

Prepared in cooperation with the Massachusetts Office of Coastal Zone Management

# **High-Resolution Geophysical Data From the Inner Continental Shelf: South of Martha's Vineyard and North of Nantucket, Massachusetts**

Open-File Report 2016–1168

U.S. Department of the Interior  
U.S. Geological Survey





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By Seth D. Ackerman, Laura L. Brothers, David S. Foster, Brian D. Andrews, Wayne E. Baldwin, and William C. Schwab

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U.S. Department of the Interior  
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# Contents

|                                     |     |
|-------------------------------------|-----|
| Acknowledgments .....               | iii |
| Abstract .....                      | 1   |
| Introduction.....                   | 1   |
| Geologic Setting.....               | 2   |
| Data Collection and Processing..... | 2   |
| Survey Operations .....             | 2   |
| Bathymetry.....                     | 3   |
| Acoustic Backscatter.....           | 4   |
| Seismic-Reflection Profiling .....  | 5   |
| Sampling.....                       | 5   |
| Additional Geophysical Data .....   | 6   |
| References Cited.....               | 7   |
| Figures.....                        | 10  |
| Appendix 1. Geophysical Data .....  | 18  |

## Figures

|  |    |
|--|----|
| 1. Map showing the locations of the survey areas and local physiographic features south of Martha's Vineyard and north of Nantucket, Massachusetts .....                     | 10 |
| 2. Photograph of motor vessel <i>Scarlett Isabella</i> , used for surveying in this project .....  | 11 |
| 3. Map showing tracklines along which bathymetric data were collected in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts .....            | 12 |
| 4. Map showing depth-colored shaded-relief bathymetry of the sea floor in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts .....           | 13 |
| 5. Map showing tracklines along which acoustic-backscatter data were collected in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts .....   | 14 |
| 6. Map showing acoustic-backscatter intensity of the sea floor in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts.....                    | 15 |
| 7. Map showing tracklines along which seismic-reflection profiles were collected in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts ..... | 16 |
| 8. Map showing the location of additional geophysical data in Massachusetts waters near the survey areas south of Martha's Vineyard and north of Nantucket.....              | 17 |

## Table

|  |   |
|--|---|
| 1. Survey details for the data collected in the study areas south of Martha's Vineyard and north of Nantucket, Massachusetts, May to June 2013 ..... | 3 |
|--|---|

## Conversion Factors

International System of Units to U.S. customary units

| Multiply                            | By     | To obtain                      |
|-------------------------------------|--------|--------------------------------|
| Length                              |        |                                |
| meter (m)                           | 3.281  | foot (ft)                      |
| kilometer (km)                      | 0.6214 | mile (mi)                      |
| kilometer (km)                      | 0.5400 | mile, nautical (nmi)           |
| meter (m)                           | 1.094  | yard (yd)                      |
| Area                                |        |                                |
| square kilometer (km <sup>2</sup> ) | 247.1  | acre                           |
| square kilometer (km <sup>2</sup> ) | 0.3861 | square mile (mi <sup>2</sup> ) |

## Datum

Vertical coordinate information is referenced to mean lower low water (MLLW).

Horizontal coordinate information is referenced to the World Geodetic System of 1984 (WGS 84).

## Abbreviations

|         |  |
|---------|--|
| CZM     | Massachusetts Office of Coastal Zone Management                |
| EPA     | U.S. Environmental Protection Agency                           |
| FA      | field activity   |
| FGDC    | Federal Geographic Data Committee                              |
| GeoTIFF | georeferenced tagged image file format                         |
| GIS     | geographic information system                                  |
| GPS     | Global Positioning System                                      |
| HTML    | hypertext markup language                                      |
| JPEG    | Joint Photographic Experts Group                               |
| kHz     | kilohertz  |
| MassGIS | Massachusetts Office of Geographic Information Systems         |
| MLLW    | mean lower low water   |
| MOF     | Marine Operations Facility                                     |
| MV      | motor vessel   |
| MVCO    | Martha's Vineyard Coastal Observatory                          |
| OSV     | ocean survey vessel  |
| NOAA    | National Oceanic and Atmospheric Administration                |
| PDF     | portable document format                                       |
| PNG     | portable network graphics                                      |
| RTK-GPS | Real Time Kinematic Global Positioning System                  |
| RV      | research vessel  |
| SEA     | Systems Engineering and Assessment, Ltd.                       |
| SEG-Y   | Society of Exploration Geophysicists Y format for seismic data |
| USGS    | U.S. Geological Survey   |
| UTM     | Universal Transverse Mercator                                  |
| WGS 84  | World Geodetic System of 1984                                  |
| WHOI    | Woods Hole Oceanographic Institution                           |
| XML     | extensible markup language                                     |

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## Abstract

The U.S. Geological Survey and the Massachusetts Office of Coastal Zone Management have cooperated to map approximately 185 square kilometers of the inner continental shelf south of Martha's Vineyard and north of Nantucket, Massachusetts. This report contains geophysical data collected by the U.S. Geological Survey during a survey in 2013. The geophysical data include (1) swath bathymetry collected by using interferometric sonar, (2) acoustic backscatter from the interferometric sonar, and (3) seismic-reflection profiles from a chirp subbottom profiler. These spatial data support research on the Quaternary evolution of coastal Massachusetts, the influence of sea-level change and sediment supply on coastal evolution, and efforts to understand the type, distribution, and quality of subtidal marine habitats in the coastal ocean of Massachusetts.

## Introduction

This report presents high-resolution spatial data for the sea floor south of Martha's Vineyard and north of Nantucket, Massachusetts (fig. 1). Approximately 185 square kilometers (km<sup>2</sup>) of the sea floor was mapped within these two survey areas in water depths between 6 to 32 meters (m). This report is the 17th in a series of publications produced by a cooperative mapping program between the U.S. Geological Survey (USGS) and the Massachusetts Office of Coastal Zone Management (CZM; [http://woodshole.er.usgs.gov/project-pages/coastal\\_mass/](http://woodshole.er.usgs.gov/project-pages/coastal_mass/); Ackerman and others, 2006, 2012, 2015; Andrews and others, 2010, 2012; Baldwin and others, 2016; Barnhardt and others, 2006, 2009, 2010; Foster and others, 2015; Pendleton and others, 2011, 2013, 2014a, 2014b, 2015; Turecek and others, 2012). This mapping program provides interpretive geologic datasets that can be used by managers and scientists to delineate marine resources, assess environmental change, inventory marine habitats, and support research concerning sea-level change, sediment supply, and coastal evolution. Detailed information and mapping products related to this cooperative can be accessed at [http://woodshole.er.usgs.gov/project-pages/coastal\\_mass/](http://woodshole.er.usgs.gov/project-pages/coastal_mass/).

The marine geophysical data in this report were obtained during a USGS research cruise in 2013 aboard the motor vessel (MV) *Scarlett Isabella* (fig. 2). Additional bathymetric data were recently collected by the USGS with the same interferometric sonar for unrelated research projects. Data abutting the survey area south of Martha's Vineyard were collected around the Martha's Vineyard Coastal Observatory in 2007 (fig. 1, Denny and others, 2009), and another survey was conducted within Muskeget Channel, situated between Martha's Vineyard and Nantucket, in 2010 (Pendleton and others,

2014b). Other bathymetric data from the region, collected by the National Oceanic and Atmospheric Administration (NOAA) to update navigation charts, have been used throughout this mapping program to help characterize sea-floor geology and morphology. Data from these adjacent and nearby surveys are not included in this report, but links are provided in the references section.

The overall goal of the USGS–CZM mapping cooperative is to characterize the sea floor and shallow substrate inside the 3-mile limit of State waters, using high-resolution geophysical techniques, sediment sampling, and sea-floor photography and videography. The products developed and the knowledge gained in this project have broad applicability to scientific and resource-management issues in the region. Seabed-characterization maps and geospatial data help scientists understand the processes that have shaped the inner continental shelf and coast and illustrate the geologic and geomorphic evolution of the nearshore region over time, thereby helping to evaluate the vulnerability of these coastal environments. This report provides a science foundation for managing marine habitats, addressing offshore development projects, and assessing environmental changes caused by natural processes or human activities.

## Geologic Setting

Martha’s Vineyard and Nantucket are the two largest islands in southeastern Massachusetts and are located approximately 6 and 45 kilometers (km) south of Cape Cod, respectively (fig. 1). The study area includes the inner continental shelf just south of Martha’s Vineyard, between Nomans Land Island and Muskeget Channel, and north of Nantucket Island between Tuckernuck Island and Great Point spit (fig. 1). The present-day coastal landscapes and offshore geology of these areas are the result of glacial and marine processes acting on the region over approximately the past 27,000 years (Oldale, 1992; Uchupi and Oldale, 1994; Uchupi and others, 1996; Balco, 2011). The Laurentide ice sheet was responsible for the ice-marginal deposits that form Cape Cod and the Martha’s Vineyard and Nantucket Islands. The most prominent features of these deposits are large moraine ridges (2–10 km wide; 50–100 m high) fronted by shallow-sloping outwash planes. These end moraines were deposited by the Buzzards Bay and Cape Cod Bay lobes of the Laurentide ice sheet and mark the southern extent of its most recent advance. The Buzzards Bay lobe deposited the end moraine that makes up Nomans Land and the western side of Martha’s Vineyard, while the Cape Cod Bay lobe deposited the end moraines present on the eastern side of Martha’s Vineyard and on Nantucket (Larson, 1982; Oldale, 1992). Glacial outwash planes were deposited southward of the end moraines as the glacier retreated. Following glacial retreat, Holocene sea-level rise further modified the landscape through erosional and depositional processes related to transgression (Kaye, 1964; Oldale, 1992; Uchupi and Oldale, 1994; Uchupi and others, 1996). Oceanographic processes including waves, currents and tides continue to shape the coast and adjacent sea-floor deposits (Goff and others, 2005; Gutierrez and others, 2003).

## Data Collection and Processing

### Survey Operations

A suite of acoustic sonars including an interferometric sonar (bathymetry and backscatter), a sidescan sonar (backscatter), and a chirp seismic-reflection profiler (subsurface stratigraphy and structure), were used to map approximately 185 km<sup>2</sup> of the inner continental shelf. The geophysical mapping (survey 2013–003–FA; table 1) was conducted during a research cruise aboard the MV *Scarlett Isabella* (fig. 2) from May 22 to June 11, 2013. Methods used in the collection, processing, and analysis of the data are detailed in the following sections. A full description of the data-acquisition

parameters, processing steps, and accuracy assessments can be found in the metadata files for each individual spatial dataset ([appendix 1](#)). Typically, geophysical observations are validated by the collection of sediment samples, bottom photographs, and video data soon after this type of survey. However, validation data were collected within much of this study area 18 months prior to survey 2013–003–FA during a sampling survey conducted by the USGS, the Massachusetts Office of Coastal Zone Management (CZM), and the U.S. Environmental Protection Agency (see “Sampling” section below). Sediment samples, video, and photographs were also collected in the area north of Nantucket in May 2016.

**Table 1.** Survey details for the data collected in the study areas south of Martha’s Vineyard and north of Nantucket, Massachusetts, May to June 2013.

[A U.S. Geological Survey field activity number (for example, 2013–003–FA) may also be referenced as a five-digit number (for example, 13003). kHz, kilohertz]

| Survey                 | Vessel                       | Begin date | End date   | Instrument used      |  |                             |
|------------------------|------------------------------|------------|------------|----------------------|--|-----------------------------|
|                        |                              |            |            | Bathymetry           | Backscatter <sup>1</sup>   | Seismic reflection          |
| 2013–003–FA<br>(13003) | <i>Scarlett<br/>Isabella</i> | 22-May-13  | 11-June-13 | SWATHplus<br>234 kHz | SWATHplus<br>234 kHz<br>and<br>Edgetech 4200<br>at 100 and 400 kHz | EdgeTech 512i<br>0.5–12 kHz |

<sup>1</sup>Backscatter data were collected during this survey by using the SEA SWATHplus and an Edgetech 4200 sidescan sonar; only the SWATHplus interferometric backscatter data were processed to completion and published in this report.

## Bathymetry

Approximately 1,900 linear kilometers of bathymetric data ([fig. 3](#); [table 1](#)) were acquired in the survey areas south of Martha’s Vineyard and north of Nantucket by using a Systems Engineering and Assessment, Ltd. (SEA) SWATHplus-M 234-kilohertz (kHz) interferometric sonar system at a rate of 15 pings per second. During survey 2013–003–FA, the sonar transducers were mounted on a rigid pole from the port side of the MV *Scarlett Isabella* ([fig. 2](#)) about 2.17 m below the water line. A Coda Octopus F185R motion reference unit, mounted directly above the transducers, measured vertical displacement (heave) and attitude (pitch and roll) of the vessel during data acquisition. Sound-velocity profiles were collected approximately every 2 to 4 hours with an ODIM MVP30 moving vessel profiler or an AML Oceanographic Minos-X vertical sound velocity profiler. Bathymetric data were collected with a variable range, sonar transmit power of 80 percent, transmit length of 43 cycles, and a receive length of 4,096 samples. Survey lines were run at an average speed of 5 nautical miles per hour (knots) and were spaced approximately 100 m apart to obtain overlapping swaths of data and full coverage of the sea floor.

Real Time Kinematic Global Positioning System (RTK–GPS) navigation was used to determine horizontal positioning and vertical water-level heights. Corrections were sent via cellular modem and very high frequency (VHF) radio to the survey vessel from a base station on land. The primary reference station (MOF2) was located at the USGS Marine Operations Facility (MOF) in Falmouth, Mass. ([fig. 1](#)). A NOAA VDatum transformation grid was used to offset the ellipsoidal water-level height corrections to the mean lower low water (MLLW) tidal datum within HYPACK (version 2013).

SEA SWATHplus acquisition software (version 3.07.17.00) and the Computer Aided Resource Information System (CARIS) Hydrographic Information Processing System (HIPS, version 8.0) were used to collect and process the raw bathymetric soundings. Navigation data were inspected and edited,

soundings were adjusted by using corrections from RTK–GPS water-level heights and sound-velocity profile data, and any spurious soundings were eliminated before the final processed soundings were gridded at a resolution of 5 meters per pixel (fig. 4).

Approximately 660 linear kilometers of interferometric-bathymetry data were collected by the USGS south of Martha’s Vineyard, Mass., in 2007 as part of a separate project (Denny and others, 2009) to study the area around Woods Hole Oceanographic Institution’s (WHOI) Martha’s Vineyard Coastal Observatory (MVCO). Therefore the 2013 survey avoided collecting new data over this area, with the exception of a few widely spaced coincident lines, along which data were collected for comparison to the 2007 data. The data from survey [2007–011–FA](#) were collected aboard the research vessel (RV) *Megan T. Miller* with the same bathymetric-sonar system used during the 2013 survey. The 2007 data, which were collected along tracklines spaced between 40–70 meters apart, are available in Denny and others (2009). Note that the final corrected soundings from the 2007 survey were referenced to a local vertical datum at the WHOI MVCO, not to MLLW.

The 2013 USGS swath bathymetric dataset is available as a 5-m per pixel digital elevation model in 32-bit floating point georeferenced tagged image file format (GeoTIFF) in [appendix 1](#). A depth-colored shaded-relief image can also be found in [appendix 1](#). Additional details about the acquisition and processing of the swath bathymetric data can be found in the metadata for the trackline and raster spatial datasets in [appendix 1](#).

## Acoustic Backscatter

Approximately 1,920 linear kilometers of acoustic backscatter data (figs. 5 and 6) were collected in the survey areas south of Martha’s Vineyard and north of Nantucket during USGS field activity 2013–003–FA using a SEA SWATHplus-M 234-kHz interferometric sonar system and an Edgetech 4200 SP Chirp sidescan sonar. The SWATHplus system was mounted on a rigid pole from the port side of the MV *Scarlett Isabella*, and the Edgetech 4200 was towed approximately 5 to 10 m above the sea floor from a J-frame on the stern. Navigation for the SWATHplus-M was recorded from the RTK–GPS antenna mounted directly above the SWATHplus-M system, and navigation from the Edgetech 4200 was recorded with a Global Positioning System (GPS) antenna mounted on top of the acquisition laboratory van (fig. 2). For the Edgetech 4200, horizontal offsets from the GPS antenna to the towed sidescan-sonar system, including cable-out linear layback, were measured and accounted for in the SonarWiz acquisition software (version 5.05.0015). Edgetech sidescan-sonar data were typically acquired with a swath width of 200 m (100 m to either side of vessel).

Backscatter from both the Edgetech4200 sidescan sonar and the SEA SWATHplus-M 234-kHz interferometric sonar system were preliminarily processed during the survey. Imagery from the SWATHplus system were of superior quality and used during postprocessing to produce the final backscatter mosaics. Raw data from the Edgetech 4200, which had some technical issues, were archived and not postprocessed.

SWATHplus backscatter data were processed by using SonarWiz (multiple versions between 5.06.0018 and 6.0.1.0032) between 2013 and 2015. The data were imported from SWATHplus SXR files, then line-by-line bottom-tracking corrections were applied to remove the water column at nadir. The SonarWiz automatic bottom-tracking algorithm was used and generally performed well. Automatic tracking parameters were adjusted slightly from line to line but typically were set to a blanking value of 7, a duration value of 2, and a threshold of 93 with line smoothing turned on. Some lines required manual adjustment to the automatic bottom-tracking delineation, which was performed as needed in the SonarWiz bottom-tracking editor. In general, there was also an additional altitude offset of a half meter applied to the bottom tracking in order to minimize residual nadir artifacts in some parts of the mosaic.

Gain was applied to the processing by using an empirical gain normalization function (EGN) with port and starboard intensities set to 67.

Because of the size of the survey areas, subsets of backscatter imagery were individually exported from SonarWiz at 1-m per pixel resolution and then mosaicked together into a composite, 1-m per pixel resolution 8-bit GeoTIFF file by using Global Mapper (version 17.0).

The gray-scale GeoTIFF mosaic of backscatter imagery for the survey areas can be found in [appendix 1](#). Not all backscatter data were used in the final mosaic. Omissions include data from tielines, data from files in areas where more complete or higher resolution data were available from adjacent sonar survey lines, and excessively noisy data.

Additional details about the acquisition and processing of the backscatter data can be found in the metadata for the trackline and GeoTIFF mosaic spatial datasets in [appendix 1](#).

## Seismic-Reflection Profiling

Approximately 1,920 linear kilometers of chirp seismic-reflection data were collected in the survey areas south of Martha's Vineyard and north of Nantucket using an EdgeTech Geo-Star FSSB subbottom profiling system and an SB-0512i towfish (FM swept frequency 0.5 to 12 kHz), which was mounted on a catamaran and towed between 30 and 50 m astern of the survey vessel ([fig. 7](#)). SonarWiz seismic-acquisition software (version 5.03.0016) was used to control the Geo-Star topside unit, digitally log trace data in the SEG-Y rev. 1 format (IEEE floating point), and record GPS navigation coordinates to the SEG-Y trace headers (in arc seconds of latitude and longitude, multiplied by a scalar of 100). During field activity 2013-003-FA, data were acquired by using a 0.25-second shot rate, a 5-millisecond pulse length, and a 0.5- to 8-kHz frequency sweep, with recorded trace lengths of approximately 100 milliseconds (2,170 samples per trace at a 0.000046-second sample interval).

Navigation was recorded with a GPS antenna mounted on top of the acquisition laboratory van. Horizontal offsets from the GPS antenna to the towed seismic-reflection system, including layback, were measured and accounted for during postprocessing.

Seismic-reflection data were processed by using SIOSEIS (version 2013.2; Henkart, 2011) and Seismic Unix (version 4.2; Cohen and Stockwell, 2011; Stockwell and Cohen, 2008). All navigation data were extracted from trace headers, edited, and saved to ASCII text files. Water column portions of the traces were muted, and the effects of sea-surface heave were minimized. Trace amplitudes were gained by using a time-varying function and normalized by using automatic gain control. Profiles of the final processed trace data are included in this report as 8-bit, gray-scale, variable-density plots in the portable network graphics (PNG) format. The final shot-point and trackline navigation data are also included in two Esri shapefiles in [appendix 1](#).

Additional details about the acquisition and processing of seismic-reflection data can be found in the metadata for the trackline and shot-point spatial datasets and in the metadata for the PNG profile images in [appendix 1](#).

## Sampling

A sampling survey aboard the ocean survey vessel (OSV) *Bold* (USGS field activity [2011-015-FA](#)) conducted by the USGS, CZM, and the U.S. Environmental Protection Agency (EPA) preceded the collection of geophysical data in this area. Forty-five samples from this sampling survey are coincident with the geophysical data collected during USGS field activity [2013-003-FA](#). In addition, 55 new samples were collected in May 2016 (USGS field activity [2016-005-FA](#)) in the area north of Nantucket. Data from these two sampling surveys will be used to verify the geophysical survey data and to help form the basis for future interpretive geologic maps. Spatial data, including the results of

sediment sample analyses and the locations of bottom photographs collected during these two surveys, are currently unpublished. Video of the sea floor can be accessed via the [USGS Coastal and Marine Geology Program's Video and Photograph Portal](#) (Golden and Ackerman, 2015)

## Additional Geophysical Data

Additional geophysical and geologic data, including swath bathymetry, acoustic backscatter, seismic-reflection profiles, and sampling data, are available for areas nearby and directly adjacent to the survey areas of this study (fig. 8). Some of these data were collected as part of the cooperative mapping program between the USGS and the Massachusetts Office of Coastal Zone Management (CZM); other data were collected by the USGS or NOAA during the past decade. The data and (or) additional information about these datasets are available online:

- USGS Datasets:
  - South of Martha's Vineyard (near the WHOI MVCO; Denny and others, 2009)—  
<http://pubs.usgs.gov/of/2008/1288/>
  - Muskeget Channel (Pendleton and others, 2014b)— <http://dx.doi.org/10.3133/ofr20121258>
  - Vineyard Sound (Andrews and others, 2012)—<http://pubs.usgs.gov/of/2012/1006>
  - Vineyard South and western Nantucket Sound (Baldwin and others, 2016)—  
<http://dx.doi.org/10.3133/ofr20161119>
  - Edgartown Harbor (Poppe and others, 2010)— <http://pubs.usgs.gov/of/2009/1001>
  - Buzzards Bay (Ackerman and others, 2012)—<http://pubs.usgs.gov/of/2012/1002/>
  - Buzzards Bay (Foster and others, 2015)— <http://dx.doi.org/10.3133/ofr20141220>
  - Buzzards Bay and Vineyard Sound (Ackerman and others, 2015)—  
<http://dx.doi.org/10.3133/ofr20141221>
  - Buzzards Bay and Vineyard Sound (Pendleton and others, 2014a)—  
<http://dx.doi.org/10.3133/ofr20131020>
- NOAA datasets:
  - Edgartown Harbor (H11346, surveyed in 2004)—  
[http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H10001-H12000/H11346\\_hsmdb.xml&view=hydro/survey&header=none](http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H10001-H12000/H11346_hsmdb.xml&view=hydro/survey&header=none)
  - Great Round Shoal (H11079, surveyed in 2004)—  
[http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H10001-H12000/H11079\\_hsmdb.xml&view=hydro/survey&header=none](http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H10001-H12000/H11079_hsmdb.xml&view=hydro/survey&header=none)
  - Cross Rip Channel (H12007, surveyed in 2009)—  
[http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H12001-H14000/H12007\\_hsmdb.xml&view=hydro/survey&header=none](http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H12001-H14000/H12007_hsmdb.xml&view=hydro/survey&header=none)
  - Vineyard Sound (H11920, surveyed in 2008)—  
[http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H10001-H12000/H11920\\_hsmdb.xml&view=hydro/survey&header=none](http://www.ngdc.noaa.gov/docucomp/page?url=http://surveys.ngdc.noaa.gov/mgg/NOS/hsmdb/H10001-H12000/H11920_hsmdb.xml&view=hydro/survey&header=none)

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# Figures

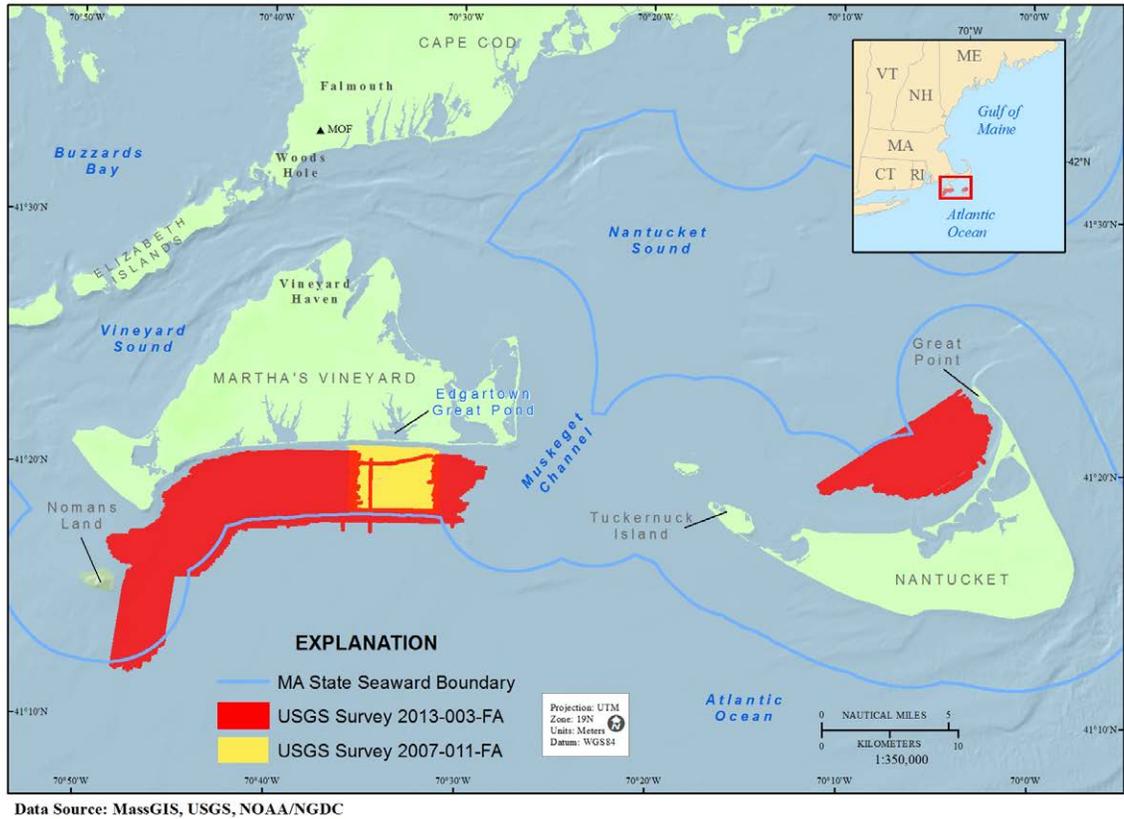


Figure 1. Map showing the locations of the survey areas (shaded in red) and local physiographic features south of Martha's Vineyard and north of Nantucket, Massachusetts. The area shaded in orange was surveyed in 2007 by the U.S. Geological Survey (USGS), using the same bathymetric sonar and seismic system for an unrelated project. Is., Island; MA, Massachusetts; MassGIS, Massachusetts Office of Geographic Information; MOF, Marine Operations Facility; NGDC, National Geophysical Data Center; NOAA, National Oceanic and Atmospheric Administration; UTM, Universal Transverse Mercator; WGS 84, World Geodetic System of 1984.



Figure 2. Photograph of motor vessel (MV) *Scarlett Isabella*, used for surveying in this project.

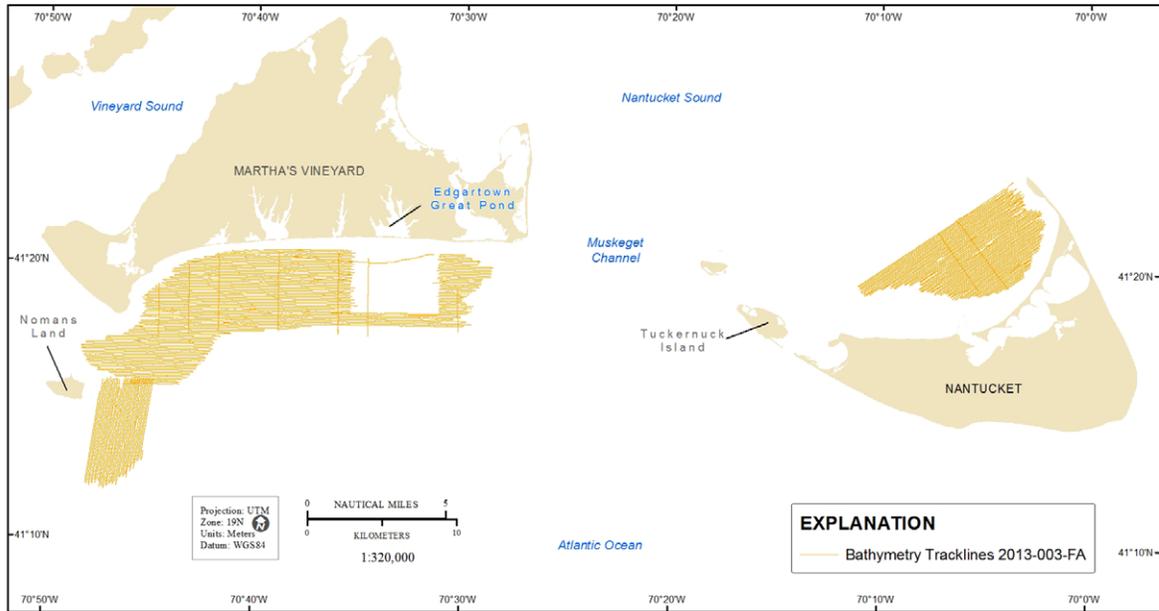


Figure 3. Map showing tracklines along which bathymetric data were collected in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts. UTM, Universal Transverse Mercator; WGS 84, World Geodetic System of 1984.

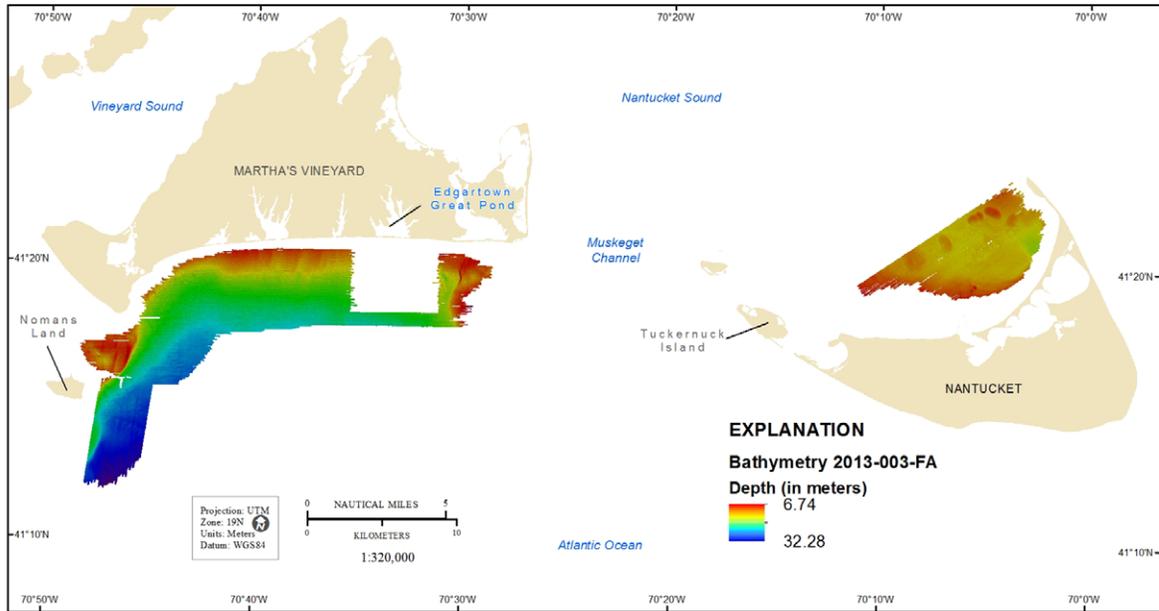


Figure 4. Map showing depth-colored shaded-relief bathymetry of the sea floor in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts. Coloring represents depth in meters, relative to the mean lower low water (MLLW) datum. UTM, Universal Transverse Mercator; WGS 84, World Geodetic System of 1984.

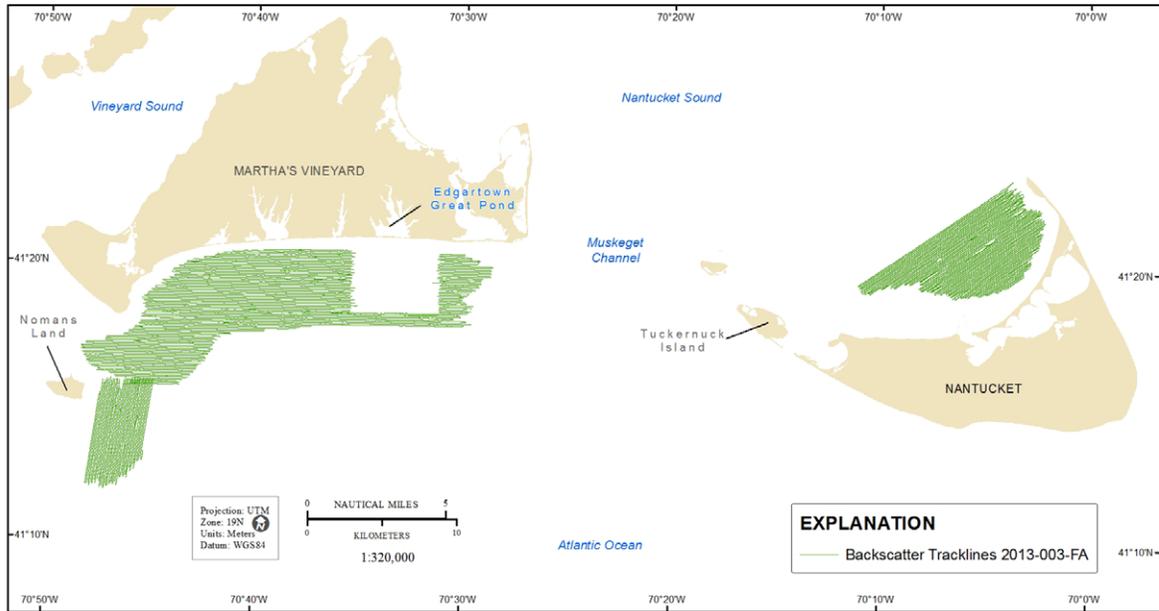


Figure 5. Map showing tracklines along which acoustic-backscatter data were collected in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts. UTM, Universal Transverse Mercator; WGS 84, World Geodetic System of 1984.

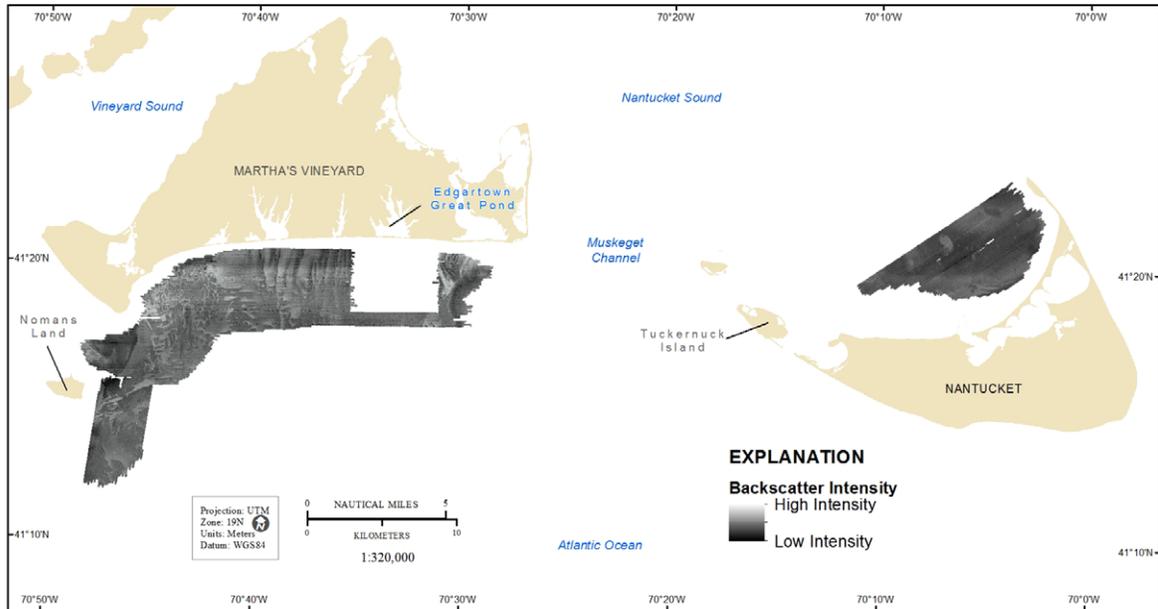


Figure 6. Map showing acoustic-backscatter intensity of the sea floor in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts. Backscatter intensity is an acoustic measure of the hardness and roughness. In general, high values (light tones) represent rock, boulders, cobbles, gravel, and coarse sand. Low values (dark tones) generally represent fine sand and muddy sediment. UTM, Universal Transverse Mercator; WGS 84, World Geodetic System of 1984.

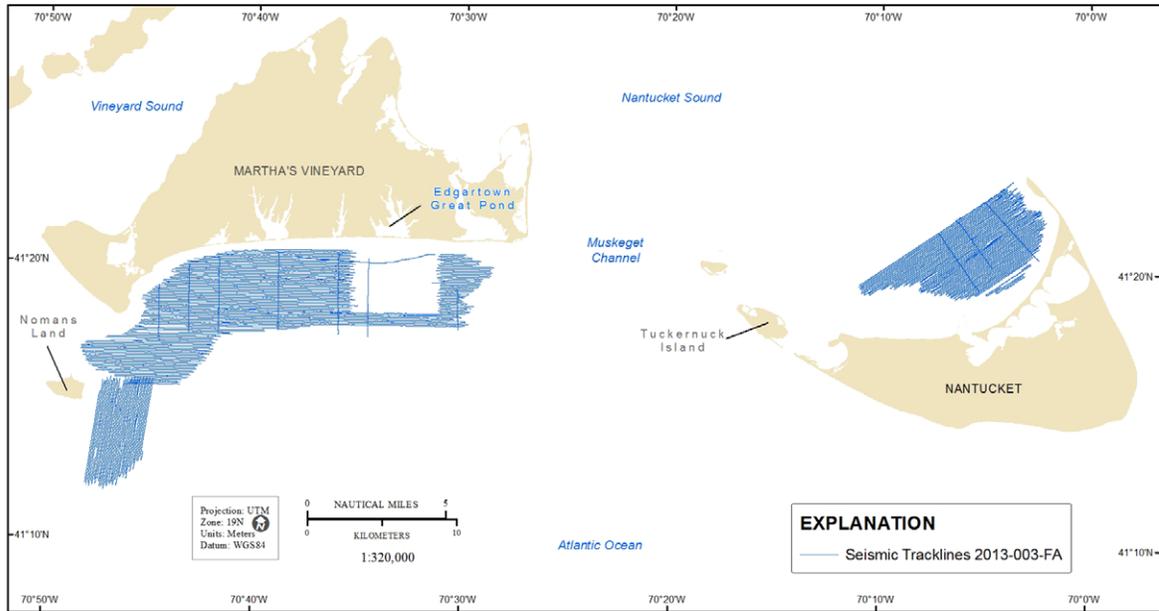
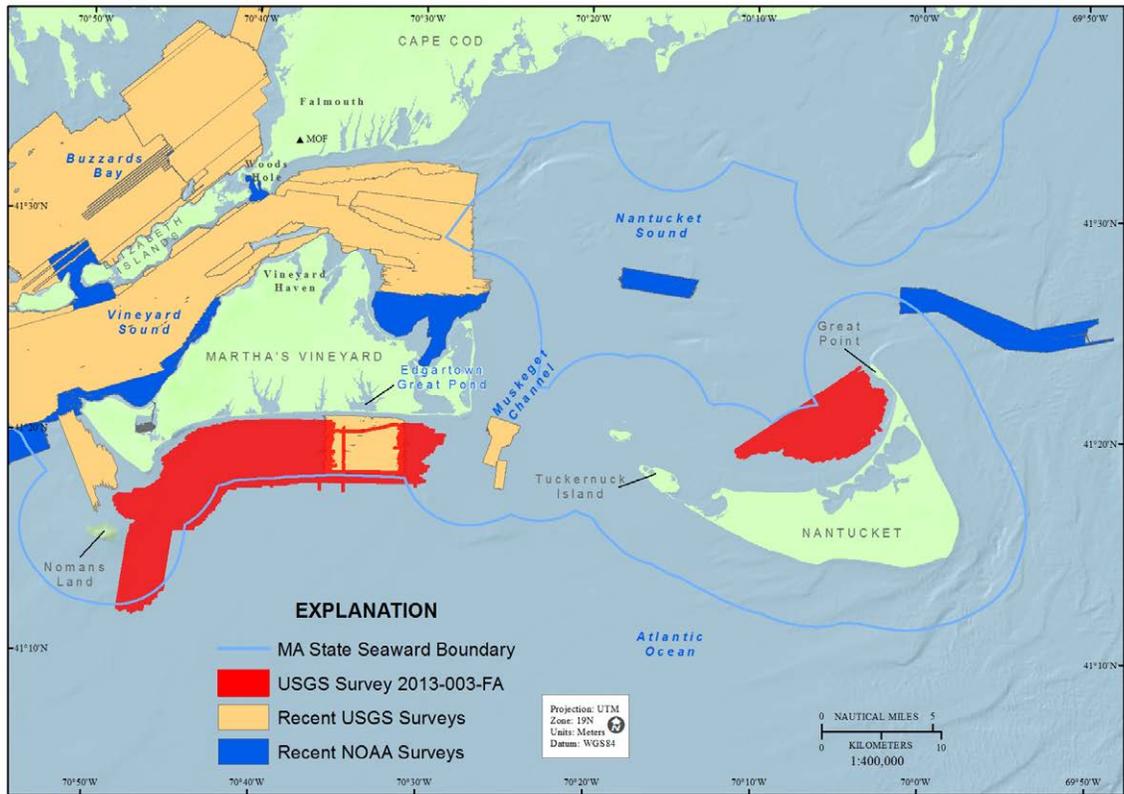


Figure 7. Map showing tracklines along which seismic-reflection profiles were collected in the survey areas, south of Martha's Vineyard and north of Nantucket, Massachusetts. UTM, Universal Transverse Mercator; WGS 84, World Geodetic System of 1984.



Data Source: MassGIS, USGS, NOAA/NGDC

Figure 8. Map showing the location of additional geophysical data in Massachusetts waters near the survey areas south of Martha's Vineyard and north of Nantucket (red polygons). These data were collected by the U.S. Geological Survey (USGS, orange polygons) and the National Oceanic and Atmospheric Administration (NOAA, blue polygons). Is., Island; MA, Massachusetts; MassGIS, Massachusetts Office of Geographic Information; MOF, Marine Operations Facility; NGDC, National Geophysical Data Center; NOAA, National Oceanic and Atmospheric Administration; UTM, Universal Transverse Mercator; WGS 84, World Geodetic System of 1984.

# Appendix 1. Geophysical Data

This section describes the data collected for this project, the location of the data, and how to access them.

## Data Format and Projection

All vector data are delivered as Esri shapefiles in the World Geodetic System of 1984 (WGS 84) geographic coordinate system. The raster data are georeferenced tagged image file format (GeoTIFF) files in Universal Transverse Mercator (UTM), Zone 19, WGS 84 projection. These data can also be accessed through the U.S. Geological Survey Coastal and Marine Geology Program Web Map server (<http://coastalmap.marine.usgs.gov/>).

All spatial data are distributed with Esri-style Federal Geographic Data Committee (FGDC) metadata in extensible markup language (XML) format. Metadata are also provided for all spatial data in text (TXT) and FGDC classic hypertext markup language (HTML) formats. Esri ArcCatalog 10.x or 9.x can also be used to examine the metadata in a variety of additional formats.

## Data Access

The complete datasets from this project can be accessed in two different ways, depending on available software.

1. If you have ArcGIS 9.x or 10.x, all shapefile and raster data may be viewed and manipulated, although Spatial Analyst extension will be required to fully work with the raster datasets. ArcGIS 10.3 or higher is required to use the ArcMap project *2016-1148\_10\_3.mxd* with all of the datasets pre-loaded.
2. If you do not have any geographic information system (GIS) software, a free software download is available to view the data.

## If You Have ArcGIS

Make a new folder structure on your computer matching the structure shown in the “Data Organization” section, then download each of the ZIP files in the data catalog below to the corresponding folder on your computer. Download the ArcMap document *2016-1148\_10\_3.mxd* to the parent "GIS" directory. This map document has all the data layers loaded in the table of contents and uses relative links, so there is no need to change any pathways for drive letters, if all folders remain the same under the parent directory (GIS). After unzipping each of the files, your GIS folder should be organized as described in the “Data Organization” section. Alternatively, you may also try to download and replicate the contents of the **GIS** folder on your computer. *Note: the ArcMap project 2016-1148\_10\_3.mxd will only work with ArcGIS version 10.3 or higher.*

## If You Do *Not* Have Any GIS Software

You can still view all the data via other free mapping applications distributed by Esri for Windows, Linux, and Unix operating systems. Download the free Esri software, ArcExplorer (<http://www.esri.com/software/arcgis/explorer/index.html>), or other open-source GIS software to view the datasets.

## Data Organization

The data are organized in folders on the Web site where this report is served (<http://dx.doi.org/10.3133/ofr20161168>). The file structure is described below. Data layers can be downloaded individually from the table below. Individual layers are provided in compressed (ZIP) files. Files in a ZIP archive can be extracted with various free software programs that can be found online.

 **GIS\_catalog.**—Top-level directory for all spatial data. Copy or download the files to this folder on a local hard drive. Note: The size of the uncompressed GIS directory is approximately 3 gigabytes (GB).

**2016-1168\_10\_3.mxd**—ArcGIS 10.3 map document with all data loaded in the ArcMap table of contents.

 **raster.**—Folder containing all raster spatial data in GeoTIFF format. Contains the following subdirectories:

 **bathy.**—Folder containing bathymetry GeoTIFF of the U.S. Geological Survey (USGS) interferometric sonar data as well as a depth-colored shaded-relief (hillshade) GeoTIFF image of the bathymetry data.

 **backscatter.**—Folder containing the sidescan-sonar backscatter GeoTIFF mosaic.

 **hyperlink\_images.**—Folder containing seismic profile images in portable network graphics (PNG) format. Seismic profile images can be hyperlinked to the 2013–003–FA\_512i\_shottrack layer in the ArcMap document (MXD) table of contents. Use the hyperlink tool in ArcGIS to click on these survey lines and view the linked image. (This should work flawlessly if the entire content of the GIS directory is copied from the disc and the seismic profile images are unzipped according to the README.txt instructions included in the hyperlink\_images folder).

 **shapefile.**—Folder containing shapefiles in geographic coordinate system WGS 84.

 **navigation.**—Folder containing ZIP-compressed raw HYPACK navigation files from USGS survey 2013–003–FA.

## Data Catalog

*Vector Data.*—The vector data are stored and delivered in shapefile format in geographic coordinates. The hyperlinks in the “Layer (metadata)” column are linked to the metadata for the shapefile. The link in the "Download file (size)" column provides access to a compressed ZIP file, which contains the shapefile and the metadata.

| Layer (metadata)                                  | Description  | Preview   | Download file (size)                            |
|---|--|---|---|
| <a href="#">2013-003-FA_BathyTracklines</a>       | Tracklines for the swath bathymetry surveys  |    | <a href="#">Shapefile</a><br>(6 megabytes [MB]) |
| <a href="#">2013-003-FA_512i_shot500</a>          | Locations of seismic shotpoints at 500-shot intervals and the unique shot navigation (in CSV format)             |    | <a href="#">Shapefile</a><br>(<1 MB)            |
| <a href="#">2013-003-FA_512i_shottrack</a>        | Tracklines of seismic profiles   |    | <a href="#">Shapefile</a><br>(21 MB)            |
| <a href="#">2013-003-FA_BackscatterTracklines</a> | Tracklines of the swath backscatter survey   |  | <a href="#">Shapefile</a><br>(8 MB)             |
| <a href="#">OUTLINE25K_POLY</a>                   | Outline of the Commonwealth of Massachusetts (from the Massachusetts Office of Geographic Information [MassGIS]) |  | <a href="#">Shapefile</a><br>(2.3 MB)           |

*Raster Data.*—The primary coordinate system for the raster data is WGS 84 UTM Zone 19. The link in the "Download file (size)" column provides access to a compressed ZIP file, which contains the raster data and the metadata.

| Raster Layer (metadata)                   | Description   | Preview   | Download file (size)                |
|---|---|---|-------------------------------------|
| <a href="#">2013-003-FA_Bath5m</a>        | 5-m bathymetric 32-bit continuous floating point GeoTIFF and depth-colored shaded-relief image            |  | <a href="#">GeoTIFFs</a><br>(40 MB) |
| <a href="#">2013-003-FA_Backscatter1m</a> | 1-meter (m) backscatter mosaic of sidescan-sonar data in 8-bit continuous unsigned integer GeoTIFF format |  | <a href="#">GeoTIFF</a><br>(104 MB) |

*Image Data.*—The link in the "Download file (size)" column provides access to a compressed ZIP file, which contains images in JPEG format and the metadata.

| Hyperlinked Images<br>(metadata)        | Description                                     | Preview   | Download file (size)                                |
|---|---|---|---|
| <a href="#">2013-003-FA_512i_images</a> | Seismic-reflection profile images in PNG format |  | <a href="#">2013-003-FA_512i_images</a><br>(844 MB) |

*Navigation Data.*—The link in the "Download (file (size))" column provides access to a compressed ZIP file, which contains the navigation files and the metadata.

| Navigation                         | Description   | Download file (size)                        |
|------------------------------------|---|---|
| <a href="#">2013-003-FA_HYPACK</a> | Navigation data from USGS survey 2013–003–FA<br>(13003) | <a href="#">2013-003-FA_HYPACK</a> (625 MB) |



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