

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT WA1406A-CM-N

Puget Sound, Vashon Island to Tacoma Narrows, Washington

Introduction

NOAA Coastal Mapping Program (CMP) Project WA1406A-CM-N provides a highly accurate database of new digital shoreline for Puget Sound, from Vashon Island to the Tacoma Narrows, including the port of Tacoma, in Washington. This is a subproject of a larger imagery acquisition project, WA1406-CM-N, which provides coverage of Southern Puget Sound from Vashon Island to Oakland Bay, Washington. 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

Photographic mission instructions for WA1406-CM-N were formulated by the Requirements Branch (RB) of the Remote Sensing Division (RSD) 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, 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 for Project WA1406-CM-N consisted of the collection of static and kinematic GPS data and Inertial Measurement Unit (IMU) data, and the acquisition of digital aerial imagery. Aerial survey operations were conducted from August 2014 through June 2016, and included 49 flight lines of natural color (RGB) and near-infrared (NIR) imagery acquired concurrently with Applanix DSS dual cameras on the NOAA King Air aircraft (N68RF) in coordination with both the Mean High Water (MHW) and Mean Lower Low Water (MLLW) tide stages. For subproject WA1406A-CM-N, a subset of 12 flight lines were used. All imagery was acquired at a nominal altitude of 10,500 feet resulting in an approximate Ground Sample Distance (GSD) that varies between 0.33 – 0.37 meters depending on the camera used and imagery type acquired.

Direct Georeferencing Data Processing

The GPS/IMU data 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 for project WA1406-CM-N was processed using Applanix POSPac MMS (ver.6.2 and

ver.7.1) software from September 2014 to September 2016. For further information refer to the Airborne Positioning and Orientation Reports (APORs) on file with other project data within the RSD Electronic Data Library.

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 calculated using an Exterior Orientation Total Propagated Uncertainty (EO-TPU ver. 2.1) tool developed by NGS. Using this tool, the predicted horizontal uncertainty at the 95% confidence level was calculated to be 0.90 meters.

NGS third order control was used to verify the horizontal integrity of the DG data. All stereo models were examined and found to have acceptable levels of parallax for mapping purposes.

Aerotriangulation

Aerotriangulation (AT) was performed by personnel of the Applications Branch (AB) of RSD in November 2021 with a subset of the project imagery which covers the port of Tacoma. Routine softcopy AT methods were applied to establish a network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. Images were measured and adjusted as a single block using the Multi-Sensor Triangulation (MST) module of BAE Systems' SOCET SET (ver. 5.6) photogrammetric software suite. 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 0.37 meters based on a 95% confidence level. An AT Report was written and is on file with other project data in the RSD Electronic Data Library. All positional data within the project is referenced to the North American Datum of 1983 (NAD83).

Compilation

The data compilation phase of this project was completed by AB personnel in February 2022. Digital mapping was performed using the Feature Extraction software module within SOCET SET. Feature identification and attribution within the 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 WA1406A-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features compiled from aerotriangulated images covering the port of Tacoma were compiled to meet a horizontal accuracy of 0.7 meters, and features compiled in the remainder of the project, from directly georeferenced images, were compiled to meet a horizontal accuracy of 1.8 meters. These accuracies, calculated at the 95% confidence level, represent predicted accuracies of well-defined points measured in the compilation phase derived by doubling the circular error calculated from AT statistics and imagery accuracy computed from the EO-TPU tool, respectively. The following table provides further information on the imagery used to complete this project:

Date	Time (UTC)	Color Imagery		Infrared Imagery		Tide Level*
		Roll	Strip / Images	Roll	Strip / Images	
8/23/2014	16:32 - 16:34	14NC72	53-049 / 16845 - 16862	14NR63	53-049 / 13593 - 13610	0.3 m
8/23/2014	16:40 - 16:42	14NC72	53-048 / 16863 - 16875	14NR63	53-048 / 13611 - 13623	0.2 - 0.3 m
8/23/2014	16:50 - 16:56	14NC72	53-047 / 16876 - 16911	14NR63	53-047 / 13624 - 13659	0.1 - 0.2 m
8/23/2014	17:03 - 17:05	14NC72	53-042 / 16912 - 16927	14NR63	53-042 / 13660 - 13675	0.2 m
8/23/2014	17:10 - 17:13	14NC72	53-037 / 16928 - 16944	14NR63	53-037 / 13676 - 13692	0.1 - 0.2 m
8/23/2014	17:19 - 17:22	14NC72	53-024 / 16945 - 16962	14NR63	53-024 / 13693 - 13710	0.1 m
8/23/2014	17:28 - 17:31	14NC72	53-030 / 16963 - 16981	14NR63	53-030 / 13711 - 13729	0.1 m
8/23/2014	17:36 - 17:38	14NC72	53-026 / 16982 - 16999	14NR63	53-026 / 13730 - 13747	0.1 m
8/23/2014	17:45 - 17:48	14NC72	53-035 / 17000 - 17018	14NR63	53-035 / 13748 - 13766	0.1 m
8/23/2014	17:55 - 18:00	14NC72	53-045 / 17019 - 17050	14NR63	53-045 / 13767 - 13798	0.1 m
8/23/2014	18:08 - 18:10	14NC72	53-043 / 17051 - 17064	14NR63	53-043 / 13799 - 13812	0.1 m
8/23/2014	18:47 - 18:48	14NC72	53-040 / 17125 - 17134	14NR63	53-040 / 13873 - 13882	0.3 m
8/23/2014	23:17 - 23:23	14NC73	53-047 / 17202 - 17237	14NR64	53-047 / 13950 - 13985	3.2 - 3.4 m
8/23/2014	23:27 - 23:29	14NC73	53-049 / 17238 - 17255	14NR64	53-049 / 13986 - 14003	3.3 m
8/23/2014	23:35 - 23:37	14NC73	53-048 / 17256 - 17268	14NR64	53-048 / 14004 - 14016	3.4 m
8/23/2014	23:41 - 23:44	14NC73	53-035 / 17269 - 17287	14NR64	53-035 / 14017 - 14035	3.4 - 3.5 m
8/23/2014	23:49 - 23:51	14NC73	53-030 / 17288 - 17306	14NR64	53-030 / 14036 - 14054	3.5 m
8/24/2014	00:12 - 00:14	14NC73	53-026 / 17307 - 17324	14NR64	53-026 / 14055 - 14072	3.5 - 3.6 m
8/24/2014	00:19 - 00:22	14NC73	53-042 / 17325 - 17340	14NR64	53-042 / 14073 - 14088	3.6 m
8/24/2014	00:30 - 00:33	14NC73	53-024 / 17356 - 17373	14NR64	53-024 / 14104 - 14121	3.5 - 3.6 m
8/25/2014	23:44 - 23:46	14NC74	53-037 / 17848 - 17864	14NR65	53-037 / 14596 - 14612	3.2 m
8/25/2014	23:54 - 23:58	14NC74	53-045 / 17865 - 17896	14NR65	53-045 / 14613 - 14644	3.2 - 3.3 m
8/26/2014	00:08 - 00:10	14NC74	53-040 / 17909 - 17918	14NR65	53-040 / 14657 - 14666	3.4 - 3.5 m
8/26/2014	00:15 - 00:17	14NC74	53-043 / 17919 - 17932	14NR65	53-043 / 14667 - 14680	3.5 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 NOS gauges. The height of the MHW tidal datum in the project area varies between 3.33 – 3.71 meters above MLLW.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of the CMP. The final QC review was completed in March 2022. 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 (ver. 10.8.1) desktop GIS 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 chart products were used in the comparison process:

- ENC US4WA10M, 38th Ed., Jan. 2020, Scale 1:80,000
- ENC US5WA22M, 42nd Ed., Sep. 2021, Scale 1:15,000
- RNCs 18474_1 and 18474_2, 11th Ed., Dec. 2015, Scales 1:40,000 and 1:20,000

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

- Project database
- Airborne Positioning and Orientation Reports (APORs)
- Aerotriangulation Report
- GC11682 in shapefile format
- Project Completion Report (PCR)
- CEF in shapefile format

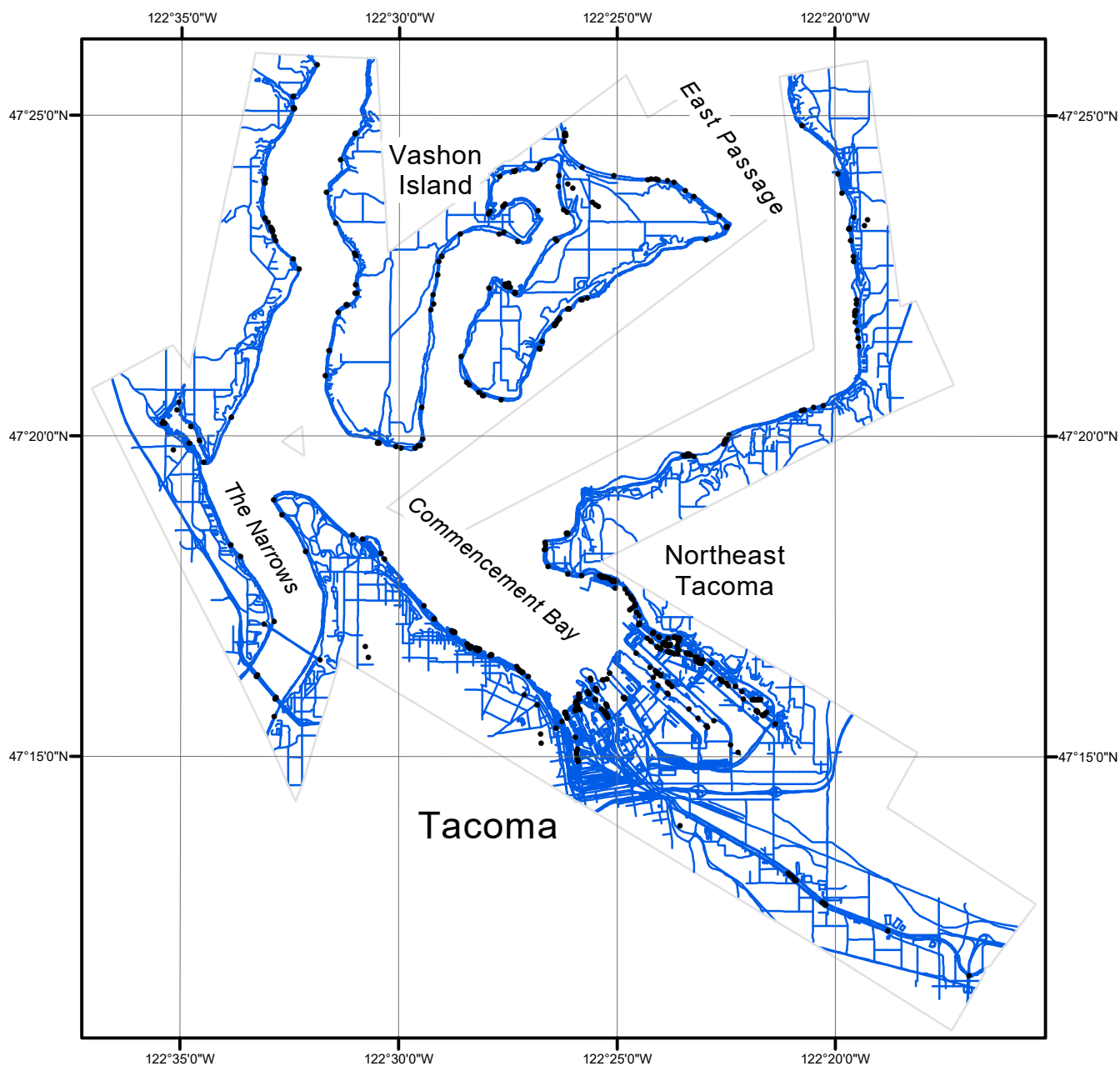
NOAA Shoreline Data Explorer

- GC11682 in shapefile format
- Metadata file for GC11682
- PCR in Adobe PDF format

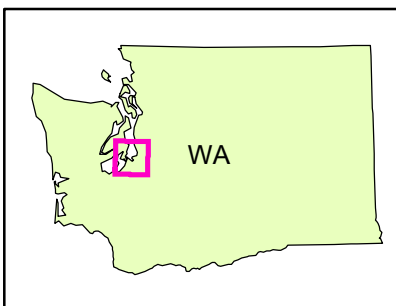
End of Report

PUGET SOUND, VASHON ISLAND TO TACOMA NARROWS

WASHINGTON



Overview



WA1406A-CM-N

GC11682