

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT ME1301B-CM-N

Passamaquoddy Bay to Cobscook Bay, Maine

Introduction

NOAA Coastal Mapping Program (CMP) Project ME1301B-CM-N provides a highly accurate database of new digital shoreline data for a portion of the coastline from Passamaquoddy Bay to Cobscook Bay, Maine. Project ME1301B-CM-N is a subproject of a larger project ME1301-CM-N, which covers St. Croix River, Oak Bay, Grand Manan Channel, Hamilton Cove to Dennison Point, Whiting Bay, Dennys Bay & including other small islands. 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

Project ME1301-CM-N was designed in response to a request for shoreline data from the Navigation Services Division of NOAA's Office of Coast Survey. Photographic mission instructions for ME1301-CM-N were formulated by the Requirements Branch (RB) of the Remote Sensing Division (RSD) following the guidelines of RSD's Photo Mission Standard Operating Procedures. The instructions discussed the project's purpose, geographic area of coverage, scope and priority, image 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 the collection of static and kinematic GPS data and Inertial Measurement Unit (IMU) data, and the acquisition of digital aerial imagery. The photographic mission operations were conducted during eleven (11) flights over the course of two years, from July 21, 2013 through June 01, 2014, with the NOAA King Air (N68RF) aircraft. Project imagery included natural color (RGB) and near-infrared (NIR) imagery acquired concurrently using an Applanix DSS-439 dual head digital camera system (two 60 mm lenses) in coordination with both MLLW and MHW tide levels.

Sixteen (16) flight lines with two thousand four hundred-seventy nine (2479) of natural color (RGB) and near-infrared (NIR) images were acquired concurrently for ME1301-CM-N, although only eleven (11) flight lines with one thousand three hundred-thirty two (1332) images were used in the completion of subproject ME1301B-CM-N. All imagery was acquired at a nominal altitude of 10,000 feet, resulting in an approximate ground sample distance (GSD) of 0.35 meters.

Direct Georeferencing Data Processing

GPS/IMU data for project ME1301-CM-N were processed by RSD personnel to yield precise camera 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 August 13 - 14 & November 6 – 8, 2013 & July 28 – 29, 2014 using various versions of POSPac MMS GPS/IMU software. 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 1.5 meters for the imagery used to compile data for ME1301B-CM-N. Sixteen (16) NGS third order geodetic control points were used to test the horizontal integrity of the DG data. All stereo-models were examined and found to have acceptable levels of parallax for mapping purposes.

Aerotriangulation

The horizontal accuracy of the directly georeferenced imagery was not adequate to support the high accuracy requirement for shoreline mapping within the 1:5,000 scale chart inset covering Eastport Harbor. Therefore eight (8) images from lines 4 and 5 were selected from all four sets of imagery (MHW-IR, MLLW-IR, MHW-RGB, MLLW-RGB) that cover the chart inset area, for a total of 32 images. Softcopy aerotriangulation (AT) was performed using these images to improve the horizontal accuracy required for mapping this area. This work was performed by RSD personnel in February 2015 utilizing a Digital Photogrammetric Workstation (DPW), which is a configuration of computer hardware, modular software components, and other associated peripheral devices. All 32 images were measured and adjusted as a single block using the SOCET SET (ver. 5.6.0) suite of digital photogrammetric software. The Multi-Sensor Triangulation (MST) module of SOCET SET was used to perform point measurements and a least-squares adjustment, and evaluate the accuracy of the solution. Upon successful completion of this process, the MST software provided the standard deviations for each aerotriangulated ground point, which were used to compute a predicted horizontal circular error of 0.49 meters based on a 95% confidence level. An AT report was written and is on file with other project data within the AB Project Archive. Positional data is referenced to the North American Datum of 1983 (NAD83).

Compilation

The data compilation phase of this project was accomplished by a member of AB in August 2015. Digital mapping was performed using the Feature Extraction software module within SOCET SET (ver. 5.6). Feature identification and attribution within the Geographic Cell (GC) were based on image analysis of the aerial imagery and information extracted from the largest scale 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.

Spatial data accuracies for project ME1301B-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were compiled to meet a horizontal accuracy of 3.0 meters at the 95% confidence level for most of the project area, or 1.0 meters for the area covered by the 1:5,000 scale Eastport Harbor chart inset. This predicted accuracy of compiled well-defined points is derived by doubling the horizontal uncertainty calculated from the EO-TPU tool or from the aerotriangulation statistics.

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

Date	Time (UTC)	Roll #	Photo #s	~ GSD	Tide Level*
6/22/2013	13:51 – 13:57	13NC45	09911 – 09956	0.35 m	5.2 – 5.8 m
6/22/2013	13:51 – 13:57	13NR40	08586 – 08631	0.35 m	5.2 – 5.8 m
6/22/2013	14:08 – 14:10	13NC45	10004 – 10019	0.35 m	5.9 – 6.0 m
6/22/2013	14:08 – 14:10	13NR40	08679 – 08694	0.35 m	5.9 – 6.0 m
6/22/2013	14:16 – 14:18	13NC45	10020 – 10036	0.35 m	6.1 – 6.3 m
6/22/2013	14:16 – 14:18	13NR40	08695 – 08711	0.35 m	6.1 – 6.3 m
6/22/2013	14:30 – 14:36	13NC45	10086 – 10132	0.35 m	6.3 – 5.7 m
6/22/2013	14:30 – 14:36	13NR40	08761 – 08807	0.35 m	6.3 – 5.7 m
6/22/2013	14:41 – 14:47	13NC45	10133 – 10177	0.35 m	5.7 – 6.4 m
6/22/2013	14:41 – 14:47	13NR40	08808 – 08852	0.35 m	5.7 – 6.4 m
6/22/2013	14:51 – 14:56	13NC45	10178 – 10211	0.35 m	6.4 – 5.6 m
6/22/2013	14:51 – 14:56	13NR40	08853 – 08886	0.35 m	6.4 – 5.6 m
6/22/2013	15:01 – 15:06	13NC45	10212 – 10245	0.35 m	5.6 – 6.6 m
6/22/2013	15:01 – 15:06	13NR40	08887 – 08920	0.35 m	5.6 – 6.6 m
6/25/2013	12:06 – 12:09	13NC46	10371 – 10386	0.35 m	-0.6 m
6/25/2013	12:06 – 12:09	13NR41	09046 – 09061	0.35 m	-0.6 m
8/11/2013	12:31 – 12:38	13NC47	10426 – 10472	0.35 m	0.1 m
8/11/2013	12:31 – 12:38	13NR42	09101 – 09147	0.35 m	0.1 m
8/11/2013	12:53 – 12:59	13NC47	10527 – 10572	0.35 m	0.1 – 0.2 m
8/11/2013	12:53 – 12:59	13NR42	09202 – 09247	0.35 m	0.1 – 0.2 m
8/11/2013	13:05 – 13:11	13NC47	10573 – 10617	0.35 m	0.3 m

8/11/2013	13:05 – 13:11	13NR42	09248 – 09292	0.35 m	0.3 m
8/11/2013	13:22 – 13:24	13NC47	10640 – 10656	0.35 m	0.3 – 0.4 m
8/11/2013	13:22 – 13:24	13NR42	09315 – 09331	0.35 m	0.3 – 0.4 m
8/12/2013	12:48 – 12:53	13NC48	10657 – 10690	0.35 m	0.2 – 0.4 m
8/12/2013	12:48 – 12:53	13NR43	09332 – 09365	0.35 m	0.2 – 0.4 m
8/12/2013	12:58 – 13:02	13NC48	10691 – 10724	0.35 m	0.4 – 0.2 m
8/12/2013	12:58 – 13:02	13NR43	09366 – 09399	0.35 m	0.4 – 0.2 m
8/12/2013	13:09 – 13:13	13NC48	10735 – 10761	0.35 m	0.3 m
8/12/2013	13:09 – 13:13	13NR43	09410 – 09436	0.35 m	0.3 m
8/12/2013	13:20 – 13:24	13NC48	10762 – 10790	0.35 m	0.4 – 0.2 m
8/12/2013	13:20 – 13:24	13NR43	09437 – 09465	0.35 m	0.4 – 0.2 m
8/12/2013	13:32 – 13:36	13NC48	10808 – 10836	0.35 m	0.3 m
8/12/2013	13:32 – 13:36	13NR43	09483 – 09511	0.35 m	0.3 m
8/17/2013	12:14 – 12:18	13NC50	10960 – 10988	0.35 m	4.2 – 5.8 m
8/17/2013	12:14 – 12:18	13NR45	09635 – 09663	0.35 m	4.2 – 5.8 m
8/17/2013	12:23 – 12:27	13NC50	10989 – 11015	0.35 m	5.7 – 5.5 m
8/17/2013	12:23 – 12:27	13NR45	09664 – 09690	0.35 m	5.7 – 5.5 m
8/18/2013	12:57 – 13:01	13NC51	11055 – 11083	0.35 m	4.5 – 6.0 m
8/18/2013	12:57 – 13:01	13NR46	09730 – 09758	0.35 m	4.5 – 6.0 m
8/18/2013	13:11 – 13:15	13NC51	11085 – 11111	0.35 m	5.3 – 4.4 m
8/18/2013	13:11 – 13:15	13NR46	09760 – 09786	0.35 m	5.3 – 4.4 m
5/29/2014	11:31 – 11:35	14NC51	11206 – 11232	0.35 m	0.4 – 0.0 m
5/29/2014	11:31 – 11:35	14NR43	08093 – 08119	0.35 m	0.4 – 0.0 m

* Tide levels are given in meters above MLLW and were calculated using the Pydro software tool with a TCARI grid referenced to verified water level observations at the time of photography from various NOS gauges in the vicinity of the project. The elevation of the MHW tidal datum in the project area varies between 4.5 – 6.1 meters above MLLW.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a member of the Applications Branch. The final QC review was completed in August 2015. The review process included analysis of the DG and AT 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 10.2.2 software. All project data was evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with source imagery and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following nautical chart was used in the comparison process:

- 13394, Grand Manan Channel Northern Part, 1:50,000, 5th Ed., Aug. /13
- 13396, Campobello Island, 1:20,000, 6th Ed., Nov. /12
 - Including Eastport Harbor Inset, 1:5,000
- 13398, Passamaquoddy Bay and St Croix River, 1:50,000, 4th Ed., Nov. /12
 - Including Saint Andrews Inset, 1:15,000

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

- Airborne Positioning and Orientation Reports (APOR)
- Aerotriangulation Report
- Project Completion Report (PCR)
- Project database
- GC11136 in shapefile format
- Chart Evaluation File (CEF) in shapefile format

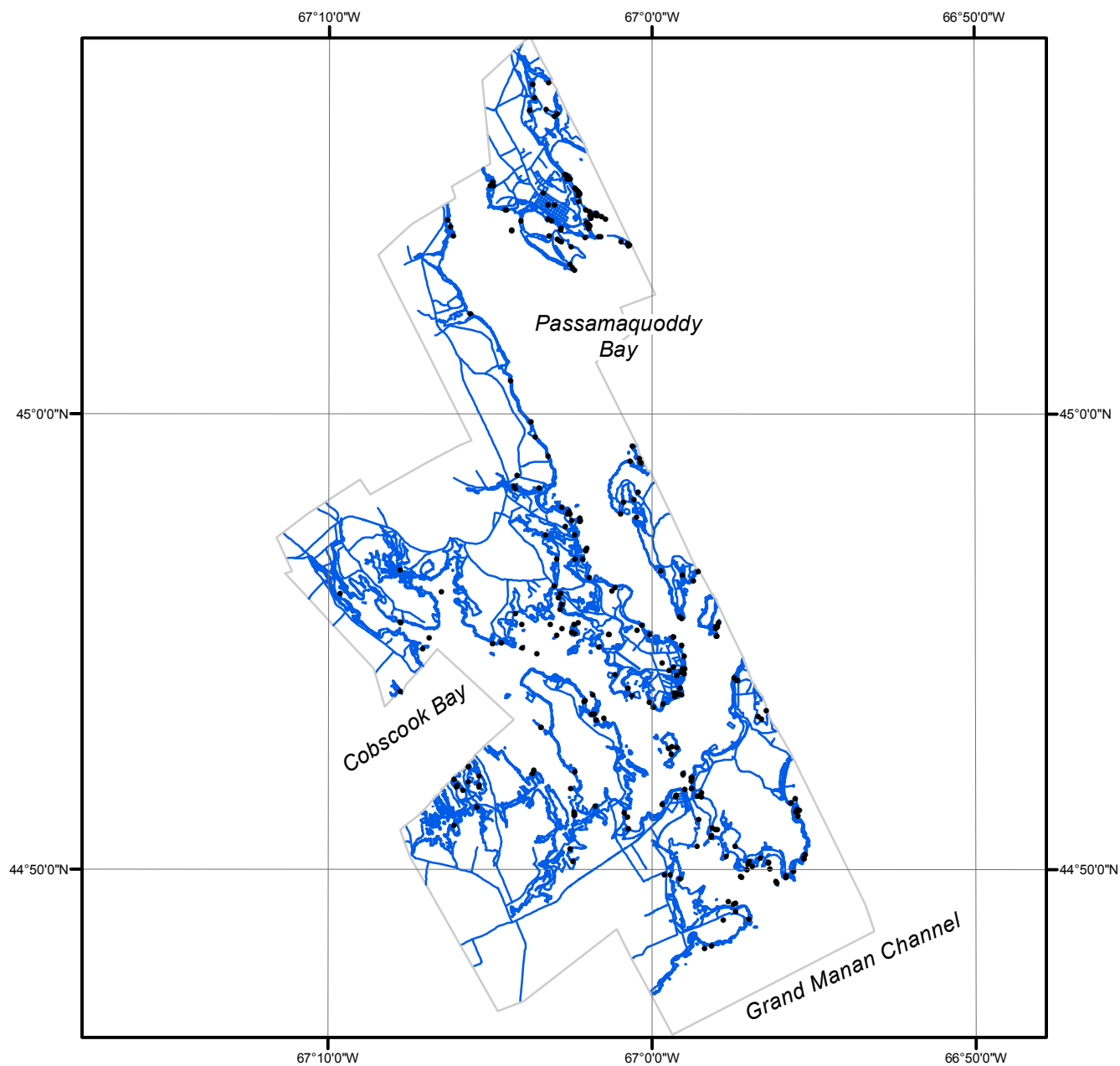
NOAA Shoreline Data Explorer

- GC11136 in shapefile format
- Metadata file for GC11136
- Digital copy of the PCR in Adobe PDF format

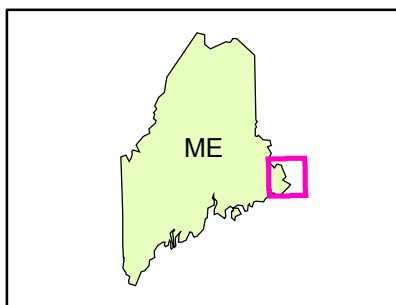
End of Report

PASSAMAQUODDY BAY TO COBSCOOK BAY

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Overview



ME1301B-CM-N

GC11136