

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT ME0702B

Tibbett Narrows to Englishman Bay, Maine

Introduction

NOAA Coastal Mapping Program (CMP) Project ME0702B provides a highly accurate database of new digital shoreline data for the southern coastal areas of Maine, stretching from Moose Neck and Tibbett Narrows in the west, to Calf Island in Englishman Bay in the east. Project ME0702B is a sub-project of a larger project, ME0702, which includes the coastal area 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	2.16	2.60	2.45
5/25/2009	2.28	2.67	2.54
5/26/2009	2.18	2.62	2.44
5/26/2009	2.22	2.57	2.42
6/10/2011	1.72	1.94	1.84
6/11/2011	1.60	1.97	1.81
6/21/2011	1.91	2.11	2.03

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 June 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 ME0702B were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features compiled from the 2008 and 2009 imagery were compiled to meet a horizontal accuracy of 4.9 meters, and features on the 2011 imagery were compiled to meet a horizontal accuracy of 3.8 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	14:46 – 14:47	09NR01	268012	00001 – 00006	0.46m	3.4
5/25/2009	14:47 – 14:48	09NR01	268012	00007 – 00012	0.46m	3.5
5/25/2009	15:04 – 15:05	09NR01	268001	00041 – 00042	0.46m	3.8
5/25/2009	15:05 – 15:06	09NR01	268001	00043 – 00047	0.46m	3.7
5/25/2009	15:06 – 15:09	09NR01	268001	00048 – 00064	0.46m	3.6
5/25/2009	15:09 – 15:10	09NR01	268001	00065 – 00069	0.46m	3.5
5/26/2009	16:03 – 16:05	09NR03	268002	00472 – 00482	0.46m	3.5
5/26/2009	16:05 – 16:06	09NR03	268002	00483 – 00488	0.46m	3.6
5/26/2009	16:06 – 16:07	09NR03	268002	00489 – 00492	0.46m	3.7
5/26/2009	16:07 – 16:09	09NR03	268002	00493 – 00501	0.46m	3.8
5/26/2009	16:24 – 16:25	09NR03	268003	00558 – 00564	0.46m	3.9
5/26/2009	16:25 – 16:27	09NR03	268003	00565 – 00571	0.46m	3.8
5/26/2009	16:27 – 16:29	09NR03	268003	00572 – 00585	0.46m	3.7
5/26/2009	16:47 – 16:48	09NR03	268004	00659 – 00660	0.46m	3.7
5/26/2009	16:48 – 16:50	09NR03	268004	00661 – 00671	0.46m	3.8
5/26/2009	16:50	09NR03	268004	00672 – 00674	0.46m	3.9
5/26/2009	16:51 – 16:52	09NR03	268004	00675 – 00685	0.46m	4.0
5/26/2009	17:05 – 17:07	09NR03	268005	00727 – 00738	0.46m	4.0
5/26/2009	17:07 – 17:08	09NR03	268005	00739 – 00741	0.46m	3.9
5/26/2009	17:08 – 17:09	09NR03	268005	00742 – 00748	0.46m	3.8
5/26/2009	17:09 – 17:10	09NR03	268005	00749 – 00753	0.46m	3.7
5/26/2009	17:27	09NR03	268006	00831 – 00832	0.46m	3.6
5/26/2009	17:28 – 17:29	09NR03	268006	00833 – 00841	0.46m	3.7

5/26/2009	17:29 – 17:31	09NR03	268006	00842 – 00853	0.46m	3.9
5/26/2009	17:31 – 17:32	09NR03	268006	00854 – 00855	0.46m	4.0
5/26/2009	17:45 – 17:46	09NR03	268007	00895 – 00900	0.46m	3.9
5/26/2009	17:46 – 17:47	09NR03	268007	00901 – 00909	0.46m	3.8
5/26/2009	17:47 – 17:49	09NR03	268007	00910 – 00918	0.46m	3.6
5/26/2009	18:09 – 18:10	09NR03	268008	01008 – 01014	0.46m	3.6
5/26/2009	18:10 – 18:11	09NR03	268008	01015 – 01020	0.46m	3.5
5/26/2009	18:11	09NR03	268008	01021 – 01022	0.46m	3.7
6/11/2011	11:29 – 11:31	11NR19	250003	03982 – 03992	0.34m	3.9
6/11/2011	11:43 – 11:45	11NR19	250004	04041 – 04054	0.34m	3.8
8/23/2008	13:17 – 13:19	08NR35	368012	15222 – 15233	0.46m	0.2
8/23/2008	13:31 – 13:33	08NR35	368004	15255 – 15268	0.46m	0.2
8/23/2008	13:33 – 13:35	08NR35	368004	15269 – 15281	0.46m	0.1
8/23/2008	13:51 – 13:56	08NR35	368001	15353 – 15381	0.46m	0.1
8/23/2008	14:11 – 14:16	08NR35	368002	15433 – 15460	0.46m	0.1
8/23/2008	14:32 – 14:37	08NR35	368003	15533 – 15560	0.46m	0.2
5/26/2009	11:44 – 11:45	09NR02	368005	00252 – 00256	0.46m	-0.2
5/26/2009	11:45 – 11:46	09NR02	368005	00257 – 00263	0.46m	-0.3
5/26/2009	11:46 – 11:47	09NR02	368005	00264 – 00266	0.46m	-0.1
5/26/2009	11:47 – 11:49	09NR02	368005	00267 – 00277	0.46m	-0.2
5/26/2009	12:01	09NR02	368006	00320 – 00321	0.46m	-0.1
5/26/2009	12:01 – 12:03	09NR02	368006	00322 – 00333	0.46m	0.0
5/26/2009	12:04 – 12:05	09NR02	368006	00334 – 00340	0.46m	-0.1
5/26/2009	12:05 – 12:06	09NR02	368006	00341 – 00344	0.46m	0.0
5/26/2009	12:24 – 12:25	09NR02	368009	00414 – 00420	0.46m	0.3
5/26/2009	12:25 – 12:26	09NR02	368009	00421 – 00424	0.46m	0.2
6/10/2011	15:42 – 15:44	11NR17	350001	03233 – 03244	0.34m	0.2
6/10/2011	15:56 – 15:59	11NR17	350002	03294 – 03314	0.34m	0.1
6/10/2011	16:22 – 16:26	11NR17	350003	03442 – 03471	0.34m	0.1
6/21/2011	13:05 – 13:10	11NR34	350004	11866 – 11899	0.34m	0.1
8/23/2008	13:17 – 13:19	08NC39	668012	07941 – 07952	0.46m	0.2
8/23/2008	13:31 – 13:33	08NC39	668004	07974 – 07987	0.46m	0.2

8/23/2008	13:33 – 13:35	08NC39	668004	07988 – 08000	0.46m	0.1
8/23/2008	13:51 – 13:56	08NC39	668001	08072 – 08100	0.46m	0.1
8/23/2008	14:11 – 14:16	08NC39	668002	08152 – 08181	0.46m	0.1
8/23/2008	14:32 – 14:37	08NC39	668003	08252 – 08279	0.46m	0.2
5/26/2009	11:44 – 11:45	09NC02	668005	00252 – 00256	0.46m	-0.2
5/26/2009	11:45 – 11:46	09NC02	668005	00257 – 00263	0.46m	-0.3
5/26/2009	11:46 – 11:49	09NC02	668005	00264 – 00277	0.46m	-0.2
5/26/2009	12:01	09NC02	668006	00320 – 00321	0.46m	-0.1
5/26/2009	12:01 – 12:03	09NC02	668006	00322 – 00333	0.46m	0.0
5/26/2009	12:03 – 12:05	09NC02	668006	00334 – 00340	0.46m	-0.1
5/26/2009	12:05 – 12:06	09NC02	668006	00341 – 00344	0.46m	0.0
5/26/2009	12:24 – 12:25	09NC02	668009	00414 – 00421	0.46m	0.3
6/10/2011	15:42 – 15:44	11NC34	650001	06040 – 06051	0.34m	0.2
6/10/2011	15:56 – 15:59	11NC34	650002	06099 – 06117	0.34m	0.1
6/10/2011	16:23 – 16:26	11NC34	650003	06254 – 06276	0.34m	0.1
6/21/2011	13:05 – 13:10	11NC57	650004	18312 – 18345	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 3.2 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 August 2013. 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

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 GC10984 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- Project database
- GC10984 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

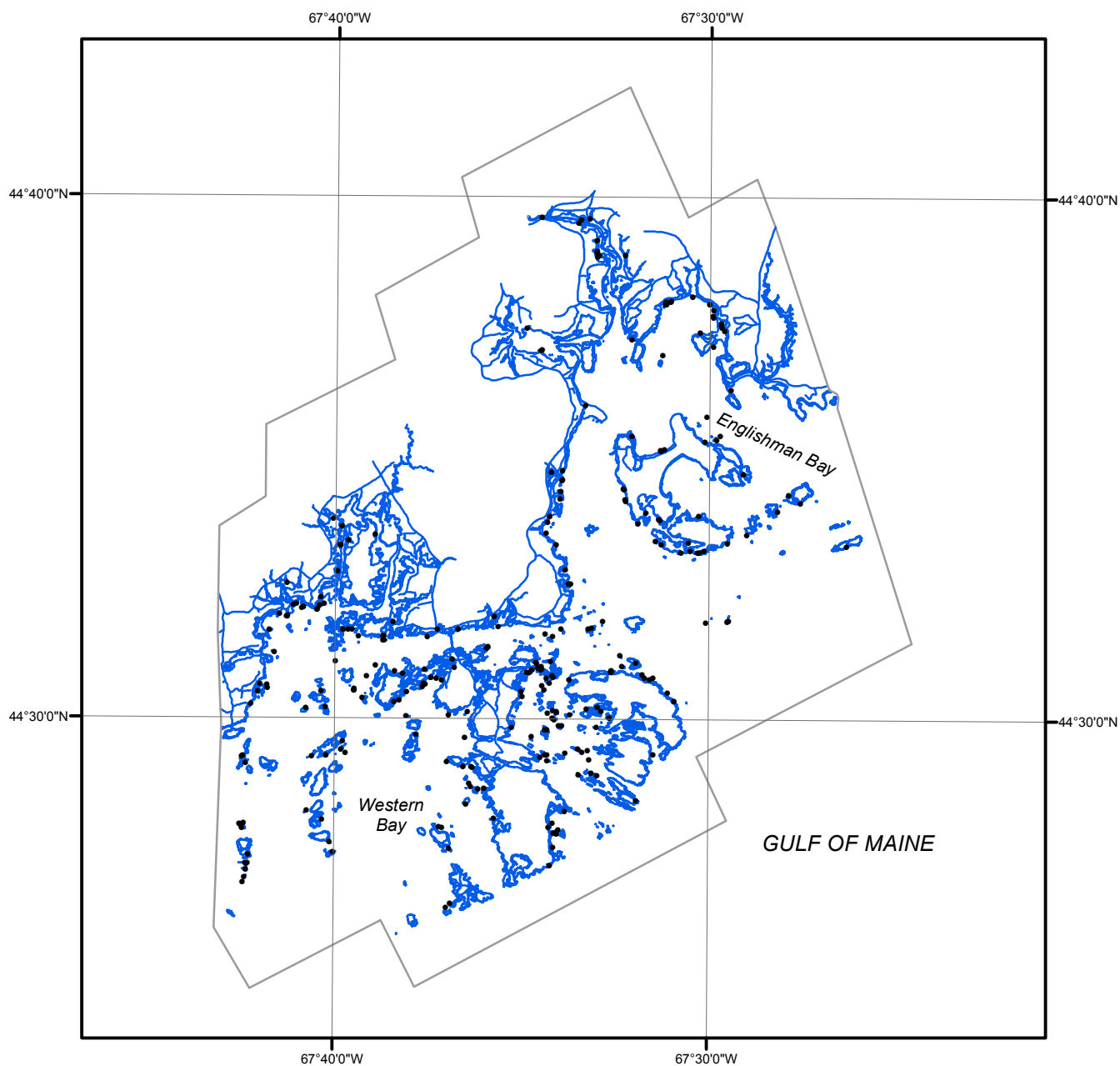
NOAA Shoreline Data Explorer

- GC10984 in shapefile format
- Metadata file for GC10984
- Digital copy of the PCR in Adobe PDF format

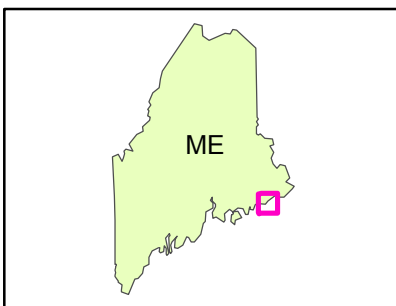
End of Report

TIBBET NARROWS TO ENGLISHMAN BAY

MAINE



Overview



ME0702B

GC10984