

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT ME0702C

Little Kennebec Bay to Bog Brook Cove, Maine

Introduction

NOAA Coastal Mapping Program (CMP) Project ME0702C provides a highly accurate database of new digital shoreline data for coastal areas of Maine from Little Kennebec Bay to Bog Brook Cove, including Machias Bay. Project ME0702C is a sub-project of a larger project, ME0702, which extends from Schoodic Head to Bog Brook Cove, Maine.

Successful completion of this project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric-quality photographs, 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 images 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 Procedures. The instructions discussed the project's purpose, geographic area of coverage, scope and priority, image 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 flight management system.

Note that the project was originally planned to use aerial film photography. After most of the flight lines were collected on film, the project was re-planned to use a digital camera, and revised project instructions were issued. Later the digital imagery flight lines were re-planned in the field to accommodate different camera lenses and flying heights than were originally intended in the revised project instructions.

Field Operations

The field operations consisted of the collection of static and kinematic Global Positioning System (GPS) data and Inertial Measurement Unit (IMU) data, and the acquisition of aerial film photography and digital aerial imagery. Initial aerial survey operations were

conducted from August 28 to September 2, 2007, with the NOAA Cessna Citation II aircraft. Natural color photographs and black and white infrared (B&W IR) photographs were acquired through use of a Wild RC-30 (film) camera with the NOS "A" lens cone at the nominal scale of 1:36,000. The collection of the B&W IR photographs was coordinated with both the MHW and MLLW tide levels. None of these photographs collected in 2007 were scanned, aerotriangulated, or used in the compilation phase.

Digital aerial survey operations were conducted on August 23rd 2008, May 25th 2009, and May 26th 2009 with the NOAA Cessna Citation II (N52RF) aircraft using an Applanix DSS-439 dual camera system (RGB & IR) with 60 mm lenses at a flying height of 13,500 feet above ground level (AGL), resulting in a nominal Ground Sample Distance (GSD) of 0.46 meters. All flight lines were planned to be collected at both the MHW and MLLW tide levels, with an end lap of 60% and side lap of 30%. By the end of 2009 four flight lines (two at MHW and two at MLLW) remained to be flown.

Beginning in 2010 a new aircraft, the NOAA King Air (N68RF), was used for this project, and the 60 mm lenses in the DSS-439 camera were replaced by 40 mm lenses. Due to the reduced focal length of the camera system, the flying height for this project was adjusted to 9,000 feet AGL in order to maintain the same nominal GSD of 0.46 meters for the imagery. All four remaining flight lines were acquired on June 25th 2010, but were rejected due to clouds, and would have to be re-flown.

By June 2011 the DSS-439 camera was once again outfitted with 60 mm lenses, but to accommodate a Lidar sensor the camera port glass had been removed from the King Air aircraft, resulting in an unpressurized altitude restriction of 10,000 feet. Consequently the remaining four flight lines were re-planned as eight lines to be flown at 10,000 feet AGL, resulting in a new nominal GSD of 0.34 meters. The re-planned flight lines were all successfully acquired on June 10th, June 11th, and June 21st 2011 with these specs.

For further information refer to the ME0702 Acquisition Summary report on file with other project data within the RSD Applications Branch (AB) Project Archive.

GPS Data Reduction

The GPS/IMU data were processed by RSD personnel to yield precise camera positions and orientations for use in the georeferencing phase of the project. The Bangor International Airport, Bangor, ME (BGR) was used as a reference station for kinematic GPS processing operations throughout the several flights and re-flights for the ME0702 project. The airborne kinematic data was processed using Applanix POSPAC (ver. 5.4) software over three dates, July 2010, July 2011, and January of 2012.

For further information refer to the Airborne Positioning and Orientation Reports (APORs 2362008, 1452009, 1462009.1, 1462009.2, 1622011, 1612011.1, & 1722011), on file with other project data within the RSD Applications Branch (AB) Project Archive.

Georeferencing

Direct Georeferencing (DG) methods using the processed kinematic GPS/IMU data were applied to establish precise exterior orientation (EO) values of the camera centers required for digital feature extraction. This work was accomplished by AB personnel in July 2013 using BAE Systems SOCET SET (version 5.6) photogrammetric software with the standard Frame Import module. The horizontal accuracy of well-defined image features 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. The predicted horizontal uncertainty at the 95% confidence level for each date of the imagery used in this project is given below in meters.

Date	Horizontal Uncertainty (meters)		
	Minimum	Maximum	Average
8/23/2008	1.92	2.53	2.27
5/25/2009	2.41	2.66	2.56
5/26/2009	1.82	2.50	2.18
5/26/2009	1.85	2.45	2.21
6/10/2011	1.42	1.87	1.67
6/11/2011	1.32	1.87	1.60
6/21/2011	1.57	1.94	1.78

Furthermore, ten NGS 3rd Order geodetic control stations and one high accuracy network tidal benchmark, distributed throughout the overall ME0702 project area, were used as check points to test the horizontal integrity of the DG data, and were measured (in most instances) on all three emulsions. Measurements of the check points in the stereo-models were compared to their published coordinates, resulting in an average offset of 0.8 meters on the MLLW color imagery, 0.6 meters on the MHW IR imagery, and 0.5 meters on the MLLW IR imagery.

All stereo-models were examined and found to be free of excessive parallax and suitable for mapping purposes.

Compilation

The data compilation phase of this project was initiated by RSD in September 2013. Digital mapping was performed using the SOCET SET Feature Extraction software module. Feature identification and attribution within the Geographic Cell (GC) were based on image analysis of the aerial photographs and information extracted from the largest scale NOAA nautical charts, the 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 ME0702C were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features compiled from the 8/23/2008 and 5/26/2009 imagery were compiled to meet a horizontal accuracy of 4.4 meters, features on the 5/25/2009 imagery were compiled to meet a horizontal accuracy of 5.1 meters, and features on the 2011 imagery were compiled to meet a horizontal accuracy of 3.4 meters. These predicted accuracies of compiled, well-defined points are derived by doubling the average horizontal uncertainty values computed from the EO-TPU tool.

The following table provides information on the tide levels and the imagery used to complete this subproject:

Date	Time (UTC)	Roll Number	Strip Number	Photo Numbers	GSD (Nominal)	Tide Level*
5/25/2009	14:59 – 15:01	09NR01	268001	00013 – 00019	0.46m	4.1
5/25/2009	15:01 – 15:02	09NR01	268001	00020 – 00026	0.46m	4.0
5/25/2009	15:02 – 15:03	09NR01	268001	00027 – 00032	0.46m	3.9
5/25/2009	15:03 – 15:05	09NR01	268001	00033 – 00042	0.46m	3.8
5/26/2009	16:08 – 16:10	09NR03	268002	00500 – 00508	0.46m	3.9
5/26/2009	16:10 – 16:11	09NR03	268002	00509 – 00514	0.46m	4.0
5/26/2009	16:11 – 16:12	09NR03	268002	00515 – 00521	0.46m	4.1
5/26/2009	16:12 – 16:14	09NR03	268002	00522 – 00529	0.46m	4.2
5/26/2009	16:19 – 16:20	09NR03	268003	00530 – 00539	0.46m	4.3
5/26/2009	16:20 – 16:21	09NR03	268003	00539 – 00540	0.46m	4.2
5/26/2009	16:21 – 16:22	09NR03	268003	00541 – 00548	0.46m	4.1
5/26/2009	16:22 – 16:24	09NR03	268003	00549 – 00559	0.46m	4.0
5/26/2009	16:52	09NR03	268004	00684 – 00685	0.46m	4.0
5/26/2009	16:52 – 16:53	09NR03	268004	00686 – 00687	0.46m	4.1
5/26/2009	16:53	09NR03	268004	00688 – 00690	0.46m	4.0
5/26/2009	16:53 – 16:54	09NR03	268004	00691 – 00695	0.46m	4.1
5/26/2009	16:54 – 16:56	09NR03	268004	00696 – 00706	0.46m	4.2
5/26/2009	17:01 – 17:03	09NR03	268005	00707 – 00712	0.46m	4.2
5/26/2009	17:03 – 17:04	09NR03	268005	00713 – 00723	0.46m	4.1
5/26/2009	17:05 – 17:06	09NR03	268005	00724 – 00729	0.46m	4.0

5/26/2009	17:31 – 17:33	09NR03	268006	00854 – 00862	0.46m	4.0
5/26/2009	17:33	09NR03	268006	00863 – 00865	0.46m	3.9
5/26/2009	17:34 – 17:35	09NR03	268006	00866 – 00876	0.46m	4.0
5/26/2009	17:42 – 17:45	09NR03	268007	00877 – 00896	0.46m	3.9
5/26/2009	18:11 – 18:14	09NR03	268008	01021 – 01035	0.46m	3.7
5/26/2009	18:14	09NR03	268008	01036	0.46m	3.6
6/10/2011	21:26 – 21:29	11NR18	250002	03864 – 03883	0.34m	3.9
6/11/2011	11:31 – 11:34	11NR19	250003	03994 – 04016	0.34m	3.9
6/11/2011	11:39	11NR19	250004	04017 – 04018	0.34m	3.9
6/11/2011	11:39 – 11:43	11NR19	250004	04019 – 04039	0.34m	3.8
8/23/2008	13:27 – 13:31	08NR35	368004	15234 – 15256	0.46m	0.2
8/23/2008	13:56 – 14:00	08NR35	368001	15380 – 15404	0.46m	0.1
8/23/2008	14:06 – 14:11	08NR35	368002	15405 – 15434	0.46m	0.1
8/23/2008	14:37 – 14:39	08NR35	368003	15559 – 15575	0.46m	0.2
8/23/2008	14:39 – 14:42	08NR35	368003	15576 – 15588	0.46m	0.3
8/23/2008	14:47 – 14:49	08NR35	368010	15589 – 15599	0.46m	0.2
5/26/2009	11:48 – 11:49	09NR02	368005	00276 – 00281	0.46m	-0.2
5/26/2009	11:49 – 11:52	09NR02	368005	00282 – 00298	0.46m	-0.1
5/26/2009	11:57 – 12:00	09NR02	368006	00300 – 00312	0.46m	0.0
5/26/2009	12:00 – 12:01	09NR02	368006	00313 – 00321	0.46m	-0.1
5/26/2009	12:26 – 12:27	09NR02	368009	00423 – 00434	0.46m	0.2
5/26/2009	12:28	09NR02	368009	00435 – 00437	0.46m	0.3
6/10/2011	15:44 – 15:47	11NR17	350001	03246 – 03269	0.34m	0.2
6/10/2011	15:52 – 15:54	11NR17	350002	03270 – 03280	0.34m	0.2
6/10/2011	15:54 – 15:56	11NR17	350002	03281 – 03295	0.34m	0.1
6/10/2011	16:26 – 16:27	11NR17	350003	03470 – 03475	0.34m	0.1
6/10/2011	16:27	11NR17	350003	03476 – 03477	0.34m	0.2
6/10/2011	16:27 – 16:28	11NR17	350003	03478 – 03482	0.34m	0.1
6/10/2011	16:28 – 16:30	11NR17	350003	03483 – 03496	0.34m	0.2
6/21/2011	13:10 – 13:14	11NR34	350004	11898 – 11925	0.34m	0.3
8/23/2008	13:27 – 13:31	08NC39	668004	07953 – 07975	0.46m	0.2
8/23/2008	13:56 – 14:00	08NC39	668001	08099 – 08123	0.46m	0.1

8/23/2008	14:06 – 14:11	08NC39	668002	08124 – 08153	0.46m	0.1
8/23/2008	14:37 – 14:39	08NC39	668003	08278 – 08294	0.46m	0.2
8/23/2008	14:39 – 14:42	08NC39	668003	08295 – 08307	0.46m	0.3
8/23/2008	14:47 – 14:49	08NC39	668010	08308 – 08321	0.46m	0.2
5/26/2009	11:48 – 11:49	09NC02	668005	00276 – 00281	0.46m	-0.2
5/26/2009	11:49 – 11:52	09NC02	668005	00282 – 00298	0.46m	-0.1
5/26/2009	11:57 – 12:00	09NC02	668006	00300 – 00312	0.46m	0.0
5/26/2009	12:00 – 12:01	09NC02	668006	00313 – 00321	0.46m	-0.1
5/26/2009	12:26 – 12:28	09NC02	668009	00423 – 00434	0.46m	0.2
5/26/2009	12:28	09NC02	668009	00435 – 00437	0.46m	0.3
6/10/2011	15:44 – 15:47	11NC34	650001	06051 – 06074	0.34m	0.2
6/10/2011	15:52 – 15:54	11NC34	650002	06075 – 06085	0.34m	0.2
6/10/2011	15:54 – 15:56	11NC34	650002	06086 – 06100	0.34m	0.1
6/10/2011	16:26 – 16:27	11NC34	650003	06275 – 06280	0.34m	0.1
6/10/2011	16:27	11NC34	650003	06281 – 06282	0.34m	0.2
6/10/2011	16:27 – 16:28	11NC34	650003	06283 – 06287	0.34m	0.1
6/10/2011	16:28 – 16:30	11NC34	650003	06288 – 06298	0.34m	0.2
6/21/2011	13:10 – 13:14	11NC57	650004	18344 – 18371	0.34m	0.1

*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 NOS gauges. The height of Mean High Water above the MLLW datum in the project area varied between 3.7 and 4.2 meters.

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 January 2014. The review process included analysis of the DG 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 9.3 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 comparison process included the following nautical chart(s):

13326, Machias Bay to Tibbet Narrows, ME; 1:40,000 scale, 13th Ed., Apr. /04
13392, Grand Manan Channel, Southern Part; 1:50,000 scale, 3rd Ed., Feb./11

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 Airborne Positioning and Orientation Report(s) (APOR)
- Hardcopy of the Project Completion Report (PCR)
- Page-size graphic plot of GC10985 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project database
- GC10985 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

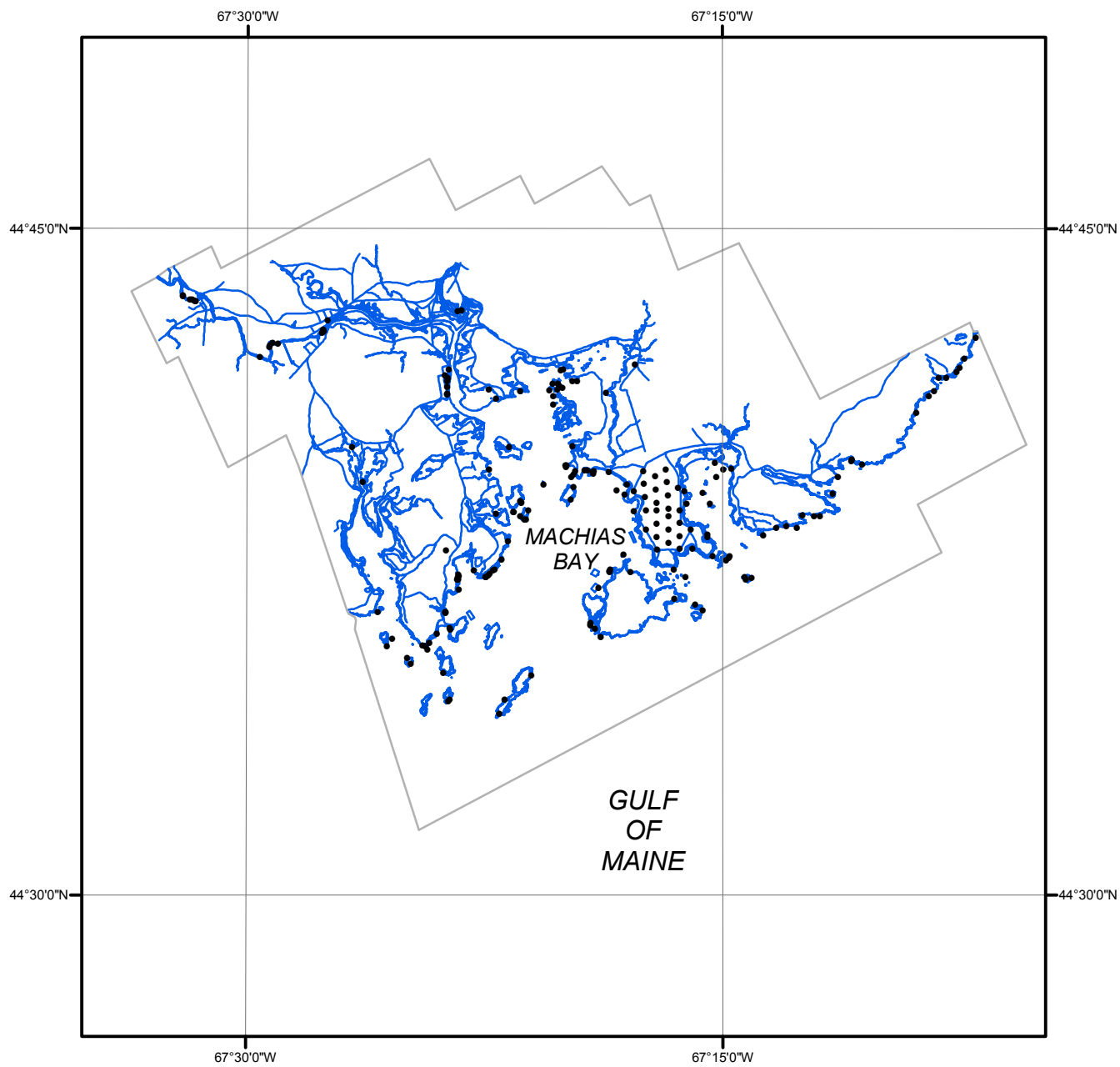
NOAA Shoreline Data Explorer

- GC10985 in shapefile format
- Metadata file for GC10985
- Digital copy of the PCR in Adobe PDF format

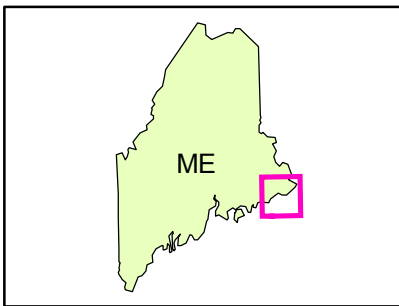
End of Report

LITTLE KENNEBEC BAY TO BOG BROOK COVE

MAINE



Overview



ME0702C

GC10985