

# **NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT**

## ***PROJECT ME0401C***

### ***West Penobscot Bay, including Vinalhaven Island***

#### **Introduction**

Coastal Mapping Program (CMP) Project ME0401C provides a highly accurate database of new digital shoreline data for the West Penobscot Bay. It includes the western shoreline from Atlantic Point in Rockland Harbor to Great Spruce Head, east to Eagle and Seal Islands, south to Matinicus Rock, including the southern half of Isleboro Island, Vinalhaven Island, and Matinicus Island. Project ME0401C is a subproject of a larger project, ME0401, which includes the shore of Maine from Pemaquid Point to Naskeag Point and includes the Penobscot River upstream to Bangor, and the offshore islands in Penobscot Bay.

Successful completion of the project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric-quality aerial photographs, and a Geographic Cell (GC) of the coastal zone which compliments 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 photography 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 design of project ME0401 was based on a comparison of image analysis to cartographic detail depicted on the pertinent NOAA nautical charts of the project site. The Remote Sensing Division (RSD) of the National Geodetic Survey, NOAA, formulated the ME0401 Project Instructions (June 9, 2004) which contains the specific field and photo mission operational guidelines. The instructions, as provided to Tuck Mapping Solutions, Inc. (TMSI), discussed the project's purpose, geographic area of coverage, scope and priority; photographic and ground control requirements; flight line priority; tide and sun angle coordination; Global Positioning Systems (GPS) data collection procedures and guidelines for both kinematic and static surveys; data recording and handling instructions; and contact communication information.

Nautical charts provided by RSD showed the limits of the color, black & white infrared (B&W IR) and tide sensitive photography areas. Photo scales for the color and B&W IR photography were determined by RSD staff to attain the required mapping accuracies. A

waiver to utilize a 700nm filter during the acquisition of the B&W IR film was approved previously. NOAA approved waiver for this filter on the camera without requiring a new camera calibration report by the USGS.

Included in correspondence from TMSI to NOAA on July 25, 2002, was a document titled Quality Control Procedures for NOAA Coastal Mapping Projects. These procedures and requirements were followed by TMSI throughout the project.

## **Field Operations**

TMSI photographic mission operations were conducted on September 30, 2004, October 29, 2004, October 30, 2004, May 13, 2005, June 2, 2005, June 4, 2005, June 20, 2005, June 21, 2005, July 21, 2005, August 26, 2005, October 20, 2005, October 21, 2005, October 7, 2006, and October 8, 2006. Aerial photographic coverage of the project site consisted of natural color and black & white infrared photographs at a nominal scale of 1:36000. Tide-coordinated photography was conducted at both the mean high water (MHW) and mean lower low water (MLLW) levels. Natural color and black & white infrared photographs were acquired at MHW and only black & white infrared photographs were acquired at MLLW.

TMSI used two base stations, Z 151 (NGS PID PE1053) and NAIL (a temporary non-NGS station). Z 151, the primary station, was a Leica dual frequency GPS receiver with an antenna mounted on a tripod. NAIL had the same configuration and was a backup to for Z 151. There was one data failure on May 13, 2005, for Z 151 that required the use of the backup station data. GPS data was submitted for OPUS solutions to verify the stations. TMSI performed the necessary GPS surveys to locate aerial control and checkpoints. Multiple two hour sessions observed by TMSI were submitted for OPUS solutions and a mean of the values was used to determine the control and checkpoint coordinates.

See the Photographic Flight Reports and Ground Control Reports for additional information.

## **GPS Data Reduction**

GPS data was collected and processed to provide precise positions of the camera centers for application as photogrammetric control in the aerotriangulation phase of the project completion. TMSI acquired static GPS datasets of stations Z 151 and NAIL during all photography missions. After the flight missions, the project data was downloaded and processed using NovAtel's Waypoint GrafNav (versions 7.60.2425 and 7.80.2315) software. Forward and reverse trajectories were compared during the processing phase to ensure accuracy. Camera event file data was then applied to the final trajectory to obtain coordinates for the photo centers. A GPS Data Processing Report was written and is on file with other project data within the RSD Applications Branch (AB) Project Archive.

## **Aerotriangulation**

Routine softcopy aerotriangulation methods were applied to extend the network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. TMSI personnel initiated the softcopy

aerotriangulation work in June 2007, utilizing a digital photogrammetric workstation (DPW), which is a configuration of computer processor and monitor, and BAE Systems SOCET SET ver. 5.3 software equipment and peripheral devices. The softcopy aerotriangulation work was completed in July 2007.

The natural color photography flown September 30, 2004 to June 4, 2005, the B&W IR MLLW photography flown June 2 to August 26, 2005, and the B&W IR MHW flown June 21, 2005 to October 8, 2006 were all processed as three blocks each, except for the photography over the southern islands (Matinicus, Ragged, Wooden Ball, and Seal Island), were not be tied to the rest of the photography, and was processed as its own block.. Upon successful completion of the block adjustment, SOCET SET's Multi Sensor Triangulation (MST) module provided the RMS of the standard deviations for all aerotriangulated ground points, which were used to determine the radius of the 95% confidence circle to be from 1.1 to 1.3 meters for all adjusted photographs, and 0.6 to 0.9 meters for the southern island block. The Aerotriangulation Report is on file with other project data within the RSD AB Project Archive.

The project database consists of camera calibration data, interior orientation parameters for each frame, airborne GPS antenna position and offset data, adjusted exterior orientation parameters for each frame, positional listing of all measured points, the control file and refined image coordinates as listed in the Project Database section of the Aerotriangulation Report. Positional data is based on the North American Datum of 1983 (NAD 83), and is referenced to UTM Zone 19 in meters.

## **Compilation**

The data compilation phase of the project was accomplished by TMSI in March 2008. Digital mapping was performed using Digital Photogrammetric Workstations (DPWs) in conjunction with BAE SOCET SET ver. 5.4. Feature identification and the assignment of cartographic codes were based on image analysis of natural color photography and B&W IR photography and information extracted from appropriate NOAA Nautical Charts and the US Coast Guard Light List. Cartographic feature attribution was assigned in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST) as required.

Cartographic features were compiled to meet a horizontal accuracy at the 95% confidence level of 2.5 meters for the main block of photographs, and 1.9 meters for the southern island block. This predicted accuracy of compiled, well-defined points is derived by doubling the circular error derived from aerotriangulation statistics.

See Table 1 for information on all aerial photographs used for project ME0401C.

**Table 1 - Compilation Sources**

| <b>Date</b> | <b>Time<br/>(UTC)</b> | <b>Roll<br/>Number</b> | <b>Film</b> | <b>Frames</b> | <b>Scale<br/>(nominal)</b> | <b>Tide Level*<br/>(m)</b> |
|-------------|-----------------------|------------------------|-------------|---------------|----------------------------|----------------------------|
| 09/30/2004  | 1644-1649             | 0411CN01               | Color       | 0014-0023     | 1:36000                    | 3.7                        |
| 09/30/2004  | 1706-1710             | 0411CN01               | Color       | 0049-0056     | 1:36000                    | 3.8                        |
| 09/30/2004  | 1821-1826             | 0411CN01               | Color       | 0148-0156     | 1:36000                    | 3.1                        |
| 09/30/2004  | 1854-1855             | 0411CN01               | Color       | 0189-0192     | 1:36000                    | 2.6                        |
| 05/13/2005  | 1526-1532             | 0520CN02               | Color       | 0294-0301     | 1:36000                    | 1.1                        |
| 05/13/2005  | 1638-1639             | 0520CN02               | Color       | 0352-0354     | 1:36000                    | 1.8                        |
| 05/13/2005  | 1646-1647             | 0520CN02               | Color       | 0356-0358     | 1:36000                    | 2.0                        |
| 05/13/2005  | 1650-1700             | 0520CN02               | Color       | 0361-0372     | 1:36000                    | 2.0                        |
| 06/04/2005  | 1609-1614             | 0520CN03               | Color       | 0376-0386     | 1:36000                    | 2.2                        |
| 06/04/2005  | 1616-1618             | 0520CN03               | Color       | 0390-0394     | 1:36000                    | 2.2                        |
| 06/04/2005  | 1626-1628             | 0520CN03               | Color       | 0396-0399     | 1:36000                    | 2.0                        |
| 06/02/2005  | 1751-1755             | 0520R01                | MLLW-IR     | 0041-0049     | 1:36000                    | 0.0                        |
| 06/02/2005  | 1808-1810             | 0520R01                | MLLW-IR     | 0063-0066     | 1:36000                    | 0.0                        |
| 06/02/2005  | 1832-1832             | 0520R01                | MLLW-IR     | 0098-0099     | 1:36000                    | 0.1                        |
| 06/04/2005  | 1927-1928             | 0520R01                | MLLW-IR     | 0112-0115     | 1:36000                    | 0.3                        |
| 06/04/2005  | 1941-1944             | 0520R01                | MLLW-IR     | 0121-0126     | 1:36000                    | 0.3                        |
| 06/04/2005  | 1946-1951             | 0520R01                | MLLW-IR     | 0129-0139     | 1:36000                    | 0.3                        |
| 06/04/2005  | 1959-2004             | 0520R01                | MLLW-IR     | 0143-0154     | 1:36000                    | 0.3                        |
| 06/04/2005  | 2006-2007             | 0520R01                | MLLW-IR     | 0157-0159     | 1:36000                    | 0.3                        |
| 06/04/2005  | 2012-2013             | 0520R01                | MLLW-IR     | 0161-0163     | 1:36000                    | 0.3                        |
| 06/21/2005  | 2101-2102             | 0520R02                | MLLW-IR     | 0358-0361     | 1:36000                    | 0.1                        |
| 06/21/2005  | 2108-2109             | 0520R02                | MLLW-IR     | 0362-0364     | 1:36000                    | 0.2                        |
| 07/21/2005  | 2028-2031             | 0520R03                | MLLW-IR     | 0395-0401     | 1:36000                    | 0.1                        |
| 07/21/2005  | 2047-2050             | 0520R03                | MLLW-IR     | 0413-0418     | 1:36000                    | 0.1                        |
| 07/21/2005  | 2057-2058             | 0520R03                | MLLW-IR     | 0421-0424     | 1:36000                    | 0.0                        |
| 06/21/2005  | 1431-1432             | 0520R02                | MHW-IR      | 0285-0287     | 1:36000                    | 3.2                        |
| 06/21/2005  | 1518-1519             | 0520R02                | MHW-IR      | 0335-0337     | 1:36000                    | 3.0                        |
| 06/21/2005  | 1537-1538             | 0520R02                | MHW-IR      | 0354-0355     | 1:36000                    | 3.0                        |
| 10/07/2006  | 1456-1457             | 0620R05                | MHW-IR      | 0629-0631     | 1:36000                    | 3.5                        |
| 10/07/2006  | 1459-1503             | 0620R05                | MHW-IR      | 0634-0641     | 1:36000                    | 3.5                        |
| 10/07/2006  | 1513-1514             | 0620R05                | MHW-IR      | 0653-0655     | 1:36000                    | 3.5                        |
| 10/07/2006  | 1553-1554             | 0620R05                | MHW-IR      | 0670-0672     | 1:36000                    | 3.3                        |
| 10/07/2006  | 1606-1610             | 0620R05                | MHW-IR      | 0682-0690     | 1:36000                    | 3.4                        |
| 10/08/2006  | 1436-1440             | 0620R05                | MHW-IR      | 0751-0758     | 1:36000                    | 3.3                        |
| 10/08/2006  | 1444-1448             | 0620R05                | MHW-IR      | 0759-0766     | 1:36000                    | 3.3                        |
| 10/08/2006  | 1457-1500             | 0620R05                | MHW-IR      | 0771-0777     | 1:36000                    | 3.4                        |
| 10/08/2006  | 1507-1513             | 0620R05                | MHW-IR      | 0780-0790     | 1:36000                    | 3.4                        |
| 10/08/2006  | 1514-1517             | 0620R05                | MHW-IR      | 0793-0798     | 1:36000                    | 3.4                        |
| 10/08/2006  | 1624-1626             | 0620R06                | MHW-IR      | 0853-0856     | 1:36000                    | 3.3                        |

\* The gauges used to determine tidal heights within this project are Bangor (BNG) and Bar Harbor (BH). Tide height for color photography is for actual tide station shown. Tide levels for IR are given relative to MLLW and are based on gauge verified observations then adjusted for COOPS Tidal Zoning. The mean tide range for the project area varies from 0.0 to 3.8 meters.

## **Final Review**

A TMSI team completed the final review in September 2008. The GC was evaluated for completeness and accuracy. The review process included analysis of aerotriangulation results and assessment of the identification and attribution of cartographic features 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 GIS 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:

- 13303 Approaches to Penobscot Bay, 1:40000, 12<sup>th</sup> edition, September 2002
- 13305 Penobscot Bay, 1:40000, 28<sup>th</sup> edition, 5 May 2001
- 13307 Camden-Rockport & Rockland Harbors, 1:20000, 10<sup>th</sup> edition, 27 October 2001
- 13308 Fox Islands Thorofare, 1:15000, 12<sup>th</sup> edition, April 2004
- 13309 Penobscot River, 1:40000, 28<sup>th</sup> edition, September 2002

## **End Products and Deliverables**

The following specifies the location and identification of the products generated during the completion of this project:

### **RSD Applications Branch Project Archive:**

- Hard copy of Airborne Positioning and Orientation Report
- Hard copy of Aerotriangulation Report
- Hard copy of the Project Completion Report
- Page-size graphic plot of GC10681 file contents

### **RSD Electronic Data Library:**

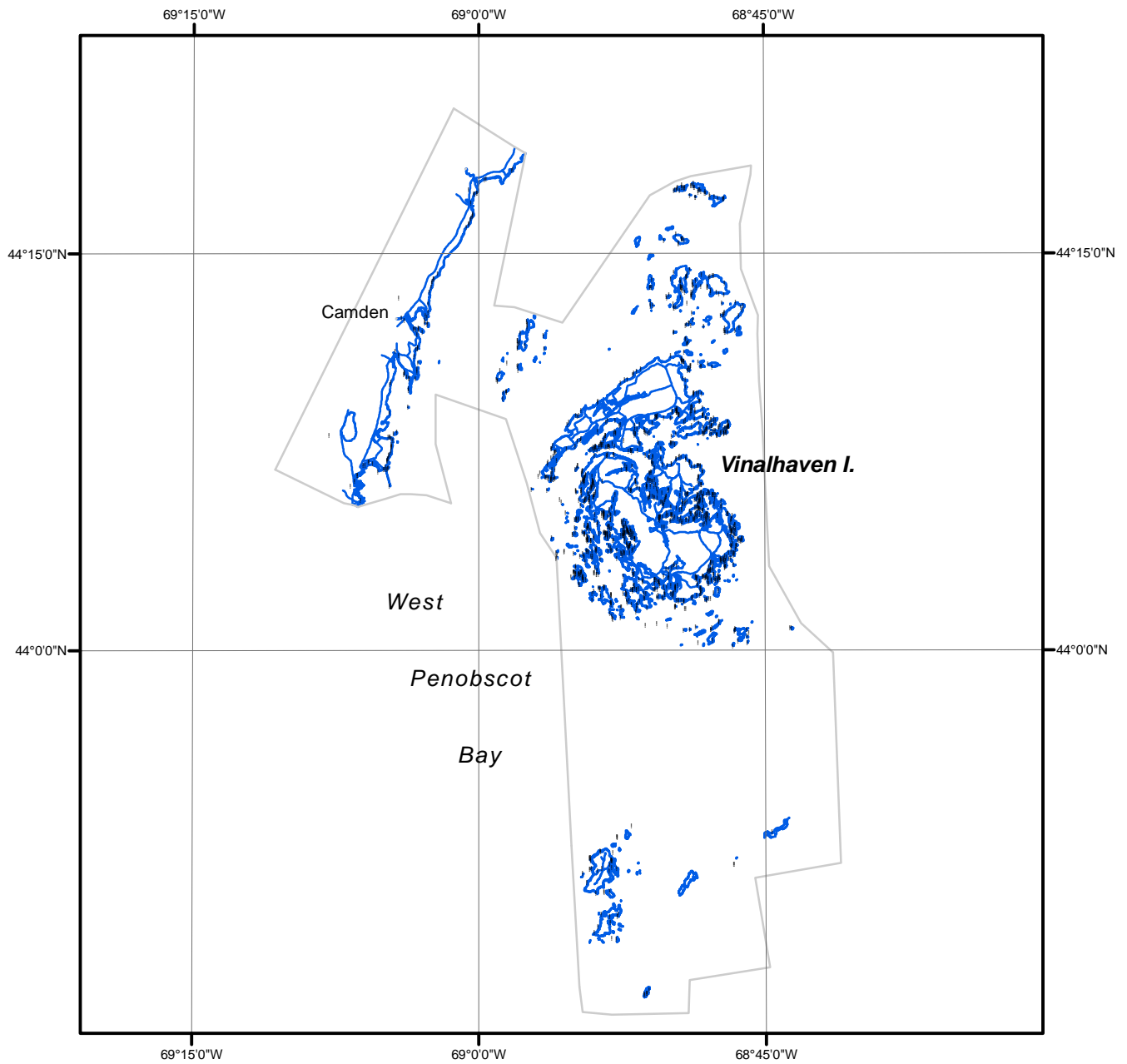
- Project Database
- Digital copy of GC10681 in Shapefile format
- Digital Copy of Project Completion Report in Adobe PDF format

### **NOAA Shoreline Data Explorer:**

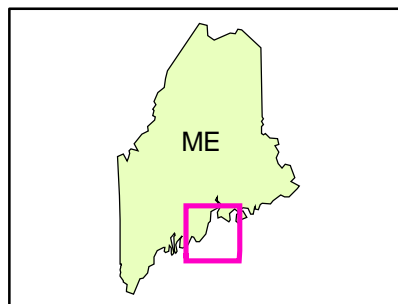
- GC10681
- Metadata file for GC10681
- Digital Copy of the Project Completion Report in Adobe PDF format

## **End of Report**

# WEST PENOBSCOT BAY, INCLUDING VINALHAVEN ISLAND MAINE



Overview



ME0401C

GC10681