NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT NY1409-TB-C

Coney Island to Montauk, New York

Introduction

NOAA Coastal Mapping Program (CMP) Project NY1409-TB-C provides a highly accurate database of new digital shoreline data for a portion of the Eastern Coastline of the United States extending from Coney Island to Montauk, New York. The approximate bounding coordinates of the project are 40° 29' to 41° 08' north latitude, and 71° 48' to 74° 04' west longitude. Project NY1409-TB-C is the northernmost part of a topographic/bathymetric lidar mapping initiative to provide updated shoreline data from Winyah Bay, South Carolina to Montauk, New York in the wake of Hurricane Sandy.

Successful completion of this project resulted in a densification of the National Spatial Reference System, a set of controlled metric-quality aerial photographs, lidar point cloud data, and digital feature data of the coastal zone which complements the Nautical Charting Program as well as geographic information systems (GIS) for a variety of coastal zone management applications.

The project database consists of information measured and extracted from aerial lidar data and digital imagery, and metadata related to shoreline extraction and derivation. Base mapping was conducted within both digital GIS and stereo softcopy photogrammetric environments using associated cartographic practices supplemented with lidar derived Mean High Water (MHW) and Mean Lower Low Water (MLLW) contour data.

Project Design

NY1409-TB-C was designed to support:

1) Application of topographic/bathymetric (topobathy) data acquired under the Sandy Supplemental Topo-Bathy project at the National Geodetic Survey (NGS),
2) Chart update activity of the Marine Chart Division (MCD),
3) Bathymetric data assessment by the Hydrographic Surveys Division (HSD).

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.

Field Operations

The field operations for NY1409-TB-C consisted of acquisition of topobathy lidar data, digital aerial imagery, static and kinematic GPS data, and Inertial Measurement Unit (IMU) data. Static GPS data were collected to support aerial data acquisition and processing operations, as well as to assess the accuracy of post-processed lidar data.

Lidar Data Acquisition
The topobathy lidar acquisition was conducted from November 11, 2013 through July 27, 2014 and consisted of a total of 262 lidar acquisition missions for airborne laser point cloud data. Lidar was captured with an approximate nominal point density of ≥ 4 pulses per square meter through the use of the Riegl VQ-820G sensor. The data were collected within a +/- 2 hour time window of the Mean Lower Low Water (MLLW) tide stage at a nominal altitude of 1,000 feet with a 50% swath overlap.

Digital Aerial Imagery Acquisition
The digital imagery acquisition for NY1409 was conducted from April 25, 2014 through June 8, 2014 and consisted of a total of ten flight lines of natural color imagery, tide coordinated within 25% of the Mean Range. Imagery was captured at a nominal altitude of 10,000 feet with a ground sample distance (GSD) of 0.30 meters through the use of Intergraph *Z/I Imaging* large format Digital Mapping Cameras (DMC) with a focal length of 120 millimeters.

Ground Control
A total of 126 ground control points were established in the NY1409-TB-C project area using a combination of traditional static, fast-static, rapid-static, real-time kinematic, and post processed kinematic GPS techniques. Survey field work was performed between November 23, 2013 and June 03, 2014. A Ground Survey Report is on file with other project data within the NGS Remote Sensing Division (RSD) Electronic Data Library.

GPS Data Processing

Acquisition aircraft were equipped with either an Applanix POSAV Model 510 IMU and/or a dual-frequency Trimble BD960 to collect the ABGPS and IMU data. NGS CORS, and several Cooperative CORS stations, were used for base stations on the project, with at least two of these CORS stations being used to process each POSAV dataset 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

LIDAR point cloud data for all of the areas acquired under the Sandy Supplemental Topo-Bathy project were processed from January 2014 to September 2015 using the following steps:

1) Riegl RiProcess software was utilized to transform the lidar point cloud into a mapping projection and check the calibration stability.
2) Terrasolid software was utilized for assessing relative and absolute accuracies between overlapping lifts and relative with each lift, initial point cloud classification, editing of the lidar point cloud, and for classification of water surface, erroneous returns, bathymetric surface and bare earth points.
3) Refraction correction was performed through Dewberry's Lidar Processor.
4) Additional QC, point classification, and formatting were performed with GeoCue, Terrasolid, and Global Mapper Software.
5) NOAA VDatum software was used to convert the vertical datum of the lidar points from NAD83 ellipsoid to local MHW and MLLW tidal datums.

6) QTModeler and custom ArcGIS Scripts were used to produce bare earth MHW and MLLW digital elevation models (DEMs) at a 1 meter grid resolution and the extraction and formatting of MHW and MLLW Shoreline Shapefiles.
7) Accuracy Assessment: the lidar point cloud was 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 91,460 sample sites in the project area (63,748 MHW and 27,712 MLLW sites) to determine the uncertainty of the vectors. Based on this assessment:
    a. MHW lidar derived shoreline vectors meet a horizontal accuracy ranging from 1.0 to 2.8 meters at 95% CE,
    b. MLLW lidar derived shoreline vectors meet a horizontal accuracy ranging from 1.3 to 4.2 meters at 95% CE.

The journal article "Lidar-Derived National Shoreline: Empirical and Stochastic Uncertainty Analyses" (2010), published in the Journal of Coastal Research, contains more detailed information, and is on file in the RSD Electronic Data Library.

Aerotriangulation

The overall Sandy Supplemental Topo-Bathy project was divided into two parts for AT purposes: a southern section and a northern section. Project NY1409-TB-C was included in the northern section. The aerotriangulation (AT) phase of the project was performed using digital AT methods to establish the network of photogrammetric control required for the compilation phase. The Intergraph ImageStation Automatic Triangulation (ISAT) software (ver. 6.1) was used to perform automatic point measurements and interactive point measurements of tie points. See the *AT North Report* for the Sandy Supplemental Topo-Bathy project on file with other project data within the RSD Electronic Data Library for more information.

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 at the 95% confidence level (95% CE) of 0.29 meters for the NY1409 sub-block. 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). Stereo-models were examined and found to have acceptable levels of parallax for mapping purposes.

Compilation

The data compilation phase of this project was completed in September 2015 and accomplished in two phases: 1) Automated extraction from topo-bathy lidar, and 2) manual extraction using digital stereo imagery.

1) Lidar Shoreline approach: MHW and MLLW shoreline vectors (in shapefile format) for the outer coastline were delineated using the DEMs discussed above (LiDAR processing section) along with a Raster-to-Vector (R2V) script implemented within ESRI ArcGIS 10.2 software. Subsequently, digital orthoimagery and/or stereoscopic imagery were used to review, edit, and attribute the lidar shoreline vectors. The lidar derived shoreline data were limited to terrain features at the land/water interface and did not include

engineered, elevated features such as bulkheads, piers, bridges, landmarks, etc. The MHW ("Shoreline") and MLLW ("Contour") shape files were then imported into BAE Systems SOCET SET (SS) software (version 5.6.0), and a Feature Database (FDB) was created.

2) Manual Compilation approach: The manual data compilation phase was accomplished using a Digital Photogrammetric Workstation (DPW), which consists of a stereo-enabled PC-based graphics workstation running the Windows 2007 operating system and SOCET SET suite of digital photogrammetric software (version 5.6.0). The FDB, created above, was populated with additional features compiled using the SS Feature Extraction software module based on imagery analysis of the processed digital images and information extracted from the appropriate NOAA Nautical Charts, the U.S. Coast Guard Light List and other ancillary sources. 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. Features compiled using this method meet a horizontal accuracy of 0.6 meters at the 95% confidence level. This accuracy is derived by doubling the 95% CE computed from the AT solution.

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

Date	Time (UTC)	Flight Line	Photo ID	Tide Level*
04/28/2014	16:27 – 16:29	30-107	0021 – 0013	0.1 m.
04/28/2014	16:37 – 16:47	30-109	0001 – 0051	0.0 m.
04/28/2014	17:02 – 17:03	30-109	0122 – 0128	0.2 – 0.0 m.
04/28/2014	17:21 – 17:25	30-110	0115 – 0096	0.0 m.
04/28/2014	17:29 – 17:34	30-110	0072 – 0048	0.1 m.
04/28/2014	17:36 – 17:44	30-110	0040 – 0001	0.1 – 0.0 m.
06/07/2014	13:34 – 13:36	R30-107	0012 – 0001	0.2 m.
06/07/2014	13:43 – 13:47	R30-106	0001 – 0020	0.2 m.
06/07/2014	14:11 – 14:14	R30-105	0015 – 0001	0.3 m.
06/07/2014	14:22 – 14:26	30-104	0001 – 0024	0.3 m.
06/07/2014	14:40 – 14:41	30-101	0004 – 0001	0.3 m.
06/07/2014	14:45 – 14:47	30-102	0001 – 0011	0.3 m.
06/07/2014	15:22 – 15:23	R30-108	0004 – 0010	0.3 – 0.4 m.
06/08/2014	12:48 – 12:53	R30-110	0095 – 0073	0.2 m.
06/08/2014	12:57 – 12:59	R30-110	0047 – 0041	0.2 m.
06/08/2014	13:15 – 13:18	30-103	0019 – 0001	0.4 m.

* Water levels are given in meters above MLLW and are based on verified observations recorded by the NOS tide gauges at Sandy Hook, Montauk, and Newport, with time and height offsets applied to discrete tidal zones in the project area. The elevation of the MHW tidal datum along the outer coast in the project area varies between 0.72 – 1.55 meters above MLLW. The "R" prefix for the flight line ID indicates re-flights of lines or portions of lines.

Quality Control / Final Review

Quality control tasks were conducted by RSD personnel and the final QC review was completed in February, 2016. The review process included analysis of AT results and assessment of the identification and attribution of digital feature data within the GC according to image analysis, using Stereo and Ortho-image data, and criteria defined in C-COAST. The quality control process concluded with an inspection of topological connectivity within the GC using ArcGIS 10.2 software. All project data was evaluated for compliance to CMP requirements.

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

- 12350, Jamaica Bay and Rockaway Inlet, NY, 1:20,000 scale, 60th Ed., Aug. 2011
- 12352, Shinnecock Bay to East Rockaway Inlet, NY, 1:40,000 scale, 35th Ed., Feb. 2016
- 12353, Shinnecock Light to Fire Island Light, NY, 1:80,000 scale, 19th Ed., Nov. 2011
- 12358, Shelter Island Sound & Peconic Bays, NY, 1:40,000 scale, 21st Ed., Jul. 2011
- 12402, New York Lower Bay – Northern Part, NY, 1:15,000 scale, 12th Ed., Jun. 2012
- 13205, Block Island Sound and Approaches, RI, CT, NY, 1:80,000 scale, 40th Ed., Jul. 2014
- 13209, Block Island Sound and Gardiners Bay, NY, 1:40,000 scale, 27th Ed., May 2014
  Including 1:7,500 scale inset of Montauk Harbor

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

- Ground Control Report
- Airborne Positioning and Orientation Reports (APOR)
- Aerotriangulation Report
- Project Completion Report (PCR)
- Project database
- GC11176 in shapefile format
- Chart Evaluation File (CEF) in shapefile format

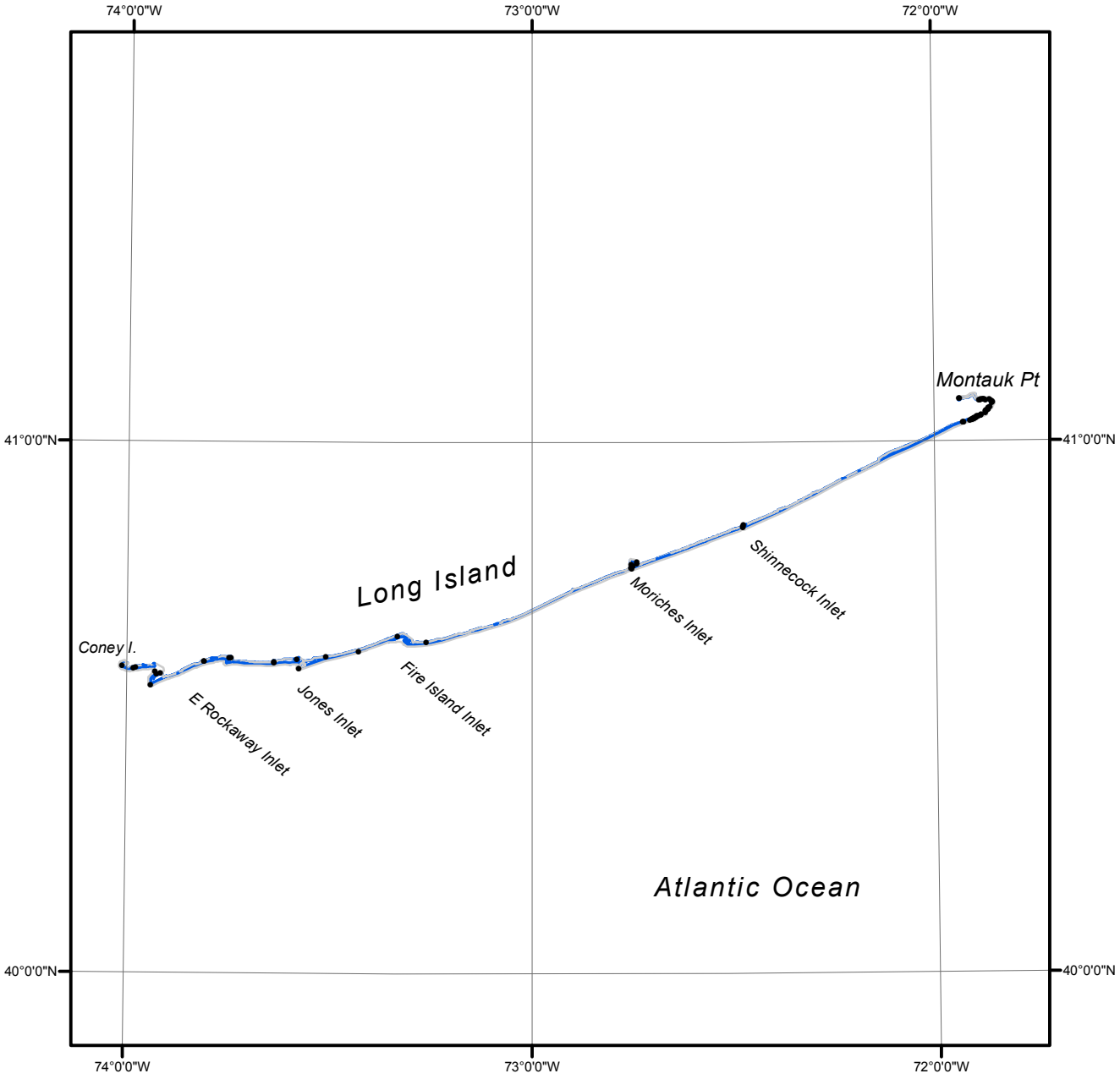
NOAA Shoreline Data Explorer

- GC11176 in shapefile format
- Metadata file for GC11176
- Digital copy of the PCR in Adobe PDF format

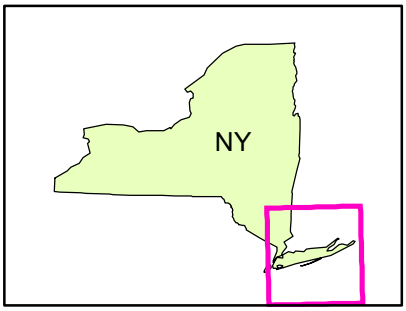
End of Report

CONEY ISLAND TO MONTAUK

NEW YORK



Overview



NY1409-TB-C

GC11176