NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT MN0904A

Isle Royale, Michigan

Introduction

NOAA Coastal Mapping Program (CMP) Project MN0904A provides a highly accurate database of new digital shoreline data for Isle Royale, in Lake Superior, Michigan. Project MN0904A is a sub-project of a larger project, MN0904, which includes shoreline mapping for the north coast of Lake Superior from Isle Royale, near the Canadian border, to Lutsen, Minnesota.

Successful completion of this project resulted in 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 photographs and metadata related to photogrammetric compilation. Base mapping was conducted in a digital environment using stereo softcopy photogrammetry and associated cartographic practices.

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 13B, dated January 2008. 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.

This project used digital aerial imagery previously acquired under a contract with the National Geospatial-Intelligence Agency (NGA). The purpose of the NGA project was to produce digital ortho-rectified images maps of the U.S./Canada border regions in the Great Lakes. NOAA recognized the value of using the NGA project data for updating the nautical charts under the Coastal Mapping Program, and arranged with NGA to obtain the original stereo imagery and associated positioning data needed for photogrammetric mapping.

NOAA forwarded all of the NGA provided project imagery, aerotriangulation output data, ground control coordinates, airborne GPS and IMU data, and Photogrammetric Reports to NOVA Digital Systems, Inc. in order to support photogrammetric processing and feature compilation. NOAA also provided shapefiles depicting the shoreline to be mapped, the boundaries of the main project and sub-project compilation areas, and flight lines and exposure centers of the imagery to be used for compilation.

Field Operations

Since all source data was provided by NGA through NOAA, NOVA was not required to perform any field operations in connection with this project. The field operations that were performed by NGA's contractor (3001, Inc.) and their sub-contractor (Photo Science, Inc) are described in detail in their Photogrammetric Report for AOI 23, which covers this project area. Following is a brief summary of the field operations as described in that report.

AOI 23:
Field operations included the surveying of ground control points (GCPs) and the acquisition of aerial imagery. Coordinates of three (3) GCPs were established using static and rapid-static GPS techniques. Survey field work was performed on 9/10/2008 and 9/12/2008 by Photo Science, Inc. Aerial imagery was acquired using two Z/I DMC digital cameras operated by Photo Science, Inc. in nine flights flown between 6/14/2009 and 8/12/2009. Thirty-one (31) lines of panchromatic, RGB, and NIR imagery were acquired at an approximate altitude of 9,840 feet above mean terrain, resulting in a nominal pan-sharpened image resolution of 0.30 meters GSD. Airborne GPS and Inertial Measurement Unit (IMU) data were collected during the image acquisition flights, along with NAVCOM VueStar data (a global satellite based GPS augmentation system), in order to determine precise camera position and orientation parameters.

GPS Data Reduction

Since pre-processed GPS and IMU data was provided by NGA through NOAA, NOVA was not required to perform any GPS data reduction for this project. All GPS/IMU data processing tasks were completed by Photo Science, Inc. and are described in detail in their Photogrammetric Report for AOI 23, which covers this project area. Following is a brief summary of the GPS/IMU data processing tasks described in that report.

Final GCP coordinate values were determined utilizing precise point positioning techniques using Applanix TerraPOS (ver. 1.2) software and the NGS Online Positioning User Service (OPUS). Though the NAVCOM VueStar system provided decimeter level GPS navigation information in real time, the airborne GPS (ABGPS) data was post-processed using TerraPOS software to improve on the real time results. The Applanix POSPac (AIR) software (ver. 5.1) was used to process the IMU data, and with the POSProc and POSEO modules, post-processed GPS was combined with the IMU data to compute an optimally accurate navigation solution, and final exterior orientation (EO) parameters (x, y, z, omega, phi, kappa) for each image.

Aerotriangulation

Since final exterior orientation values for each photograph were provided by NGA through NOAA, NOVA was not required to perform any Aerial Triangulation (AT) for this project. All AT tasks were completed by Photo Science, Inc. and are described in detail in their Photogrammetric Report for AOI 23, which covers this project area.

For most of the NGA border imagery project Photo Science was required to perform ground survey and AT work for all the photos covering the U.S. side of the border (AT was not required for photos on the Canada side). For AOI 23, however, an exception was made for the portion of the area covering Isle Royale. Despite Isle Royale being within U.S. territory, Photo Science was instructed to use only the ABGPS/IMU derived EO parameters for all imagery over the

island. Aerotriangulation was only performed for the part of AOI 23 covering the mainland U.S. and not for the part over Isle Royale. This was due to the difficulty of travelling to and on the island, which is a national park with limited access, no road network, and a prohibition against wheeled vehicles. It was determined that ground control survey work would have been cost prohibitive on the island, and could not have been accomplished within the time allotted on the project schedule.

Since NOAA shoreline mapping project MN0904A includes only Isle Royale, AT was not performed, and a standard horizontal accuracy was not calculated for any of the imagery in this project.

Compilation

The data compilation phase of the project was initiated by NOVA in January 2010. Digital feature extraction was completed in a softcopy stereo environment using Socet Set v5.3.0 Features extraction software. All coding and classification of features occurred as features were collected, and was based on interpretation of the project imagery, and on information extracted from the appropriate NOAA nautical charts 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.

Due to the lack of ground control and aerotriangulation spatial data accuracies for Project MN0904A could not be determined according to standard Federal Geographic Data Committee (FGDC) practices, but instead were estimated based on commonly expected results of ABGPS/IMU derived EO parameters, and on a comparison with two 3rd order stations in the NGS Geodetic Control Database. Cartographic features were compiled to meet a horizontal accuracy of 2.0 meters at the 95% confidence level based on this estimate.

The following table provides information on aerial photographs used in the project completion:

Date	Time (UTC)	AOI Block	Line Number	Photo Numbers	GSD (nominal)	Lake Level*
6/14/2009	14:53 – 14:57	23	61027	14 – 46	0.30 m	183.3 m
6/14/2009	15:05 – 15:09	23	61026	52 – 20	0.30 m	183.3 m
6/14/2009	15:21 – 15:25	23	61025	24 – 56	0.30 m	183.3 m
6/14/2009	15:33 – 15:35	23	61024	51 – 31	0.30 m	183.3 m
6/14/2009	15:49 – 15:50	23	61023	36 – 42	0.30 m	183.3 m
6/14/2009	15:57 – 15:59	23	61022	59 – 41	0.30 m	183.3 m
6/14/2009	17:11 – 17:16	23	61028	46 – 07	0.30 m	183.3 m
7/11/2009	13:36 – 13:43	23	61026	53 – 116	0.30 m	183.3 m
7/11/2009	13:50 – 14:00	23	61025	123 – 57	0.30 m	183.3 m
7/11/2009	14:06 – 14:15	23	61024	52 – 132	0.30 m	183.3 m

7/12/2009	15:45 – 15:54	23	61027	48 – 107	0.30 m	183.3 m
7/12/2009	16:00 – 16:08	23	61028	47 – 97	0.30 m	183.3 m
8/06/2009	13:32 – 13:45	23	61023	140 – 43	0.30 m	183.4 m
8/06/2009	13:51 – 14:01	23	61022	60 – 145	0.30 m	183.4 m
8/11/2009	14:13:59	23	61027	47	0.30 m	183.4 m

* Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the Grand Marais, Lake Superior Station in Minnesota. The Low Water Datum (LWD) for the portion of Lake Superior covered by this project is 183.2 m. above IGLD 1985.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion. The final QC review was completed in June 2010. 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 ArcMap 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:

14976 - Isle Royale, Scale 1:40,000, 18th Ed. Nov./04
14968 - Grand Portage Bay, Minn. to Shesheeb Point, Ont., Scale 1:120,000, 28th Ed. Sep./04

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 Photogrammetric Report
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10840 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project Database
- GC10840 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- Chart Evaluation File in shapefile format

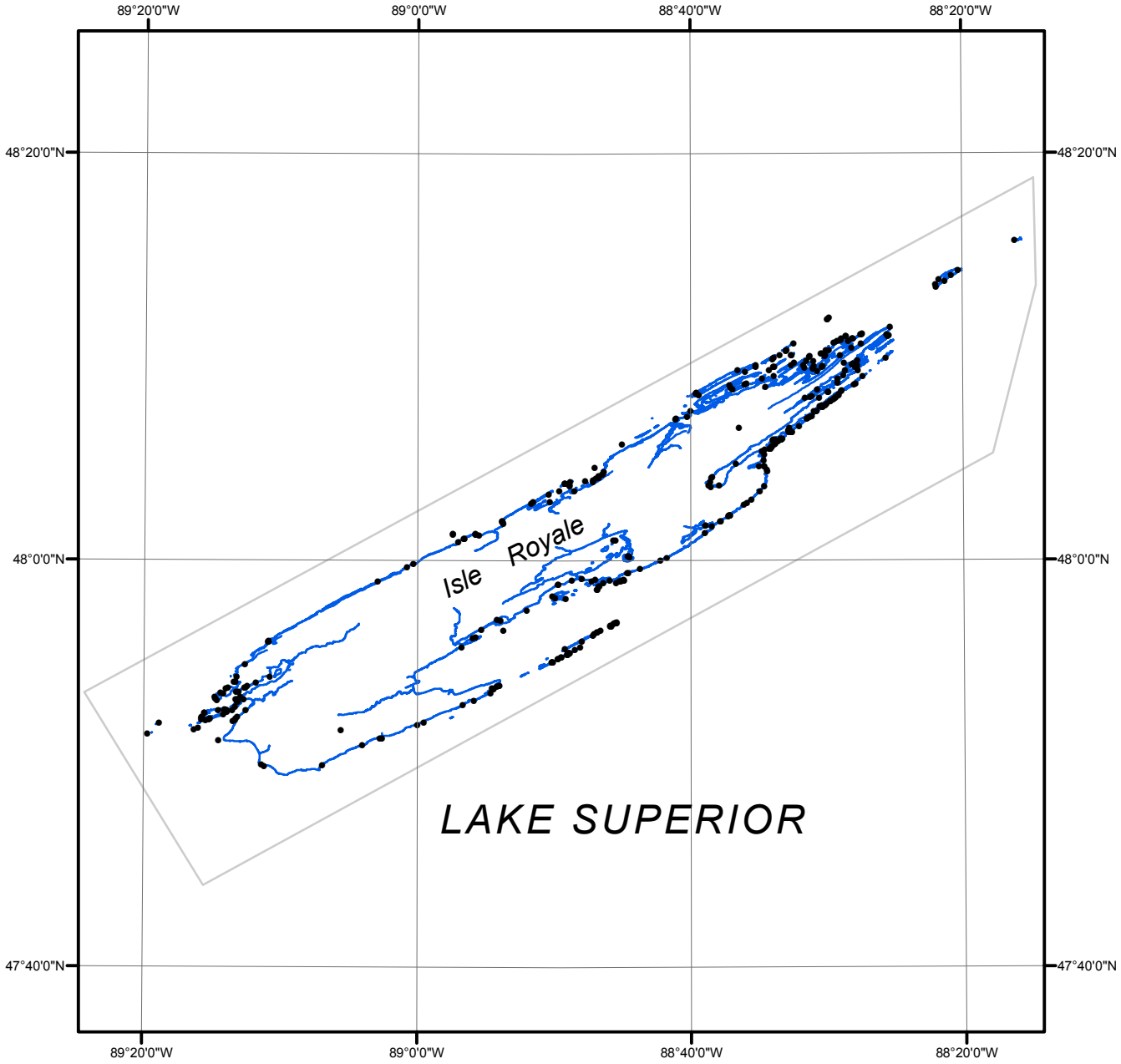
NOAA Shoreline Data Explorer

- GC10840 in shapefile format
- Metadata file for GC10840
- Digital copy of the PCR in Adobe PDF format

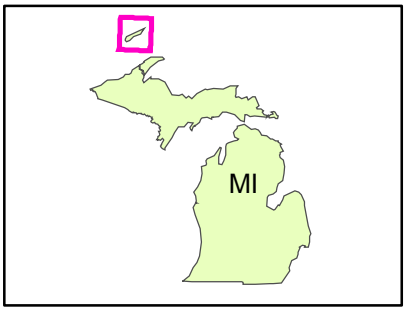
End of Report

ISLE ROYALE

MICHIGAN



Overview



MN0904A

GC10840