The backscatter image revealed a circular pattern of increased backscatter in a small ring. Filtered backscatter showed similar patterns of hard surfaces in the southwest and the center of the site and soft sediment throughout the survey area (Figure 3-9). The side-scan sonar mosaic revealed large sand wave or linear sand ridge features (wavelength about 10-15 m) along the margin of the shallower area (Figure 3-10). The patterns in the rock material are less clear, but there are hard targets consistent with rubble or boulder, many as large as 5 m (Figure 3-10).

3.3 Benthic Survey Results

Massachusetts Coastal Zone Management collected grab samples during 2012 from Boston Harbor to the New Hampshire Border (including areas near IBDS and GHDS) to support habitat mapping (AECOM 2013). The results were analyzed in relation to broad habitat characterization goals but provide a description of the benthic assemblages in the region. Within the large survey area, two distinct faunal assemblages were identified that generally corresponded to a location in either Massachusetts Bay or Ipswich Bay. This general distinction related to a Bray-Curtis cluster analysis that grouped the samples into eleven infaunal groups (Figure 3-11). Six of these (infaunal groups 1 A-E and group 2 A) were predominantly north of Cape Ann and five (groups 2 B-F) south of Cape Ann (AECOM 2013). Samples taken near the potential disposal sites reflected this general distribution (Tables 3-1 and 3-2; Figures 3-12 and 3-13), but several samples near GHDS were identified as outliers.

GHDS is located partially on a rocky platform and partially on a slope, while most of the Coastal Zone Management samples collected near the site consisted primarily of gravelly sand, grouped with the Massachusetts Bay assemblage and broadly reflected conditions on the slope (Figure 3-14). Three samples (50, 53 and 369), to the south and southwest of the site, were identified as benthic outliers, grouping with Ipswich Bay stations (infaunal group 1E). Station 54, located within the potential disposal site and Station 51 to the west were both characterized as Massachusetts Bay infaunal group 2F dominated by spionid polychaetes and nuculid bivalves (AECOM 2013). The abundance of benthic organisms ranged from 360 to 1972 (mean 879) in samples in the region of GHDS, with the number of taxa ranging from 30 to 58 (mean 41) species (Table 3-3). The Shannon Diversity (H´ log e) ranged from 1.82 (Station 50) to 2.63 (Station 53) with a mean of 2.43 (Table 3-3). The Pielou's Evenness (J´) index ranged from 0.53 (Station 50) to 0.77 (Station 53) with a mean of 0.66 (Table 3-3).

The IBDS is located in similar depths to GHDS but with less slope and the presence of isolated rock ridges. The samples collected near the site were sand or gravelly sand, and all were grouped with the Ipswich Bay assemblage (Figure 3-15).

The stations near IBDS had a much lower range of total organisms (79 to 453, mean of 290) and somewhat lower number of taxa (20 to 43, mean 32; Table 3-4) than GHDS. However, the Shannon Diversity was similar to GHDS and Pielou’s evenness was slightly higher. Diversity ranged from 1.82 (Station 127) to 3.22 (Station 337) with a mean of 2.56 (Table 3-4). Evenness ranged from 0.59 (Station 127) to 0.88 (Station 338) with a mean of 0.74 (Table 3-4). No stations were located within the potential IBDS; stations 316 and 338 were the closest. Station 316 was part of infaunal group 1C which was dominated by Corophiid amphipods and tube-building polychaetes. Station 338 was an outlier, the only station in infaunal group 1A out of 207 stations. This group had relatively low abundance and diversity with dominance of Capitellid polychaetes.

Table 3-1.

AECOM 2012 Benthic Infaunal Station Locations and Data near GHDS

Station	Latitude	Longitude	Water Depth (m)	Sediment	Infaunal Group[a]
50	42° 33.627'	70° 42.642'	15-30	Slightly Gravelly Sand	1E
51	42° 33.729'	70° 41.775'	30-100	Slightly Gravelly Muddy Sand	2F
53	42° 33.563'	70° 39.985'	30-100	Slightly Gravelly Sand	1E
54	42° 34.070'	70° 39.732'	30-100	Slightly Gravelly Muddy Sand	2F
66	42° 34.804'	70° 38.080'	30-100	Slightly Gravelly Muddy Sand	2E
279	42° 33.509'	70° 41.027'	30-100	Gravelly Muddy Sand	2E
294	42° 34.572'	70° 38.782'	30-100	Slightly Gravelly Muddy Sand	2E
369	42° 33.488'	70° 40.298'	30-100	Slightly Gravelly Sand	1E

Table 3-2.

AECOM 2012 Benthic Infaunal Station Locations and Data near IBDS

Station	Latitude	Longitude	Water Depth (m)	Sediment	Infaunal Group[a]
123	42° 43.625'	70° 40.226'	30-100	Sand	1C
126	42° 42.760'	70° 39.642'	30-100	Sand	1C
127	42° 41.806'	70° 40.085'	15-30	Sand	1B
128	42° 41.750'	70° 41.711'	15-30	Sand	2A
129	42° 41.797'	70° 42.734'	15-30	Sand	1D
130	42° 42.292'	70° 41.858'	15-30	Slightly Gravelly Sand	1E
132	42° 44.059'	70° 43.141'	15-30	Sand	1E
158	42° 42.141'	70° 38.707'	30-100	Sand	1D
161	42° 43.157'	70° 38.700'	30-100	Slightly Gravelly Sand	2D
316	42° 42.684'	70° 40.174'	30-100	Sand	1C
337	42° 42.125'	70° 39.445'	15-30	Sand	1D
338	42° 43.233'	70° 40.112'	30-100	Slightly Gravelly Muddy Sand	1A
339	42° 43.718'	70° 39.406'	30-100	Sand	1C

[a] Infaunal group refers to the results of a Bray-Curtis analysis of 207 infaunal samples in Massachusetts Bay and Ipswich Bay. Infaunal groups 1 A-E and 2A were characteristic of Ipswich Bay, groups 2 B-F were characteristic of Massachusetts Bay (Figure 3-11).

Table 3-3.

Summary Statistics by Station for AECOM 2012 Benthic Infaunal Samples near GHDS (AECOM 2013)

Station	Abundance (All data)	Abundance (Analyzed Data)	Number of Taxa	Common	Less Common	Rare	H′ ($\log_e$)	J′
50	1003	1003	32	10	11	11	1.82	0.53
51	985	983	58	13	22	23	2.58	0.64
53	360	360	30	8	10	12	2.63	0.77
54	1973	1972	43	14	19	10	2.26	0.60
66	586	585	42	14	19	9	2.55	0.68
279	767	762	46	12	20	14	2.54	0.66
294	997	996	39	13	14	12	2.54	0.69
369	360	357	37	13	10	14	2.49	0.69
Mean	879	877	41	12.1	15.6	13.1	2.43	0.66

Table 3-4.

Summary Statistics by Station for AECOM 2012 Benthic Infaunal Samples near IBDS (AECOM 2013)

Station	Abundance (All data)	Abundance (Analyzed Data)	Number of Taxa	Common	Less Common	Rare	H′ ($\log_e$)	J′
123	366	366	31	7	13	11	2.14	0.62
126	439	432	40	9	14	17	2.74	0.74
127	224	224	22	8	11	3	1.82	0.59
128	270	270	28	12	8	8	2.40	0.72
129	163	160	32	10	10	12	2.96	0.86
130	242	237	20	6	9	5	2.24	0.75
132	453	448	26	12	9	5	2.14	0.66
158	342	342	35	9	14	12	2.71	0.76
161	413	403	42	7	17	18	2.71	0.72
316	342	338	43	9	15	19	2.68	0.71
337	202	202	42	11	13	18	3.22	0.86
338	79	79	25	12	9	4	2.83	0.88
339	238	224	33	7	3	13	2.63	0.75
Mean	290	287	32	9.2	11.2	11.2	2.56	0.74

3.4 Visual Characterization of Benthic Grab Samples

At GHDS, several attempts were made to collect grab samples on 14 and 15 August 2013. Strong winds hampered grab sampling efforts, and the seafloor over parts of the survey area appeared to be too hard to allow for collection of intact grab samples. Grab samples were collected at three locations (Table 3-5, Figure 3-16), with G-2 on the edge of the rock outcrop in the northeast quadrant and G-1 and G-3 near the southern boundary of GHDS where the terrain appears more even and flat. A few pieces of 1 inch-size gravel and shell hash were found at G-2. G-1 contained olive brown clay loam with trace shells and some tubes, while G-3 contained gravelly sand. Photographs of sediment samples collected are provided in Appendix B. The results are within the variability seen in the 2012 benthic survey and Ford and Voss (2010).

At IBDS, two grab samples were collected on 15 August 2013 within the site (Table 3-5, Figure 3-17). As shown in the photographs in Appendix B, the IBDS sediments grabbed were composed of sand and one sample contained a sand dollar.

3.5 Surface Marker Buoy Observations

Many lobster trap-style surface marker buoys were observed during the GHDS survey and they were observed to be in the deeper, softer sediment area to the south (Figure 3-18). A single panoramic photograph also captures the density of the surface marker buoys at GHDS (Appendix C).

Several surface marker buoys were observed at IBDS and were categorized by color and style (Figure 3-19).

Table 3-5.

Station Locations and Descriptions of Visual Grabs Collected at GHDS and IBDS

Station ID	Latitude	Longitude	Description
GHDS			
SED-G1	42° 33.898'	70° 39.990'	olive brown clay loam, some tubes, trace shells. 3 photos
SED G-2	42° 34.225'	70° 40.052'	grab recovers ~1 inch gravel and shell hash
SED G-3	42° 33.943'	70° 39.725'	gravelly sand
IBDS			
SED-I1	42° 42.871'	70° 41.019'	fine/medium olive brown sand, few tubes at surface, trace shell hash
SED-I2	42° 42.845'	70° 40.587'	fine/medium olive light brown sand, 2 sand dollars, trace shell hash, few tubes

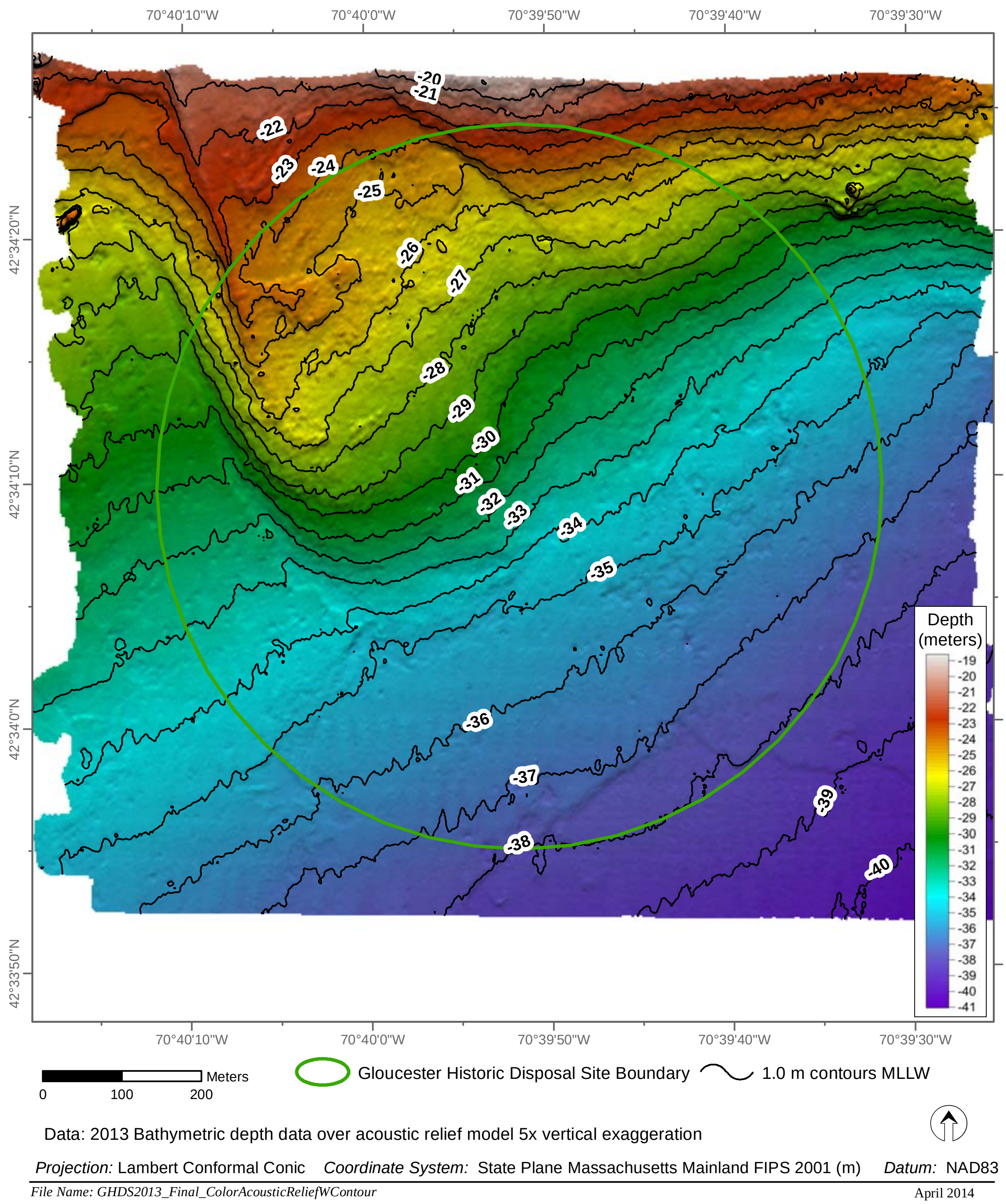

Figure 3-1. Bathymetric contour map of GHDS – August 2013

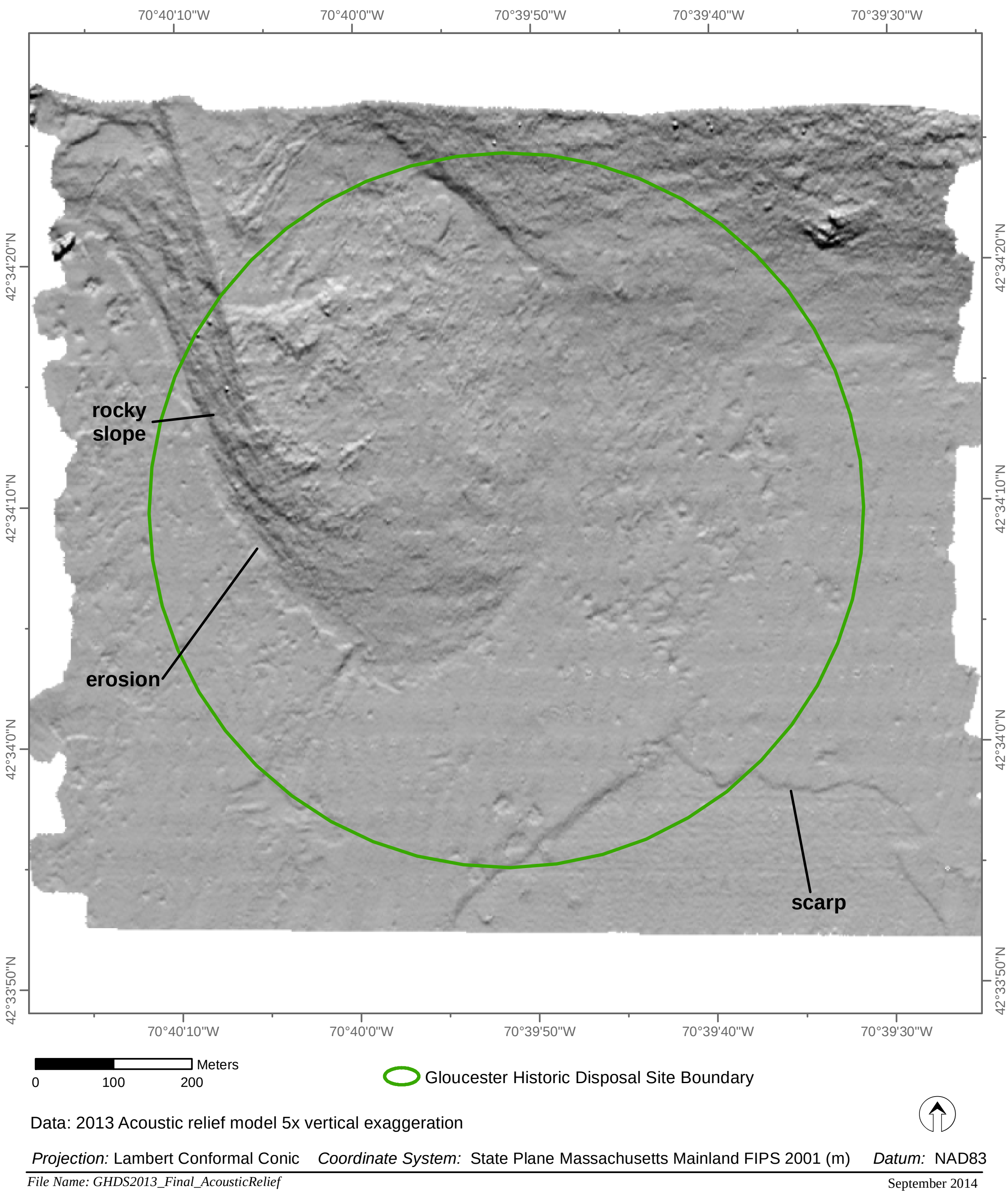

Figure 3-2. Acoustic relief model of GHDS – August 2013

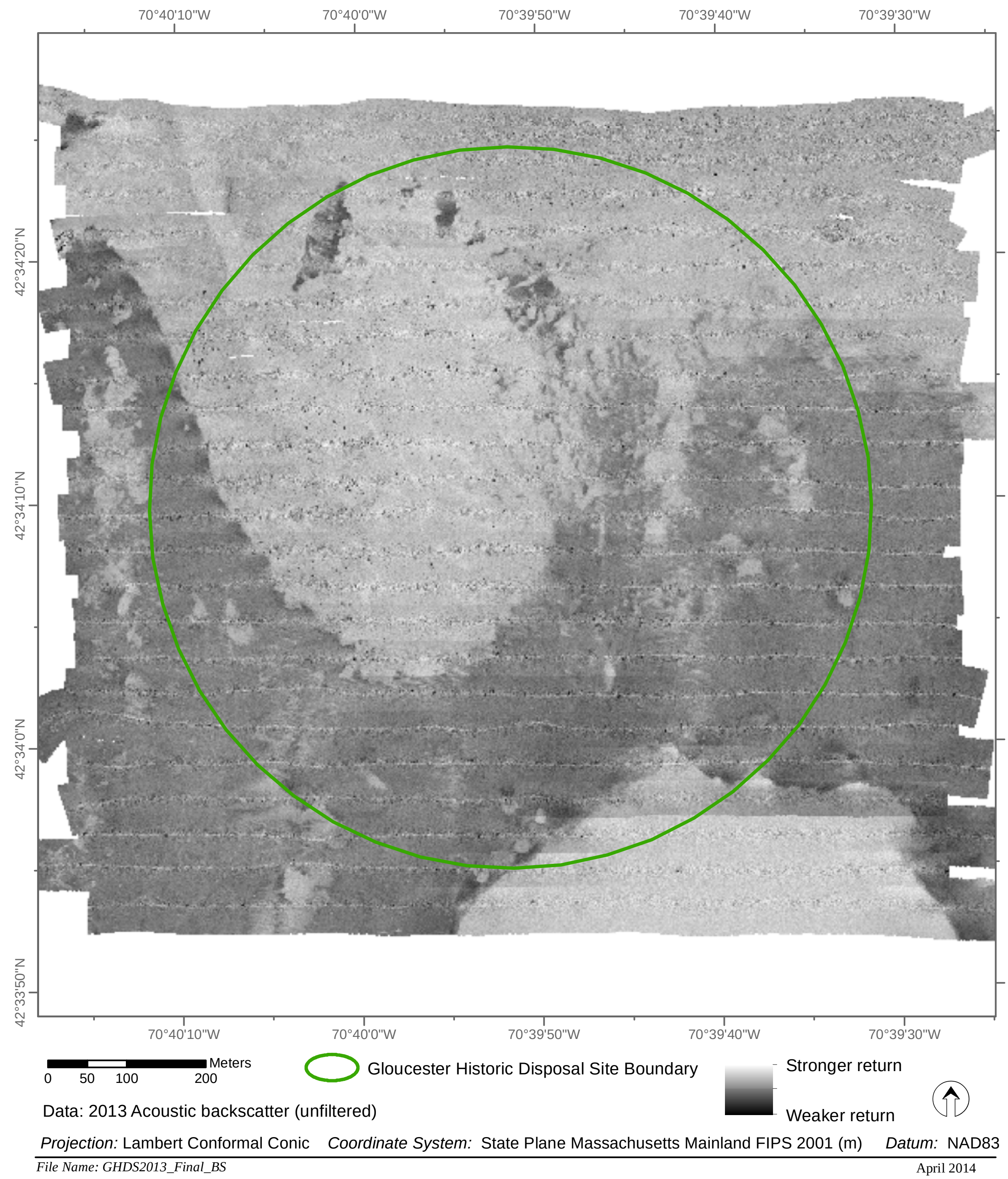

Figure 3-3. Mosaic of unfiltered acoustic backscatter of GHDS – August 2013

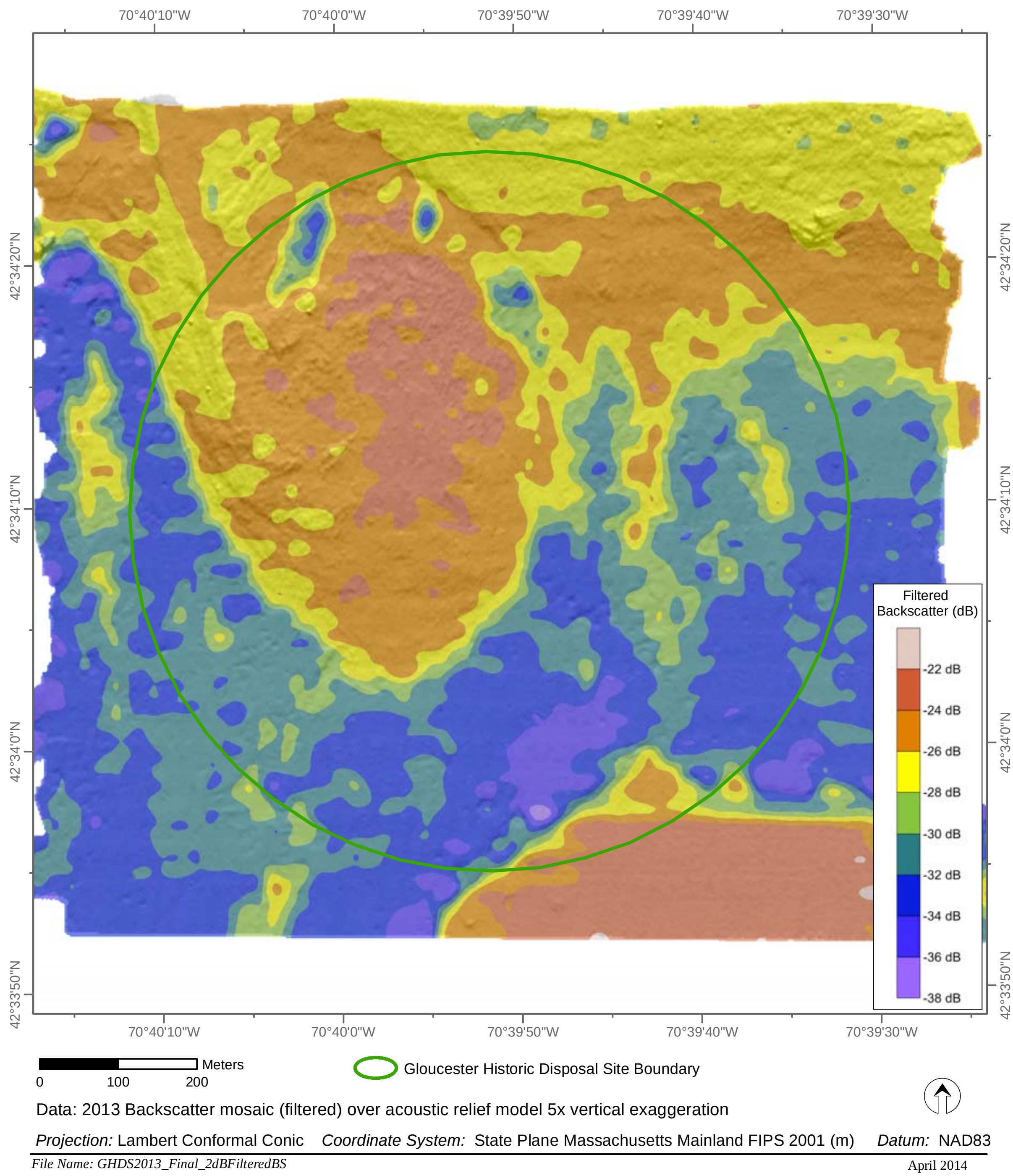

Figure 3-4. Mosaic of filtered acoustic backscatter of GHDS – August 2013

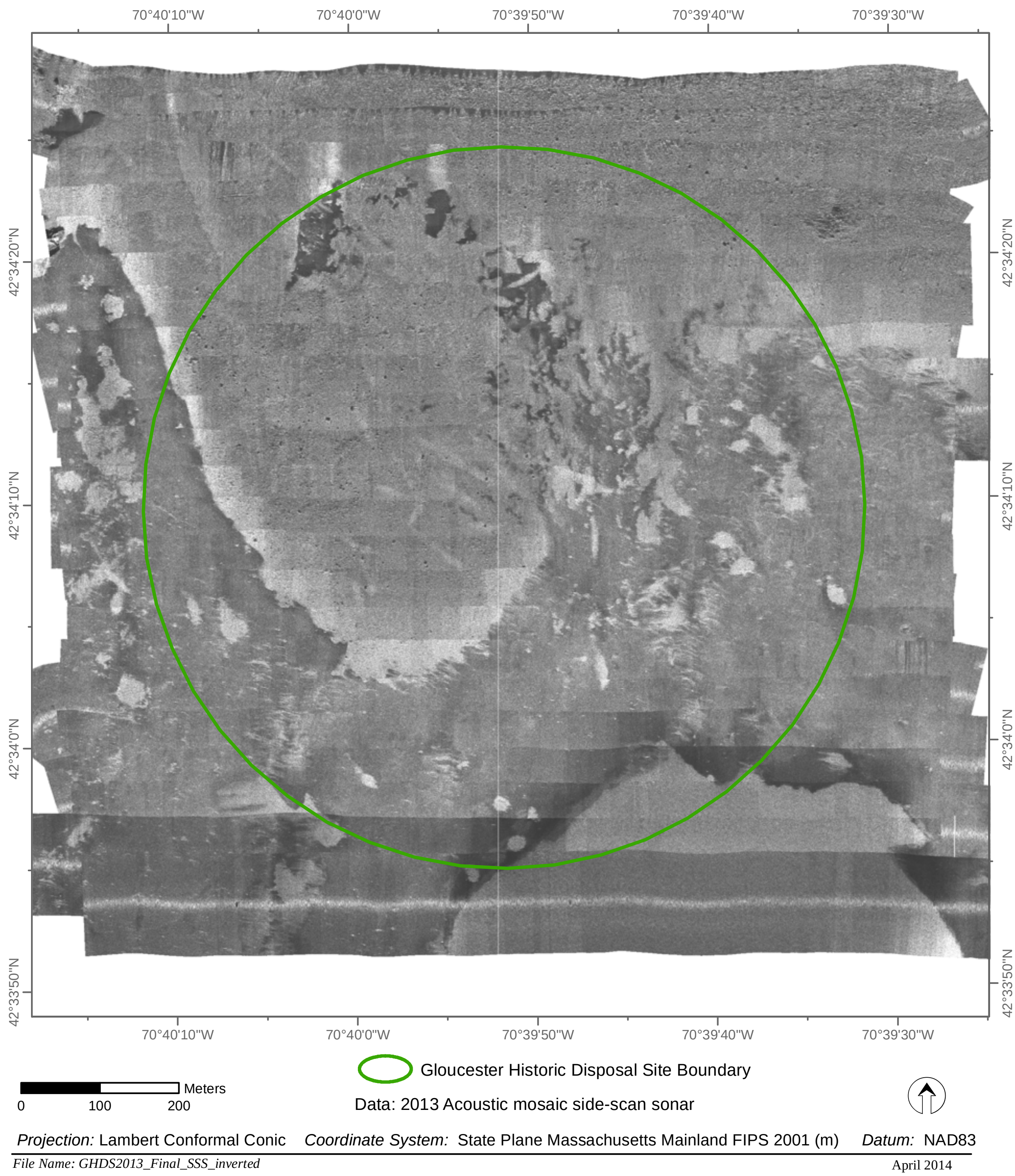

Figure 3-5. Mosaic of side-scan sonar of GHDS – August 2013

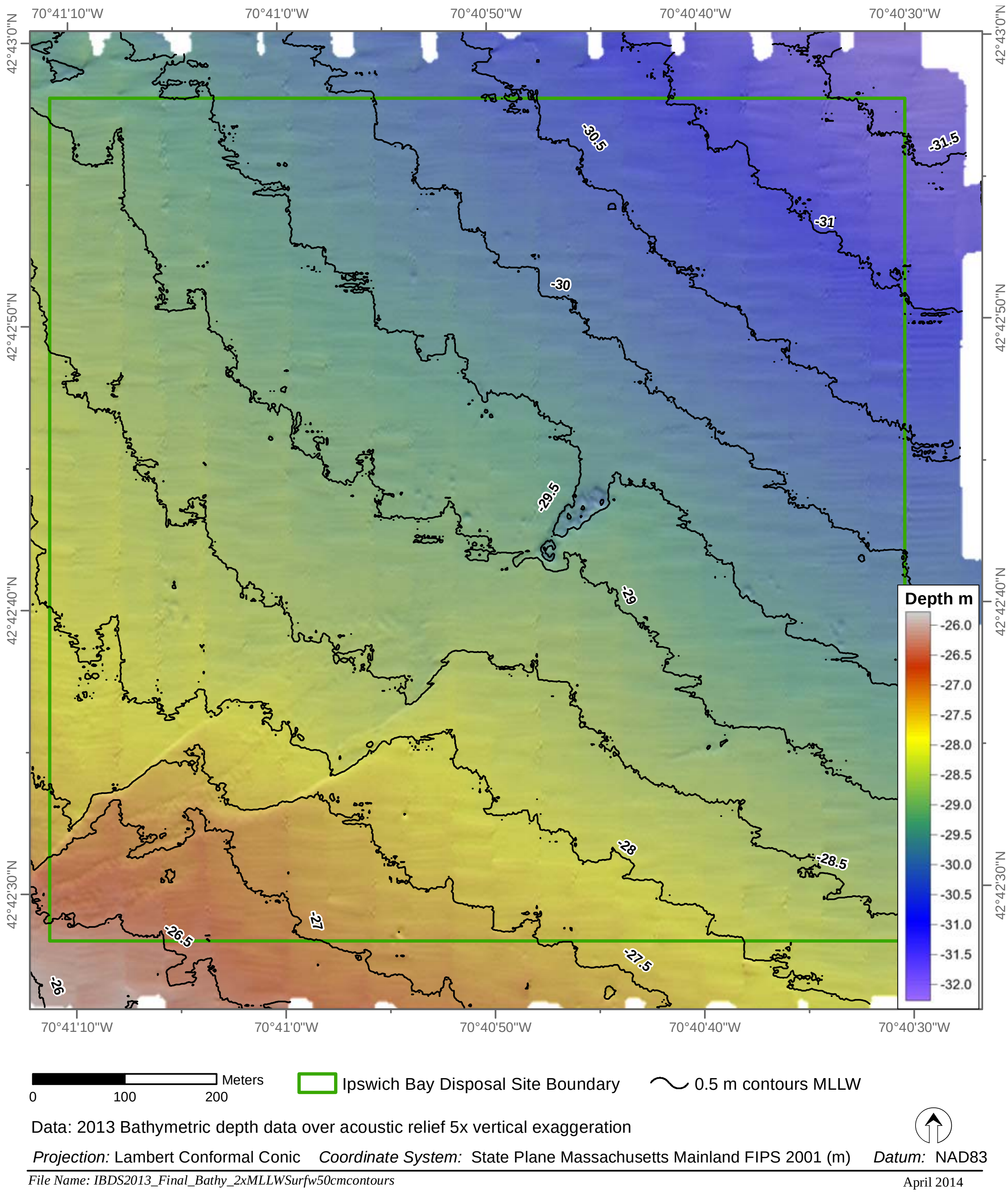

Figure 3-6. Bathymetric contour map of IBDS – August 2013

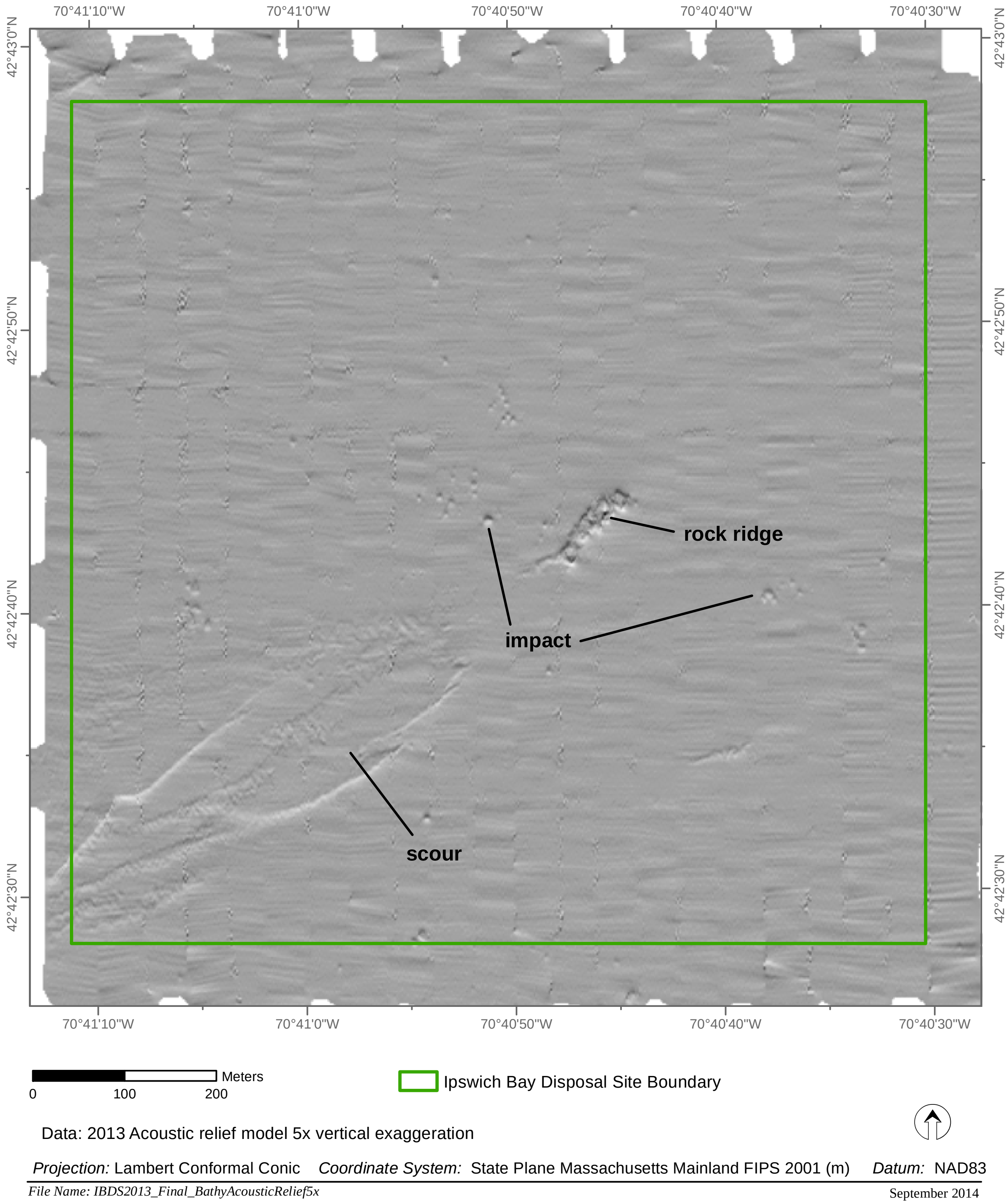

Figure 3-7. Acoustic relief model of IBDS – August 2013

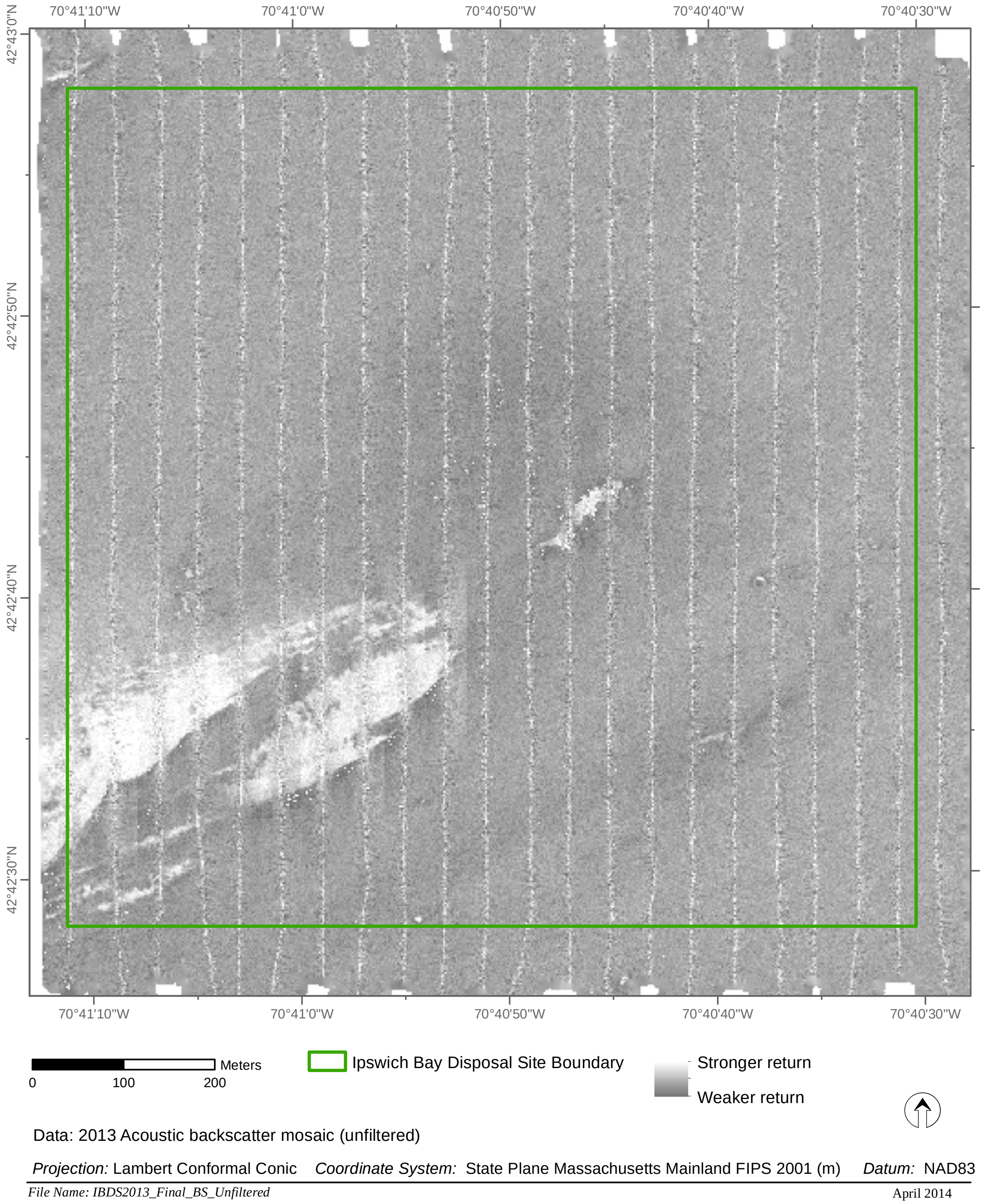

Figure 3-8. Mosaic of unfiltered acoustic backscatter of IBDS – August 2013

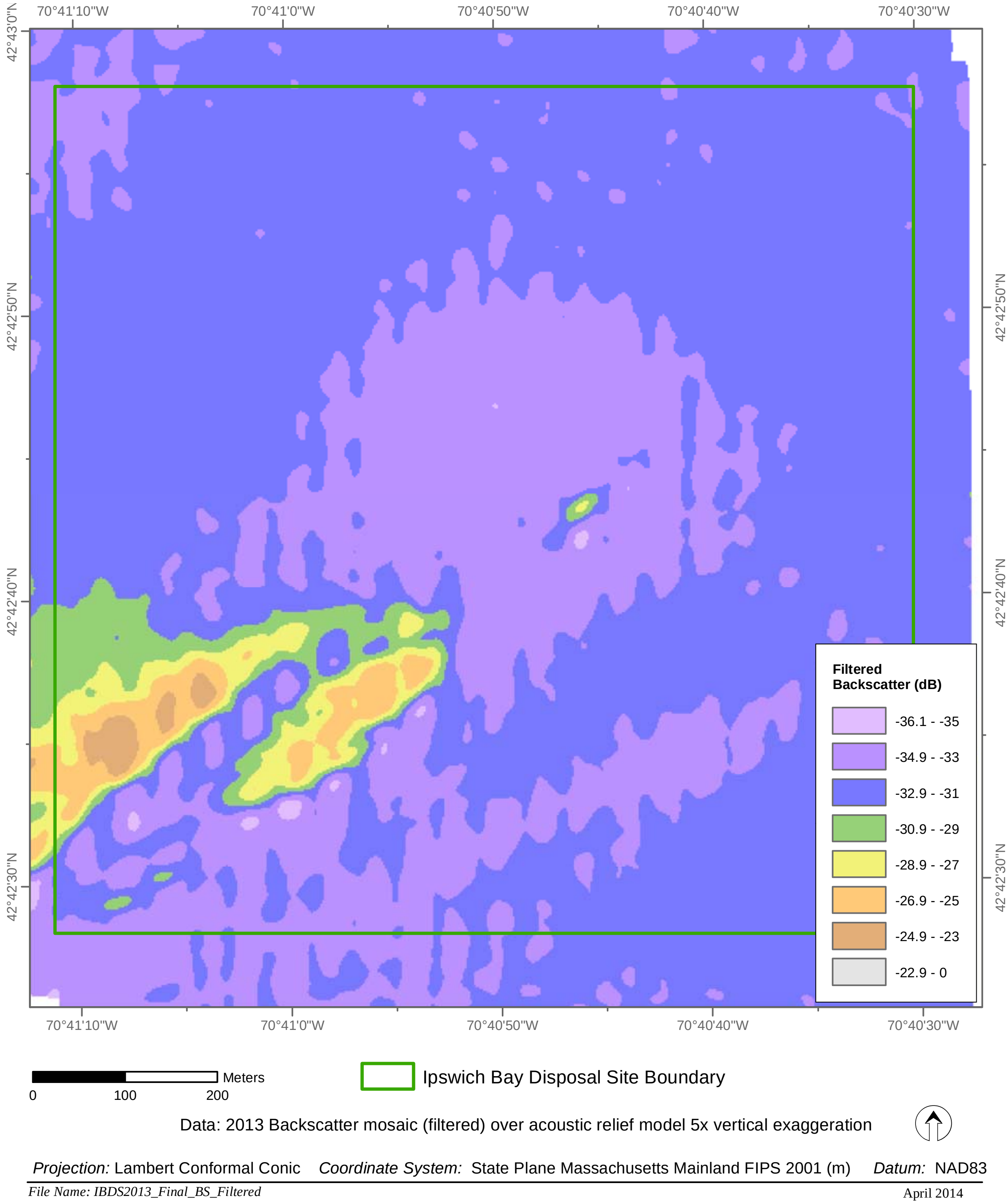

Figure 3-9. Mosaic of filtered acoustic backscatter of IBDS – August 2013

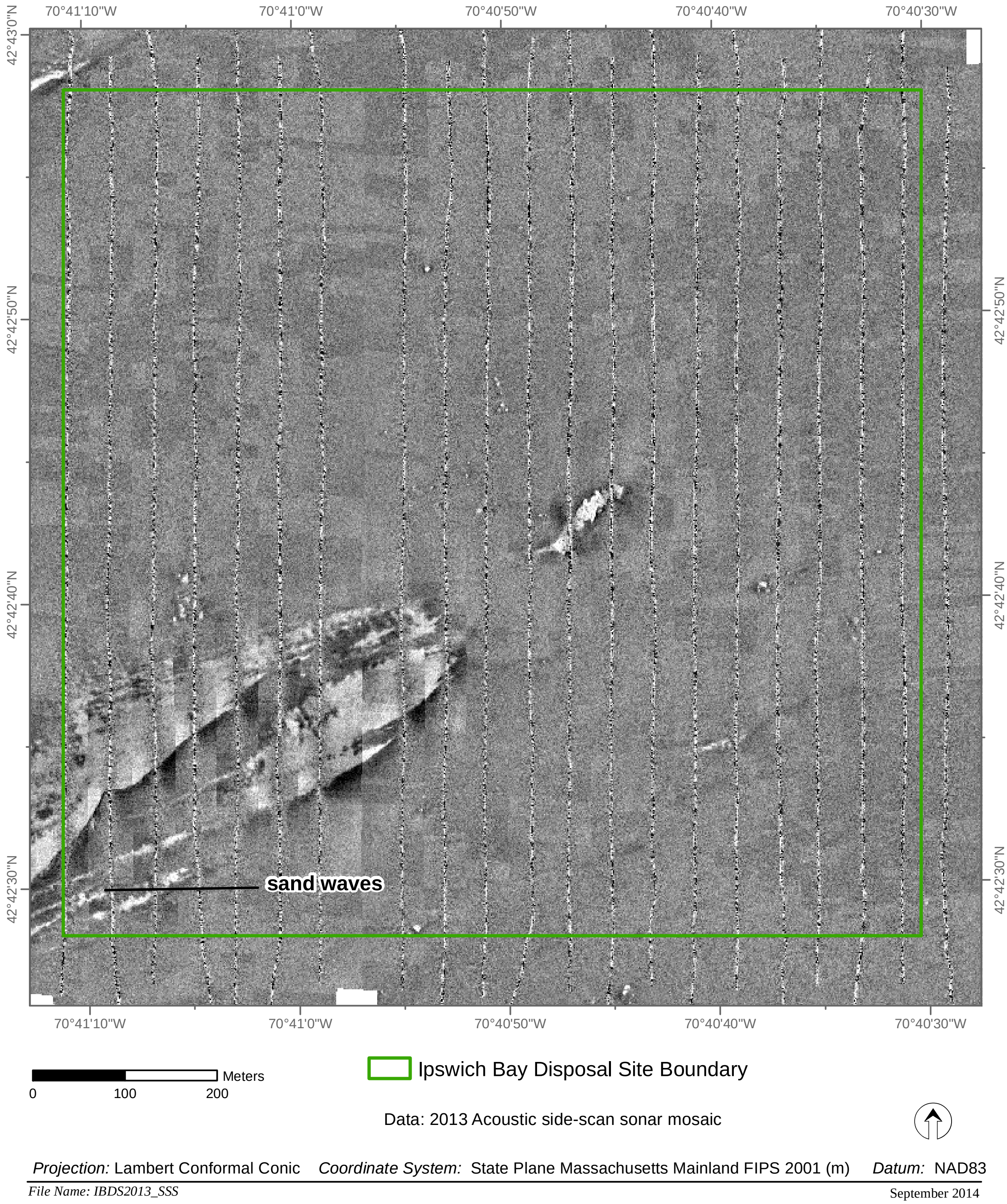

Figure 3-10. Mosaic of side-scan sonar of IBDS – August 2013

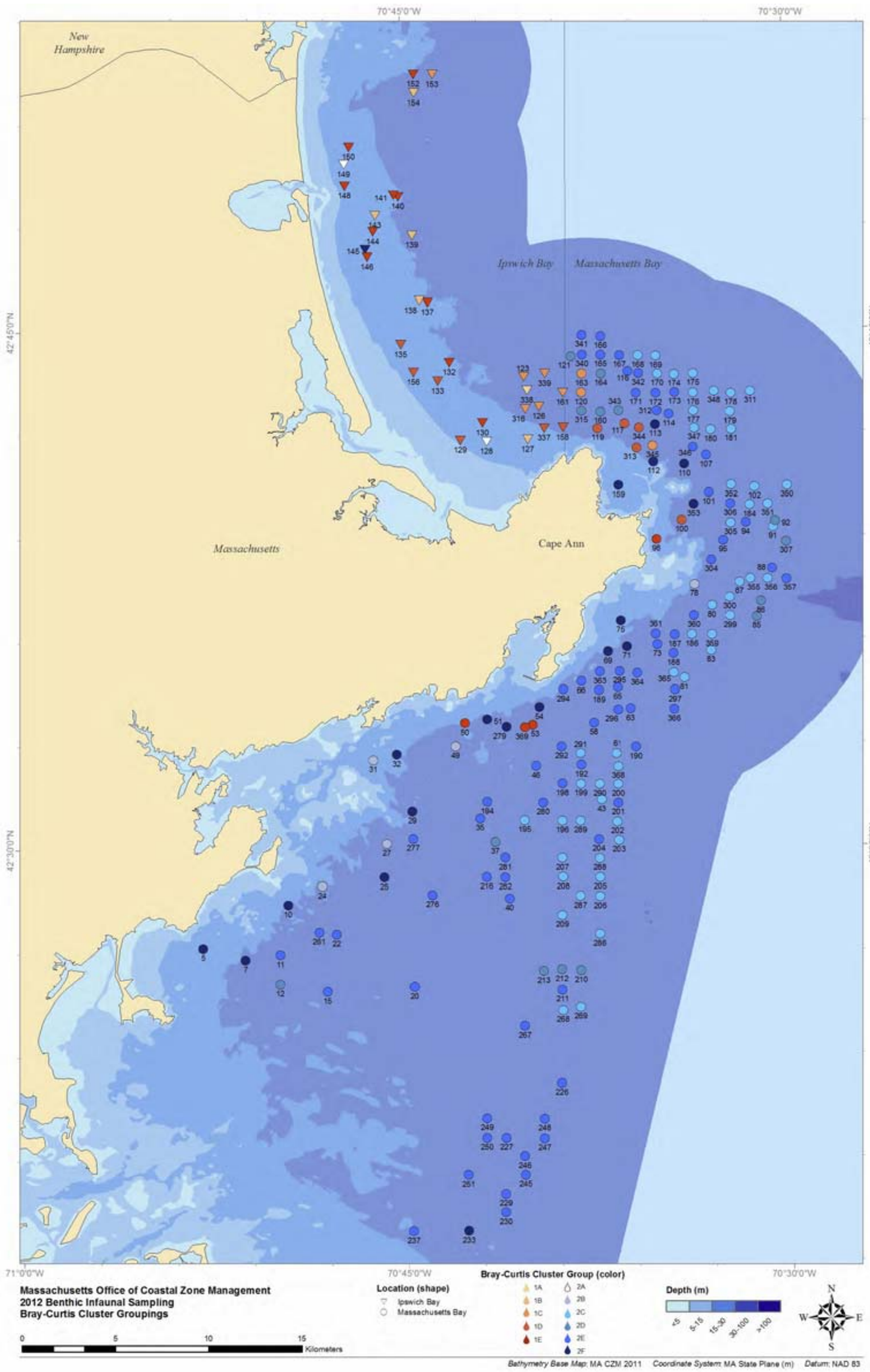

Figure 3-11. Map of Bray-Curtis cluster groups for the 207 stations sampled along the North Shore (AECOM 2013)

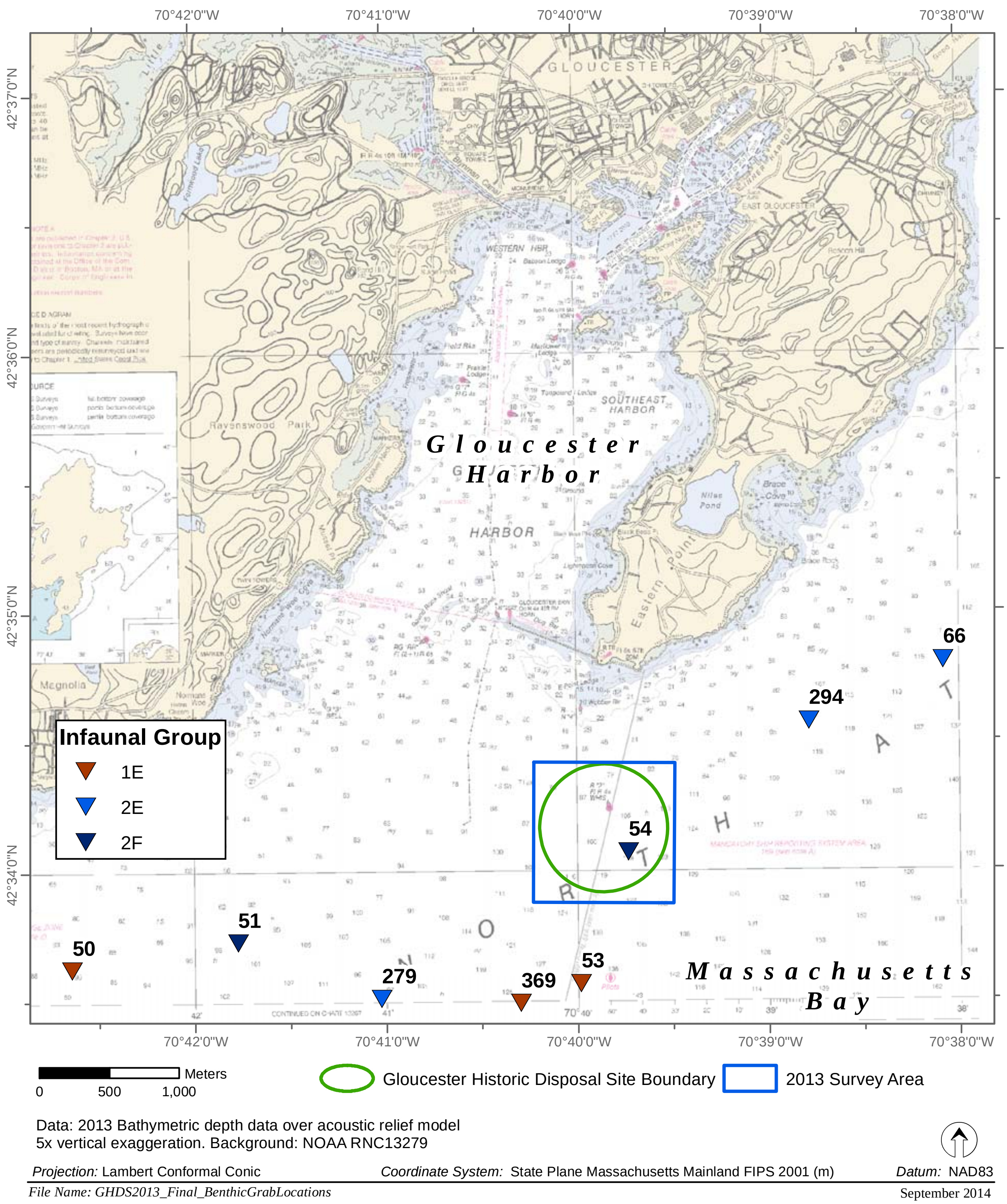

Figure 3-12. Benthic grab sampling locations near GHDS with sample identification number and infaunal group category

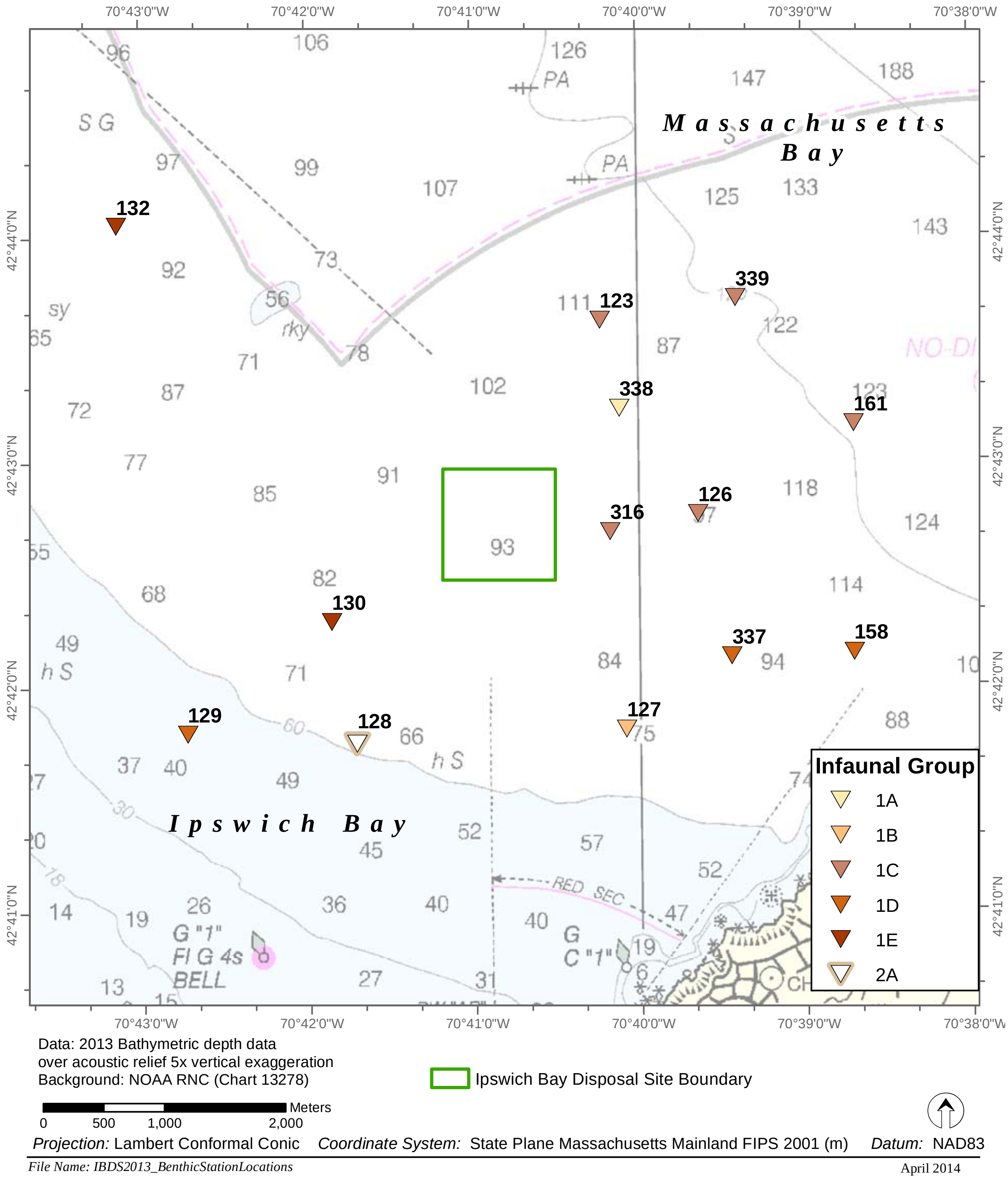

Figure 3-13. Benthic grab sampling locations near IBDS with sample identification number and infaunal group category

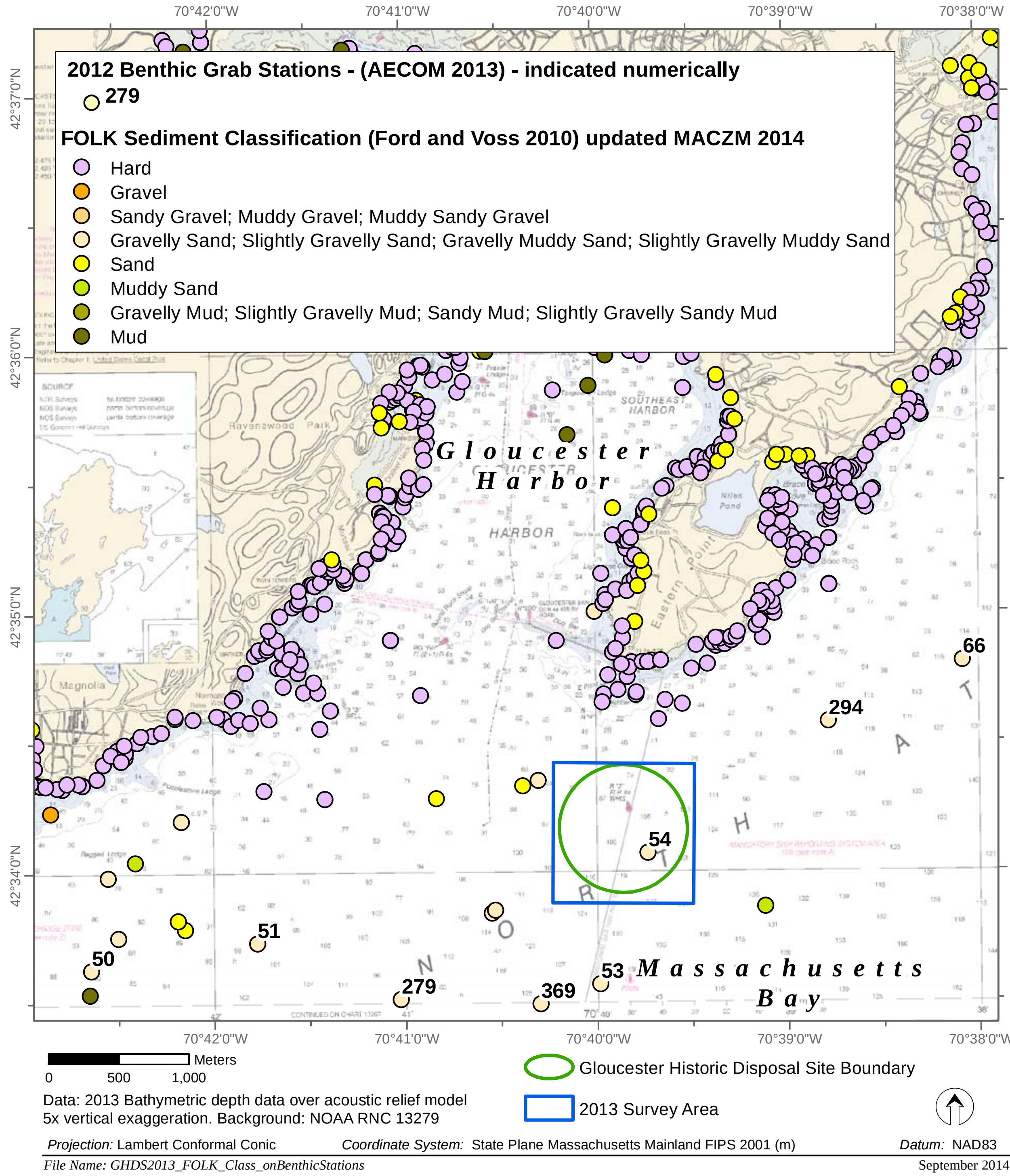

Figure 3-14. Benthic grab sampling grain size results near GHDS with sediment data from previous studies

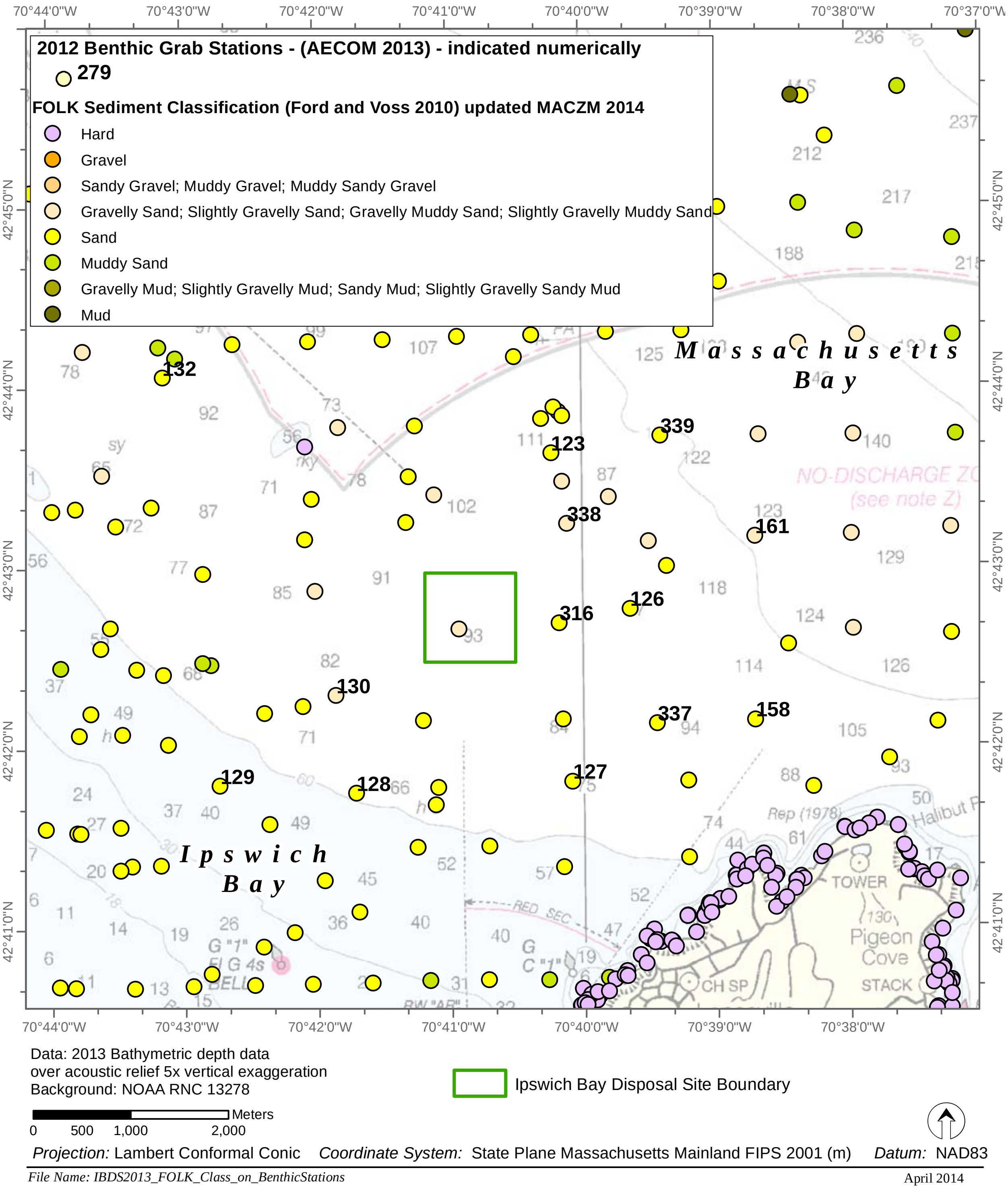

Figure 3-15. Benthic grab sampling grain size results near IBDS with sediment data from previous studies

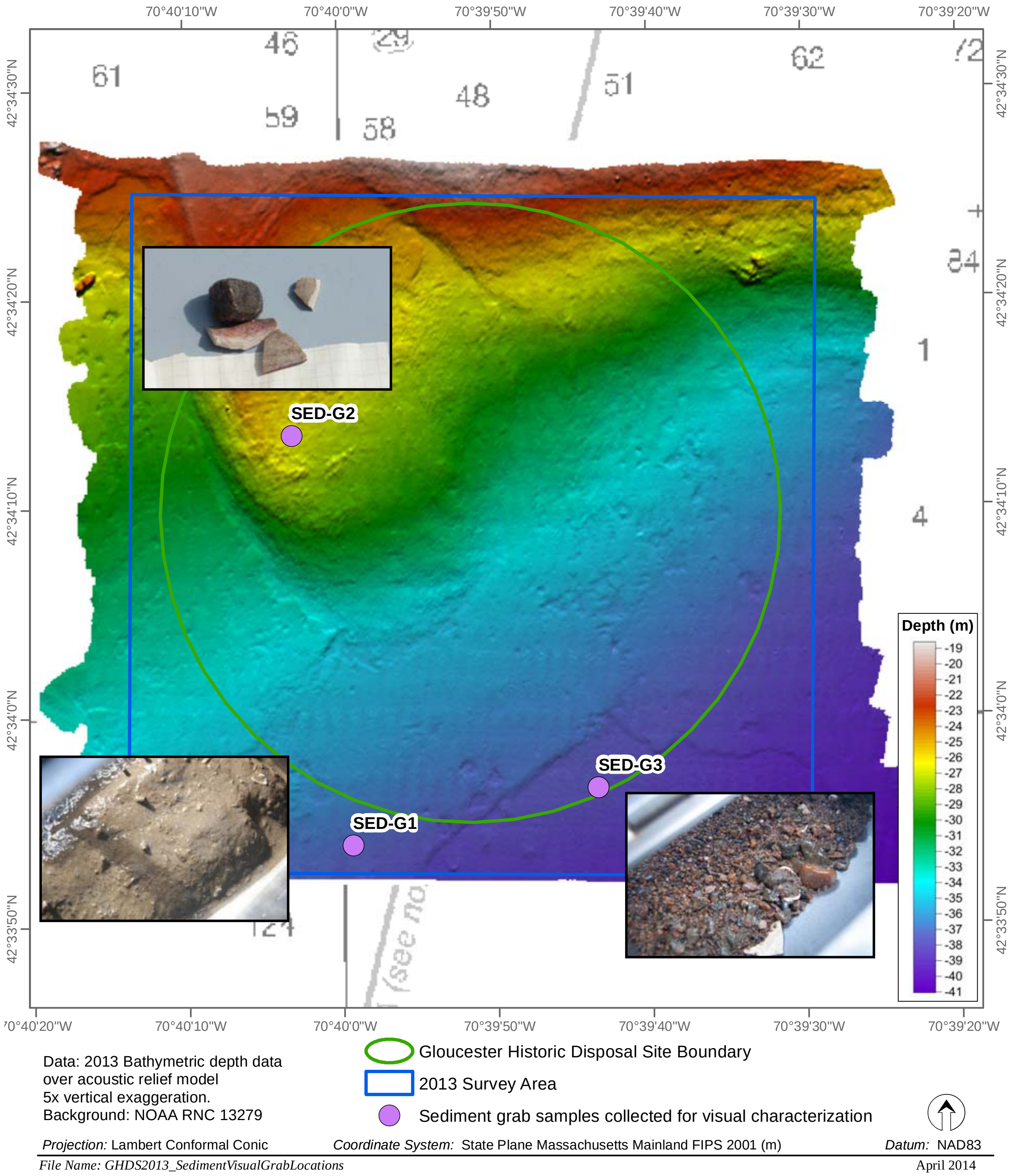

Figure 3-16. Sediment grab sample stations and photos at GHDS with bathymetric depth data over acoustic relief model

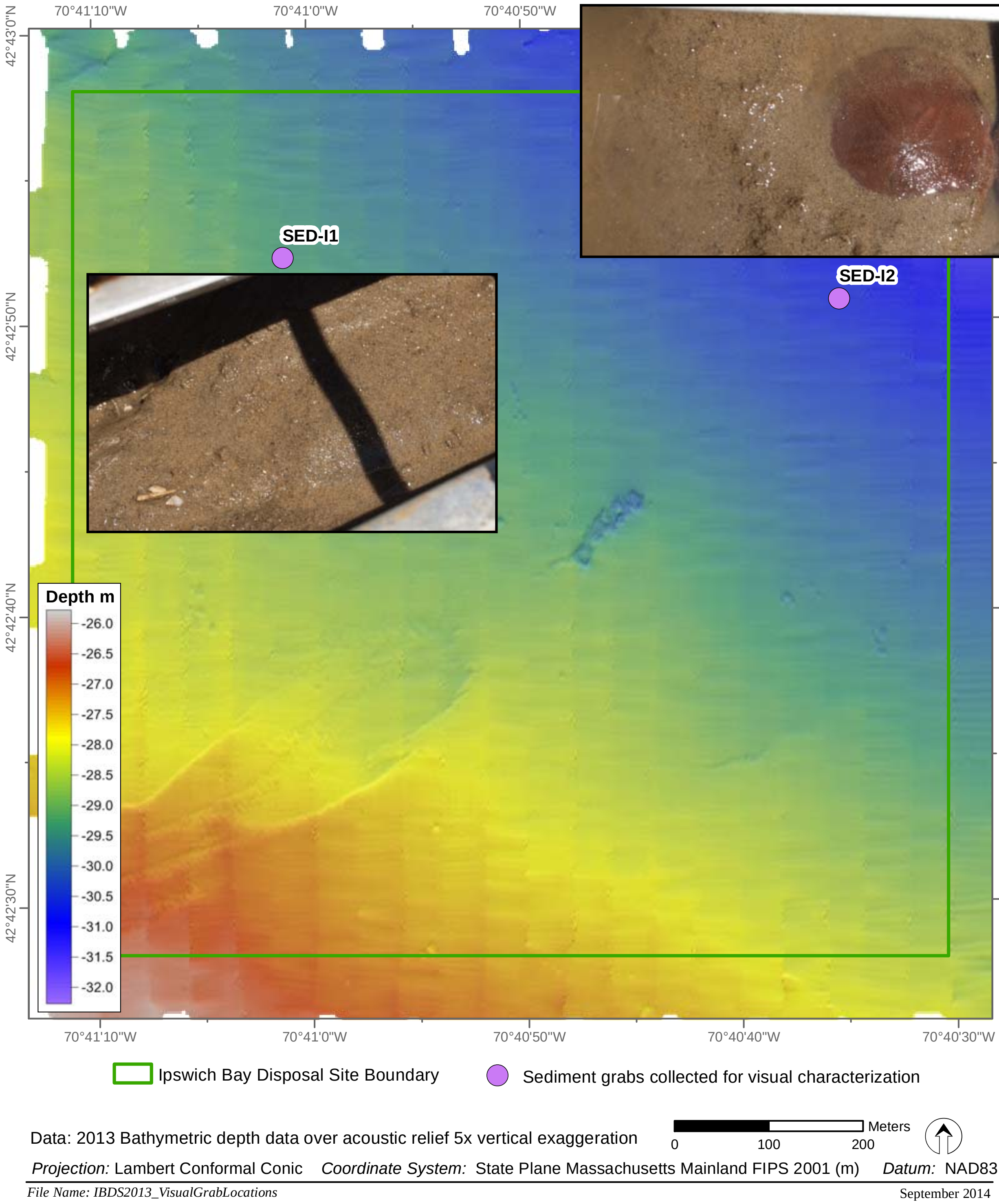

Figure 3-17. Sediment grab sample stations and photos at IBDS with bathymetric depth data over acoustic relief model

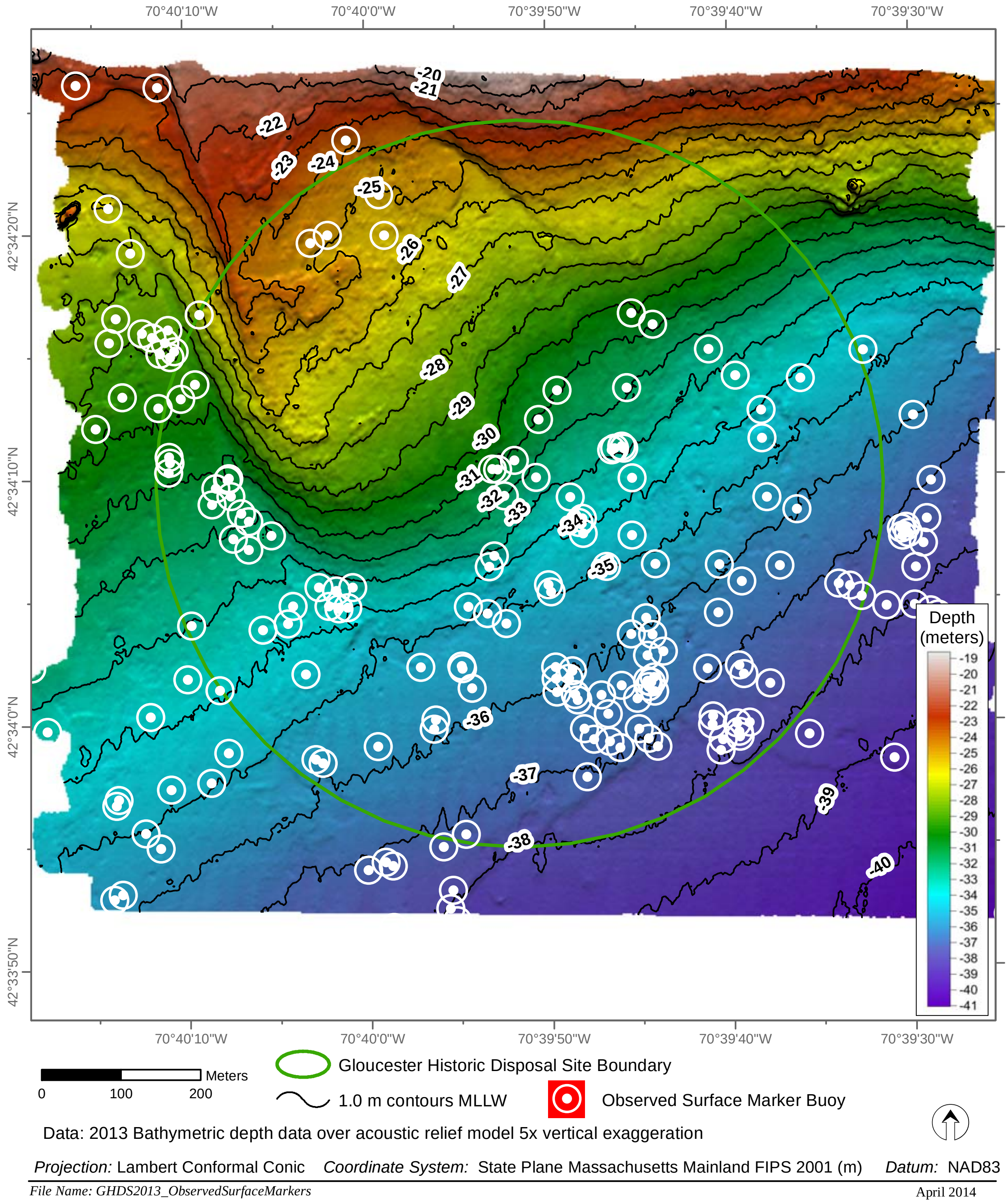

Figure 3-18. Surface marker buoy observations at GHDS

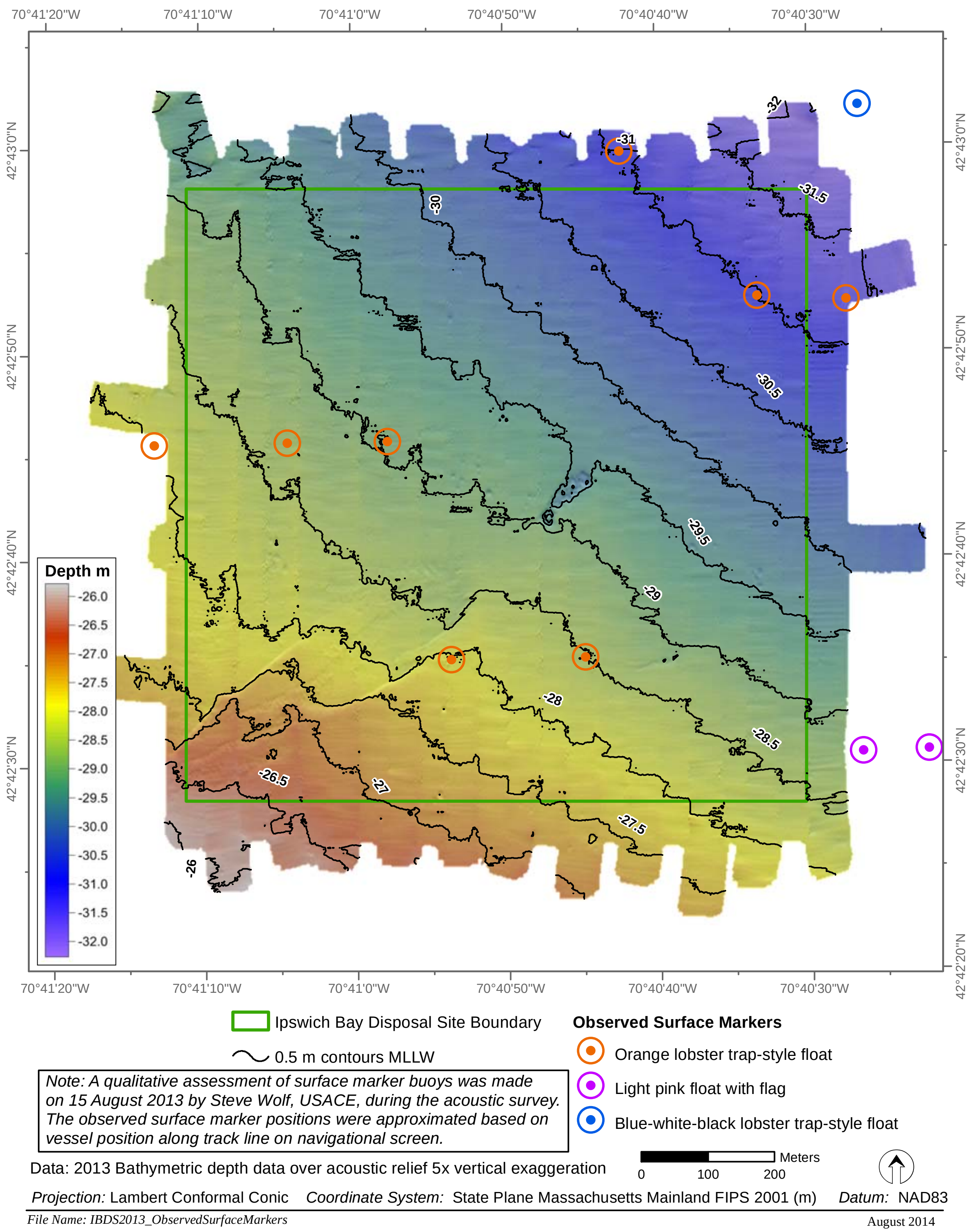

Figure 3-19. Surface marker buoy observations at IBDS

4.0 SUMMARY

The 2013 survey of Gloucester Historic and Ipswich Bay Disposal Sites provided general characterization of the depth, sediment and benthic characteristics of each site.

Gloucester Historic Disposal Site

- The terrain of GHDS was highly variable, varying in depth by about 12.2 m (40 ft) and substratum from hard bottom to muddy sand.
- The location of GHDS included a large rock promontory complex covered with large boulders and evidence of scour around the margin.
- The benthic communities at GHDS were similar to communities found in the same depth and substrate within Massachusetts Bay.
- There was evidence of older dredged material placement activities (prior to 1977) in the deeper flat portion of the site, with no evidence of erosion.

Ipswich Bay Disposal Site

- The terrain at IBDS was an even, gently sloping seafloor varying only by about 3.1 m (10 ft) in depth and is predominantly sand.
- The location of IBDS included a sand ridge with evidence of periodic sediment transport (large sand waves or linear sand ridges.
- The benthic communities near IBDS were similar to communities found in the same depth and substrate in Ipswich Bay.
- There was evidence of potential historic placement of coarse dredged material near the center of the site.

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 processed acoustic survey data
- Field notes
- Field pictures

Appendix A

Table of Common Conversions

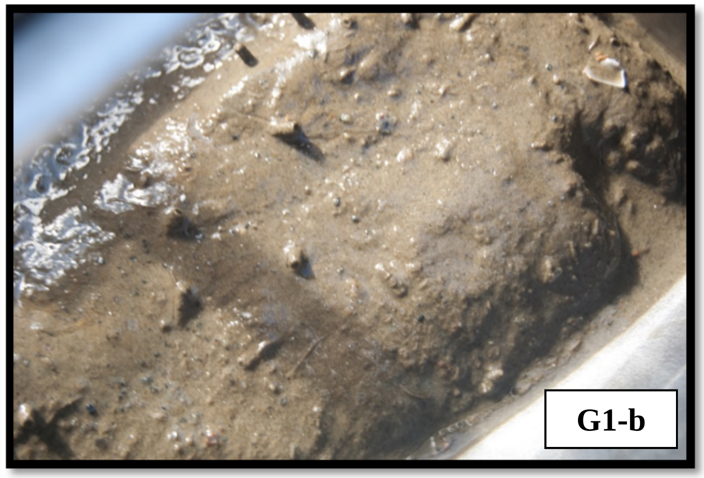
Metric Unit Conversion to English Unit		English Unit Conversion to Metric Unit	
1 meter 1 m	3.2808399 ft	1 foot 1 ft	0.3048 m
1 square meter 1 m^2	10.7639104 ft^2	1 square foot 1 ft^2	0.09290304 m^2
1 kilometer 1 km	0.621371192 mi	1 mile 1 mi	1.609344 km
1 cubic meter 1 m^3	1.30795062 yd^3	1 cubic yard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

Appendix B

Visual Grab Photographs from GHDS and IBDS

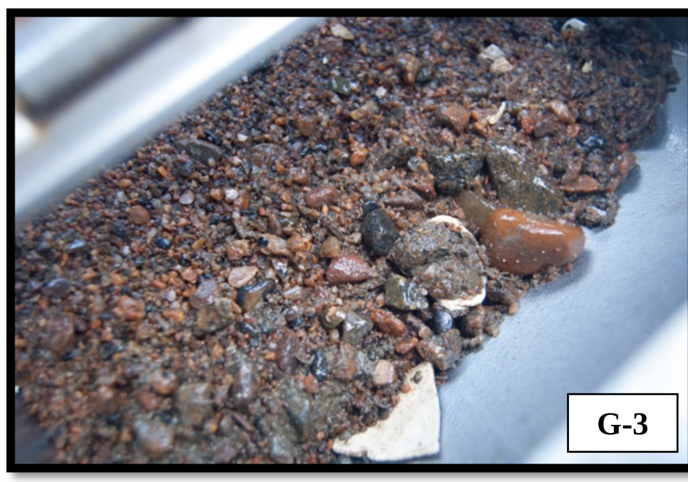
Visual Grabs from Gloucester Historic Disposal Site

G1-a



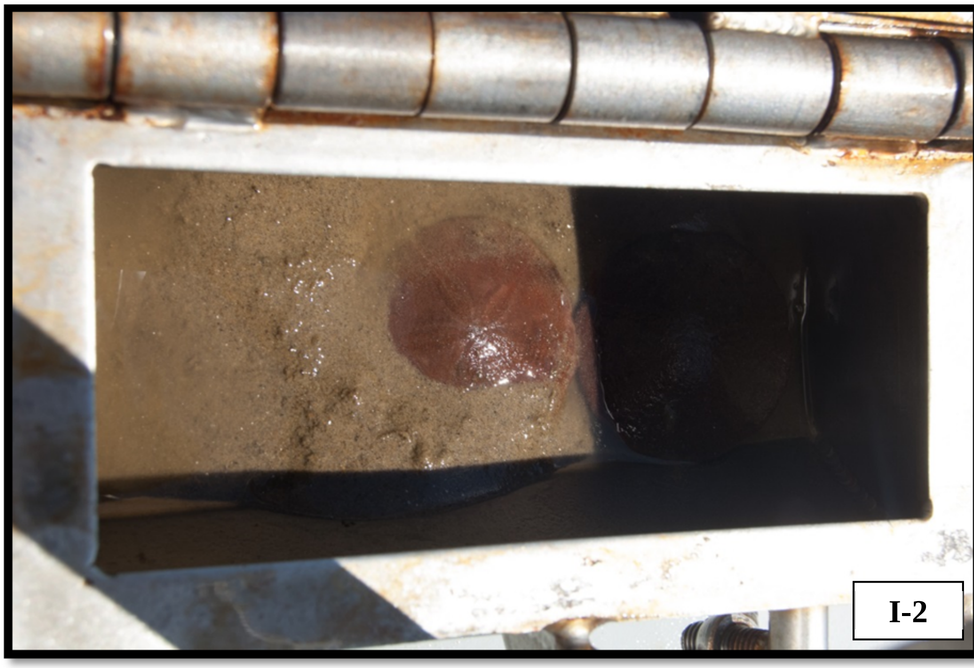
G1-b

G-2



G-3

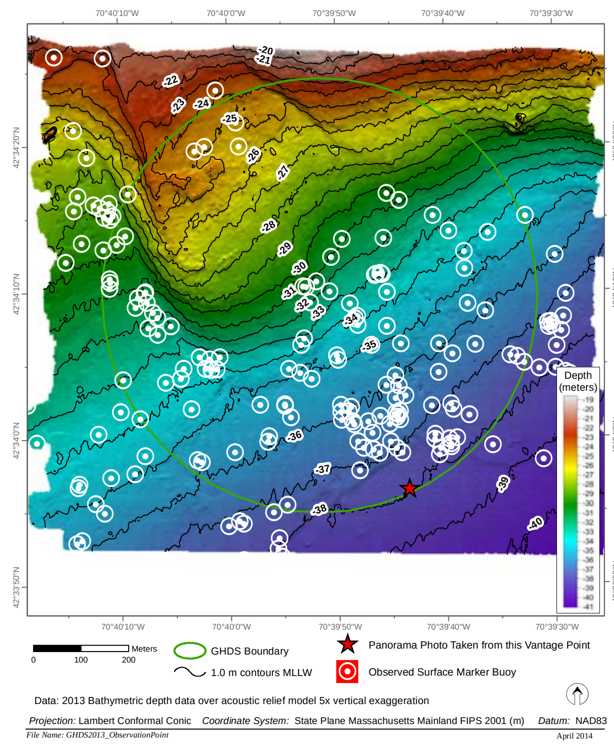
Visual Grabs from Ipswich Bay Disposal Site



Appendix C

Panorama Photograph of Observed Fishing Gear at GHDS


Jetty Distance ~2000 m
Buoy Distance ~580 m


70°40'10"W
70°40'0"W
70°39'50"W
70°39'40"W
70°39'30"W
42°34'20"N
42°34'10"N
42°34'0"N
42°33'50"N
Depth (meters)
Meters
0
100
200
GHDS Boundary
1.0 m contours MLLW
Panorama Photo Taken from this Vantage Point
Observed Surface Marker Buoy
Data: 2013 Bathymetric depth data over acoustic relief model 5x vertical exaggeration
Projection: Lambert Conformal Conic Coordinate System: State Plane Massachusetts Mainland FIPS 2001 (m) Datum: NAD83
File Name: GHDS2013_ObservationPoint
April 2014