

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT MI0803

Keweenaw Waterway, Michigan

Introduction

NOAA Coastal Mapping Program (CMP) Project MI0803 provides a highly accurate database of new digital shoreline data for the Keweenaw Waterway from the entrance at Lake Superior in the north to Keweenaw Bay in the south and includes Portage Lake, Torch Bay and Torch Lake.

Successful completion of this project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric-quality digital aerial imagery, 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 digital aerial imagery 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 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 Procedure. The instructions discussed the project's purpose, geographic area of coverage, scope and priority; photographic requirements; flight line priority; Global Positioning System (GPS) data collection procedures and guidelines for both kinematic and static surveys; data recording and handling instructions; and contact and communication information. RB created a Project Layout Diagram, 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 and Internal Measurement Unit (IMU) data and the acquisition of digital aerial imagery. The photographic mission operations were conducted on May 9th, 2008, with the NOAA Cessna Citation II (N52RF) aircraft. Seven (7) strips of natural color digital images, resulting in a total of one hundred eighty (180) images, were acquired through the use of an Applanix DSS 439 dual camera system with two 60 mm lenses at an approximate ground sample distance of 0.47 meters. One hundred eighty (180) Black & White Infrared (IR) images were also collected in tandem with the color imagery, but they were only used for reference in this project.

A temporary GPS base station was established at the Sawyer International Airport (SAW) using static GPS positioning techniques. Airborne kinematic GPS/IMU data was collected to determine precise camera positions and orientations in order to establish a control network necessary for aerotriangulation. Data collection operations were conducted in accordance with the GPS Controlled Photogrammetry Field Operations Manual. No ground control survey operations were required for this project.

GPS Data Reduction

GPS and IMU data was processed to provide precise positions of camera centers for application as photogrammetric control in the aerotriangulation phase of project completion. The static GPS base station data was processed in May 2008 using the NGS Online Processing User Service (OPUS). The airborne kinematic data was processed using Applanix POSPAC (ver. 4.4) software in June 2008. Refer to the Airborne Positioning and Orientation Report (APOR) on file with other project data within the RSD Applications Branch (AB) Project Archive.

Aerotriangulation

Routine softcopy aerotriangulation methods were applied to establish the 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 initiated by RSD personnel in December 2008 utilizing a Digital Photogrammetric Workstation (DPW), which is a configuration of computer hardware, modular software components and other associated peripheral devices. The digital color imagery were measured and adjusted as a single block using BAE Systems Inc. SOCET SET (version 5.4.1) photogrammetric suite in conjunction with the Multi-Sensor Triangulation (MST) software module. Upon successful completion of the aerotriangulation process, the MST software provided the standard deviations of the residuals for each aerotriangulated ground point, which were used to compute a predicted horizontal circular error of 0.7 meters based on a 95% confidence level. An Aerotriangulation Report was written and is on file with other project data within the RSD Project Archive.

The project database consists of project parameters and options, camera calibration data, airborne GPS/IMU antenna position and offset data, adjusted exterior orientation parameters, and positional listing of all measured points. Positional data is referenced to the North American Datum of 1983 (NAD 83).

Compilation

The data compilation phase of this project was initiated by RSD in January 2009. Digital mapping was performed using a DPW in conjunction with the SOCET SET Feature Extraction software module. Feature identification and attribution within the Geographic Cell (GC) were based on image analysis of the digital imagery and information extracted from the appropriate NOAA nautical charts, US 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.

Spatial data accuracies for Project MI0803 were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were compiled to meet a horizontal accuracy of 1.4 meters at the 95% confidence level. The predicted accuracy of compiled, well defined points is derived by doubling the circular error calculated from the aerotriangulation statistics.

The following table provides information on digital imagery used in project completion:

Date	Time (UTC)	Roll Number	Image Numbers	Resolution (GSD)	Tide Level*
05-09-08	15:51-15:58	08NC15	3176-3211	0.47 m	183.2
05-09-08	16:04-16:07	08NC15	3212-3224	0.47 m	183.2
05-09-08	16:11-16:13	08NC15	3225-3239	0.47 m	183.2
05-09-08	16:19-16:21	08NC15	3240-3250	0.47 m	183.2
05-09-08	16:26-16:32	08NC15	3251-3280	0.47 m	183.2
05-09-08	16:36-16:43	08NC15	3281-3319	0.47 m	183.2
05-09-08	16:53-17:01	08NC15	3320-3355	0.47 m	183.2

*Lake levels are given in meters above IGLD 1985 and are based on actual observations recorded by the NOS gauge at Ontonagon, Michigan at the time of photography.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of AB. Final QC review was completed in August 2009, including 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 9.2 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:

14972, Keweenaw Waterway Including Torch Lake, MI, 1:30,000 scale, 26th Ed.
including Hancock and Houghton Inset, 1:10,000 scale

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 Airborne Positioning and Orientation Report (APOR)
- Hardcopy of the Aerotriangulation Report

- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10753 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project database
- GC10753 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- Chart Evaluation File in shapefile format

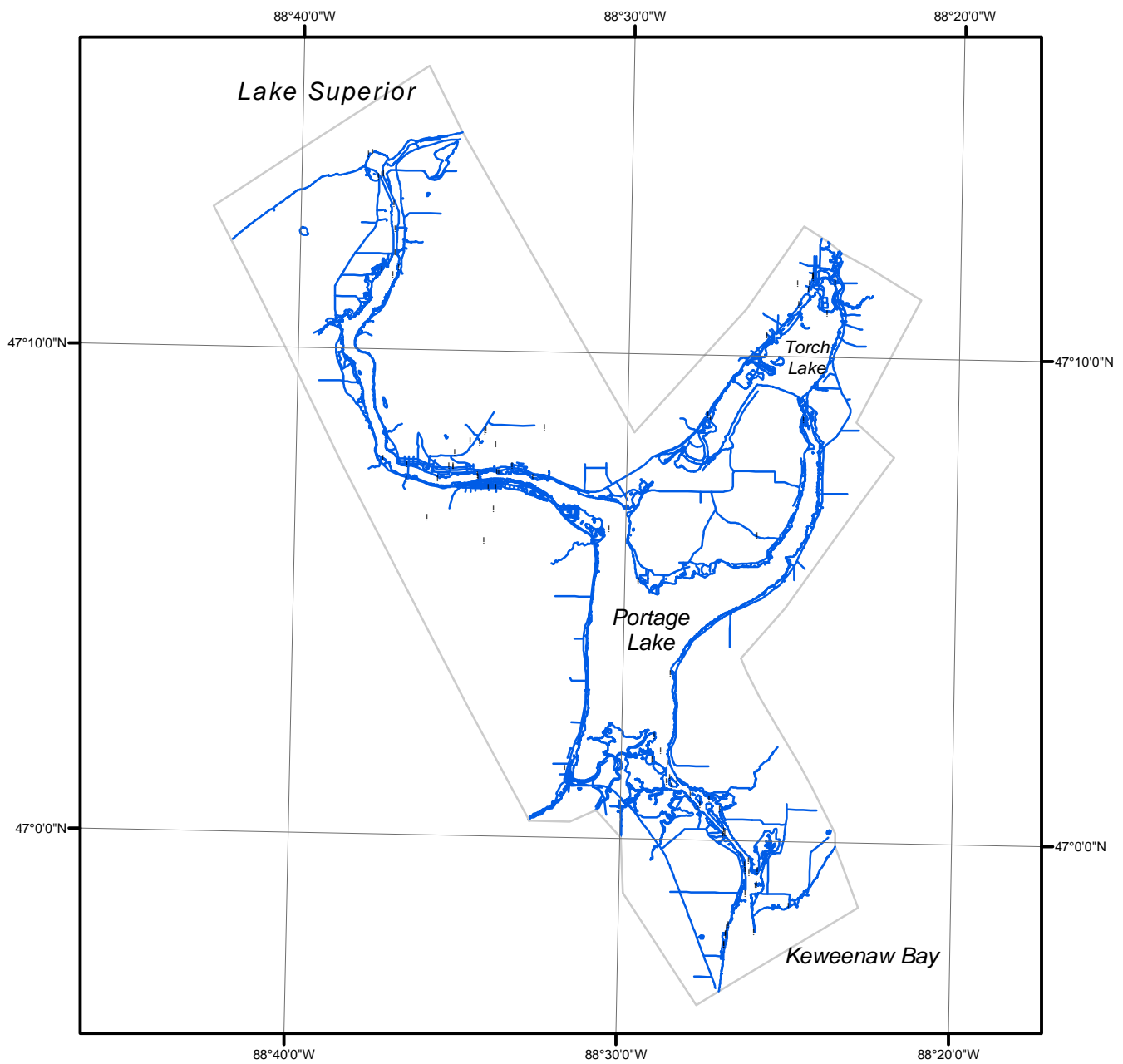
NOAA Shoreline Data Explorer

- GC10753 in shapefile format
- Metadata file for GC10753
- Digital copy of the PCR in Adobe PDF format

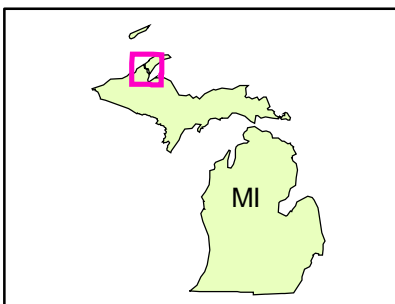
End of Report

KEWEENAW WATERWAY

MICHIGAN



Overview



MI0803

GC10753