W00661

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service

# DESCRIPTIVE REPORT

| | |
|---|---|
| Type of Survey: | Navigable Area |
| Registry Number: | W00661 |

## LOCALITY

| | |
|---|---|
| State(s): | California |
| General Locality: | Long Beach |
| Sub-locality: | San Pedro Bay and Southwest Basin |

**2022**

CHIEF OF PARTY
John M. Staly

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REGISTRY NUMBER:

# HYDROGRAPHIC TITLE SHEET

**W00661**

INSTRUCTIONS: The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

| | |
|---|---|
| State(s): | **California** |
| General Locality: | **Long Beach** |
| Sub-Locality: | **San Pedro Bay and Southwest Basin** |
| Scale: | **25000** |
| Dates of Survey: | **04/20/2022 to 04/28/2022** |
| Instructions Dated: | **N/A** |
| Project Number: | **ESD-PHB-22** |
| Field Unit: | **David Evans and Associates, Inc.** |
| Chief of Party: | **John M. Staly** |
| Soundings by: | **Teledyne RESON SeaBat T50-R (MBES)** |
| Imagery by: | **N/A** |
| Verification by: | **Pacific Hydrographic Branch** |
| Soundings Acquired in: | **meters at Mean Lower Low Water** |

Remarks:

***Any revisions to the Descriptive Report (DR) applied during office processing are shown in red italic text. The DR is maintained as a field unit product, therefore all information and recommendations within this report are considered preliminary unless otherwise noted. The final disposition of survey data is represented in the NOAA nautical chart products. All pertinent records for this survey are archived at the National Centers for Environmental Information (NCEI) and can be retrieved via https://www.ncei.noaa.gov/. Products created during office processing were generated in NAD83 UTM 11N, MLLW. All references to other horizontal or vertical datums in this report are applicable to the processed hydrographic data provided by the field unit.***

# DESCRIPTIVE REPORT MEMO

February 09, 2023

**MEMORANDUM FOR:** Pacific Hydrographic Branch

**FROM:** Report prepared by PHB on behalf of field unit
John M. Staly, CH
Project Manager, David Evans and Associates

**SUBJECT:** Submission of Survey W00661

The purpose of this hydrographic survey is to support the POLB Harbor Sounding Program and update bathymetric maps with current data that is suitable for nautical charting updates to meet the National Oceanic and Atmospheric Administration (NOAA), Office of Coast Survey (OCS), Categorized Zone of Confidence A1 (CATZOC A1) standards.

Please see the attached report for products that were created for this survey.

All soundings were reduced to Mean Lower Low Water using VDatum. The horizontal datum for this project is North American Datum of 1983 (NAD 83). The projection used for this project is Universal Transverse Mercator (UTM) Zone 11.

Please see the attached report for more information about the data acquisition and processing that occurred for survey W00661.

Three Dangers to Navigation were reported and registered by NDB.

David Evans and Associates, Inc. - on behalf of the Port of Long Beach - acquired the data outlined in this report. Additional documentation from the data provider may be attached to this report.

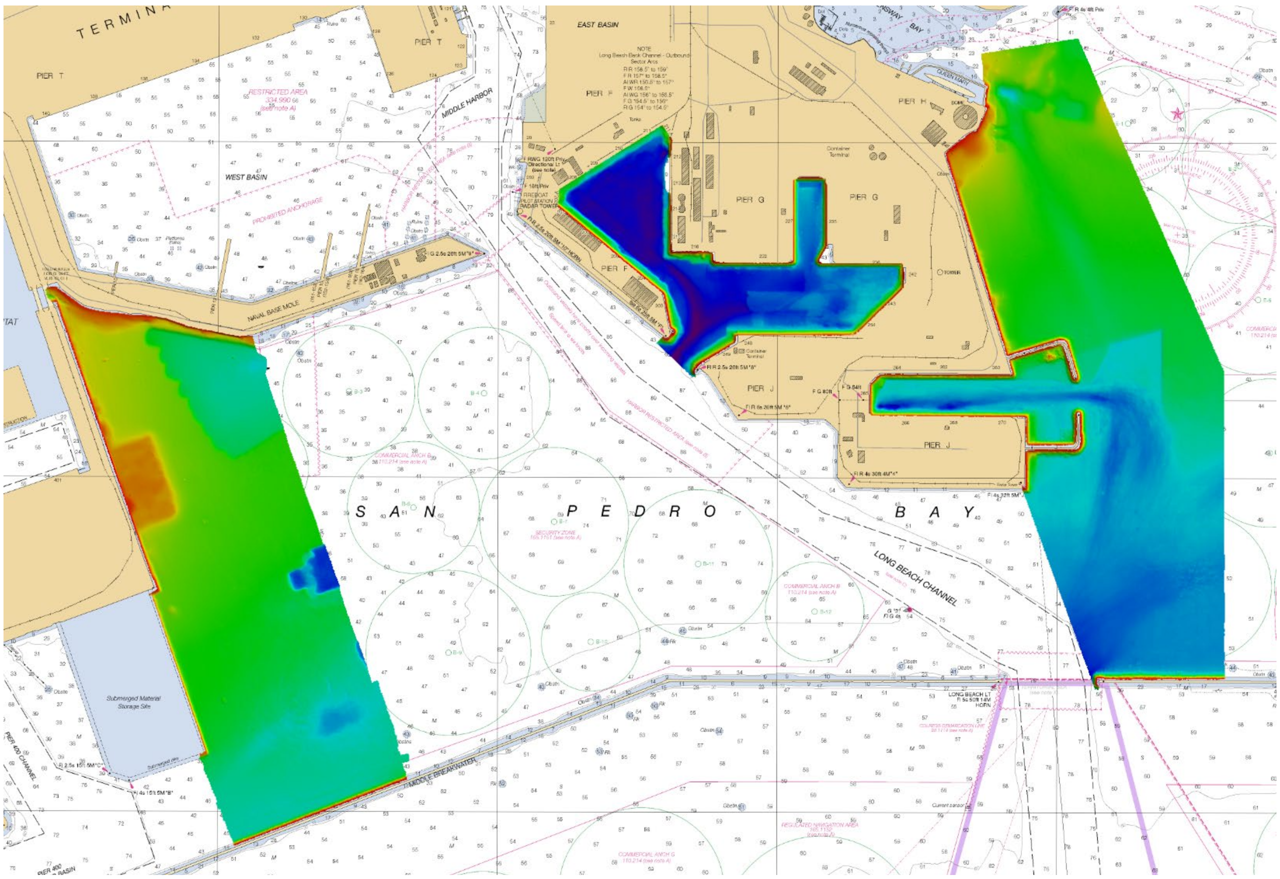
This survey does meet charting specifications and is adequate to supersede prior data.

# Port of Long Beach
# Harbor Sounding Program

## W00661 - Hydrographic Survey Report
## NOAA ESD Submission

Southeast Basin (Area 4), San Pedro Bay West (Area 5), Sand Pedro Bay East (Area 7)

**April 2022**




***Prepared by:***

DAVID EVANS AND ASSOCIATES INC.
MARINE SERVICES


David Evans and Associates, Inc.
Marine Services Division
2801 SE Columbia Way, Suite 130
Vancouver, WA 98661


***Owner:***

Port of LONG BEACH
THE PORT OF CHOICE


Port of Long Beach
415 W. Ocean Blvd.
Long Beach, CA 90802

# Port of Long Beach
# Harbor Sounding Program
## W00661 - Hydrographic Survey Report
## NOAA ESD Submission

Southeast Basin (Area 4), San Pedro Bay West (Area 5), Sand Pedro Bay East (Area 7)

**August 2022**

***Prepared by:***


**John M. Staly, CH**
NSPS-THSOA Certified Hydrographer, #322
David Evans and Associates, Inc.
Project Manager


***Reviewed by:***



**Jonathan L. Dasler, PE, PLS**
NSPS-THSOA Certified Hydrographer, #107
David Evans and Associates, Inc.
Senior Vice President, Director of Marine Services

**TABLE OF CONTENTS**

## LIST OF FIGURES



## LIST OF TABLES



## LIST OF APPENDICES

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **ASCII** | American Standard Code for Information Interchange |
| **CATZOC A1** | Categorized Zone of Confidence rating A1 |
| **CLBRTN** | City of Long Beach Real-Time Reference Network |
| **DEA** | David Evans and Associates, Inc. |
| **DtoN** | Danger to Navigation |
| **ENCs** | Electronic Navigational Charts |
| **GMT** | Greenwich Mean Time |
| **GNSS** | Global Navigation Satellite System |
| **GPS** | Global Positioning System |
| **HIPS** | Hydrographic Information Processing System |
| **HVF** | HIPS Vessel File |
| **Hz** | Hertz |
| **IHO** | International Hydrographic Organization |
| **kHz** | kilohertz |
| **kW** | kilowatt |
| **MHW** | Mean High Water |
| **MLLW** | Mean Lower Low Water, Epoch 1983-2001 |
| **NAD83(2007)** | North American Datum of 1983, 2007 realization |
| **NMEA** | National Marine Electronics Association |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NOS** | National Ocean Service |
| **NTRIP** | Networked Transport of RTCM via Internet Protocol |
| **Obst** | Obstruction |
| **OCS** | Office of Coast Survey |
| **PDT** | Pacific Daylight Time |
| **POLB** | Port of Long Beach |
| **POS/MV** | Position and Orientation System for Marine Vessels |
| **PPS** | Pulse Per Second |
| **Rk** | Rock |
| **RTCM** | Radio Technical Commission for Maritime Services |
| **RTK** | Real-Time Kinematic |
| **SBET** | Smoothed Best Estimate of Trajectory |
| **S/V** | Survey Vessel |
| **TVU** | Total Vertical Uncertainty |
| **USACE** | United States Army Corps of Engineers |
| **UTC** | Coordinated Universal Time |
| **Wk** | Wreck |
| **ZDA** | Global Positioning System Timing Message |

# 1.0 INTRODUCTION

Between April 20, 2022, and April 28, 2022, David Evans and Associates, Inc. (DEA), Marine Services Division, conducted a high-resolution hydrographic survey using Object Detection multibeam coverage in the Port of Long Beach (POLB) (Figure 1). The purpose of this hydrographic survey is to support the POLB Harbor Sounding Program and update bathymetric maps with current data that is suitable for nautical charting updates to meet the National Oceanic and Atmospheric Administration (NOAA), Office of Coast Survey (OCS), Categorized Zone of Confidence A1 (CATZOC A1) standards.

Specifically, this effort included the following:

- Southeast Basin (Figure 1, Area 4)
- San Pedro Bay West (Figure 1, Area 5)
- San Pedro Bay East (Figure 1, Area 7)

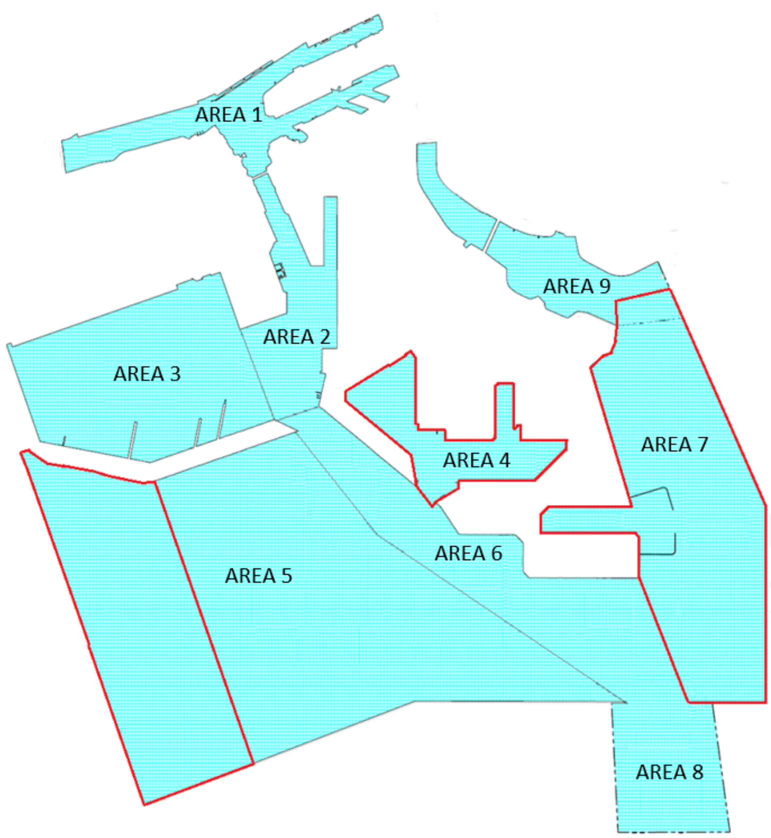



**Figure 1. Port of Long Beach Hydrographic Survey Index Map with survey areas in red**

DEA submitted a report of survey, map products, and a series of digital deliverables to the Port of Long Beach on October 26, 2022.

This report, which was written specifically to support the External Source Data (ESD) submission to NOAA OCS, describes data acquisition, processing, and quality control methodology, as well as summarizes the project's horizontal and vertical control. A list of deliverables included with the

ESD submission is included in Section 6.0 Deliverables of this report. A table listing project metadata required for the ESD submission process is included in Appendix A. Data acquisition, processing and reporting for this survey closely follows methods used for prior ESD survey W00628, which was performed by David Evans and Associates, Inc. for the Port of Long Beach. Survey W00628 was accepted by the NOAA processing branch and assessed to support CATZOC A1 requirements for coverage, quality, uncertainty, and feature detection.

Surveys were performed under the direction of a California-licensed Professional Land Surveyor and National Society of Professional Surveyors - The Hydrographic Society of America (NSPS-THSOA) Certified Hydrographer.

Dates of Hydrography for the survey are included in Table 1.

**Table 1. W00661 Dates of Hydrography**

| Survey Dates | Day of the Year |
|---|---|
| 4/20/2022 | 110 |
| 4/21/2022 | 111 |
| 4/22/2022 | 112 |
| 4/23/2022 | 113 |
| 4/24/2022 | 114 |
| 4/25/2022 | 115 |
| 4/26/2022 | 116 |
| 4/27/2022 | 117 |
| 4/28/2022 | 118 |

## 2.0 HORIZONTAL AND VERTICAL DATUMS

The horizontal datum for this survey is the California State Plane Zone 5, NAD83, 2007 realization (NAD83 (2007)), which is the datum used by Port of Long Beach. The vertical datum is Mean Lower Low Water, Epoch 1983-2001 (MLLW). The horizontal and vertical units are in U.S. Survey Feet.

For the purposes of the NOAA ESD submission, the coordinate reference system (CRS) for the CARIS HIPS project and derivative products has been changed to NAD83 (2011), UTM Zone 11 North. The transformation was necessary to overcome a known bug in HIPS which prevents the incorporation of designated soundings into finalized surfaces which use a CRS with horizonal units in feet.

All time tagging in HYPACK software and in the hydrographic survey logs are Coordinated Universal Time (UTC), which is a time standard equivalent to Greenwich Mean Time (GMT), which is seven hours ahead of Pacific Daylight Time (PDT).

# 3.0 BATHYMETRIC SURVEYS

## 3.1 Survey Area and Coverage

The full survey area included Area 4, the west side of Area 5, and Area 7, which was extended north into Area 9. Figure 2 shows the overall data coverage overlaid on the NOAA raster navigation chart, soundings in feet, with significant overlap achieved beyond the boundaries of the individual areas. Occasional small object detection holidays exist along the edges of the survey area or along the tops of break waters.

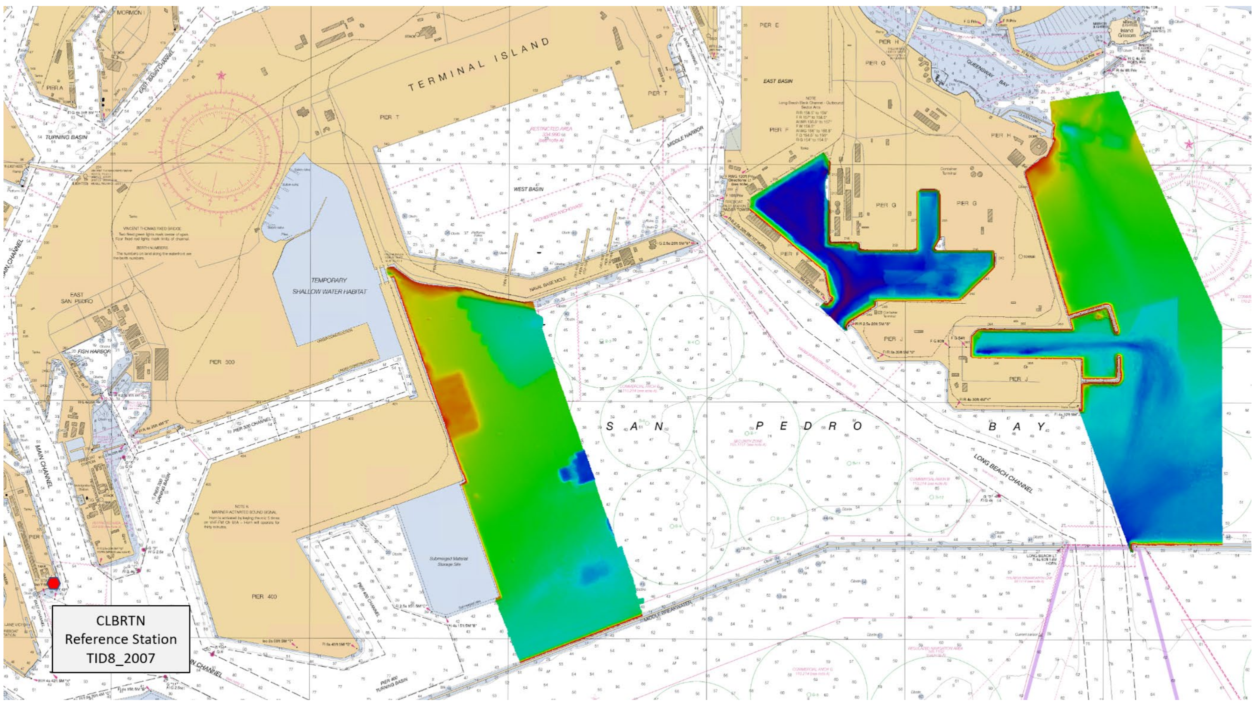



**Figure 2. Overview of survey area with multibeam hillshade imagery of coverage**

The survey exceeded the Special-Order Hydrographic Survey specification as defined by the International Hydrographic Organization (IHO), September 2020, IHO Standards for Hydrographic Surveys, Special Publication No. 44, Edition 6.0.0, and NOAA CATZOC A1 requirements for multibeam bathymetric surveys.

## 3.2 Control

Control for the survey was provided by the City of Long Beach Real-Time Reference Network (CLBRTN), which provided Real-Time Kinematic (RTK) corrections to the survey vessel via Networked Transport of Radio Technical Commission for Maritime Services (RTCM) via Internet Protocol (NTRIP). This provided the survey vessel global navigation satellite system (GNSS) correctors for precise horizontal and vertical positioning relative to NAD83(2007) geographic positions and ellipsoid heights. Archived observables from the CLBRTN were also used for post-processing corrections during cellular outages. Table 2 includes final coordinates and elevations for the CLBRTN reference station used to control hydrographic surveys.

**Table 2. CLBRTN Hydrographic Survey Control**

| Designation | Use | NAD83(2007) | | |
|---|---|---|---|---|
| | | Latitude | Longitude | Ellipsoid Height |
| ***TID8_2007*** | GNSS Reference Station | N 33 43 13.15076 | W 118 16 16.94541 | -30.401 meters |

HYPACK software was used to project NAD83(2007) geographic positions to California Zone 5 coordinates in U.S. Feet. A custom separation model that was compiled for the Port of Long Beach by DEA was used to reduce ellipsoid heights to MLLW. The model was compiled from NOAA's VDatum model, adjusted to fill gaps in the grid and vertically adjust NAD83(2007) ellipsoid heights to match MLLW published values for Tidal Benchmark 941 0660 Tidal 8, which is the primary benchmark for the NOAA, National Ocean Service (NOS) water level station 941 0660 at Port of Los Angeles. DEA established the vertical adjustment relative to corrections from the CLBRTN NAD83(2007) during previous multiple RTK and static GNSS observations on 941 0660 Tidal 8.

## 3.3 Survey Vessel and Equipment

### *3.3.1 Survey Vessel*

The vessel used for the multibeam hydrographic survey was DEA's customized 27-foot aluminum-hulled survey vessel (S/V) *Seahawk* (Figure 3), powered by twin 200-HP outboard engines. The Seahawk is a North River offshore vessel customized by DEA for safe and efficient hydrographic survey operations. The vessel is equipped with port and starboard sonar mounts, 7.5 kW generator, GNSS and inertial positioning and motion reference system, mounts for a mobile laser scanner, equipment rack with hydrographer workstation, and twin Garmin multifunction displays for radar, chart plotter, and sonar.


**Figure 3: Multibeam Survey Vessel *Seahawk***

### *3.3.2 Data Acquisition System*

All multibeam bathymetry data were acquired in HYPACK HYSWEEP. Data from each survey sensor was date- and time-stamped and logged in individual survey line files in HSX file format. The software also displayed real-time coverage and other quality control information (position quality, individual sonar beam quality, etc.).

All time-tagging of bathymetric data in HYPACK software and in the hydrographic survey logs are Coordinated Universal Time (UTC), which is a time standard equivalent to Greenwich Mean Time (GMT), which is seven hours ahead of Pacific Daylight Time (PDT).

### *3.3.3 Multibeam Echosounder System*

The multibeam echosounder consisted of a Teledyne RESON SeaBat dual-head T50R. The system utilized two sonar heads mounted on port and starboard custom side-mount struts. The sonars were operated at 360 kilohertz (kHz) with 512 beams per sonar head and tilted 15-degrees port and starboard. Range adjustments were made during acquisition as dictated by changes in water depth.

### *3.3.4 Position, Heading, and Motion Reference Systems*

Position, heading, and vessel attitude were acquired with an Applanix Position and Orientation System for Marine Vessels (POS/MV) with GNSS and inertial reference system, which was used to measure attitude, heading, heave, and position. The system was comprised of an Inertial Motion Unit (IMU), multi-frequency GNSS antennas, and a data processor. A secondary Trimble SPS855 GNSS receiver was installed over the vessel reference point to be used for vertical control for the survey.

The RESON sonar processor was provided a Pulse Per Second (PPS) and National Marine Electronics Association (NMEA) Global Positioning System Timing Message (ZDA) to achieve precise synchronization of sonar measurements with position and attitude data from the POS/MV.

The POS/MV integrated multi-frequency RTK-GNSS, and inertial reference system, were used as the motion sensor for this survey. The POS/MV is a 6-degree-of-freedom motion unit, with a stated accuracy of 0.02 meters, or 2% for TrueHeave, and 0.02 degrees for roll, pitch, and heading. Real-time displays of the vessel motion accuracy were monitored throughout the survey with the MV-POSView controller program.

### *3.3.5 Sound Speed Measurements*

An AML Oceanographic Micro X housing (SN:010992) with SV-Xchange sound velocity sensor (SN:209142) mounted on the Teledyne RESON T50 sonar head was input into the RESON processor, and sound speeds from the sensor were used in real-time during acquisition. An AML Oceanographic Smart X Profiler (SN: 005588) with sound velocity (SN:206832), pressure (SN306797), and temperature (SN:404148) Xchange sensors was used as the sound speed profiler during multibeam operations, with casts taken to the full depth of the project.

### *3.3.6 Vertical Measurements*

All bathymetric data was time-tagged and recorded relative to the vessel reference point. Using a fixed vertical reference for both the sonar and GNSS systems, as opposed to using the water surface and making water surface observations, provides improved vertical accuracy as it considers dynamic changes in draft and local water surface variations in the vicinity of the survey. The sonar fixed draft was used to reference the soundings to the project vertical datum. Vertical reference point measurements, which approximately represent the water surface elevation, were obtained using each navigation system: the Applanix POS/MV and the Trimble SPS-855 RTK-GNSS receiver. RTK correctors were applied to the shipboard GNSS for logging of approximate water surface elevations at a rate of five hertz (Hz).

# 4.0 EQUIPMENT CALIBRATION

## 4.1 Patch Test

Patch tests were conducted to measure alignment offsets between the IMU sensor and the Teledyne RESON T50 sonars. In addition, these tests were used to confirm no time delays were present between the time-tagged sensor data. Patch tests consisted of a series of lines run in a specific pattern. A precise timing latency test was performed by running multiple lines in the same direction at differing speeds over a known feature on the seafloor.

Roll alignment was determined by evaluating reciprocal lines run over a flat bottom. The pitch tests consisted of a set of reciprocal lines located on a steep slope. The yaw error was determined by running parallel lines in opposite directions over the same area as the pitch tests. All lines were run at approximately 3 to 6 knots. Patch tests were run in the vicinity of the survey site. Patch test average values applied in CARIS HIPS software are listed in Table 3. All values were input and applied to all bathymetric data in the HIPS Vessel File (HVF).

**Table 3. Patch Test Values**

| Date | Time | Sensor | Latency (seconds) | Pitch (degrees) | Roll (degrees) | Yaw (degrees) |
|---|---|---|---|---|---|---|
| 4/20/2022 | 00:00 | RESON T50 Port | 0.000 | -0.390 | 14.683 | -0.600 |
| | | RESON T50 Stbd | 0.000 | 0.173 | -14.753 | -0.385 |
| 4/21/2022 | 12:00 | RESON T50 Port | 0.000 | -0.400 | 14.677 | -0.525 |
| | | RESON T50 Stbd | 0.000 | 0.143 | -14.737 | -0.500 |
| 4/22/2022 | 14:00 | RESON T50 Port | 0.000 | -0.510 | 14.647 | -0.325 |
| | | RESON T50 Stbd | 0.000 | -0.020 | -14.770 | 1.625 |
| 4/23/2022 | 14:00 | RESON T50 Port | 0.000 | -0.467 | 14.638 | -0.155 |
| | | RESON T50 Stbd | 0.000 | 0.117 | -14.750 | 1.500 |
| 4/26/2022 | 15:00 | RESON T50 Port | 0.000 | -0.550 | 14.660 | -0.200 |
| | | RESON T50 Stbd | 0.000 | 0.033 | -14.723 | 1.650 |
| 4/27/2022 | 14:00 | RESON T50 Port | 0.000 | -0.400 | 14.677 | -0.485 |
| | | RESON T50 Stbd | 0.000 | -0.100 | -14.760 | 1.600 |
| 4/28/2022 | 14:00 | RESON T50 Port | 0.000 | -0.597 | 14.633 | -0.300 |
| | | RESON T50 Stbd | 0.000 | -0.050 | -14.703 | 1.800 |

## 4.2 Position and Vertical Check

A horizontal position check and vertical check were conducted on NOS tidal benchmark 941 0660 Tidal 8, which is the primary benchmark for NOS water level station 941 0660, Port of Los Angeles. To conduct this check, the survey vessel pulled alongside the pier, and the Zephyr 3 Rover GNSS antenna from the Trimble SPS855 secondary positioning system was positioned on the monument with a 5.56-foot adjustable survey pole, and data was logged in HYPACK software while receiving RTK-GNSS corrections from the CLBRTN CMR_X_2007 mount point. The position was compared to NAD83(2007) California Zone 5 coordinates in U.S. Feet that was acquired by Psomas in October 2016 (Table 4), and the vertical check was compared to the NOS published value of 13.76 Feet MLLW.

**Table 4. Psomas Position on 941 0660 Tidal 8**

| California Geodetic Coordinates of 1983 | Deg. | Min. | Seconds |
|---|---|---|---|
| Latitude: | 33 | 43 | 11.44146 |
| Longitude: | 118 | 16 | 22.21728 |
| Ellipsoid Height (m): | | | -31.730 |

| CCS 83, Zone 5 Coordinates | Meters | US Survey Feet |
|---|---|---|
| Northing: | 524,421.403 | 1,720,539.22 |
| Easting: | 1,974,709.401 | 6,478,692.42 |
| Combined Factor: | 1.0000877 | |

| NAD83 | |
|---|---|
| Epoch: | 2007.00 |
| FGDC Acc.: | 1.0 cm |
| Survey by: | Psomas |
| Adj.: | Oct 2016 |

The horizontal position obtained from 50 observed RTK-GNSS samples yielded an average position error North 0.02 feet (0.06 cm) and East 0.02 feet (0.06 cm), with a standard deviation of North 0.00 feet (0 cm) and East 0.01 feet (0.3 cm) relative to the Psomas position in Table 4. This is well within the positioning requirements for the survey. The RTK-GNSS vertical check resulted in a MLLW elevation 0.10 feet (3 cm) lower than the NOS published MLLW elevation with a standard deviation of 0.01 feet (0.3 cm) over 271 samples. This is well within the expected vertical accuracy.

In addition, a vessel tide float was conducted near the NOS water level station 941 0660, Port of Los Angeles, and compared to 6-minute verified MLLW data logged by the station. A HYPACK line was logged for 27 minutes, and data was compared to four NOS water level observations at the even 6-minute interval using a 3-minute average centered on the 6-minute observation. The comparison resulted in an average water level observation 0.03 (0.9 cm) feet lower than the NOS observed water level with a standard deviation of 0.06 feet (1.8 cm).

## 4.3 Bar Check

During the survey, the sonar poles were lowered to a deeper draft to minimize aeration on the sonar head. Two sets of bar checks were performed to confirm and document the draft of the multibeam transducer on the *Seahawk* to before and after lowering the sonar poles. The bar checks were accomplished by lowering a bar on a marked chain below the sonar head to a known distance from the water surface, reading port and starboard drafts for an average draft, acquiring a sound speed cast, and logging multibeam on the bar.

The bar check was assessed at 6 feet below the water surface. The average difference between the bar depth and the port sonar-corrected multibeam depth was 0.11 and 0.08 feet (3.4 and 2.4 cm) with a standard deviation of 0.07 feet (2.1 cm). The average difference between the bar depth and the starboard sonar-corrected multibeam depth was 0.11 and 0.07 feet (3.4 and 2.1 cm) with a standard deviation of 0.04 feet (1.2 cm).

### 4.4 Sound Speed Sensor Calibration

DEA submits sound speed sensors for factory calibration annually per NOAA specifications. In addition, a comparison is made to other sensors periodically during the survey to validate that the sensors are operating within design parameters.

## 5.0 DATA PROCESSING AND ANALYSIS

### 5.1 Data Processing

Post-processing of multibeam and vessel-based laser data was conducted utilizing HIPS versions 11.4.4, 11.4.8, and 11.4.13. Patch test data were analyzed, and alignment corrections were applied during processing. Smoothed Best Estimate of Trajectory (SBET) files were calculated using Applanix POSPAC for post-processing of combined inertial-GNSS data sets to account for any RTK dropouts for horizontal positioning and to extract ellipsoidally referenced GPS heights. The CLBRTN reference station PLB1 (2007) was used for POSPAC processing SBET files. SBETs were applied in HIPS by loading by day. The “Georeference - Compute GPS Tides” process in HIPS is the primary means by which bathymetric data is reduced to chart datum.

HIPS references all data to an ellipsoid height of the waterline obtained by RTK-GNSS and then applies the separation model to the ellipsoid-referenced data to achieve soundings relative to chart datum (MLLW). The separation model is an XYZ surface that represents the difference between the ellipsoid, NAD83(2007), and MLLW for a given geographic area. The XYZ separation model used for this workflow was a CARIS CSAR file and represents the difference between NAD83(2007) and MLLW at a given location.

Sound velocity profiles were used to correct multibeam slant range measurements and to compensate for any ray path bending. These were applied in CARIS using the closest in distance and time algorithm.

Processing began by verifying attitude (heave, pitch, roll, and heading) and navigation data, which were reviewed and accepted. Using the CARIS subset editor, sounding data were reviewed for quality and data flyers. Sounding data, including sonar beams reflecting from sediment in the water column, returns from aquatic life, or noise due to aeration in the water column, were carefully reviewed before being flagged as rejected. Soundings on significant features were designated and exported as an independent American Standard Code for Information Interchange (ASCII) file for mapping obstructions and capturing least depths.

For the purposes of submission through the NOAA ESD pipeline, data were reprocessed to incorporate sounding Total Propagated Uncertainty (TPU) and the creation of bathymetric surfaces using the CUBE gridding technique. Surfaces were generated following NOAA Object Detection grid resolution requirements defined in the 2022 Hydrographic Surveys Specifications and Deliverables (HSSD) and using the 2022 NOAA CUBE parameters file. Finalized CUBE grids were generated using the “greater of the two” option for the final uncertainty value and appropriate depth thresholds for Object Detection surfaces.

Object Detection Coverage surfaces submitted with this survey are listed in Table 5.

**Table 5. Submitted Surfaces**

| Surface Name | Surface Type | Resolution (m) | Depth Range (m) |
|---|---|---|---|
| W00661_MB_50cm_MLLW.csar | CARIS Raster Surface (CUBE) | 0.5 | 0.198 – 22.083 |
| W00661_MB_50cm _MLLW_Final.csar | Finalized CARIS Raster Surface (CUBE) | 0.5 | 0.280 – 20.646 |
| W00661_MB_1m _MLLW.csar | CARIS Raster Surface (CUBE) | 1 | 0.208 – 22.071 |
| W00661_MB_1m _MLLW_Final.csar | Finalized CARIS Raster Surface (CUBE) | 1 | 18.002 – 22.172 |

## 5.2 Multibeam Crossline Sonar Beam Analysis

The multibeam sonar recorded 512 beams for each sonar ping covering a 120-degree swath, 60 degrees to either side of nadir (vertical below the sonar). The swath width was filtered to 60 degrees per side for Areas 1, 2 and 3, and 45 degrees per side for Area 8 to each side of nadir, and a crossline analysis was conducted to prove each of the sonar beams within the swath met accuracy requirements for the survey. The analysis involved running survey lines that crossed orthogonal to the primary survey line pattern and comparing the soundings from individual sonar beams in the crossline data to a 1-foot grid from the main scheme lines. The U.S. Army Corps of Engineers (USACE) requirement for maintenance dredging in water depths 15 feet to 75 feet, approximate depth range for this survey, is +/- 0.8 feet at a 95% confidence level. The analysis was also conducted using the IHO Special Order depth accuracy standards, which was modified from a 0.25-meter (0.82-foot) minimum accuracy to a 0.0762-meter (0.25-foot) minimum accuracy. This standard also uses a factor to increase the allowable inaccuracy based on depth. The IHO-modified Special Order allowable total vertical uncertainty (TVU) formula is listed below:

$$+-\sqrt{a^2+(b*d)^2}$$

Where:

a = 0.25 feet or 0.0762 meters (IHO Special Order calls for a= 0.25 meters)
b = 0.0075 (IHO Special Order depth factor)
d = water depth in feet

Figures 4 and 5 depict the results of this crossline beam analysis to document all beams used in the 120- and 90-degree swaths (60 and 45 degrees per side) meet both USACE requirements and IHO Special Order modified requirements. All beams exceeded 95% of soundings passing.

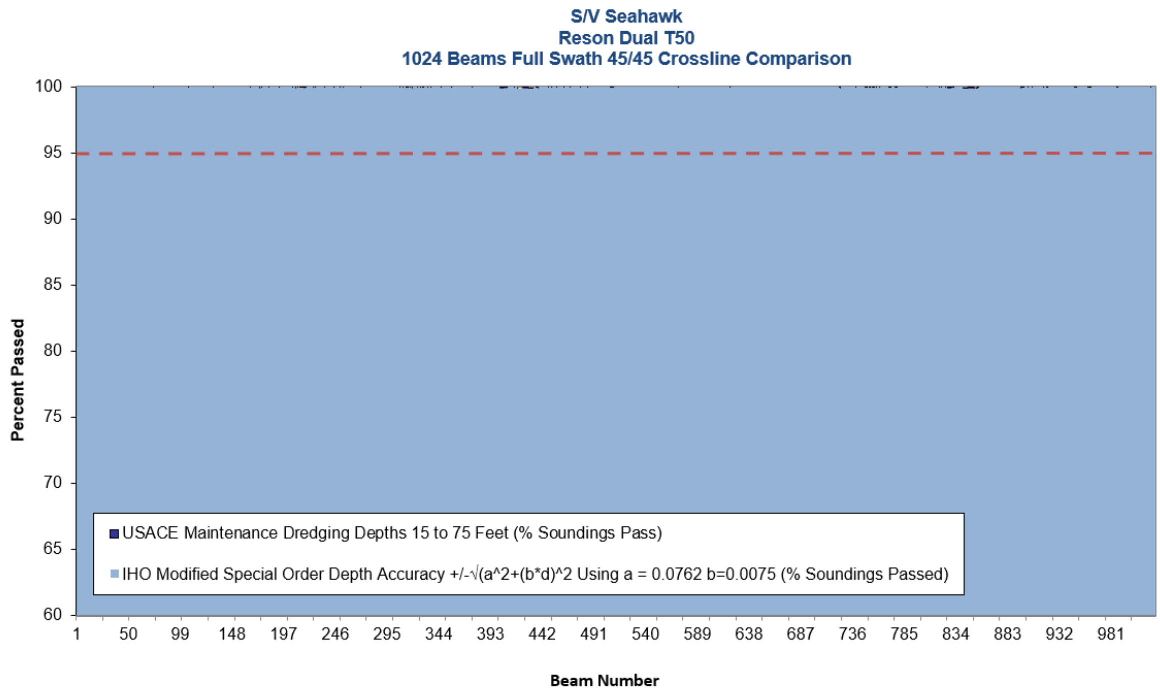



**Figure 4. Histogram of crossline beam analysis Area 4**

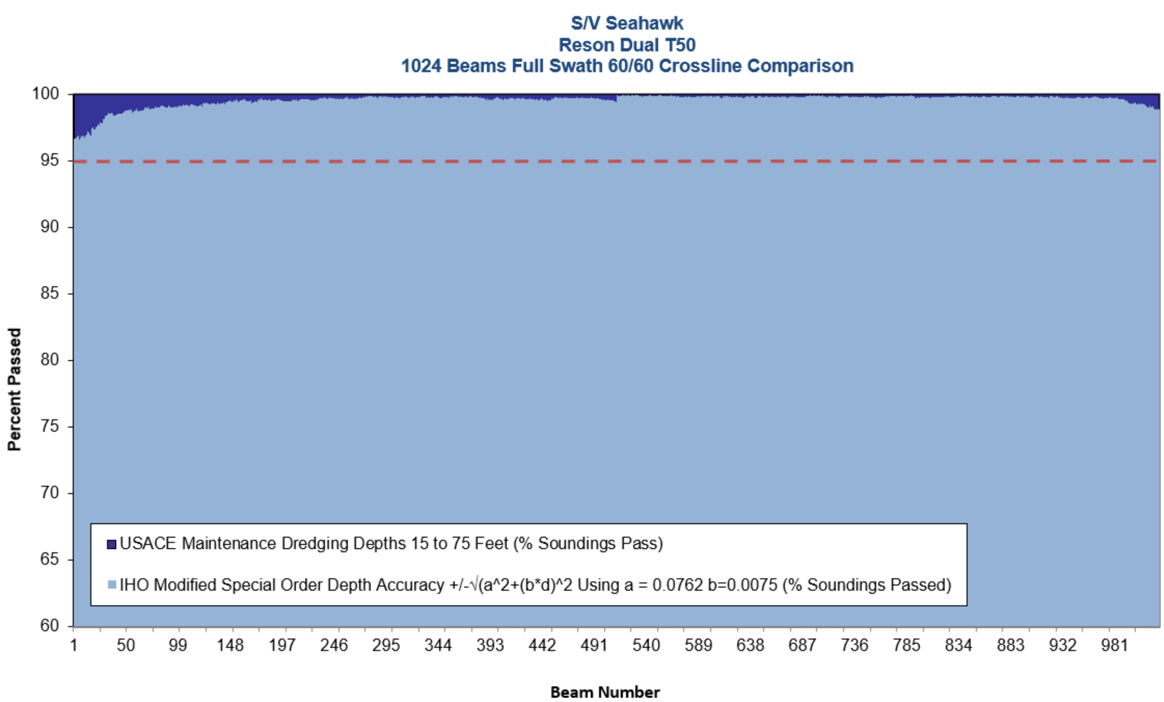



**Figure 5. Histogram of crossline beam analysis Area 5**

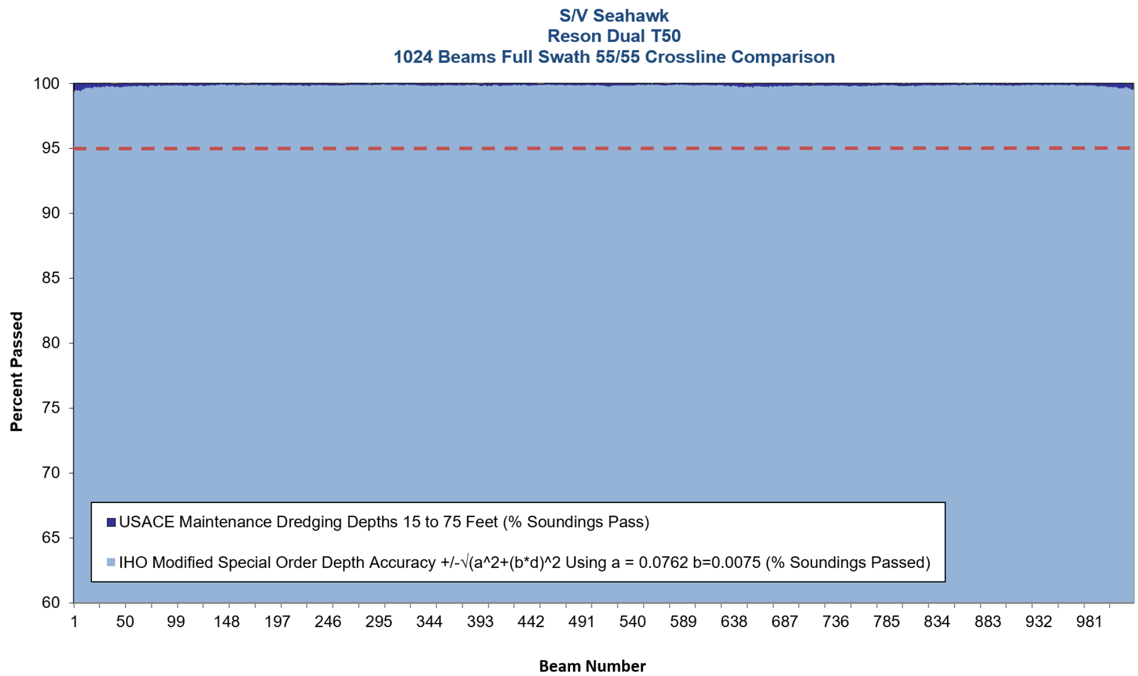
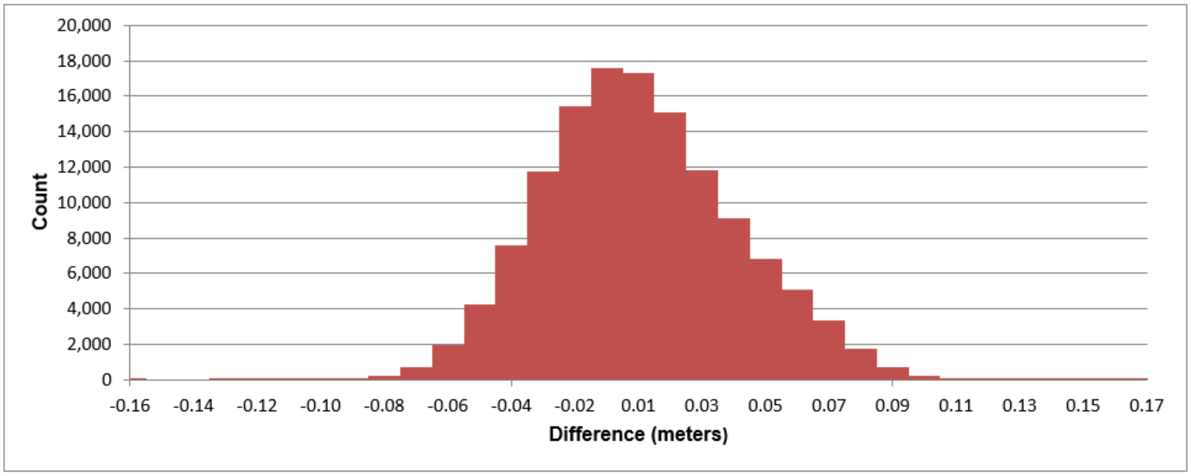



**Figure 6. Histogram of crossline beam analysis Area 7**

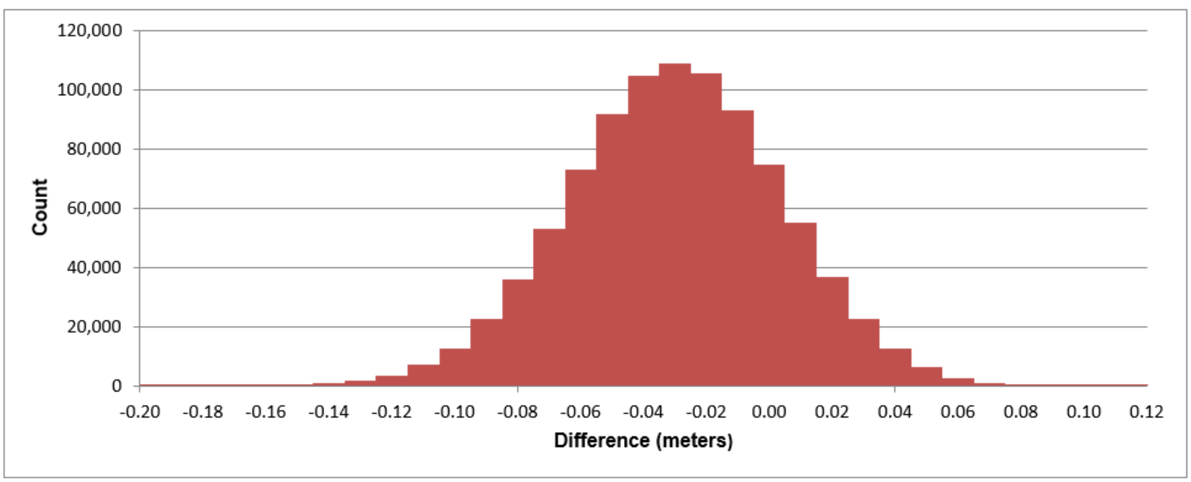
## 5.3 Multibeam Crossline Difference Analysis

To assess the precision of the survey, crossline data was gridded at a 1-foot resolution, consistent with the resolution grid from the main survey lines. A difference analysis was conducted between the surfaces to evaluate whether the precision of the survey met project requirements. The USACE typical repeatability (precision) requirement for maintenance dredging in water depths 15 to 75 feet, depth range for most of this survey, is 0.3 feet. Figures 7, 8, and 9 present the full results of the analysis and document that the survey exceeds USACE requirements for repeatability, with the maximum mean difference in Area 5 (Figure 8) of 0.03 meters (0.10 feet vs. required 0.3 feet), and the maximum standard deviation at a 95% confidence level in Area 7 (Figure 9) was 0.04 meters (+/- 0.13 feet vs. required +/- 0.8 feet) for the full range of survey depths. The larger minimum and maximum values are a result of comparing grid nodes at 1-foot resolution on slopes and features within the survey area.



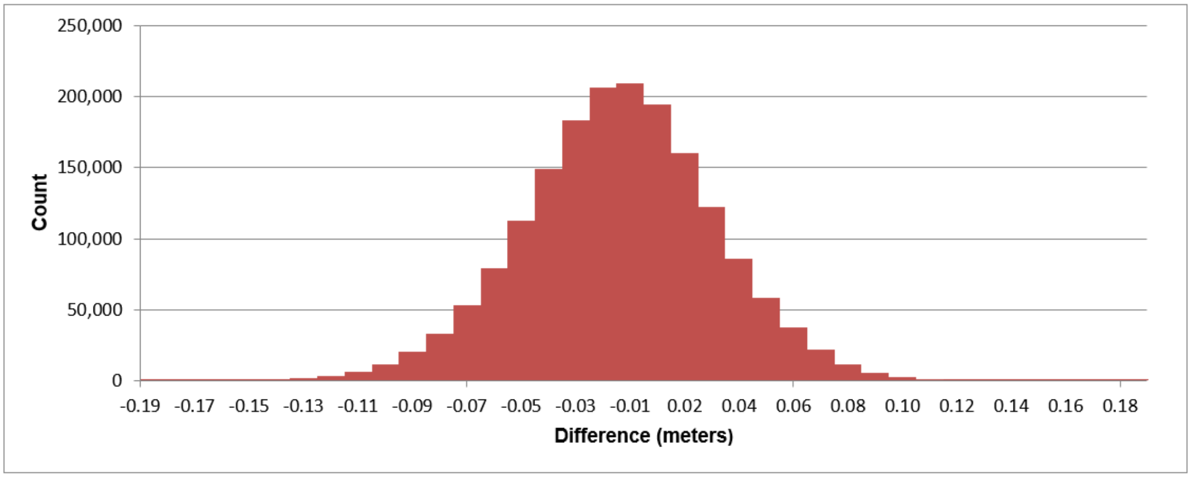

| | | | |
|---|---|---|---|
| Mean: | -0.01 m | Standard Deviation: | 0.03 m |
| Minimum: | -0.16 m | Bin size: | 0.01 m |
| Maximum: | 0.17 m | Number of Nodes: | 131,137 |

**Figure 7. Histogram of crossline versus main line gridded data difference Area 4**




| | | | |
|---|---|---|---|
| Mean: | -0.03 m | Standard Deviation: | 0.03 m |
| Minimum: | -0.2 m | Bin size: | 0.01 m |
| Maximum: | 0.14 m | Number of Nodes: | 131,137 |

**Figure 8. Histogram of crossline versus main line gridded data difference Area 5**




| | | | |
|---|---|---|---|
| Mean: | -0.01 m | Standard Deviation: | 0.04 m |
| Minimum: | -0.19 m | Bin size: | 0.01 m |
| Maximum: | 0.19 m | Number of Nodes: | 1,773,018 |

**Figure 9. Histogram of crossline versus main line gridded data difference Area 7**

## 5.4 Uncertainty

Sounding TPU was computed specifically for the NOAA ESD submission. The HIPS vessel file was modified to include accurate values for parameters used in the computation process. Table 6 includes values for additional parameters used during TPU computation not stored in the HVF. The value used for Tide Measured uncertainty represents the uncertainty of the GNSS ellipsoid height measurements. The value used for Tide Zoning represents the published maximum cumulative uncertainty (MCU) for the regional VDatum grid covering the survey area.

**Table 6. TPU Parameters**

| Parameter | Uncertainty |
|---|---|
| SVP Measured | 0.5 m/s |
| SVP Surface | 0.03 m/s |
| Tide Measured | 0.03 m |
| Tide Zoning | 0.081 |

The NOAA Pydro QC Tools was used to evaluate uncertainty values in the finalized CUBE surfaces generated from the survey data. Results from this analysis are presented in Figures 10 and 11. The mean grid uncertainty for depths reported for the 50-centimeter surface is 0.17 meters. This value is representative of the general depth uncertainty for the entire survey and has been included in the Positional Accuracy Vertical field in Appendix A. The best estimate for horizontal position accuracy for the survey reported in Appendix A is 0.1 meters.

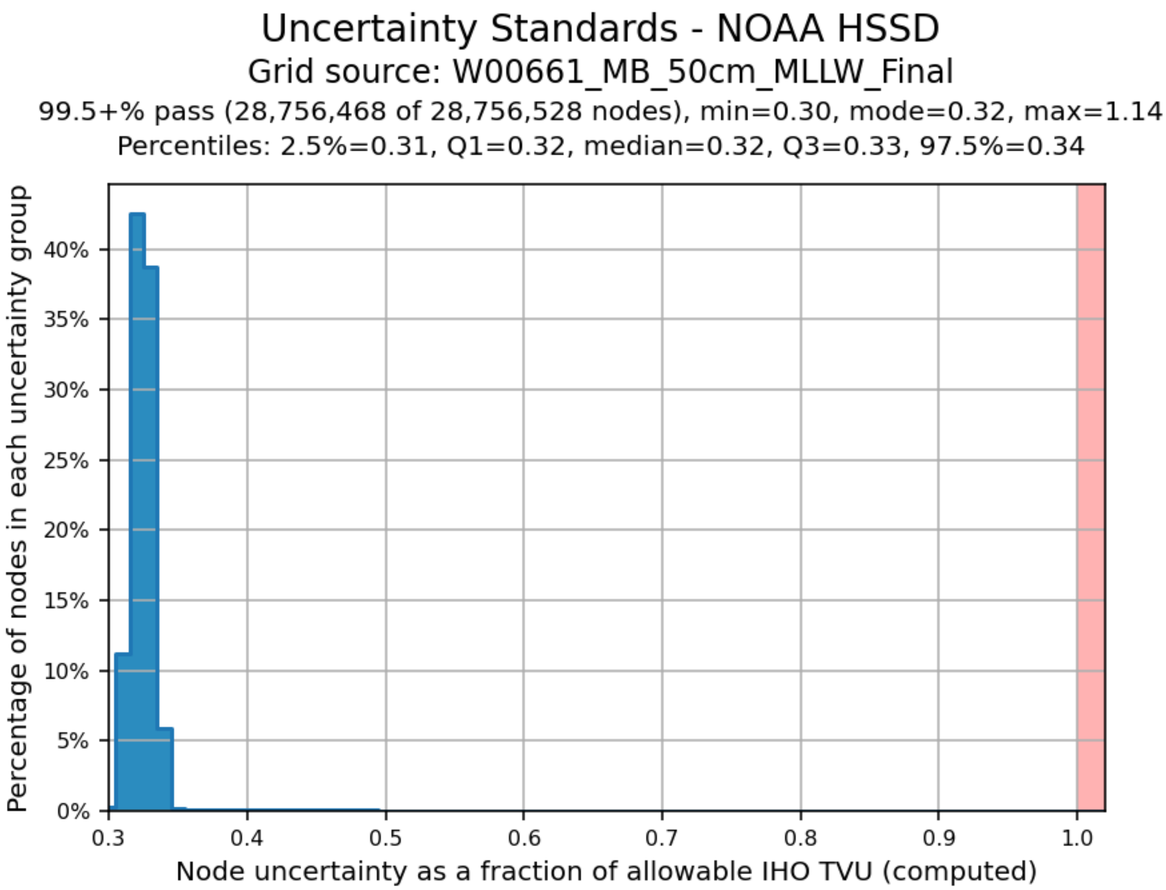



**Figure 10. Node TVU Statistics – 50 centimeters, finalized**

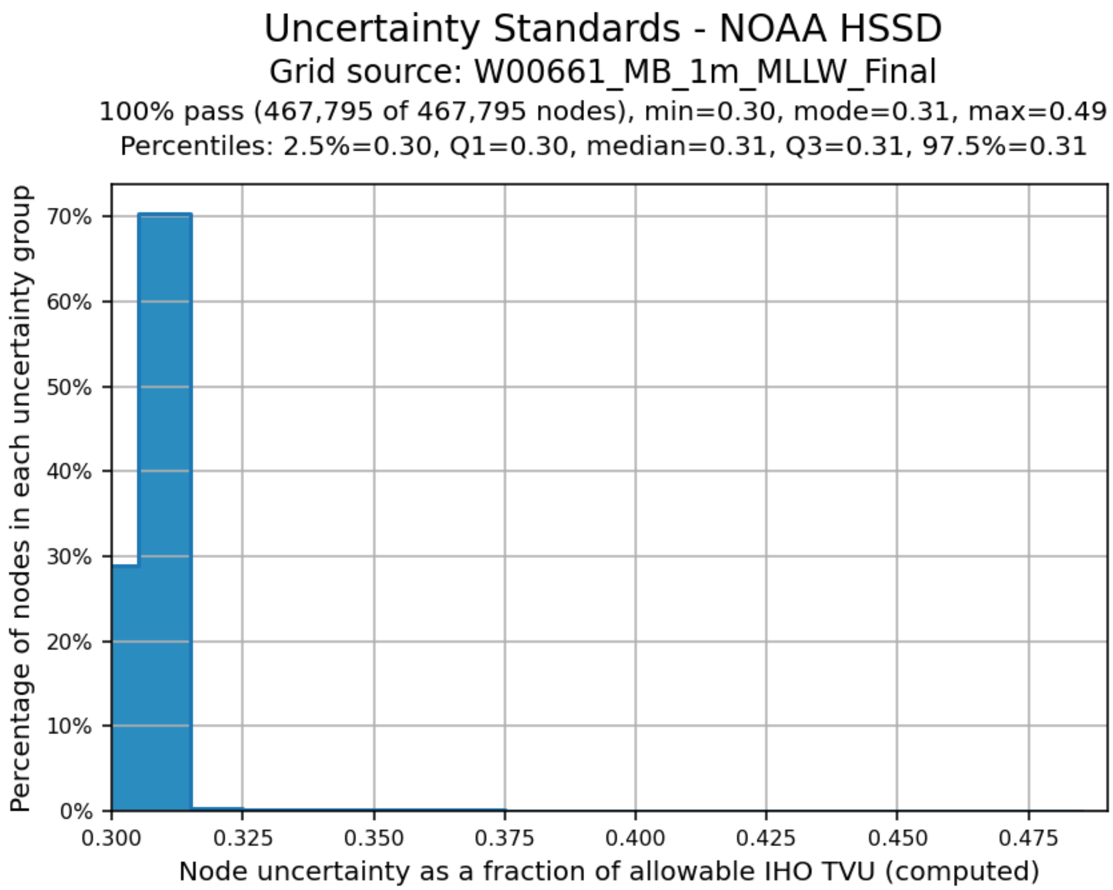



**Figure 11. Node TVU Statistics – 1 meter, finalized**

## 5.5 Junctions

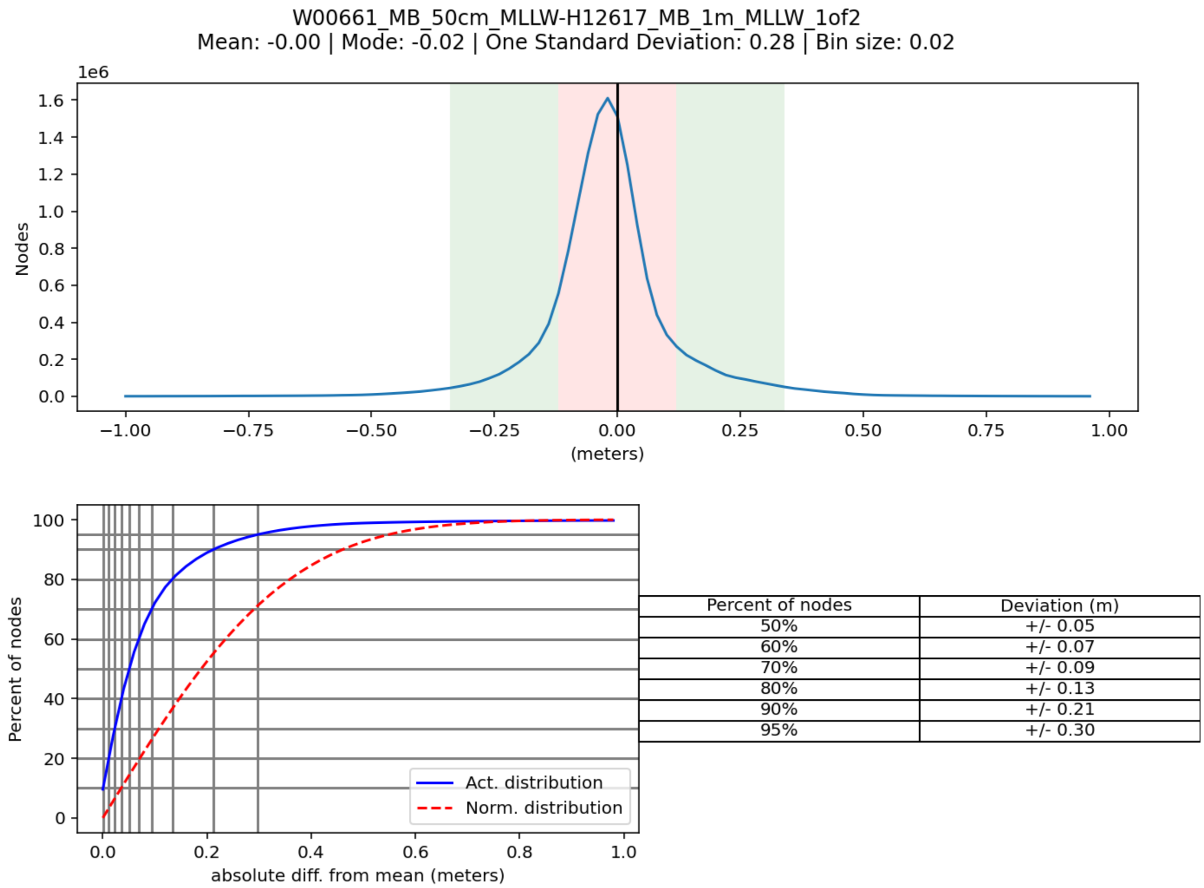
The survey junctions with NOAA prior surveys H12617 (performed in 2013) and H13197 (performed in 2018) and a previous POLB Harbor Sounding Program (performed in 2020), which has been assigned NOAA registry number W00628. A junction comparison was performed by computing a difference surface between bathymetric surfaces from the recent and prior surveys. Bathymetric Attributes Grids for the prior NOAA surveys were downloaded from NOAA's National Centers for Environmental Information (NCEI) website. The H13197 Variable Resolution (VR) surface was converted to a 2-meter single resolution surface prior to differencing as shown in Table 7. The NOAA Pydro Gridded Surface Comparison Tool was used to perform this analysis. The registry number W00628 was not applied to the 2020 POLB survey until after it was submitted through the ESD process. Surfaces from this survey used Area_5_Area_6_MB in the file naming scheme.

**Table 7. Junction Surveys**

| Registry Number | Year | Field Unit | Resolution |
|---|---|---|---|
| H12617 | 2013 | NOAA Ship *Fairweather* | 1 meter |
| H13197 | 2018 | NOAA Ship *Rainier* | VR (1 meter) |
| W00628 | 2020 | David Evans and Associates, Inc. | 0.5 meter |
| W00660 | 2021 | David Evans and Associates, Inc. | 0.5 meter |

<u>H12617</u>

The mean difference between the POLB survey and H12617 survey depths is 0 centimeters, shown in Figure 12.

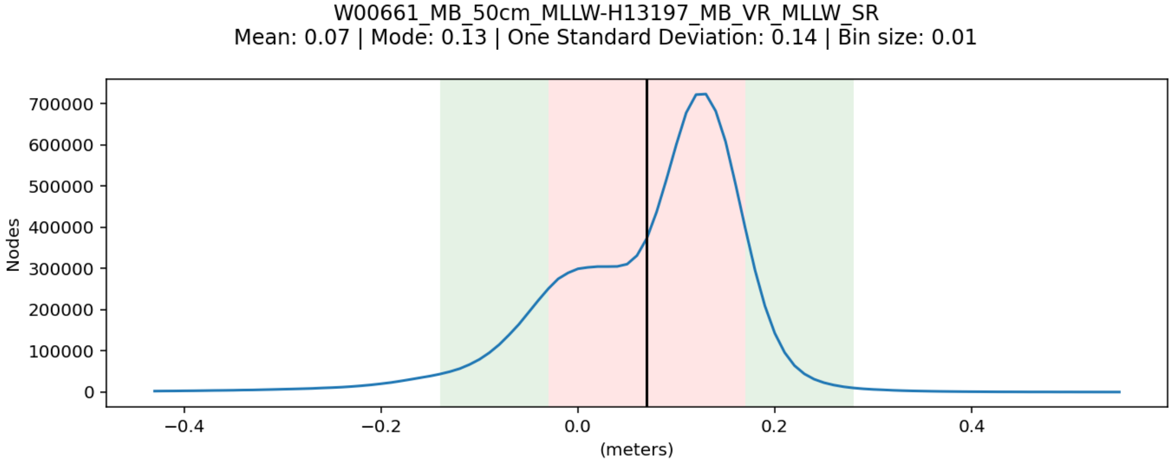


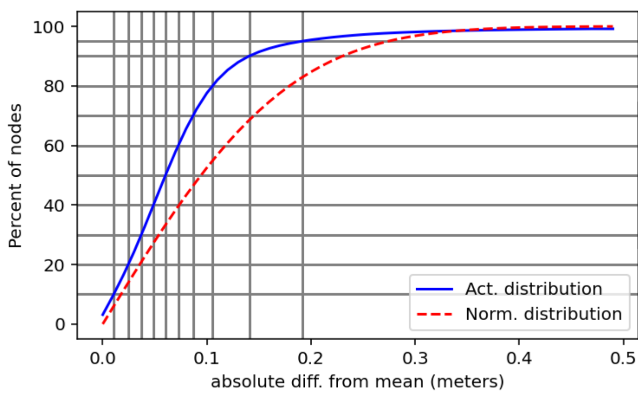

| Percent of nodes | Deviation (m) |
|---|---|
| 50% | +/- 0.05 |
| 60% | +/- 0.07 |
| 70% | +/- 0.09 |
| 80% | +/- 0.13 |
| 90% | +/- 0.21 |
| 95% | +/- 0.30 |

**Figure 12. Distribution summary plot of differences between DEA survey and NOAA survey H12617**

<u>H13197</u>

The mean difference between the POLB survey and H13197 survey depths is 7 centimeters (POLB survey shoaler than H13197), shown in Figure 13.



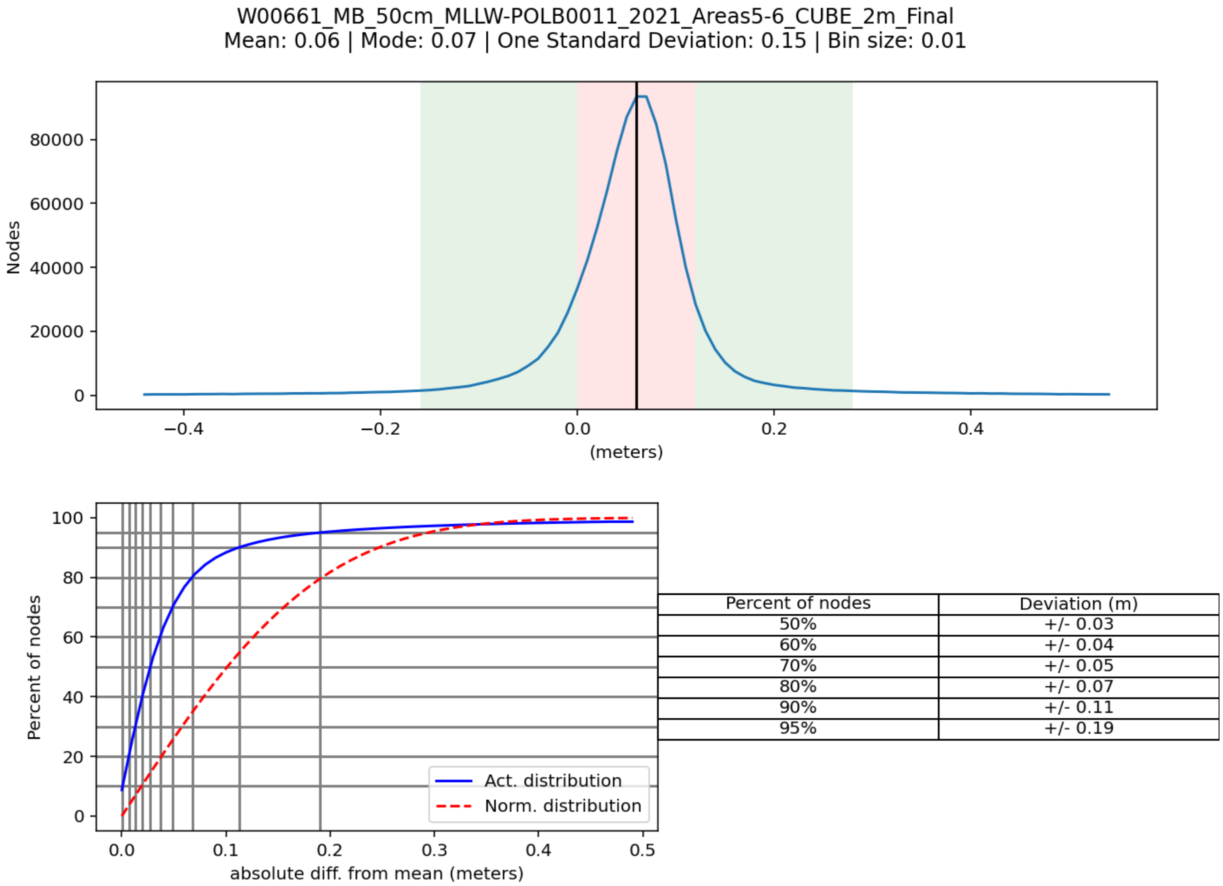




| Percent of nodes | Deviation (m) |
|---|---|
| 50% | +/- 0.06 |
| 60% | +/- 0.07 |
| 70% | +/- 0.09 |
| 80% | +/- 0.11 |
| 90% | +/- 0.14 |
| 95% | +/- 0.19 |

**Figure 13. Distribution summary plot of differences between DEA survey and NOAA survey H13197**

<u>W00628</u>

The mean difference between the POLB survey and W00628 survey depths is 6 centimeters (POLB survey shoaler than W00628), shown in Figure 14.

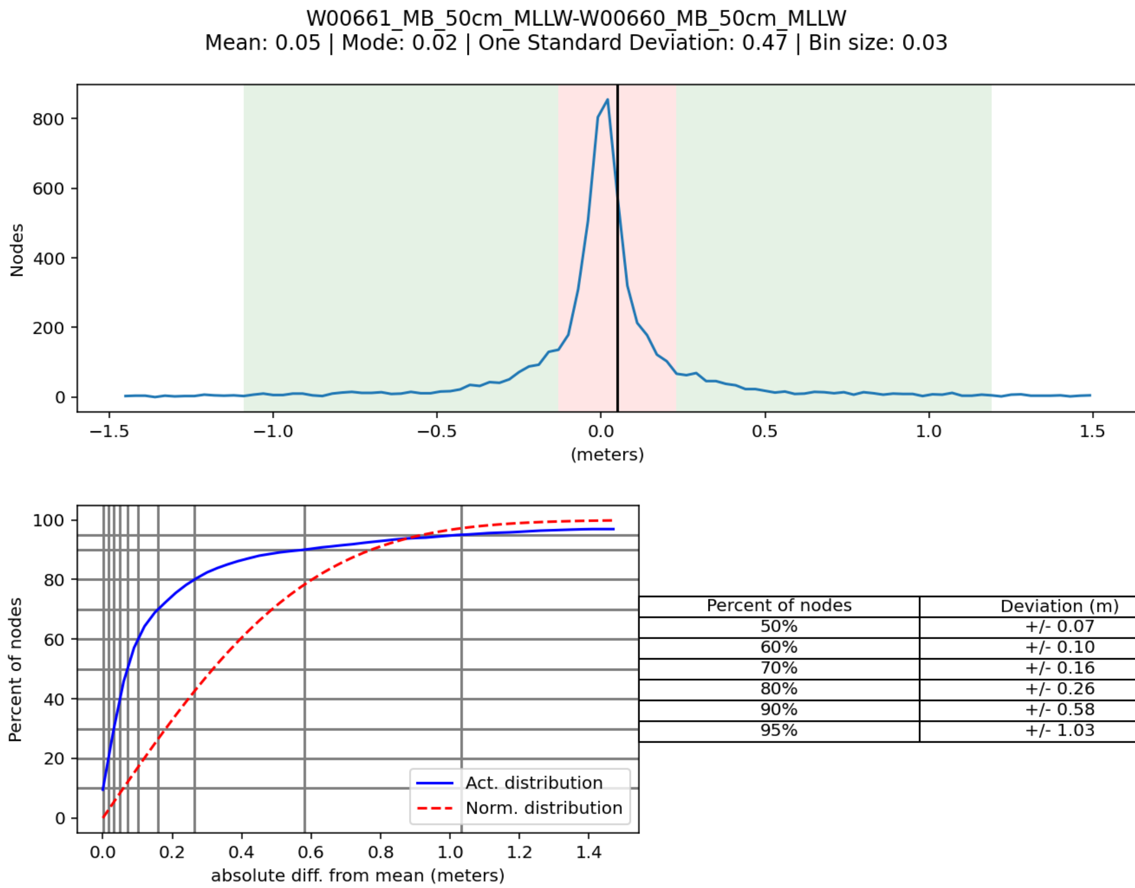



| Percent of nodes | Deviation (m) |
|---|---|
| 50% | +/- 0.03 |
| 60% | +/- 0.04 |
| 70% | +/- 0.05 |
| 80% | +/- 0.07 |
| 90% | +/- 0.11 |
| 95% | +/- 0.19 |

**Figure 14. Distribution summary plot of differences between DEA survey and NOAA survey H13197**

<u>W00660</u>

The mean difference between the POLB survey and W00660 survey depths is 5 centimeters (POLB survey shoaler than W00660), shown in Figure 15.




| Percent of nodes | Deviation (m) |
|---|---|
| 50% | +/- 0.07 |
| 60% | +/- 0.10 |
| 70% | +/- 0.16 |
| 80% | +/- 0.26 |
| 90% | +/- 0.58 |
| 95% | +/- 1.03 |

**Figure 15. Distribution summary plot of differences between DEA survey and W00660**

## 5.6 Density

Sounding density was analyzed using the NOAA requirement that 95% of all grid nodes are populated using at least five soundings. Each submitted surface was analyzed using NOAA Pydro QC Tools and found to meet density requirements. Individual surface results are presented in Figures 16 and 17.

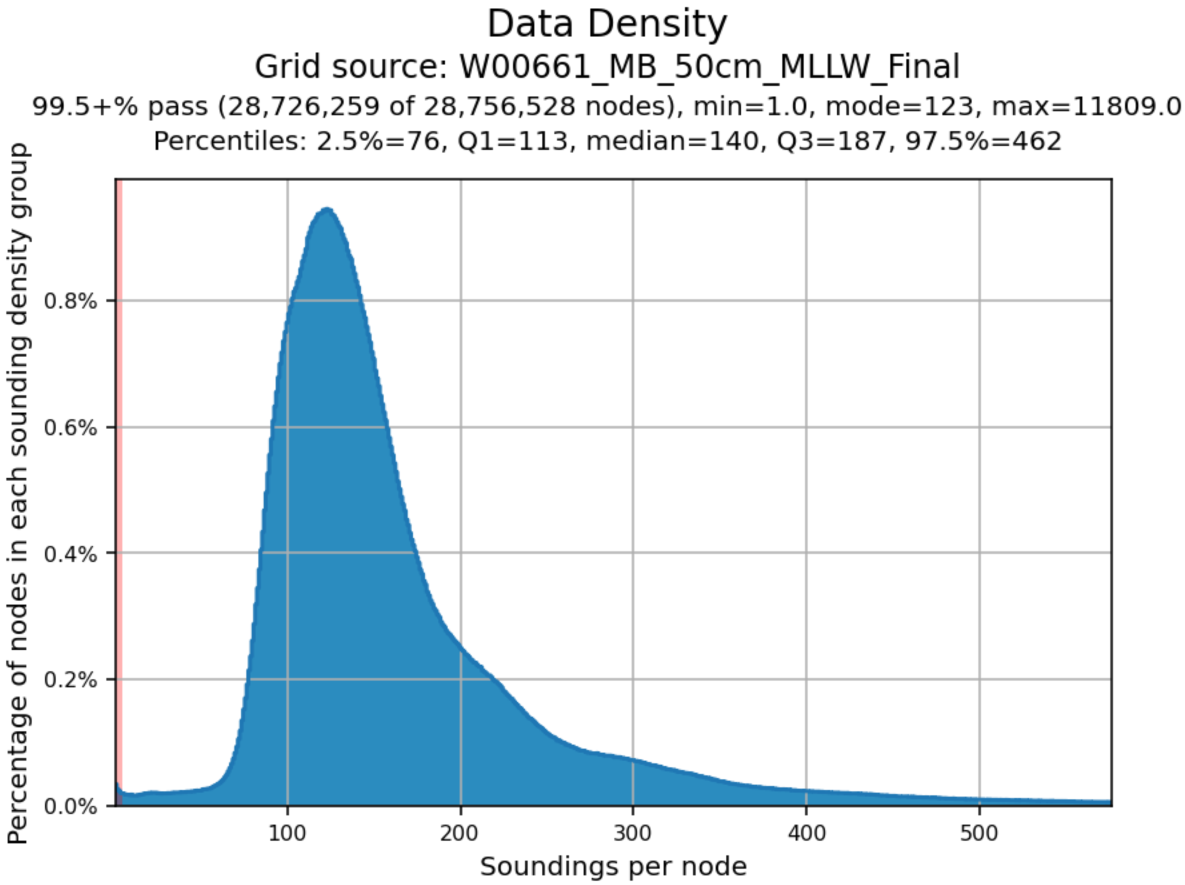



**Figure 16. Node density statistics – 50cm finalized**

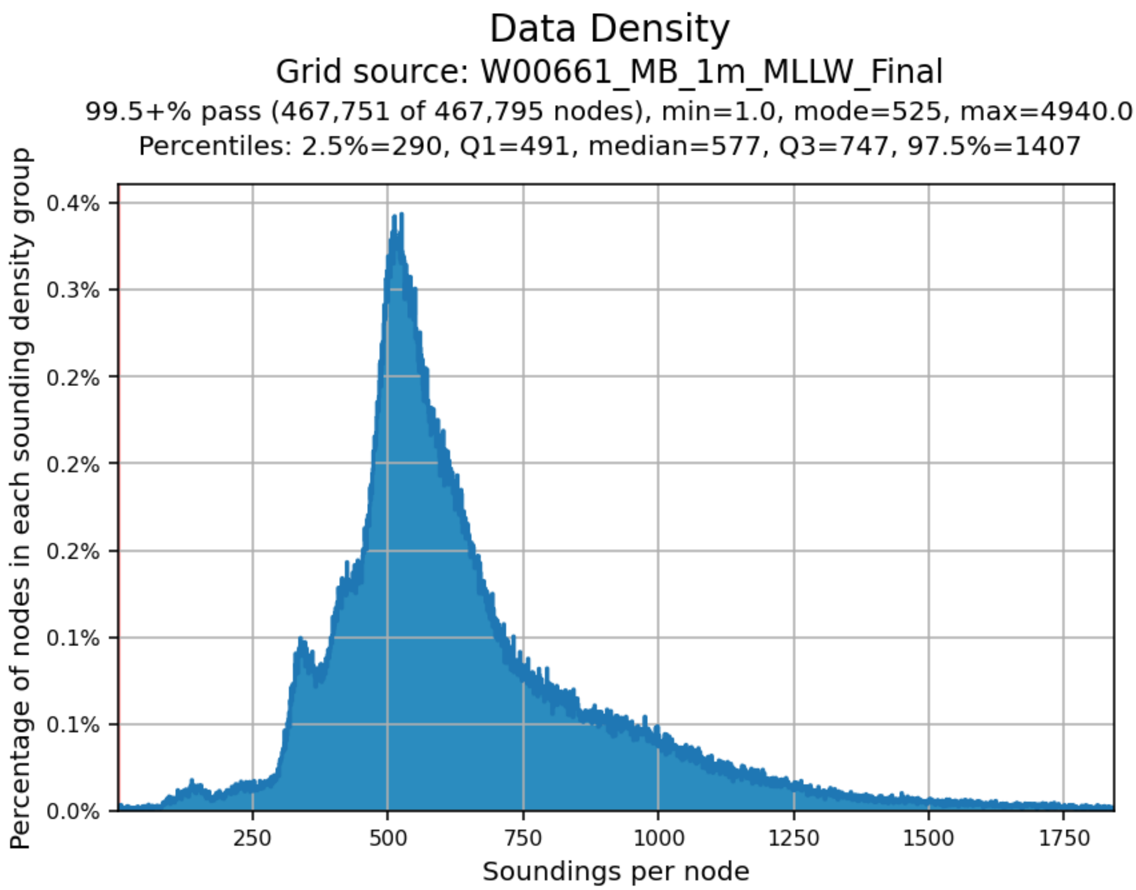



**Figure 17. Node density statistics - 1m finalized**

## 5.7 Backscatter

Time series backscatter was logged in HYPACK 7k format during acquisition but was not processed. HYPACK 7k files have been included with the Raw data deliverables.

## 5.8 Features

Multibeam data were reviewed to determine the presence of features meeting the height threshold for Object Detection Coverage set in the HSSD (2022). HIPS designated sounded were used to denote the least depth of all submerged features present in the survey data. These least depths were integrated into bathymetric surfaces during the surface finalization process.

An S-57 feature file was created for the survey following the standard practice for a Final Feature File set in the HSSD (2022). In lieu of a standard CSF, a subset of charted features such as obstructions, wrecks, underwater rocks and shoreline construction features were selected from the ENCs and copied to the S-57 Feature File. These charted features were then addressed where applicable.

Charted obstructions and underwater rocks were addressed using the attribute descrp as either Delete (where a charted feature was disproved using 100% MBES) or Delete/New (where position/depth has been updated) or Delete/New and a geometry change (where depth has been updated and the feature has been changed from point to area). Where an unsurveyed obstruction was identified from the MBES data, descrp = New was used.

Three Danger to Navigation (DtoN) reports were submitted to the Pacific Hydrographic Branch (PHB). These obstructions are listed below and were included in the survey's feature file.

W00661 DtoN 01was submitted on September 14, 2022, reporting one uncharted obstructions.

W00661 DtoN 02 was submitted on September 14, 2022, reporting one uncharted obstructions.

W00661 DtoN 03 was submitted on September 26, 2022, reporting three uncharted obstructions.

### 5.9 Chart Comparison

A chart comparison was performed by comparing survey depths to a digital surface generated from the Band 6 electronic navigational charts (ENCs) covering the survey area. The results of the comparison are detailed below. The ENCs used during the chart comparison are listed in Table 8. A graphic showing the magnitudes of the differences between the survey and charts is shown in Figures 18 through 20.

**Table 8. ENCs used during the chart comparison**

| ENC | Scale | Edition | Update Application Date | Issue Date |
|---|---|---|---|---|
| US6LGBCB | 5000 | 5 | 08/12/2022 | 08/12/2022 |
| US6LGBCC | 5000 | 5 | 08/16/2022 | 08/16/2022 |
| US6LGBCD | 5000 | 7 | 08/16/2022 | 08/16/2022 |
| US6LGBDC | 5000 | 7 | 08/11/2022 | 08/31/2022 |
| US6LGBDD | 5000 | 3 | 06/25/2021 | 06/25/2021 |

**Figure 18. Depth Difference Between W00661 Survey Area 4 and Band 6 ENC**

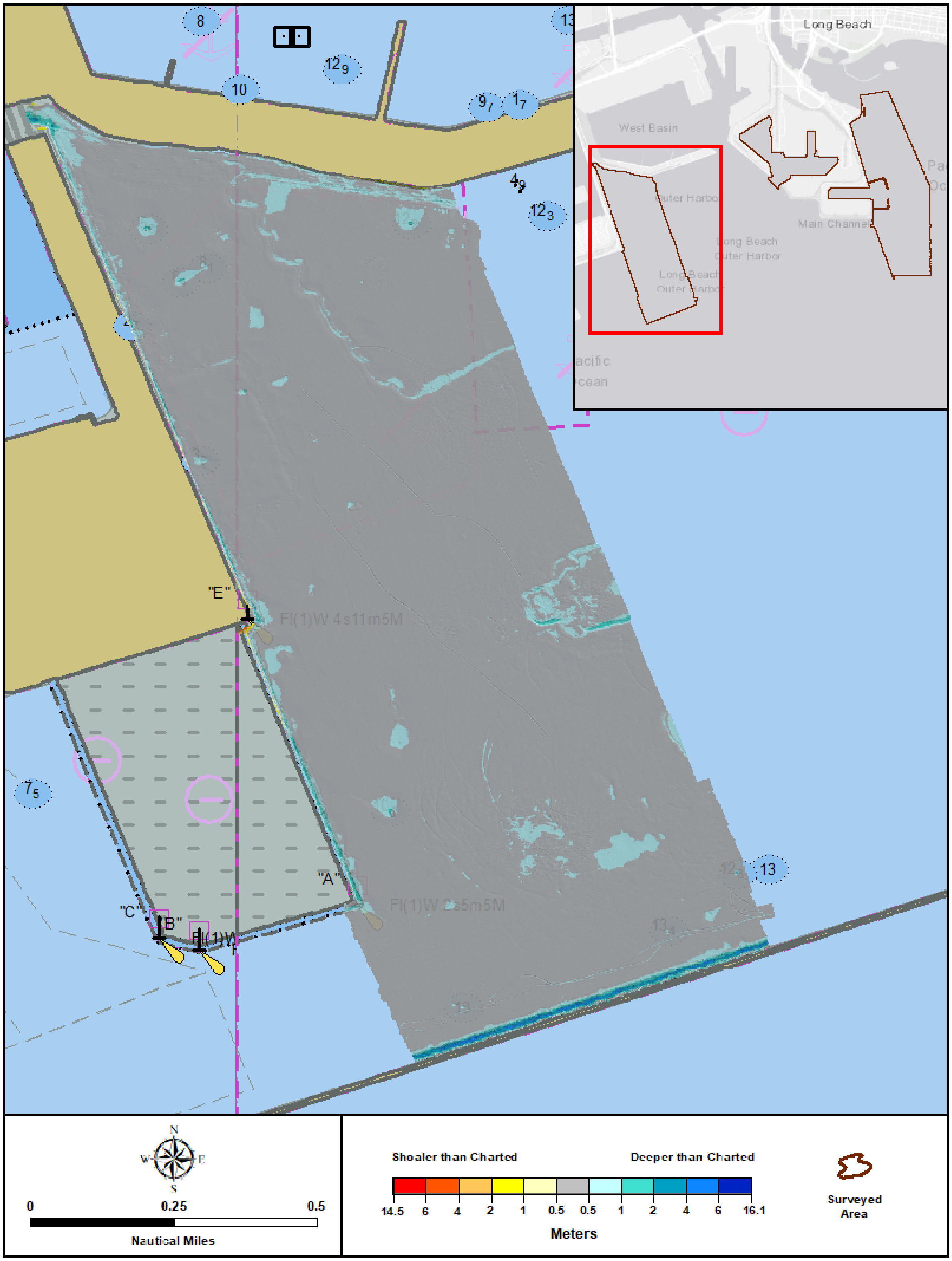



**Figure 19. Depth Difference Between W00661 Survey Area 5 and Band 6 ENCs**

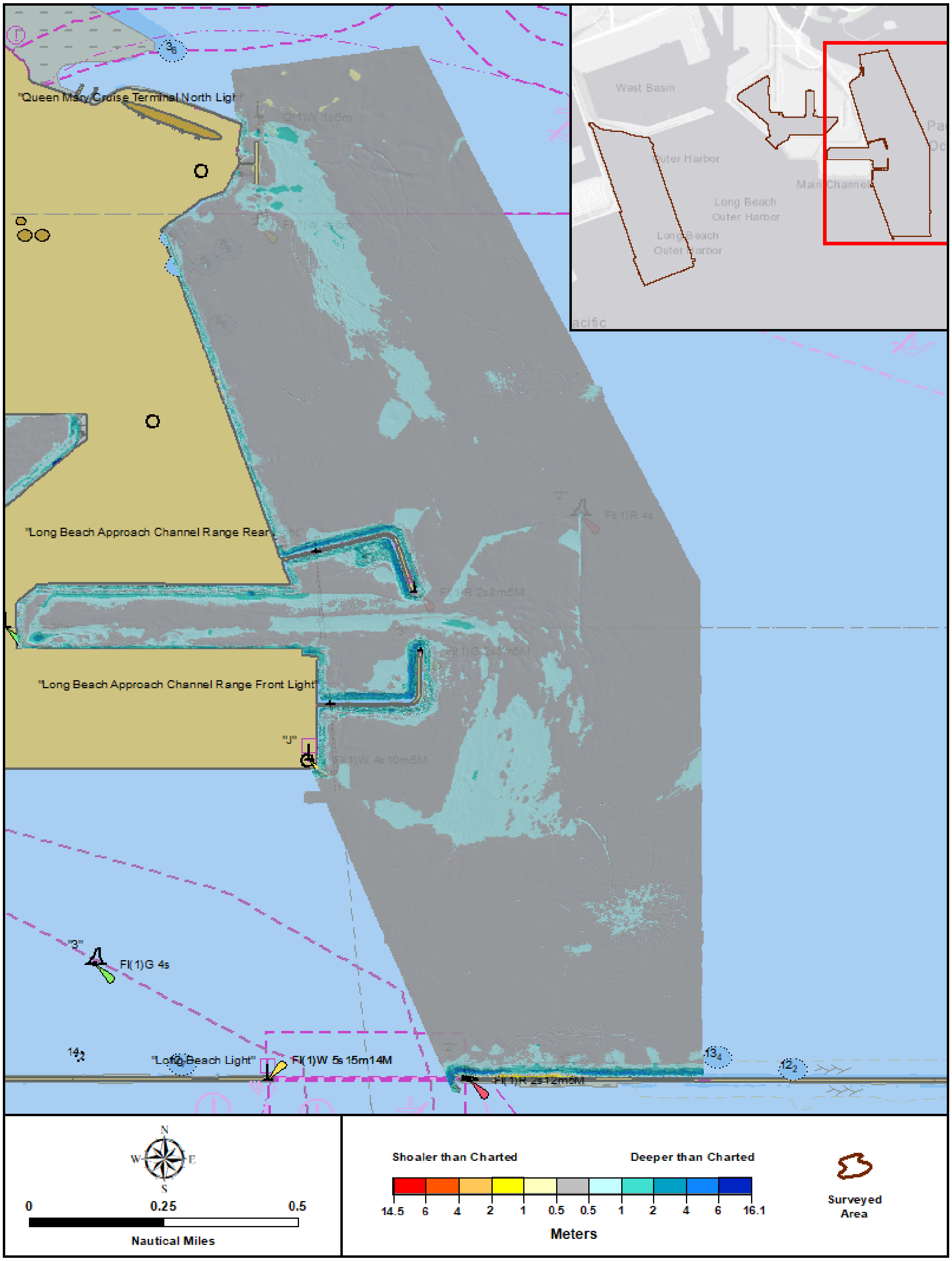



**Figure 20. Depth Difference Between W00661 Survey Area 7 and Band 6 ENCs**

## 6.0 DELIVERABLES

Deliverables were submitted to the NOAA EDS team on a USB drive with a directory structure following Appendix I: Data Directory Structure of the HSSD (2022). Digital deliverables included the following:

1. Raw Data
2. Processed Data in CARIS HIPS format
3. Object Detection Coverage Bathymetric Surfaces
4. Feature File
5. Project report
6. Processed SBET

**APPENDIX A**
**Project Metadata**

## NOAA External Source Data Summary Information

| ISO 19115 Metadata Term (not ISO) | Definition |
|---|---|
| **Title** | Port of Long Beach, San Pedro Bay |
| **Responsible Party** | Port of Long Beach |
| **Contact Info** | Kimberley A. Holtz, Survey Division Director, Port of Long Beach |
| **Phone** | 562-283-7271 |
| **Electronic Mail Address** | kim.holtz@polb.com |
| **Online Resource** | [https://polb.com/](https://polb.com/) |
| **Legal Constraint: License** | Data licensing form (NOAA-W00661_Data-Licensing-Form.pdf) included with the survey submittal. |

| Quality of Bathymetric Data | | | |
|---|---|---|---|
| ISO 19115 Metadata Term (not ISO) | Definition | Format | |
| **Acquisition Start Date Time** | 20220420 | YYYYMMDD | Required |
| **Acquisition End Date Time** | 20220428 | YYYYMMDD | Required |
| **Vertical Coordinate Reference System** | Mean Lower Low Water (MLLW) | String | Required |
| **Vertical Unit of Measure** | Meters | String | Required |
| **Positional Accuracy Vertical** | 0.17 | Float | Vital |
| **Horizontal Coordinate Reference System** | PROJCS["NAD83(2011) / UTM zone 11N",<br>GEOGCS["NAD83(2011)",<br>DATUM["NAD83 (National Spatial Reference System 2011)",<br>SPHEROID["GRS 1980",6378137,298.2572221010041,<br>AUTHORITY["EPSG","7019"]],<br>AUTHORITY["EPSG","1116"]],<br>PRIMEM["Greenwich",0,<br>AUTHORITY["EPSG","8901"]], | OGC WKT | Required |

| | | | |
|---|---|---|---|
| | UNIT["degree (supplier to define representation)",0.0174532925199433, AUTHORITY["EPSG","9122"]], AUTHORITY["EPSG","6318"]], PROJECTION["Transverse_Mercator", AUTHORITY["EPSG","16011"]], PARAMETER["latitude_of_origin",0], PARAMETER["central_meridian",-117], PARAMETER["scale_factor",0.9996], PARAMETER["false_easting",500000], PARAMETER["false_northing",0], UNIT["metre",1, AUTHORITY["EPSG","9001"]], AUTHORITY["EPSG","6340"]] | | |
| **Positional Accuracy Horizontal** | 0.10 | Float | Vital |
| **(Full Bathymetric Coverage Achieved)** | True | True / False | Vital |
| **(Full seafloor Coverage Achieved)** | True | True / False | Vital |
| **(Resolution)** | 0.5, 1.0 | Float | Vital |
| **(Significant Features Detected)** | True | True / False | Vital |
| **(Least Depth of Detected Features Measured)** | True | True / False | Vital |
| **(Size of Features Detected)** | 1.0 | Float | Vital |

| Survey Equipment and Process Steps | | | |
|---|---|---|---|
| ISO 19115 Metadata Term (not ISO) | Definition | Format | |
| **(Multibeam Sensor)** | Reson SeaBat T50R Dual Head | String | Required |
| **(Vertical Beam Sensor)** | N/A | String | Required |
| **(Side Scan Sensor)** | N/A | String | Required |
| **(Lidar Sensor)** | N/A | String | Required |
| **(Interferometric Sensor)** | N/A | String | Required |
| **(Attitude and Positioning Equipment)** | Applanix POS/MV 320 version 5 | String | Conditional |
| **(Sound Velocity Sensors)** | AML Micro SV Xchange (surface sound speed), AML Oceanographic Smart X (sound speed profiles) | String | Conditional |
| **(Sound Velocity Processing)** | Sound velocity profiles were used to correct slant range measurements and to compensate for any ray path bending. These were applied in CARIS using the closest in distance and time algorithm. | String | Conditional |
| **(Vertical Datum Processing)** | ERS methods using post processed kinematic (PPK) SBET and custom VDatum based separation file. Soundings reduced to MLLW in CARIS HIPS. | String | Conditional |
| **(Processing Software)** | CARIS HIPS (versions 11.4.4, 11.4.8, and 11.4.13) | String | Conditional |