NOAA COASTAL MAPPING PROGRAM
PROJECT COMPLETION REPORT

PROJECT CA1101B

San Pedro Bay to Rincon Point, California

Introduction

NOAA Coastal Mapping Program (CMP) Project CA1101B provides a highly accurate database of new digital shoreline data for outer coastal areas of Southern California. The project extends from San Pedro Bay to Rincon Point, California. This project is a subset of a larger mapping project, CA1101, which encompasses the California shoreline from the Mexican border to Rincon Point (see *Field Operations* below*)*.

Successful completion of this project resulted in a densification of the National Spatial Reference System (NSRS) 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 aerial light detection and ranging (lidar), digital camera imagery, satellite imagery, and metadata related to shoreline extraction and derivation. Base mapping was conducted in a digital GIS environment and associated cartographic practices were performed.

Project Design

The Requirements Branch (RB) of the Remote Sensing Division (RSD) formulated the project instruction as part of the federal Integrated Ocean and Coastal Mapping (IOCM) initiative. The purpose of this project was to extract the Mean High Water (MHW) shoreline for the California outer coastline to update NOAA nautical charts. The instructions discussed the project's purpose, geographic area of coverage, scope and priority. RB created a Project Layout Diagram.

Field Operations

The field operations for this project were conducted by Fugro EarthData, Inc. through a larger IOCM effort coordinated by the United States Army Corps of Engineers (USACE) Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) as part of the National Coastal Mapping Program (NCMP) to depict the elevation above and below the water line in the California coastal zone. Airborne acquisition by Fugro EarthData, Inc. consisted of topographic lidar collected with a Leica ALS60 system and RGB (color) imagery collected with a Leica ADS40 sensor. Data coverage generally extends along the coastline approximately 500 meters inland. The ALS60 topographic lidar sensor was used to acquire elevation data between October 15 and November 11, 2009 with a pulse repetition rate (PRF) of 200kHz at 1064nm to produce a nominal 1 meter post spacing point cloud. The ADS40 imagery was acquired between October 7 and October 26, 2010 to produce a 24-bit RGB ortho-rectified mosaic with a resolution of 35 cm. The imagery collected with the ADS40 sensor was **not** coordinated with the tides.

Outside Source Contractor Data Processing

Lidar:
Fugro EarthData, Inc. processed the topographic lidar data into a LAS version 1.0 formatted file, classified as (1) unclassified, (2) ground, (7) low/noise, (9) water, and (12) overlap, in accordance with the American Society for Photogrammetry and Remote Sensing (ASPRS) classification standards. The native ALS60 lidar data is not generally in a format accessible to most GIS software. Specialized Fugro Earthdata, Inc. in-house and commercial software processed the native lidar data into 3-dimensional positions that could be imported into standard GIS software for visualization and further analysis. Horizontal positions were provided in decimal degrees of latitude and longitude, and referenced to the North American Datum of 1983 (NAD83). Vertical positions were originally referenced to the NAD83 ellipsoid and provided in meters. The National Geodetic Survey's (NGS) GEOID09 model was used to transform the vertical positions from ellipsoid to orthometric heights referenced to the North American Vertical Datum of 1988 (NAVD88). The 3-D position data were sub-divided into a series of LAS files, each covering approximately 5 kilometers of shoreline. These data depict heights at the time of the survey and are only accurate for that time. Further information on Fugro EarthData Inc. processing of the lidar data can be found in the original metadata files delivered with the product.

Vertical differences between the bare earth DEM created from the lidar data and surveyed ground truth data is unbiased and within ±15 cm (RMSE) in flat terrain and within ±30 cm (RMSE) in hilly terrain. The ground truth positions were obtained using post processed KGPS methods, with a horizontal accuracy better than ±50cm and a vertical accuracy better than ±15cm. All data was quality controlled by JALBTCX for acceptance into the NCMP.

Aerial Imagery:
Fugro EarthData, Inc. processed the Leica ADS40 sensor data into RGB ortho-rectified mosaics using the following procedures. The sensor produces 12-bit data with three color bands that are not generally in a format accessible to most GIS software. Fugro EarthData, Inc., using specialized in-house and commercial software packages, processed the image data into GIS-compatible products for visualization and further analysis. Horizontal positions were provided in decimal degrees of latitude and longitude and are referenced to the North American Datum of 1983 (NAD83). Imagery was ortho-rectified and mosaicked into tiles that extend approximately 5 km along the shore. These images depict the existing conditions of the beach and nearshore at the time of the survey and are only accurate for that time. Further information on Fugro EarthData Inc. processing of the image data can be found in the original metadata files delivered with the product.

This orthophotography was produced to be fully compliant with the American Society for Photogrammetry and Remote Sensing Accuracy Standards for Class 1 mapping requirements at a scale of 1:2400 with a 0.35 meter pixel resolution. RMSE at the 95% Confidence Level is 0.60 m. Compliance with this accuracy standard was ensured by the placement of GPS ground control. The following additional checks were performed: (1) The ground control and airborne GPS data stream were validated through a fully analytical bundle aerotriangulation adjustment. (2) The DTM (Digital Terrain Model) data was checked against the project control. The

technician visited and confirmed the accuracy of the project mass points during initial compilation. (3) Any topographic data was checked for edge match, consistency of attribution, and cartographic quality through visual inspection. (4) Digital orthophotography was validated through an inspection of edge matching and visual inspection for image quality. All data was quality controlled by JALBTCX for acceptance into the NCMP.

Internal RSD Data Processing:

LIDAR point cloud data were processed using the combined chain of:

1) Ingest of lidar point clouds into the GeoCue Workflow Management software.
2) The lidar data was transformed to MHW utilizing NOAA's VDatum: California – Southern California from Morro Bay south to US/Mexico border, Version 01 grids.
3) GeoCue DEM CuePac processing software was utilized to produce MHW digital elevation models (DEM) at a 1 m. pixel resolution.

Further details on NGS/RSD lidar processing, shoreline extraction, and accuracy assessment can be found in the following article, which is on file in the RSD Project Archive:

> "LIDAR-Derived National Shoreline: Empirical and Stochastic Uncertainty Analyses" (White, S.A.; Parrish, C.E.; Calder, B.R.; Pe'eri, S.; and Rzhanov, Y.) in *Pe'eri, S. and Long, B. (eds.), Applied LIDAR Techniques,* in the Journal of Coastal Research, Spring 2011, Special Issue No. 62, 62-74.

Extraction/Derivation:

The data extraction/derivation phase of this project was initiated by RSD in December of 2010 and was performed utilizing the following approaches.

A MHW shoreline vector (in shapefile format) for the outer coast, from San Pedro Bay to Rincon Point, California was extracted through a custom script implemented within ESRI's ArcGIS 9.3 software. The customized script performs contouring of a MHW shoreline vector, smoothing/simplification, and formatting/population of attribution fields compatible with the RSD final shapefile format. Subsequently, the ADS40 ortho-rectified mosaic images and satellite imagery were used to review, edit, and attribute the lidar shoreline vector.

Additional coastal features were compiled using the ADS40 orthos (2D format) in combination with a "heads-up" manual digitizing method. The lack of tide-coordination and 3D visualization as well as the high-energy wave environment (present during the ADS40 survey) hindered a consistent interpretation of off-shore features. Therefore, a decision rule was implemented to preclude from compilation such features as Rocks, Ledges, and Reefs, as well as elevated features such as Landmarks and Aids to Navigation. Custom tools implemented within ESRI's ArcGIS 9.3 software were utilized for attribution.

The 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.

Cartographic features were compiled to meet a horizontal accuracy of 5 meters at the 95% confidence level. This is a conservative estimate based on the expected uncertainty of lidar-derived shoreline as described in the JCR article cited above.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of AB. The final QC review was completed in September 2011. The review process included analysis 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 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:

Chart 18724, Port Hueneme and Approaches, Scale 1:20,000, 2nd Ed., Mar./09
Chart 18725, Port Hueneme to Santa Barbara, Scale 1:50,000, 29th Ed., Aug./08
Chart 18740, San Diego to Santa Rosa I., Scale 1:234,270, 42nd Ed., Mar./07
Chart 18744, Santa Monica Bay, Scale 1:40,000, 33rd edition, Aug./10
Chart 18746, San Pedro Channel, Scale 1:80,000, 38th edition, Nov./09
Chart 18749, San Pedro Bay, Scale 1:20,000, 43rd edition, Apr./10
Chart 18751, Los Angeles and San Pedro Bay Harbors, Scale 1:12,000, 46th Ed., Aug./09

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 the Project Completion Report (PCR)
- Page-size graphic plot of GC10872 file contents, attached to PCR

Remote Sensing Division Electronic Data Library

- GC10872 in shapefile format
- Digital copy of the PCR in Adobe PDF format
- CEF in shapefile format

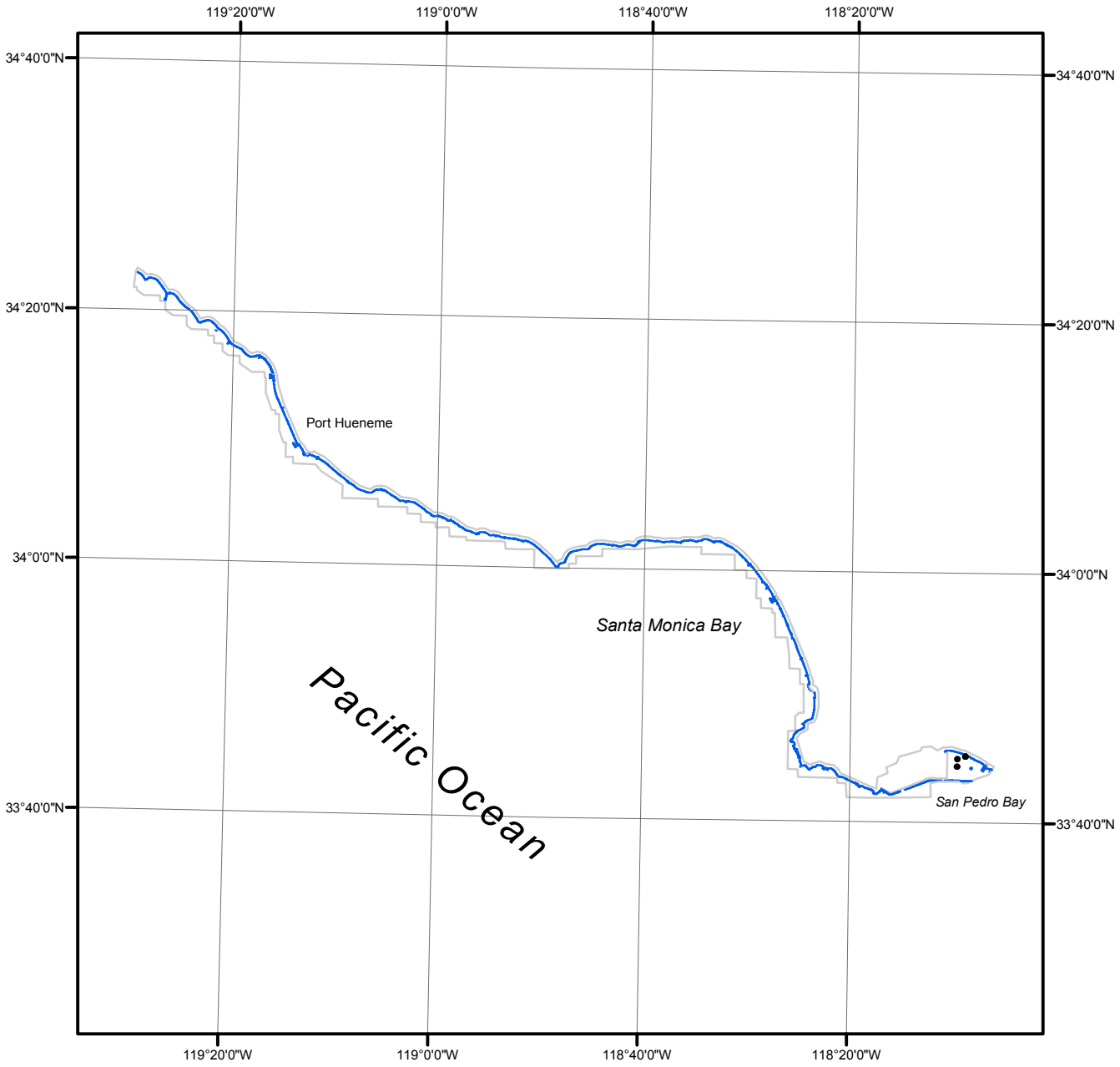
NOAA Shoreline Data Explorer

- GC10872 in shapefile format
- Metadata file for GC10872
- Digital copy of the PCR in Adobe PDF format

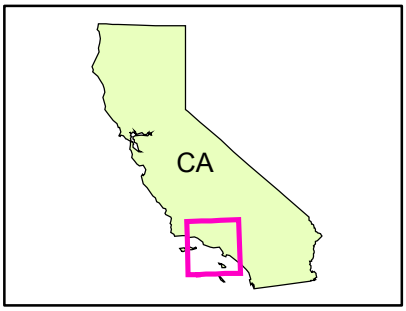
End of Report

SAN PEDRO BAY TO RINCON POINT

CALIFORNIA



Overview



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