NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT MI1001A-CM-N

Stonington to Dutch Johns Point, Michigan

Introduction

NOAA Coastal Mapping Program (CMP) Project MI1001A-CM-N provides highly accurate digital shoreline data for a portion of Lake Michigan from Stonington to Dutch Johns Point, Michigan including various surrounding islands and tributaries. MI1001A-CM-N is a subproject of a larger project, MI1001-CM-N, which covers the entire eastern shore of Lake Michigan. 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 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, photographic requirements, Global Positioning System (GPS) data collection procedures and guidelines for both kinematic and static surveys, and data recording and handling instructions. RB also created project layout diagrams, flight maps, and input files for the aircraft's flight management system.

Field Operations

The field operations consisted of the collection of static and kinematic GPS data, Inertial Measurement Unit (IMU) data, the acquisition of digital aerial imagery, and the collection of ground control points. Photographic mission operations for MI1001-CM-N were conducted from September 7, 2010 to July 5, 2011 with the NOAA King Air (N68RF) aircraft. Two hundred and four flight lines of color imagery, along with simultaneous black & white infrared (IR) imagery, were acquired with an Applanix Digital Sensor System (DSS) 439 aerial camera at a nominal altitude of 10,000 feet, resulting in an approximate ground sample distance (GSD) of 0.35 meters. For subproject MI1001A-CM-N, only thirty-one strips of color imagery and IR imagery were used.

Photo Science, Inc. (PSI) was contracted by RSD to collect ground control points (GCPs). A total of seventeen GCPs were established for MI1001A-CM-N using static GPS techniques. Three additional photo-identifiable check points were also occupied at well-defined discrete locations. Survey field work was performed between April 30th and May 9th, 2013.

GPS Data Reduction

The GPS/IMU data was processed by RSD personnel to yield precise positions and orientations of camera centers for application as photogrammetric control in the aerotriangulation phase of

project completion. 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 kinematic GPS data was processed using Applanix POSPAC (ver. 6.1) software in January 2013. For further information refer to the Airborne Positioning and Orientation Reports (APOR) on file with other project data within the Remote Sensing Division Electronic Data Library. All positional data is referenced to the North American Datum of 1983 (NAD 83).

Aerotriangulation

Routine softcopy aerotriangulation (AT) methods were applied to establish a network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. This work was completed by PSI personnel in August 2013 using a softcopy photogrammetric workstation. The color and IR images were measured and adjusted as a single block using Intergraph ImageStation Automatic Triangulation (ISAT ver. 5.1) software which was used to perform automatic point measurements and interactive point measurements of tie points. The photo measurements were then exported into BAE Systems BINGO (ver. 6.2) aerotriangulation software within SOCET SET to perform the final bundle block adjustment. The analysis tools within BINGO were used to further refine the AT solution and to evaluate the accuracy of the adjustment. Upon successful completion of the aerotriangulation process, the BINGO software provided the RMS of the standard deviations of the residuals for each aerotriangulated ground point, which were used to compute a predicted horizontal circular error of 1.0 meters based on a 95% confidence level. As a final check, each of the ground control check points were measured and the coordinates compared to the coordinates of the surveyed points. An Aerotriangulation Report was completed and is on file with other project data within the RSD Electronic Data Library.

Compilation

The data compilation phase of the project was initiated by PSI personnel in August 2013. The work was accomplished using a Digital Photogrammetric Workstation (DPW), which is a configuration of computer hardware, modular software components and other associated peripheral devices. The Feature Extraction module was used within BAE Systems' SOCET SET (ver. 5.6) photogrammetric software. Feature identification and the assignment of cartographic codes were based on image analysis of the project digital images and information extracted from the appropriate NOAA Nautical Charts, 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). Selected features were further modified with additional descriptive information to refine general classification.

Spatial data accuracies for Project MI1001A-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were compiled to meet a horizontal accuracy of 2.0 meters at the 95% confidence level. This predicted accuracy of well-defined points is based on a doubling of the circular error derived from the aerotriangulation statistics.

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

Date	Time (UTC)	Color Imagery		Infrared Imagery		Lake Level
		Roll	Images	Roll	Images	
7-03-2011	13:15 – 13:25	11NC43	10913 – 10978	11NR22	4846 – 4912	176.2
7-03-2011	13:29 – 13:38	11NC43	10979 – 11045	11NR22	4913 – 4980	176.2
7-03-2011	13:45 – 13:56	11NC43	11069 – 11142	11NR22	5002 – 5076	176.3
7-03-2011	14:00 – 14:09	11NC43	11143 – 11209	11NR22	5167 – 5239	176.3
7-03-2011	14:16 – 14:26	11NC43	11234 – 11305	11NR22	5077 – 5144	176.3
7-03-2011	14:31 – 14:38	11NC43	11306 – 11363	11NR22	5240 – 5298	176.3
7-03-2011	14:46 – 14:54	11NC43	11385 – 11440	11NR22	5318 – 5374	176.3
7-03-2011	15:00 – 15:02	11NC43	11441 – 11453	11NR22	5375 – 5387	176.3
7-03-2011	15:10 – 15:15	11NC43	11454 – 11482	11NR22	5388 – 5416	176.3
7-03-2011	15:19 – 15:23	11NC43	11483 – 11510	11NR22	5417 – 5444	176.3
7-03-2011	15:27 – 15:30	11NC43	11511 – 11532	11NR22	5445 – 5466	176.3
7-03-2011	15:35 – 15:35	11NC43	11533 – 11537	11NR22	5467 – 5471	176.3
7-03-2011	15:40 – 15:44	11NC43	11538 – 11565	11NR22	5472 – 5499	176.3
7-03-2011	15:49 – 15:53	11NC43	11566 – 11594	11NR22	5500 – 5528	176.2
7-03-2011	16:09 – 16:11	11NC43	11605 – 11618	11NR22	5539 – 5552	176.2
7-03-2011	16:16 – 16:19	11NC43	11619 – 11638	11NR22	5553 – 5572	176.2
7-07-2011	14:41 – 14:46	11NC44	12640 – 12674	11NR23	6574 – 6608	176.3
7-07-2011	14:50 – 14:53	11NC44	12675 – 12693	11NR23	6609 – 6627	176.3
7-07-2011	14:58 – 15:01	11NC44	12694 – 12715	11NR23	6628 – 6649	176.3
7-07-2011	15:05 – 15:07	11NC44	12716 – 12731	11NR23	6650 – 6665	176.3
7-07-2011	15:13 – 15:15	11NC44	12732 – 12745	11NR23	6666 – 6679	176.3
7-07-2011	15:36 – 15:38	11NC44	12794 – 12804	11NR23	6728 – 6738	176.3
7-07-2011	15:58 – 16:01	11NC44	12841 – 12862	11NR23	6775 – 6796	176.3
7-07-2011	16:06 – 16:09	11NC44	12863 – 12884	11NR23	6797 – 6818	176.3
7-07-2011	17:02 – 17:06	11NC44	13000 – 13033	11NR23	6934 – 6967	176.3
9-18-2011	13:52 – 13:58	11NC45	13077 – 13119	11NR24	7011 – 7053	176.1
9-18-2011	14:05 – 14:10	11NC45	13120 – 13155	11NR24	7054 – 7089	176.1
9-18-2011	14:19 – 14:23	11NC45	13156 – 13179	11NR24	7090 – 7113	176.1
9-18-2011	14:28 – 14:32	11NC45	13180 – 13204	11NR24	7114 – 7138	176.1

9-18-2011	14:41 – 14:44	11NC45	13205 – 13221	11NR24	7139 – 7155	176.1
9-18-2011	14:51 – 14:56	11NC45	13222 – 13252	11NR24	7156 – 7186	176.1
9-18-2011	15:02 – 15:07	11NC45	13254 – 13284	11NR24	7188 – 7218	176.1

* Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the Port Inland station in Michigan. The Low Water Datum (LWD) for Lake Michigan is 176.0 meters.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of PSI. The final QC review was completed in November 2013. 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 (ver. 10.1) software. All project data were evaluated for compliance to CMP requirements.

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

- 14908, Dutch Johns Point to Fishery Pt, 1:80,000 scale (w/1:15,000 inset), 19th Ed., Jan. 2016
- 14909, Upper Green Bay, 1:80,000 scale, 21st Ed., Feb. 2016
- 14911, Waugoshance Point to Seul Choix Point, 1:80,000 scale, 22nd Ed., Feb. 2016
- 14915, Little Bay De Noc, 1:30,000 scale, 26th Ed., Mar. 2014

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
- GC10981 in shapefile format
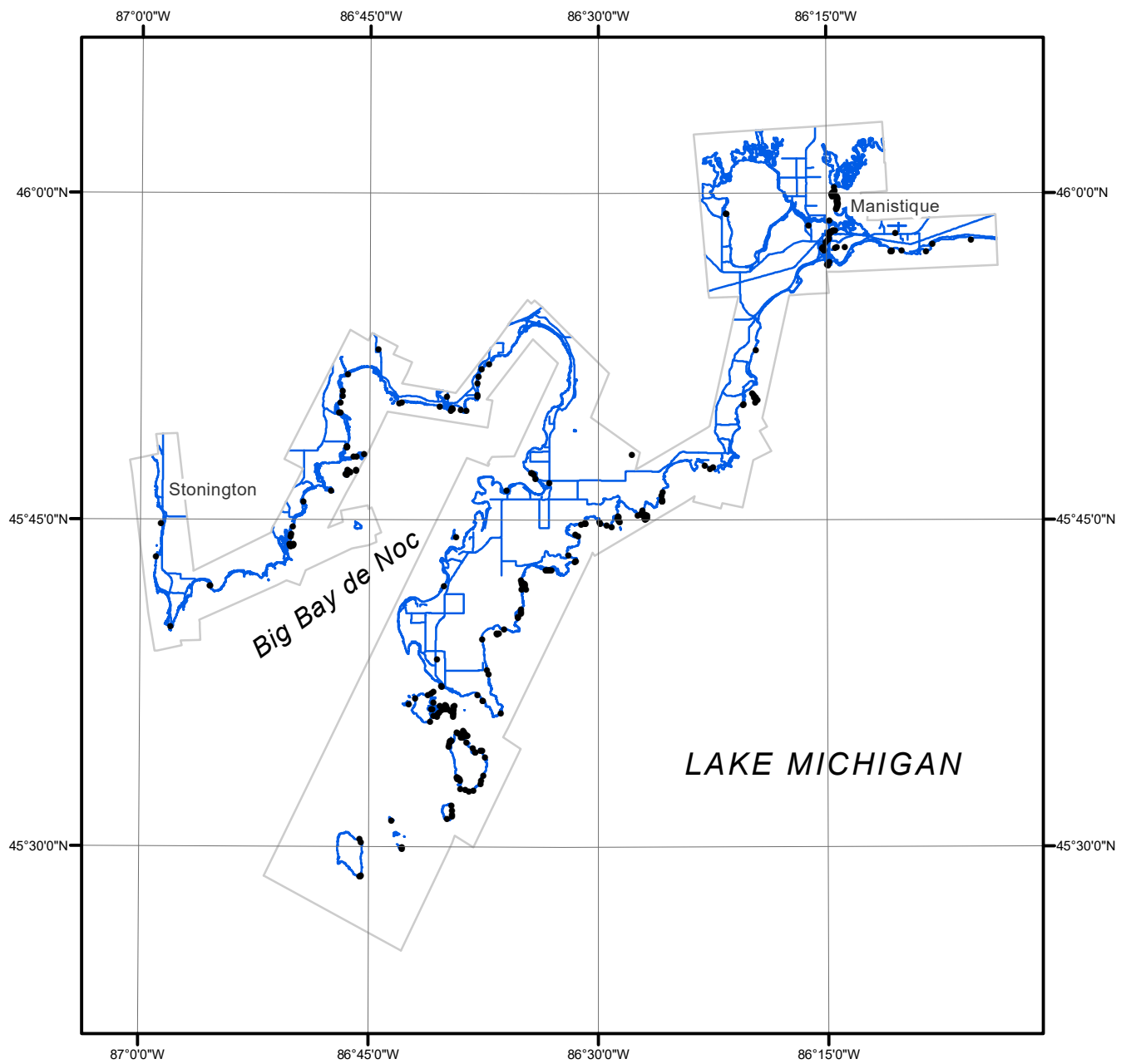- Chart Evaluation File in shapefile format

NOAA Shoreline Data Explorer

- GC10981 in shapefile format
- Metadata file for GC10981
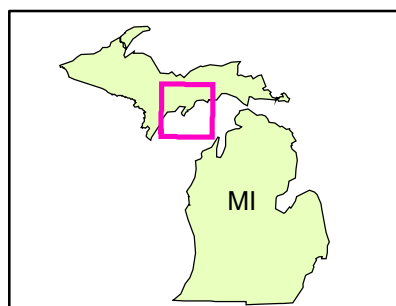- Digital copy of the PCR in Adobe PDF format

End of Report

STONINGTON TO DUTCH JOHNS POINT

MICHIGAN

87°0'0"W 86°45'0"W 86°30'0"W 86°15'0"W

46°0'0"N

Manistique

45°45'0"N

Stonington

Big Bay de Noc

LAKE MICHIGAN

45°30'0"N

87°0'0"W 86°45'0"W 86°30'0"W 86°15'0"W

Overview

MI

MI1001A-CM-N

GC10981