# NOAA COASTAL MAPPING PROGRAM
# PROJECT COMPLETION REPORT

## *PROJECT MA1601B-TB-C*

## *Nantucket Island, Massachusetts*

## Introduction

NOAA Coastal Mapping Program (CMP) Project MA1601B-TB-C provides a highly accurate database of new digital shoreline data for Nantucket Island, Massachusetts. Project MA1601B-TB-C is a subproject of a larger project, MA1601-TB-C, which includes Martha's Vineyard, Nantucket Island, and nearby smaller islands and shoals.

The project database consists of information measured and extracted from aerial photographs and metadata related to photogrammetric compilation. Base mapping was conducted in a digital environment using stereo softcopy photogrammetry and associated cartographic practices, supplemented with lidar-derived Mean High Water (MHW) and Mean Lower Low Water (MLLW) data. The Geographic Cell (GC) may be used in support of the NOAA Nautical Charting Program (NCP) as well as geographic information systems (GIS) for a variety of coastal zone management applications.

## Project Design

The NOAA National Geodetic Survey (NGS) formulated the Project Instructions for this project following the guidelines of the "Scope of Work, Shoreline Mapping for the Coastal Mapping Program" (SOW), Version 14A, dated October 24, 2012. The instructions discussed the project's purpose, geographic area of coverage, scope and priority; data acquisition, processing, accuracy, and compilation requirements; product delivery and reporting instructions; and contact and communication information. NOAA also provided shapefiles depicting the shoreline to be mapped and the boundaries of the main project area.

Dewberry subcontracted Leading Edge Geomatics, LLC (LEG) for the aerial imagery and lidar acquisition phase of the project. LEG was responsible for the planning, acquisition, and processing of all aerial data in order to support photogrammetric and lidar processing for feature compilation. This includes the establishment of ground control, and the post-processing of airborne GPS data. In addition, LEG provided shapefiles of the flight lines and exposure centers of the imagery to be used for compilation.

## Field Operations

Dewberry and LEG performed field operations for project MA1601-TB-C consisting of the acquisition of aerial photographs and topobathy lidar, as well as the surveying of ground control points (GCPs) accuracy assessment checkpoints (CPs), and the establishment of base stations to support aerial collection and real-time kinematic (RTK) survey operations.

A total of fifty (50) CPs and nineteen (19) GCPs were surveyed by Dewberry using a Trimble Network RTK GPS system with Virtual Reference Station techniques. Survey field work was

performed between September 27 and December 9, 2016. For further information see the CP and GCP Survey Reports on file with other project data within the RSD Electronic Data Library.

Additional ground survey operations were conducted by LEG in October 2016 to support subsequent aerial imagery and lidar collections. A total of two (2) aerial base stations, nine (9) RTK base stations, two (2) control points, 58 aerial photo targets, and 203 lidar vertical control points were surveyed using a combination of traditional static and RTK GPS techniques. For further information see the MA1601-TB-C Nantucket and Martha's Vineyard Control Report on file within the RSD Electronic Data Library.

The LIDAR acquisition was conducted by LEG from October 5, 2016 thru October 31, 2016 and consisted of a total of 630 passes using a Piper Navajo aircraft at an altitude of 400 m. (AGL) to complete the entire 234 square mile project area. Topo-bathy lidar data was collected with a Leica/AHAB Chiroptera II Lidar system at an aggregate nominal point density of 13.2 pulses per square meter (topo) and 2.6 ppsm (bathy), with a nominal swath width of 291 meters and a 50% swath overlap. For further information see the Topobathy Final Report of Survey on file within the RSD Electronic Data Library.

The aerial photography phase of the project was conducted by LEG from October 30, 2016 thru November 23, 2016 using a Cessna 206 aircraft. A total of 57 flight lines of color-infrared imagery were acquired and tide-coordinated within 25% of the Mean Range of tide around MLLW. Of these flight lines, 33 were used for the MA1601B-TB-C subproject. Imagery was captured at a nominal altitude of 3000 m. (9800 ft.), with an approximate ground sample distance (GSD) of 25 cm, through the use of an Ultracam LP digital aerial camera having a focal length of 70 mm, and equipped with forward motion compensation and a stabilized camera mount. For further information see the MA1601-TB-C Photo Acquisition Status Final Report on file within the RSD Electronic Data Library.

## GPS Data Processing

For the lidar acquisition the airborne GPS data was processed using the Inertial Explorer from Waypoint. For the aerial imagery acquisition the kinematic GPS/IMU data was collected using an Applanix POSAV Model 410 IMU unit with a dual-frequency Trimble BD960 to collect the INS data. Airborne GPS data was processed using the Applanix POSPac kinematic On-The-Fly (OTF) software, with single-base processing utilizing a CORS station (MAFA) for a base station, to achieve the final photo center locations. For further information refer to the Airborne Positioning and Orientation Report (APOR) on file with other project data within the RSD Electronic Data Library.

## Lidar Data Processing

LEG collected the raw topobathy lidar data for Project MA1601-TB-C and performed the initial processing and quality control, including calibration, checks for data voids, relative swath accuracy, refraction correction, and preliminary vertical accuracy assessment. Initial processing confirmed that the lidar data products meet or exceed the requirements set out in the Statement of Work, and LEG delivered the calibrated lidar swath data to Dewberry in December 2016.

Dewberry utilized a variety of software for lidar data processing, including Leica LP360, TerraScan, Esri ArcGIS, QT Modeler, GeoCue, Global Mapper, and Dewberry's proprietary

LIDAR Processor tool. Data processing included additional quality checks and accuracy assessments of the preliminary swath data, breakline creation to define the land/water interface, point classification, automated and manual editing of the lidar tiles, QA/QC, and final formatting of the LAS tiles. The final processed lidar products that were delivered to NOAA included the raw point cloud data (swaths), breaklines, classified LAS tiles, topobathy DEM tiles, void polygon layer, intensity image tiles, confidence maps, and FGDC compliant metadata files.

NGS received the 7030 classified lidar tiles covering the project area, and used NOAA VDatum software to convert the vertical datum of the lidar points from NAD83 ellipsoid to local MHW and MLLW tidal datums. QT Modeler and custom ArcGIS Scripts were used to produce bare earth MHW and MLLW digital elevation models at a 1 meter grid resolution and to create and format the MHW and MLLW vectors into shapefile format.

The lidar point cloud was first compared to higher accuracy ground control points to determine vertical uncertainties of the data set, and then compared to the morphologic slope around the derived shoreline at a large number of sample sites in the MA1601B-TB-C subproject area to determine the uncertainty of the derived vectors. Based on this assessment the MHW lidar-derived shoreline vectors meet a horizontal accuracy of 1.54 meters at the 95% confidence level, and the MLLW lidar-derived shoreline vectors meet a horizontal accuracy of 2.94 meters at the 95% confidence level.

NOAA supplied the lidar-derived MHW and MLLW shapefiles to be segmented, edited, and attributed by Dewberry. For further information refer to the Final Report of Survey on file with other project data within the RSD Electronic Data Library.

## Aerotriangulation

The aerotriangulation (AT) phase of project MA1601-TB-C was performed by LEG using digital AT methods to establish the network of photogrammetric control required for the compilation phase. Inpho Match-AT software was used to perform automatic point measurements and interactive point measurements of tie points.

The Root Mean Square (RMS) of the standard deviations in both X and Y directions were calculated and used to determine a predicted horizontal circular error of 0.16 meters at the 95% confidence level. An Aerotriangulation (AT) Report is on file with other project data within the RSD Electronic Data Library.

The project database consists of project parameters and options, camera calibration data, interior orientation parameters, ground control parameters, adjusted exterior orientation parameters, and positional listing of all measured points. Positional data is referenced to the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD88).

## Compilation

The data compilation phase of the project was initiated by Dewberry personnel in July 2017. Digital mapping was performed with the SOCET for ArcGIS module of SOCET SET. This enabled compilation of features into an Esri Geodatabase where topological and attribution relationships could be enforced. Once compilation was complete, the geodatabase features were exported to shapefile format. Feature attribution was assigned in compliance with the Coastal

Cartographic Object Attribute Source Table (C-COAST), which provides the definition and attribution scheme for the full range of cartographic features pertinent to the CMP. Selected features were further modified with additional descriptive information to refine general classification.

Spatial data accuracies for subproject MA1601B-TB-C were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features compiled from the aerial imagery were compiled to meet a horizontal accuracy of 0.3 meters at the 95% confidence level. This predicted accuracy of compiled, well defined points is derived by doubling the circular error calculated from the Nantucket Island aerotriangulation statistics. The horizontal accuracy of the lidar-derived vectors is given in the section above on Lidar Data Processing.

The following table provides information on the imagery used to complete this project:

| Date | Time (UTC) | Flight Line | Photo ID | Tide Level * |
|---|---|---|---|---|
| 11/4/2016 | 14:18 – 14:28 | 008 | 200034 – 200070 | 0.5 |
| 11/5/2016 | 13:54 – 14:00 | 009 | 300001 – 300043 | 0.4 |
| 11/5/2016 | 14:05 – 14:14 | 010 | 300044 – 300073 | 0.4 |
| 11/5/2016 | 14:16 – 14:20 | 011 | 300074 – 300099 | 0.4 |
| 11/5/2016 | 14:23 – 14:29 | 012 | 300100 – 300121 | 0.4 – 0.5 |
| 11/5/2016 | 14:31 – 14:34 | 013 | 300122 – 300141 | 0.5 |
| 11/5/2016 | 14:38 – 14:43 | 014 | 300142 – 300159 | 0.5 |
| 11/5/2016 | 14:45 – 14:48 | 015 | 300160 – 300175 | 0.5 |
| 11/5/2016 | 14:51 – 14:55 | 016 | 300176 – 300189 | 0.5 |
| 11/5/2016 | 14:57 – 14:58 | 017 | 300190 – 300199 | 0.5 |
| 11/5/2016 | 15:07 – 15:15 | 018 | 300200 – 300232 | 0.5 |
| 11/22/2016 | 16:22 – 16:26 | 030 | 500020 – 500046 | 0.3 |
| 11/22/2016 | 16:30 – 16:37 | 031 | 500047 – 500073 | 0.2 |
| 11/22/2016 | 17:00 – 17:04 | 032 | 500145 – 500159 | 0.2 |
| 11/22/2016 | 17:13 – 17:15 | 033 | 500191 – 500204 | 0.2 |
| 11/22/2016 | 17:18 – 17:21 | 034 | 500205 – 500216 | 0.2 |
| 11/22/2016 | 18:18 – 18:19 | 041 | 500333 – 500339 | 0.2 |
| 11/22/2016 | 18:21 – 18:24 | 042 | 500340 – 500350 | 0.2 |
| 11/22/2016 | 18:31 – 18:35 | 043 | 500372 – 500399 | 0.2 |
| 11/22/2016 | 18:40 – 18:44 | 044 | 500400 – 500414 | 0.3 |
| 11/23/2016 | 14:28 – 14:33 | 045 | 600019 – 600050 | 0.8 |
| 11/23/2016 | 14:36 – 14:38 | 046 | 600051 – 600062 | 0.8 |
| 11/23/2016 | 14:41 – 14:44 | 047 | 600063 – 600074 | 0.7 |
| 11/23/2016 | 14:47 – 14:49 | 048 | 600075 – 600087 | 0.7 |
| 11/23/2016 | 14:53 – 14:56 | 049 | 600088 – 600100 | 0.7 |
| 11/23/2016 | 14:58 – 15:00 | 050 | 600101 – 600110 | 0.7 |

| 11/23/2016 | 15:02 – 15:05 | 051 | 600111 – 600122 | 0.6 |
|---|---|---|---|---|
| 11/23/2016 | 15:23 – 15:27 | 053 | 600135 – 600149 | 0.6 |
| 11/23/2016 | 15:29 – 15:31 | 054 | 600150 – 600163 | 0.6 |
| 11/23/2016 | 15:43 – 15:49 | 056 | 600176 – 600196 | 0.5 |
| 11/23/2016 | 15:52 – 15:56 | 057 | 600197 – 600224 | 0.5 |

\* Water levels are given in meters above MLLW and are based on verified observations recorded by the NOS tide gauge at Nantucket Island (Station ID: 8449130) in Massachusetts. The elevation of the MHW tidal datum at the Nantucket gauge is 0.985 meters above MLLW.

## Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of Dewberry. The final QC review was completed in March 2018. The review process included analysis of aerotriangulation results and assessment of the identification and attribution of digital feature data within the GC according to image analysis and criteria defined in C-COAST. The quality control process concluded with an inspection of topological connectivity within the GC using ArcGIS 10.5.1 software. All project data was evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with project imagery and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following nautical charts were used in the comparison process:

- 13241, Nantucket Island, 1:40,000 scale, 18th Ed., Mar. 2014
- 13242, Nantucket Harbor, 1:10,000 scale, 18th Ed., Dec. 2011

## End Products and Deliverables

The following specifies the location and identification of the products generated during the completion of this project:

**Remote Sensing Division Electronic Data Library**
- Project database
- Ground Survey Reports
- Airborne Positioning and Orientation Report (APOR)
- Aerotriangulation Report
- Photo Acquisition Status Final Report
- Topobathy Final Report of Survey
- GC11326 in shapefile format
- Project Completion Report (PCR)
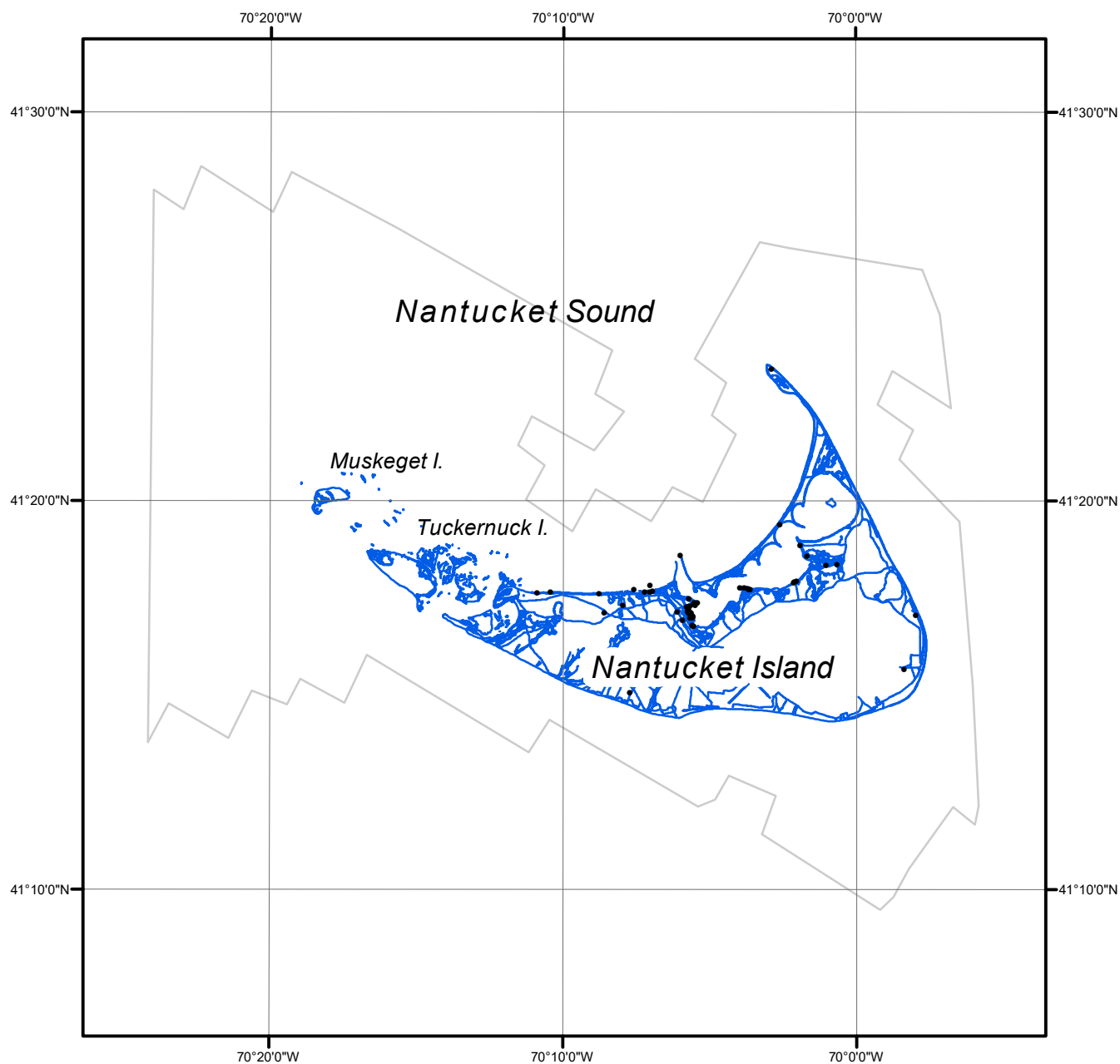- Chart Evaluation File (CEF) in shapefile format

**NOAA Shoreline Data Explorer**
- GC11326 in shapefile format
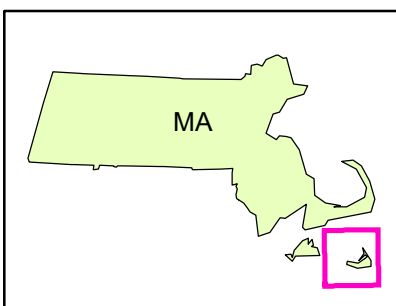- Metadata file for GC11326
- PCR in Adobe PDF format

## End of Report

# NANTUCKET ISLAND

# MASSACHUSETTS

70°20'0"W  70°10'0"W  70°0'0"W

41°30'0"N

*Nantucket Sound*

*Muskeget I.*

41°20'0"N

*Tuckernuck I.*

*Nantucket Island*

41°10'0"N

70°20'0"W  70°10'0"W  70°0'0"W

Overview

MA

MA1601B-TB-C

GC11326