NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT NJ1301

Barnegat Inlet, New Jersey

Introduction

NOAA Coastal Mapping Program (CMP) Project NJ1301 provides a highly accurate database of new digital shoreline data for Barnegat Inlet, New Jersey. The project area includes the Barnegat Inlet, the Barnegat Coast Guard Station as well as portions of Barnegat Bay. The approximate bounding coordinates are 39°43' to 39°48' latitude, and 74°04' to 74°09' longitude.

Successful completion of this project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric-quality aerial photographs, lidar point cloud, and digital feature data of the coastal zone which complements the Nautical Charting Program (NCP) 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 light detection and ranging (lidar) data, digital camera 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.

Project Design

NJ1301 was designed to support:

1) Application of Topographic/Bathymetric (topobathy) data derived from research operations ongoing at the National Geodetic Survey (NGS)
2) Bathymetric data assessment by the Hydrographic Surveys Division (HSD)
3) Chart update activity of the Marine Chart Division (MCD)

The Requirements Branch (RB) of the Remote Sensing Division (RSD) formulated the photographic mission instructions for this project following the guidelines of the Photo Mission Standard Operating Procedures. The instructions discussed the project's purpose, geographic area of coverage, scope and priority, imagery and lidar requirements, Global Positioning System (GPS) data collection procedures and guidelines, instructions for data recording and handling, and mission communication protocols. RB created a Project Layout Diagram, flight maps and input files for the aircraft flight management system.

Field Operations

The field operations 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

Sixty (60) lines of Topographic/Bathymetric (topobathy) lidar were acquired on September 23/24 of 2013 using a Riegl VQ820G LIDAR system on board the NOAA Twin Otter aircraft (N46RF). The topobathy lidar 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 (single swath point density = 18pt/m^2).

Digital Aerial Imagery Acquisition

Eleven Lines of natural color digital aerial imagery (281 images) were collected on September 29, 2013 using an Applanix Digital Sensor System 439 (DSS439) onboard the NOAA King Air aircraft (N68RF). The imagery was collected at a mid-tide stage and at a nominal altitude of 4,000 feet with a ground sample distance (GSD) of 0.14m.

For both acquisitions, base stations were established at the Atlantic City airport (KACY) and within the project site, using static GPS. Airborne kinematic GPS data were collected to determine precise sensor positions (XYZ) for the lidar and camera systems.

GPS/IMU Data Processing and Direct Georeferencing

GPS and IMU data were processed by RSD personnel to yield precise sensor positions and orientations for direct georeferencing (DG) of the imagery. A local GPS base station was established for use as a reference station for kinematic GPS processing operations. The position of the base station was determined using the NGS Online Processing User Service (OPUS), which computed fixed baseline solutions from nearby CORS stations. The airborne kinematic data was processed using Applanix POSPAC (ver. 5.4) software in October of 2013. For further information refer to the Airborne Positioning and Orientation Reports (APOR) on file with other project data within the RSD Applications Branch (AB) Project Archive.

The processed GPS/IMU data were used to derive precise exterior orientation (EO) values of the camera centers required for digital feature extraction. The predicted horizontal accuracy of the imagery was determined by propagating sensor EO and image measurement uncertainties through the photogrammetric collinearity equations using an Excel spreadsheet based Exterior Orientation Total Propagated Uncertainty (EO-TPU) tool developed by NGS. Using this tool, the predicted horizontal uncertainty at the 95% confidence level was calculated to be 0.5 meters.

Two NGS third order geodetic control points (“Barnegat Lighthouse” and “Barnegat Coast Guard Flagtower”) were used to verify the horizontal integrity of the DG data. All stereo-models were examined and found to have acceptable levels of parallax for mapping purposes.

LIDAR Data Processing

LIDAR point cloud data were processed in September 2013 using the following steps:

1) Riegl RiProcess software was utilized to transform the lidar point cloud into a mapping projection, check the calibration stability, and perform refraction corrections to bathymetric returns.
2) Terrasolid software was utilized for editing of the lidar point cloud, and for classification of water surface, erroneous returns, bathymetric surface and bare earth points.
3) NOAA VDatum software was used to convert the vertical datum of the lidar points from NAD83 ellipsoid to local MHW and local MLLW tidal datums.
4) GeoCue lidar processing software was used to produce bare earth MHW and MLLW digital elevation models (DEMs) at 1 meter grid resolution.
5) Accuracy Assessment: the lidar point cloud was compared to higher accuracy ground control points and the morphologic slope around the derived shoreline for 391 sample sites in the project area (117 MHW and 274 MLLW sites). Based on this assessment:
    a. MHW lidar derived shoreline vectors meet a horizontal accuracy of 0.6 meters at 95% CE,
    b. MLLW lidar derived shoreline vectors meet a horizontal accuracy of 1.6 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 Project Archive.

Compilation

The data compilation phase of this project was completed in February 2014 by RSD personnel and accomplished in two phases: Automated extraction from topobathy lidar and 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 with a Raster-to-Vector (R2V) script implemented within ESRI ArcGIS 10.1 software. Subsequently, the September 29 imagery was used to review, edit, and attribute the lidar shoreline vector. 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, and a Feature Database (FDB) was created.

2) Manual Compilation approach: The FDB, created above, was subsequently populated with additional features compiled using the SS Feature Extraction software module in combination with the stereo-images. This served to integrate all coastal features within a single FDB. The manual data compilation phase utilized the traditional RSD digital mapping approach of manual interpretation

integrated within a “heads-up” digitizing environment. Features compiled using this method meet a horizontal accuracy of 1.0 meter at 95% confidence level – derived by doubling the 95% CC computed in the TPU model discussed above.

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

Date	Time (UTC)	Roll Number	Strip	Photo Numbers	GSD (nominal)	Tide Level *, #
9/29/2013	14:11	13NC75	120005	24329 – 24351	0.14 m	0.4, 0.6
9/29/2013	14:17	13NC75	120006	24352 – 24379	0.14 m	0.4, 0.6
9/29/2013	14:22	13NC75	120007	24380 – 24405	0.14 m	0.4, 0.6
9/29/2013	14:27	13NC75	120008	24406 – 24433	0.14 m	0.4, 0.6
9/29/2013	14:33	13NC75	120009	24434 – 24461	0.14 m	0.4, 0.6
9/29/2013	14:39	13NC75	120010	24462 – 24484	0.14 m	0.4, 0.6
9/29/2013	14:43	13NC75	120011	24485 – 24512	0.14 m	0.4, 0.6
9/29/2013	14:49	13NC75	120012	24513 – 24540	0.14 m	0.4, 0.7
9/29/2013	14:54	13NC75	120013	24541 – 24568	0.14 m	0.4, 0.7
9/29/2013	15:01	13NC75	120014	24569 – 24598	0.14 m	0.4, 0.7
9/29/2013	15:06	13NC75	120015	24599 – 24609	0.14 m	0.4, 0.7

* Tide levels within Barnegat Bay are given in meters above MLLW and are based on verified observations at the Sandy Hook (8531680) reference station, with corrections applied to the Barnegat Inlet Inside (853615) substation within the project area. The height of the MHW tidal datum at this substation is approximately 0.7 meters above MLLW.

Tide levels on the outer coast are given in meters above MLLW and are based on verified observations at the Atlantic City (8534720) reference station, with corrections applied to the CO-OPS tidal zone (SA16). The height of the MHW tidal datum in this tidal zone is approximately 1.3 meters above MLLW.

Quality Control / Final Review

Quality control tasks were conducted by RSD personnel and the final QC review was completed in February, 2014. 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 10.1 software. All project data was evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with 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:

12324, Sandy Hook to Little Egg Harbor, NJ, 1:40,000 scale, 35th edition

End Products and Deliverables

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

RSD Applications Branch Archive

- Hardcopy of the NJ Bathy Lidar Data Acquisition Summary
- Hardcopy of the Airborne Positioning and Orientation Report (APOR)
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC11048 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project database
- GC11048 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

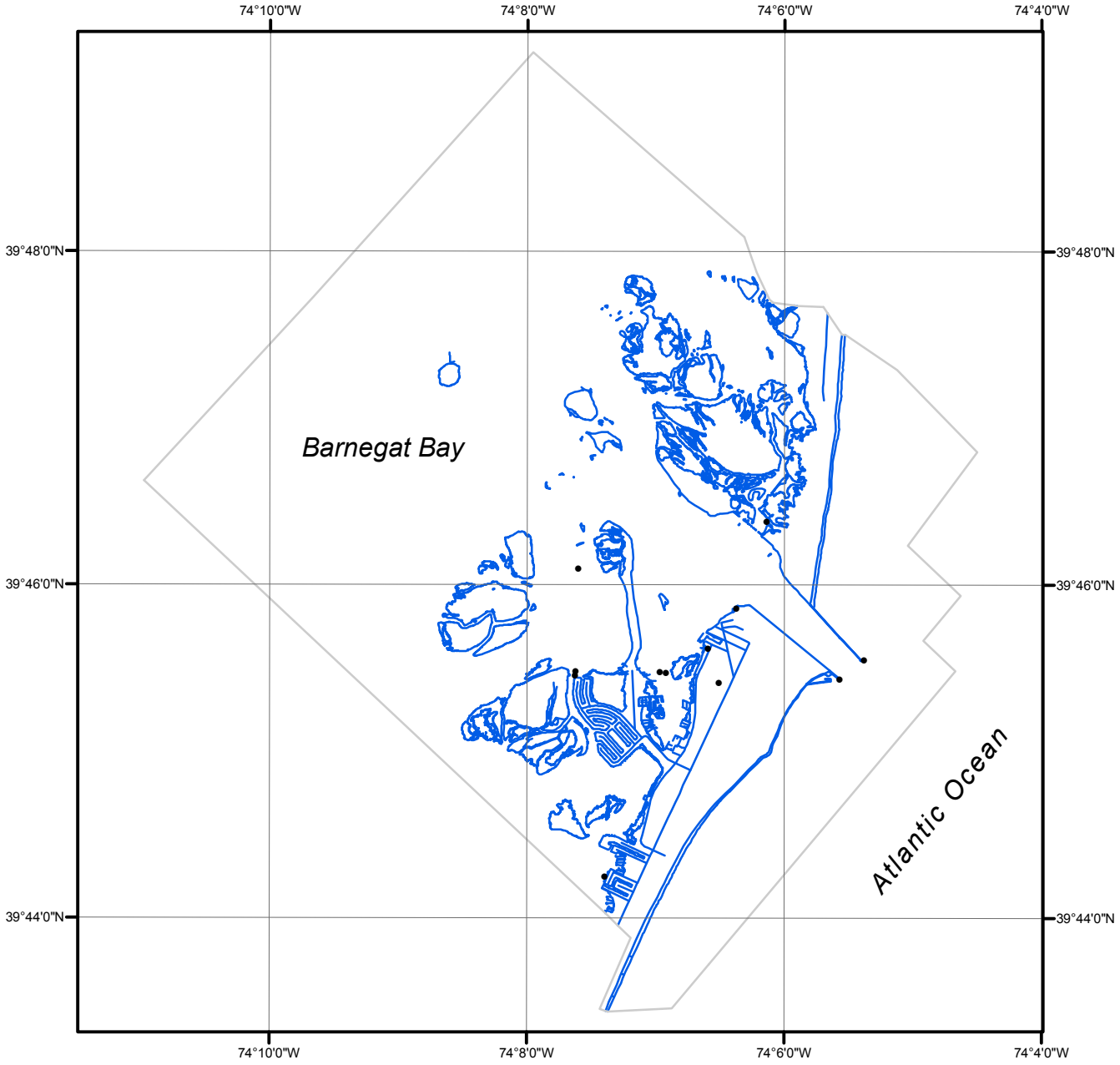
NOAA Shoreline Data Explorer

- GC11048 in shapefile format
- Metadata file for GC11048
- Digital copy of the PCR in Adobe PDF format

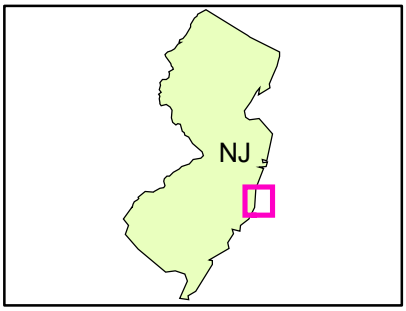
End of Report

BARNEGAT INLET

NEW JERSEY



Overview



NJ1301

GC11048