

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT MI1001D-CM-N

Grand Traverse Bay, Michigan

Introduction

NOAA Coastal Mapping Program (CMP) Project MI1001D-CM-N provides highly accurate digital shoreline data for Grand Traverse Bay, Michigan, extending around the northern end of Leelanau Peninsula from Gills Pier, and includes both West and East Arms. MI1001D-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 (RGB) 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 MI1001D-CM-N, only twenty-three strips of RGB and IR imagery were used.

Photo Science, Inc. (PSI) was contracted by RSD to collect ground control points (GCPs). A total of twelve GCPs were established for MI1001D-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 August 9 and August 11, 2014.

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 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 January 2015 using a softcopy photogrammetric workstation. The RGB and IR images were measured and adjusted as a single block using Intergraph ImageStation Automatic Triangulation (ISAT) software (v. 5.1) 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 aerotriangulation software (v. 6.2) 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 0.8 meters based on a 95% confidence level. As a final check, each of the three 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 May 2015. 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 (version 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 MI1001D-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were compiled to meet a horizontal accuracy of 1.6 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	
06-29-2011	19:04-19:12	11NC47	13549-13606	11NR26	7483-7540	176.2
06-29-2011	21:54-22:02	11NC47	14016-14072	11NR26	7950-8006	176.2
06-29-2011	22:05-22:07	11NC47	14073-14090	11NR26	8007-8024	176.2
06-29-2011	22:13-22:17	11NC47	14091-14116	11NR26	8025-8050	176.3
06-29-2011	22:26-22:32	11NC47	14118-14160	11NR26	8052-8094	176.3
06-29-2011	22:36-22:41	11NC47	14161-14201	11NR26	8095-8135	176.3
06-29-2011	22:45-22:51	11NC47	14202-14242	11NR26	8136-8176	176.3
06-30-2011	13:28-13:34	11NC48	14243-14282	11NR27	8177-8216	176.2
06-30-2011	14:53-14:55	11NC48	14529-14547	11NR27	8463-8481	176.2
06-30-2011	14:59-15:01	11NC48	14548-14556	11NR27	8482-8495	176.2
06-30-2011	15:05-15:06	11NC48	14562-14573	11NR27	8496-8507	176.2
06-30-2011	15:09-15:12	11NC48	14574-14597	11NR27	8508-8531	176.2
06-30-2011	15:22-15:32	11NC48	14619-14685	11NR27	8553-8619	176.2
06-30-2011	15:37-15:38	11NC48	14686-14690	11NR27	8620-8624	176.2
06-30-2011	15:48-15:55	11NC48	14731-14778	11NR27	8665-8712	176.2
06-30-2011	16:00-16:03	11NC48	14789-14810	11NR27	8723-8744	176.2
06-30-2011	19:02-19:10	11NC48	15283-15337	11NR27	9217-9271	176.2
07-03-2011	19:19-19:27	11NC43	12182-12239	11NR22	6116-6173	176.2
07-03-2011	19:32-19:41	11NC43	12240-12297	11NR22	6174-6231	176.2
07-03-2011	21:30-21:38	11NC50	15615-15666	11NR29	9549-9600	176.2
07-03-2011	21:43-21:49	11NC50	15667-15712	11NR29	9601-9646	176.2
07-03-2011	21:54-21:58	11NC50	15713-15742	11NR29	9647-9676	176.2
07-03-2011	22:03-22:05	11NC50	15743-15756	11NR29	9677-9690	176.2
07-03-2011	22:12-22:18	11NC50	15757-15796	11NR29	9691-9730	176.2
07-03-2011	22:22-22:25	11NC50	15797-15816	11NR29	9731-9750	176.2
07-03-2011	22:31-22:33	11NC50	15817-15826	11NR29	9751-9760	176.2

*Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the Mackinaw City 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 August 2015. 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 10.3.1 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 chart was used in the comparison process:

- 14913, Grand Traverse Bay to Little Traverse Bay, 1:80,000 scale, 20th Ed., Jan. 2016 (incl. 1:10,000 and 15,000 insets)

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 Report (APOR)
- Aerotriangulation Report
- Project Completion Report (PCR)
- Project database
- GC11083 in shapefile format
- Chart Evaluation File in shapefile format

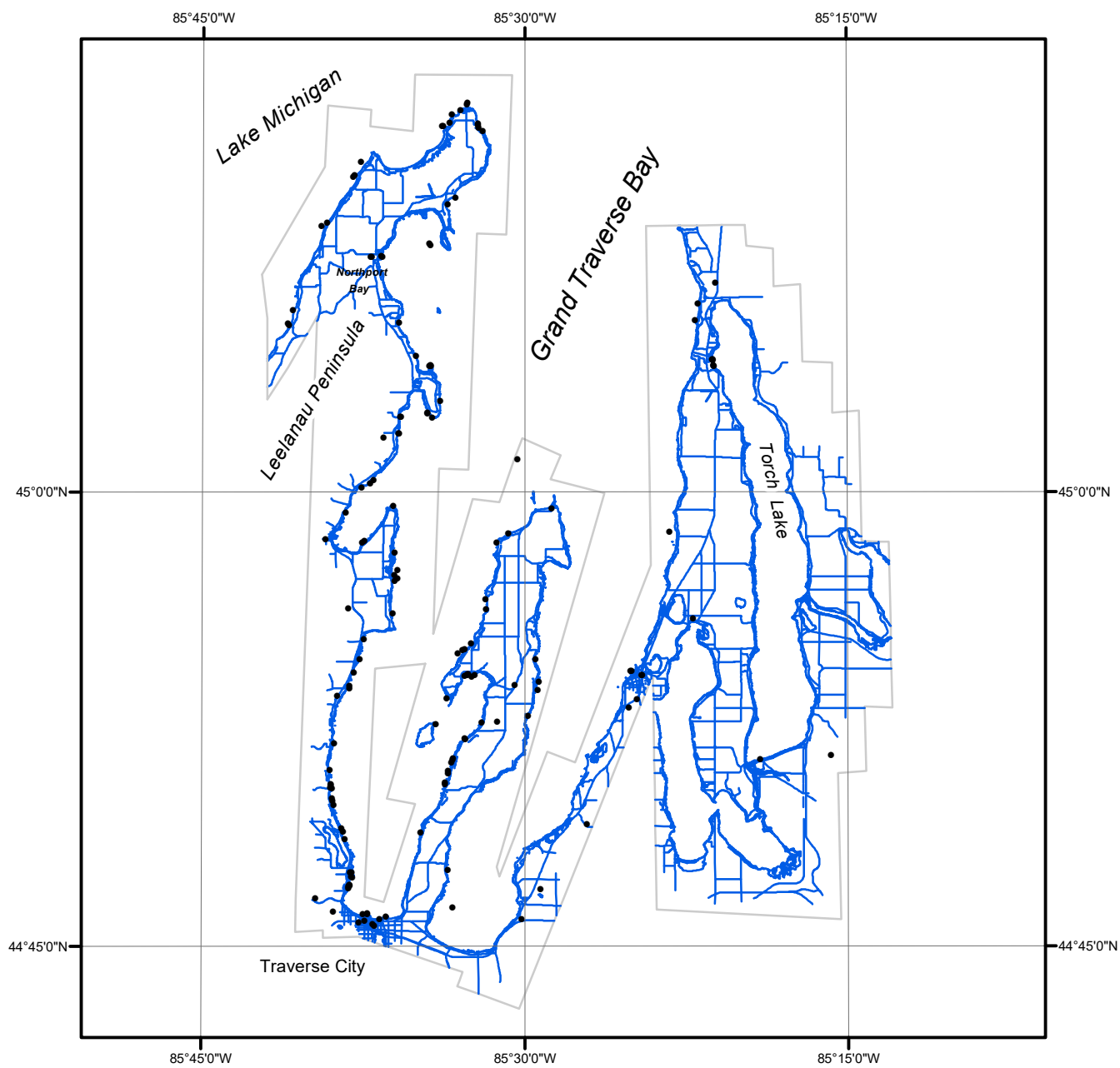
NOAA Shoreline Data Explorer

- GC11083 in shapefile format
- Metadata file for GC11083
- Digital copy of the PCR in Adobe PDF format

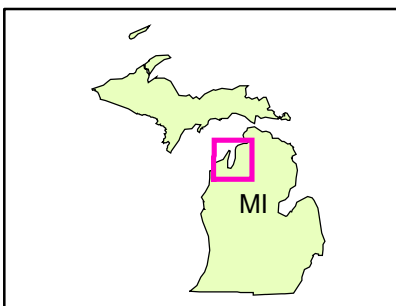
End of Report

GRAND TRAVERSE BAY

MICHIGAN



Overview



MI1001D-CM-N

GC11083