

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

## ***PROJECT WA1405-CM-N***

### ***Strait of Juan de Fuca, Cape Flattery to Dungeness Bay, Washington***

#### **Introduction**

NOAA Coastal Mapping Program (CMP) Project WA1405-CM-N provides a highly accurate database of new digital shoreline for the Strait of Juan de Fuca, from Cape Flattery to Dungeness Bay, in 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 WA1405-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 WA1405-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 with the NOAA King Air aircraft (N68RF) at a nominal altitude of 10,500 feet. Eleven flight lines of natural color (RGB) imagery and near-infrared (NIR) imagery were acquired concurrently in coordination with both the Mean High Water (MHW) and Mean Lower Low Water (MLLW) tide stages. Most of the MHW imagery was acquired in August 2014 using an Applanix DSS 439 dual head digital camera system, resulting in an approximate ground sample distance (GSD) of 0.37 meters. All of the MLLW imagery and two of the MHW flight lines were acquired in May 2016 using an Applanix DSS 560/580 dual camera, resulting in an approximate GSD of 0.33 meters for the RGB imagery and 0.35 meters for the NIR imagery.

#### **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 WA1405-CM-N was processed using Applanix POSPac MMS (ver. 6.2) software in November 2014 and Applanix POSPac MMS (ver. 7.1) software in June 2016. For

further information refer to the Airborne Positioning and Orientation Reports (APOR) 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 1.4 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 using a subset of the imagery covering Port Angeles, in February 2018. 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 module of BAE Systems' SOCET SET (ver. 5.6) photogrammetric software suite. Upon successful completion of this process, the triangulation 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 within the RSD Electronic Data Library. Positional data is referenced to the North American Datum of 1983 (NAD83).

## **Compilation**

The data compilation phase of this project was completed by RSD Applications Branch (AB) personnel in December 2018. Digital mapping was performed using the Feature Extraction software module within SOCET SET (ver. 5.6). 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 WA1405-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features compiled from directly georeferenced images were compiled to meet a horizontal accuracy of 2.8 meters, a predicted accuracy of well-defined points measured during the compilation phase, derived by doubling the imagery accuracy computed from the EO-TPU tool. Features compiled from the aerotriangulated images were compiled to meet a horizontal accuracy of 0.7 meters at the 95% confidence level, a predicted accuracy of compiled well-defined points, derived by doubling the circular error calculated from the AT statistics.

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             | Images        |              |
| 8/25/2014 | 21:21 – 21:24 | 14NC74        | 53-003 / 17646 – 17666 | 14NR65           | 14394 – 14414 | 1.9 m        |
| 8/25/2014 | 21:31 – 21:35 | 14NC74        | 53-004 / 17667 – 17689 | 14NR65           | 14415 – 14437 | 1.9 m        |
| 8/25/2014 | 21:42 – 21:45 | 14NC74        | 53-005 / 17690 – 17712 | 14NR65           | 14438 – 14460 | 1.9 m        |
| 8/25/2014 | 21:59 – 22:05 | 14NC74        | 53-006 / 17713 – 17748 | 14NR65           | 14461 – 14496 | 1.9 m        |
| 8/25/2014 | 22:40 – 22:44 | 14NC74        | 53-011 / 17749 – 17775 | 14NR65           | 14497 – 14523 | 1.9 m        |
| 8/25/2014 | 22:49 – 22:54 | 14NC74        | 53-010 / 17776 – 17809 | 14NR65           | 14524 – 14557 | 1.9 m        |
| 8/25/2014 | 22:59 – 23:05 | 14NC74        | 53-009 / 17810 – 17847 | 14NR65           | 14558 – 14595 | 1.9 m        |
| 8/27/2014 | 23:54 – 23:58 | 14NC76        | 53-008 / 18059 – 18083 | 14NR95           | 20541 – 20565 | 1.9 m        |
| 8/28/2014 | 00:03 – 00:07 | 14NC76        | 53-007 / 18084 – 18113 | 14NR95           | 20566 – 20595 | 1.9 m        |
| 5/6/2016  | 16:27 – 16:30 | 16VC48        | 53-001 / 12141 – 12159 | 16VR48           | 12145 – 12163 | 0.0 – -0.1m  |
| 5/6/2016  | 16:35 – 16:37 | 16VC48        | 53-002 / 12160 – 12178 | 16VR48           | 12164 – 12182 | -0.1 – 0.1 m |
| 5/6/2016  | 16:42 – 16:45 | 16VC48        | 53-003 / 12179 – 12199 | 16VR48           | 12183 – 12203 | 0.0 m        |
| 5/6/2016  | 16:51 – 16:54 | 16VC48        | 53-004 / 12200 – 12222 | 16VR48           | 12204 – 12226 | 0.0 – -0.1m  |
| 5/6/2016  | 16:59 – 17:03 | 16VC48        | 53-005 / 12223 – 12245 | 16VR48           | 12227 – 12249 | 0.0 – -0.1m  |
| 5/6/2016  | 17:08 – 17:14 | 16VC48        | 53-006 / 12246 – 12281 | 16VR48           | 12250 – 12285 | 0.0 – -0.1m  |
| 5/6/2016  | 17:25 – 17:29 | 16VC48        | 53-011 / 12282 – 12308 | 16VR48           | 12286 – 12312 | -0.2 – -0.1m |
| 5/6/2016  | 17:33 – 17:38 | 16VC48        | 53-010 / 12309 – 12342 | 16VR48           | 12313 – 12346 | -0.1 – -0.2m |
| 5/6/2016  | 17:43 – 17:46 | 16VC48        | 53-008 / 12343 – 12367 | 16VR48           | 12347 – 12371 | -0.2 – 0.1 m |
| 5/6/2016  | 17:50 – 17:54 | 16VC48        | 53-007 / 12368 – 12397 | 16VR48           | 12372 – 12401 | 0.2 – -0.1 m |
| 5/6/2016  | 18:02 – 18:08 | 16VC48        | 53-009 / 12398 – 12435 | 16VR48           | 12402 – 12439 | 0.0 – 0.2 m  |
| 5/6/2016  | 20:32 – 20:35 | 16VC49        | 53-001 / 12452 – 12470 | 16VR49           | 12456 – 12474 | 1.9 – 2.0 m  |
| 5/6/2016  | 20:40 – 20:43 | 16VC49        | 53-002 / 12471 – 12489 | 16VR49           | 12475 – 12493 | 2.0 – 1.9 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 1.98 – 2.17 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 February 2019. 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. 10.7.1) 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 nautical charts were used in the comparison process:

- 18460, Strait of Juan de Fuca Entrance, 14<sup>th</sup> Ed., Jan. 2013
- 18465, Strait of Juan de Fuca Eastern Part, 39<sup>th</sup> Ed., Oct. 2011
- 18468, Port Angeles, 19<sup>th</sup> Ed., Sep. 2012
- 18471, Approaches to Admiralty Inlet, 11<sup>th</sup> Ed., Dec. 2007
- 18484, Neah Bay, 12<sup>th</sup> Ed., Jun. 2006
- 18485, Cape Flattery, 17<sup>th</sup> Ed., Jan. 2013

## **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
- GC11405 in shapefile format
- Project Completion Report (PCR)
- CEF in shapefile format

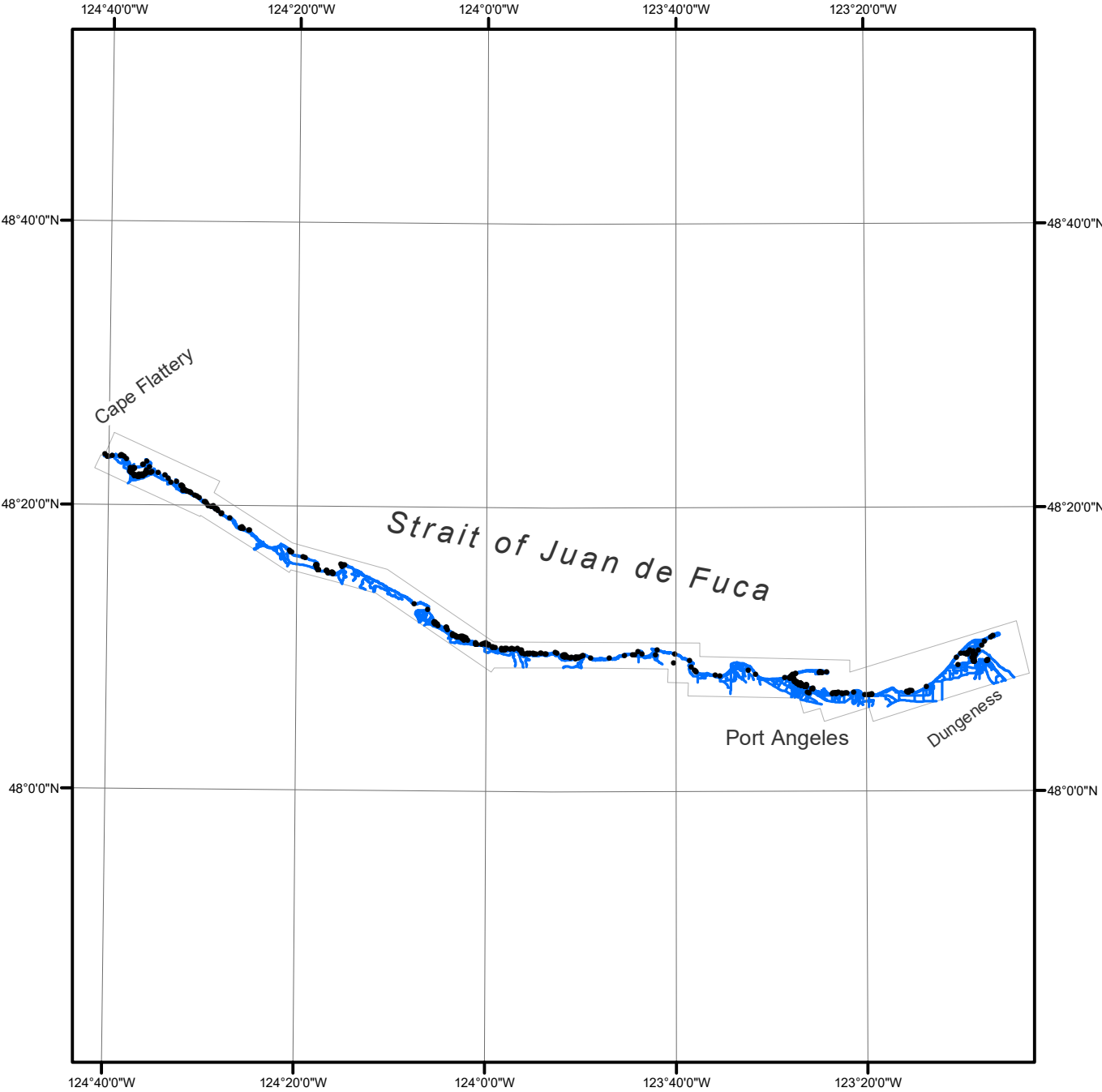
### **NOAA Shoreline Data Explorer**

- GC11405 in shapefile format
- Metadata file for GC11405
- PCR in Adobe PDF format

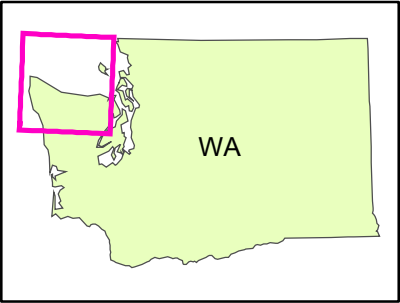
## **End of Report**

# STRAIT OF JUAN DE FUCA, CAPE FLATTERY TO DUNGENESS BAY

## WASHINGTON



Overview



WA1405-CM-N

GC11405