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

Descriptive Report

Type of Survey Habitat Mapping

Registry No. N/A

LOCALITY

State California

General Locality San Francisco Bay

Sublocality N/A

2014 - 2015

CHIEF OF PARTY

Chris Esposito

LIBRARY & ARCHIVES

DATE **June 16, 2016**

U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION **HYDROGRAPHIC TITLE SHEET**	REGISTER NO. N/A

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 California

General Locality San Francisco Bay

Locality N/A

Scale N/A Date of Survey 10/01/2014 – 12/12/2015

Instructions dated 11/24/2014 Project No. San Francisco Bay Habitat Mapping

Field Unit Fugro Pelagos, Inc. and California State University – Monterey Bay Seafloor Mapping Lab (SFML)

Chief of party Chris Esposito

Soundings by Multibeam Echo Sounder and Interferometric Sonar.

Imagery by Multibeam Echo Sounder Backscatter and Interferometric Side Scan.

Verification by Geomatics Data Solutions.

Soundings Acquired in METERS at NAVD88

REMARKS: This survey was not a charting survey, so no Registry Number or Sheet Number exists.

ALL TIMES ARE RECORDED IN UTC.

FUGRO PELAGOS INC.
3574 RUFFIN ROAD
SAN DIEGO, CA 92123

Descriptive Report to Accompany Survey – San Francisco Bay Habitat Mapping

Project: San Francisco Bay Habitat Mapping
Locality: San Francisco Bay
Sublocality: n/a
October 2014 - December 2015
Fugro Pelagos, Inc.
Chief of Party: Chris Esposito

A. Area Surveyed

The survey area spans a large portion of San Francisco Bay, from San Pablo Bay in the north to an area south of the Dumbarton Bridge. No official NOAA sheets were assigned as part of this project. Instead, the overall survey area was divided into Area A and Area B, according to the project's Statement of Work.

Area B contains the high priority, ultra-shallow survey blocks. These areas were surveyed using an interferometric sonar.

Area A contains some survey blocks that required full imagery coverage (designated as area A1 blocks) as well as survey blocks that required only 50% imagery coverage with the interferometric side scan sonar. Within the Area A1 designation, seven of the survey blocks had water depths that averaged 20 meters or greater, requiring survey with a multibeam sonar to achieve full bathymetry and backscatter imagery coverage. The seven multibeam survey blocks were named CA1B08, CA1B09, CA1B22, CA1B24, CA1B26, NA1B15, and NA1B23.

A.1 Survey Limits

Data were acquired within the following survey limits:

Northwest Limit	Southeast Limit
38° 8' 9.1" N 122° 30' 11.52" W	37° 27' 18" N 122° 2' 46.32" W

Table 1: Survey Limits

Survey limits were acquired in accordance with the project's Statement of Work, which was treated as the Project Instructions. No Project Instructions were provided by NOAA, as this survey was not a standard charting project.

A.2 Survey Purpose

This project has two purposes. The primary purpose is to provide the California Ocean Protection Council (OPC), as required for the California Seafloor Mapping Program (CSMP) modern, accurately positioned sonar imagery data of San Francisco Bay coastal and near shore waters to delineate marine habitat types. Secondarily, the survey shall provide OPC and NOAA with bathymetric survey data from a combination of multi-beam and interferometric sonars. The interferometric bathymetry will not be as accurate as the bathymetry acquired with a multi-beam sonar. Thus, the areas with water depths greater than 20 meters, which shall be surveyed with a multi-beam system, are expected to have a higher order of accuracy. The combined survey data, including the imagery and the bathymetry, will support OPC's goals as well as assist with NOAA's mandate for port and harbor maintenance (dredging), coastal engineering (beach erosion and replenishment studies), and coastal zone management.

A.3 Survey Quality

The entire survey is adequate to supersede previous data.

A.4 Survey Coverage

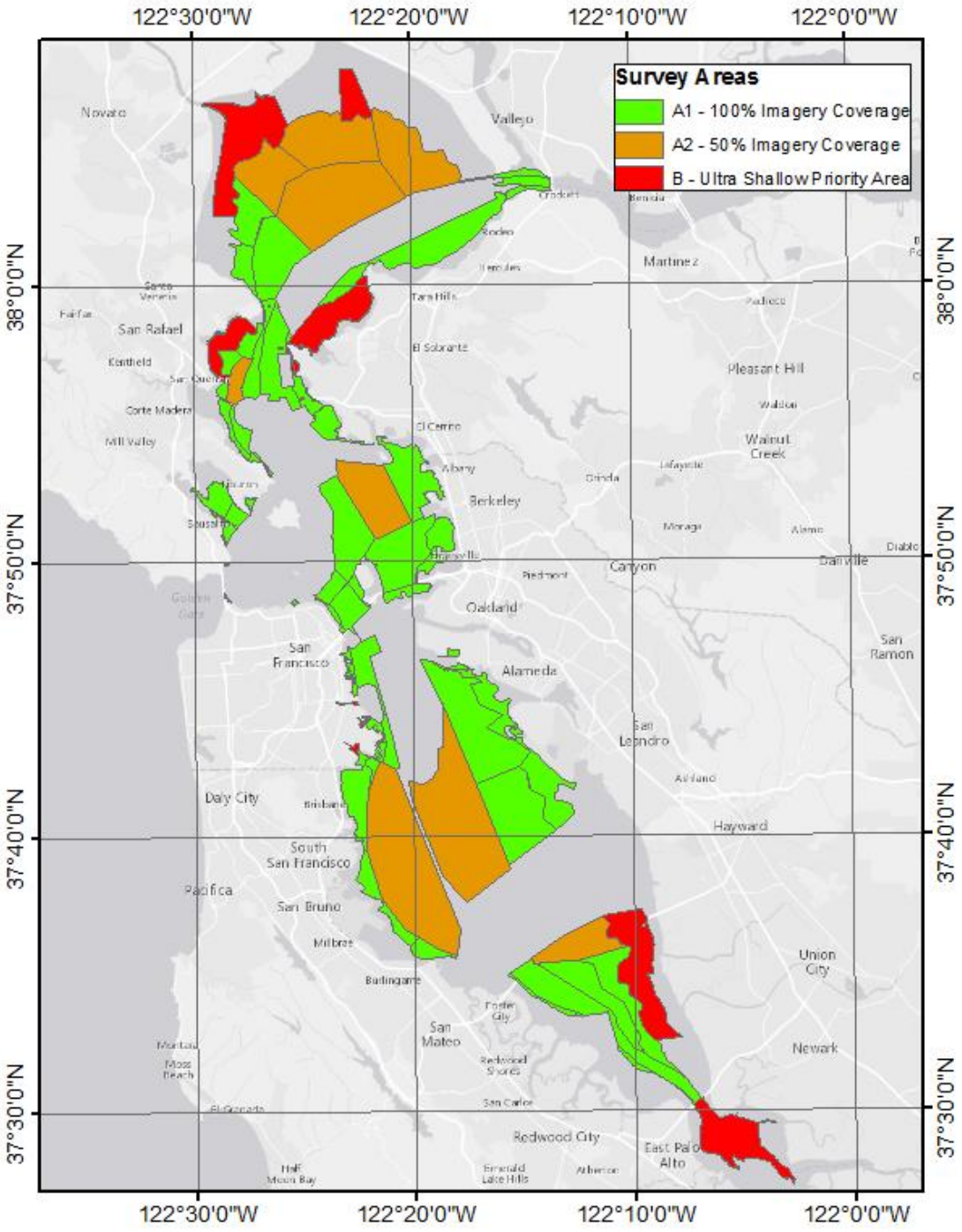

Figure 1: Coverage Overview

Survey coverage was acquired in accordance with the project's Statement of Work. Three blocks in Area B, however, contained areas that were inaccessible to the survey boat, resulting in less coverage than was planned. Blocks CBB01, CBB02, and CBB03 all contained obstacles or obstructions that prevented full imagery coverage. The western portion of CBB01 (Islais Creek

Channel) was inaccessible due to the 3rd St. & Illinois St. bridges, as shown in Figure 2.

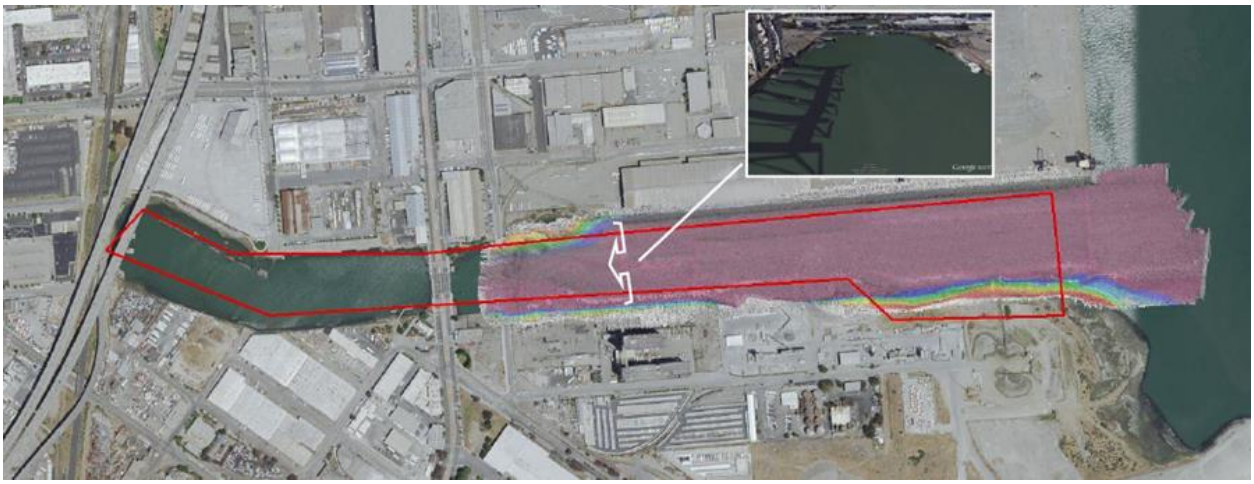

Figure 2: Block CBB01 (Islais Creek Channel) Coverage

A portion of CBB02 (India Basin) was blocked by a footbridge going out to Heron's Head Park, as shown in Figure 3.

Figure 3: Block CBB02 (India Basin) Coverage

A section of CBB03 (South Basin) was closed off by a floating boom/sea curtain, and the northwestern portion was too shallow to survey, even at high tide. Block CBB03 coverage is shown in Figure 4.

Figure 4: Block CBB03 (South Basin) Coverage

A.5 Survey Statistics

The following table lists the mainscheme and crossline acquisition mileage for this survey:

Hull ID	Mainscheme Multibeam (nautical miles)	Mainscheme Interferometric Bathy/ Side Scan Sonar (nautical miles)	Crosslines (nautical miles)
PXMKN201I192 (Locator with Reson 7101)	220.19	0	13.86
PXMKN201I192 (Locator with Edgetech 6205)	0	1277.46	30.02
ALF000804G97 (JulieAnn with Edgetech 6205)	0	1068.35	27.48
SAMA1083J999 (MacGinitie with BathySwath)	0	1402.74	18.62
YAMA3198L708 (Kelpfly with BathySwath)	0	69.11	0.74
Total	**220.19**	**3817.66**	**90.72**

Table 2: Survey Line Mileage Statistics

The survey totaled 150.56 square nautical miles.

Interferometric sonars are not a standard tool recognized in NOAA's Hydrographic Surveys Specifications and Deliverables; however, the Statement of Work for this project required interferometric data for the vast majority of the survey lines. Additionally, this specific project did not require crosslines run at the same frequency or spacing as traditional multibeam crosslines.

The true multibeam crosslines totaled 13.86 nautical miles, which is equal to 6.29% of the multibeam main scheme line length.

The following table lists the start and end dates of data acquisition for Area A and Area B. The specific dates of acquisition for each survey block are provided in the FGDC metadata delivered as part of this project.

Area	Start Date of Acquisition	End Date of Acquisition
Area A1 & A2 survey blocks	10/1/2014	12/21/2014
Area B survey blocks	3/16/2015	12/12/2015

Table 3: Dates of Survey

B. Data Acquisition and Processing

Refer to the Data Acquisition and Processing Report (DAPR) for a complete description of data acquisition and processing systems, survey vessels, quality control procedures and data processing methods. Additional information to supplement sounding and survey data, and any deviations from the DAPR are discussed in the following sections.

B.1 Equipment & Vessels

M/V Locator, a 26 feet in length with a draft of 2 feet, was equipped with a pole mounted Edgetech 6205 interferometric sonar and a Reson SeaBat 7101 multibeam echosounder system for the project. The Reson 7101 operates at a frequency of 240 kHz. The system forms 511 equi-distant across track beams, with maximum swath coverage of 150°. Operating modes such as range scale, gain, power level, ping rates, etc. were a function of water depth and data quality and were noted on the survey line logs (see the Descriptive Report Separate 1). All 7101 multibeam data files were logged in the s7k format using WinFrog Multibeam v3.09.31. The Edgetech 6205 is a dual-frequency sonar with frequencies of 550 kHz and 1600 kHz for the side scan imagery; though, the interferometric bathymetry is operated at 550 kHz. For this project, the system was operated at 550 kHz for the side scan sonar imagery. The bathymetric swath coverage was acquired at approximately 12 times water depth, though it was later reduced during processing.

M/V Julie Ann, a 26 feet in length with a draft of 2 feet, was equipped with a pole mounted Edgetech 6205 interferometric sonar. The Edgetech 6205 is a dual-frequency sonar with frequencies of 550 kHz and 1600 kHz for the side scan imagery; though, the interferometric bathymetry is operated at 550 kHz. For this project, the system was operated at 550 kHz for the side scan sonar imagery. The bathymetric swath coverage was acquired at approximately 12 times water depth, though it was later reduced during processing.

R/V MacGinitie is 27 feet in length with a draft of 1.5 feet, and was equipped with a pole mounted Bathyswath-1H, 468 kHz interferometric sonar. The bathymetric swath coverage was acquired at up 20 times water depth or 60 m range, whichever was limiting, although this coverage was later reduced during processing.

R/V KelpFly, a modified Yamaha Waverunner personal watercraft with Wing inflatable hull, 14 feet in length with a draft of 1 foot, was equipped with a hull-mounted Bathyswath-1H, 468 kHz interferometric sonar. The bathymetric swath coverage was acquired at up 20 times water depth or 60 m range, whichever was limiting, although this coverage was later reduced during processing.

B.2 Quality Control

Crosslines

Crosslines acquired for this survey totaled 2% of mainscheme acquisition.

Multibeam crosslines were planned and well distributed throughout survey areas A1 and A2 to ensure adequate quality control. Total multibeam crossline length surveyed was 13.86 nautical miles or 6.29 percent of the total main scheme line length. Each crossline was compared to the entire main scheme line plan through a 1m CUBE surface using the CARIS HIPS QC report routine.

The majority of the QC Reports fall well within the required accuracy specifications. However, a few crosslines run by the Locator contain outer beams in the QC Report that fall below the 95% confidence level due to sound velocity errors. This was to be expected during acquisition as there were heavy rainfalls in the survey areas. For this reason, not only were the outer beams in the main scheme lines filtered during processing, but the survey line spacing was conservative to minimize any sound velocity refraction in the final data set. Good conformity was still seen between the main scheme lines and the crosslines.

Figure 5: Crossline Agreement 1CA1B22-TIE01

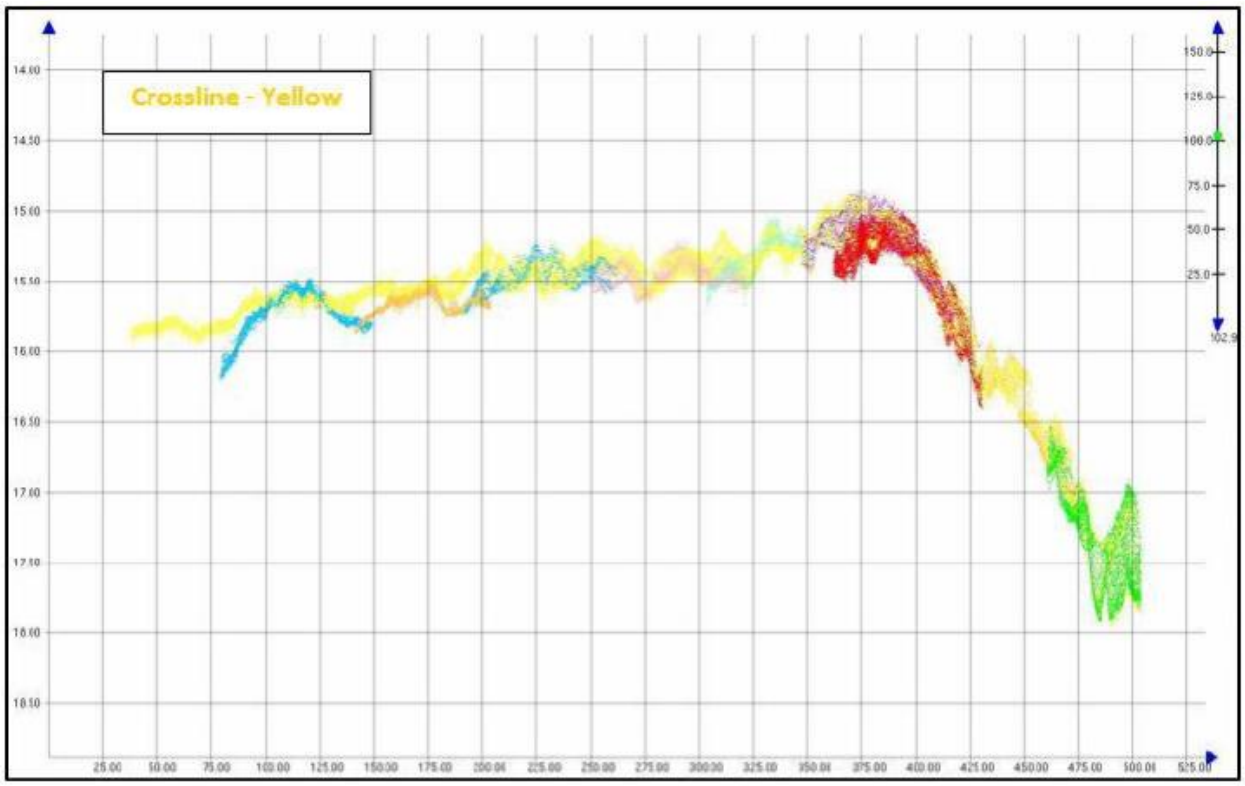

Figure 6: Crossline Agreement 1NA1B15-TIE01

For areas A1 and A2, interferometric sonar bathymetry crosslines were expected to be executed once per week, however they were acquired more often and spread out temporally and geographically within the QC areas. Interferometric sonar bathymetry was not confined to NOAA HSSD. Instead, the interferometric crosslines, can be used to approximate the amount of swath that fell within IHO Order 1a standards. The folder Separate II (Digital Data) contains the crossline reports from the CARIS HIPS QC Report routine. A manual review of these interferometric crossline reports indicates that approximately the middle 50% of the swath achieved IHO Order 1a accuracy specifications. During acquisition, the interferometric lines were set to acquire data to 6 times water depth to each side of nadir, for a total of 12 times water depth. Thus, the crossline analysis indicates that approximately half, or a total of 3 times water depth to each side of nadir, achieved IHI Order 1a specifications. This analysis agrees with a manual review of the swath in the CARIS HIPS Subset Editor window. For these reasons, the Edgetech 6205 swath was filtered in CARIS HIPS to reject any soundings that were more than 3 times the water depth from the nadir of the swath.

For area B, interferometric sonar bathymetry crosslines were executed concurrently with main scheme survey data and spread out geographically within the survey blocks. A total of 19.36 nautical miles of crosslines were surveyed, or 1.32% of the total main scheme survey line length. Interferometric sonar bathymetry was not confined to NOAA HSSD. Instead, the interferometric crosslines can be used to approximate the proportion of swath that falls within IHO Order 1a and Special Order standards. The folder Separate II (Digital Data) contains the crossline reports from

the CARIS HIPS QC Report routine. A manual review of these interferometric crossline reports indicates that IHO Order 1a accuracy specifications were achieved out to 55 m range (over 95% of accepted crossline soundings within accuracy limit). Across the entire 60m range analyzed, 99.9% of accepted soundings achieved Order 1a specifications. During acquisition of both main scheme and crossline data, the interferometric system was set to acquire data out to a maximum of 60 m range to each side of nadir, for a total of up to 120 m coverage. This maximum range was rarely realized, and coverage out to 40 m (or less) was more often the observed maximum. Of the crosslines analyzed, 98% of accepted soundings fell within 40 m range of nadir. This analysis agrees with a manual review of the swath in the CARIS HIPS Subset Editor window, with a similar proportion of main scheme retained soundings found within 40 m range.

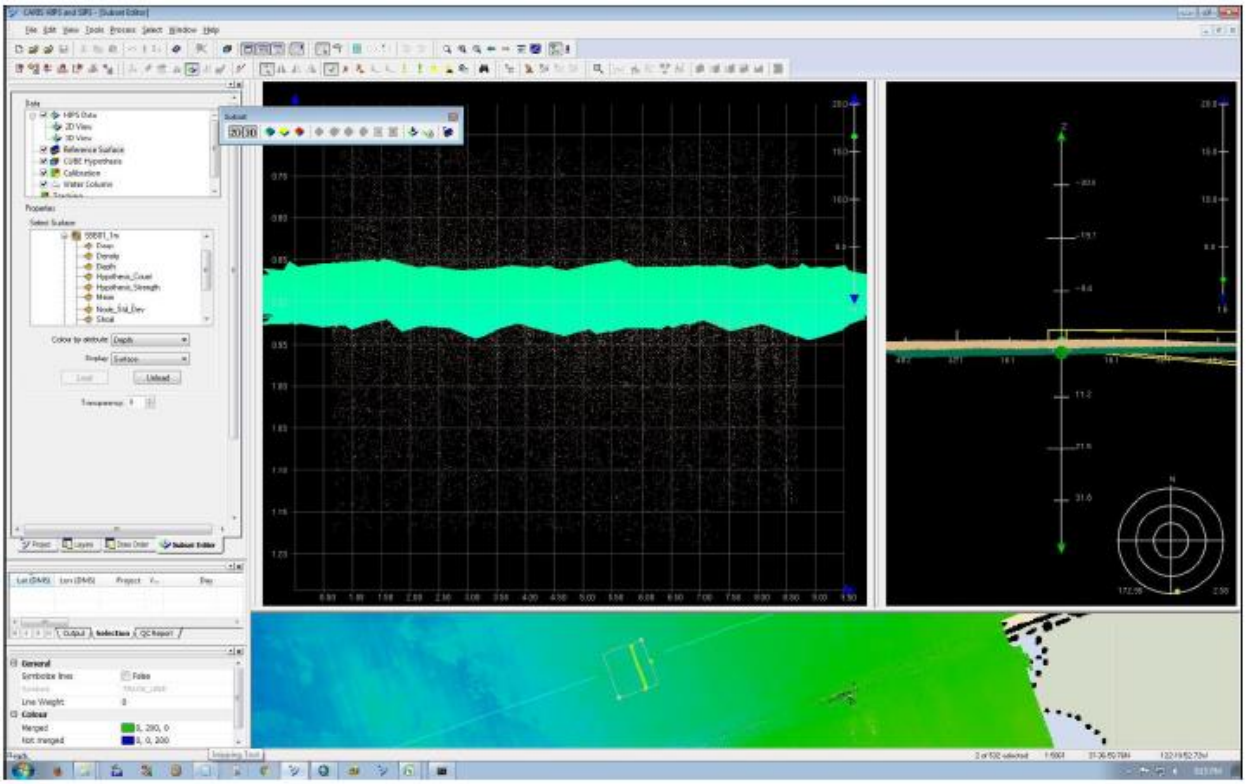

Figure 7: Crossline Agreement in Block SBB01

Uncertainty Values

The interferometric data did not have any uncertainty specifications for this survey. The multibeam data from the Reson 7101 was required to meet IHO Order 1a accuracy specifications. The bathymetry from the multibeam sonar met the IHO Order 1a specifications; while, the majority of the bathymetry from the interferometric sonars also met IHO Order 1a specifications after the outer beams of the interferometric lines in Areas A1 and A2 were filtered.

The following tide uncertainty parameters were used when calculating the total propagated

uncertainty (TPU) of the soundings in CARIS HIPS:

Tide Parameter	Uncertainty Value
Measured	0.06 meters
Zoning	0.10 meters

Table 4: Survey Specific Tide TPU Values

The following sound speed uncertainty parameters were used when calculating the total propagated uncertainty (TPU) of the soundings in CARIS HIPS:

Hull ID	Measured	Surface
PXMKN201I192 (Locator with Reson 7101)	1.50 meters/second	0.25 meters/second
PXMKN201I192 (Locator with Edgetech 6205)	0.66 meters/second	0.25 meters/second
ALF000804G97 (JulieAnn with Edgetech 6205)	0.66 meters/second	0.25 meters/second

Table 5: Survey Specific Sound Speed TPU Values

The multibeam data from the Reson 7101, which was pole mounted on the M/V Locator, met IHO Order 1a specifications. Seven survey blocks were acquired using only the Reson 7101. Images of the uncertainty surface for each of these blocks are attached to this report, including annotated highlights of areas in each block that displayed the highest levels of uncertainty. As expected, these higher levels of uncertainty were seen in areas with deeper water, areas that fell farthest from the nadir of survey lines, and areas that had rocky or sloped topography. Each of these seven multibeam blocks achieved the required IHO Order 1a standard.

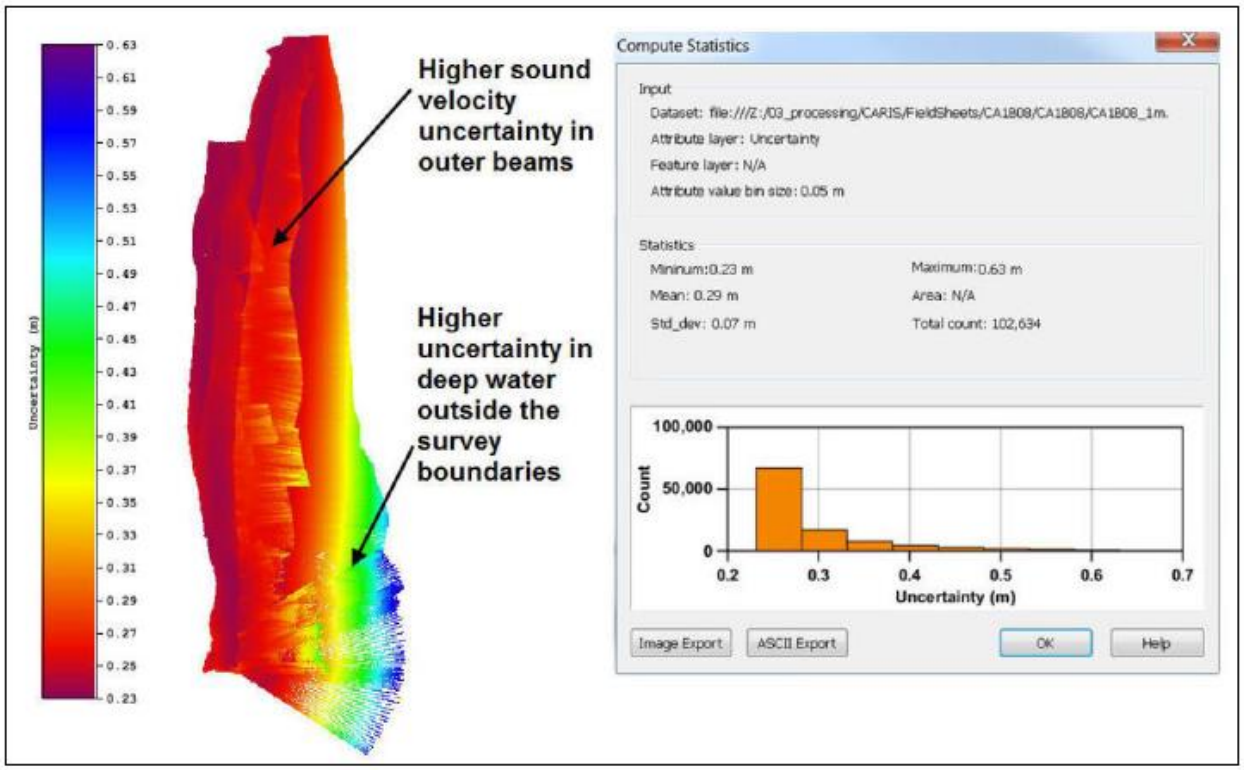

Figure 8: Block CA1B08 Uncertainty

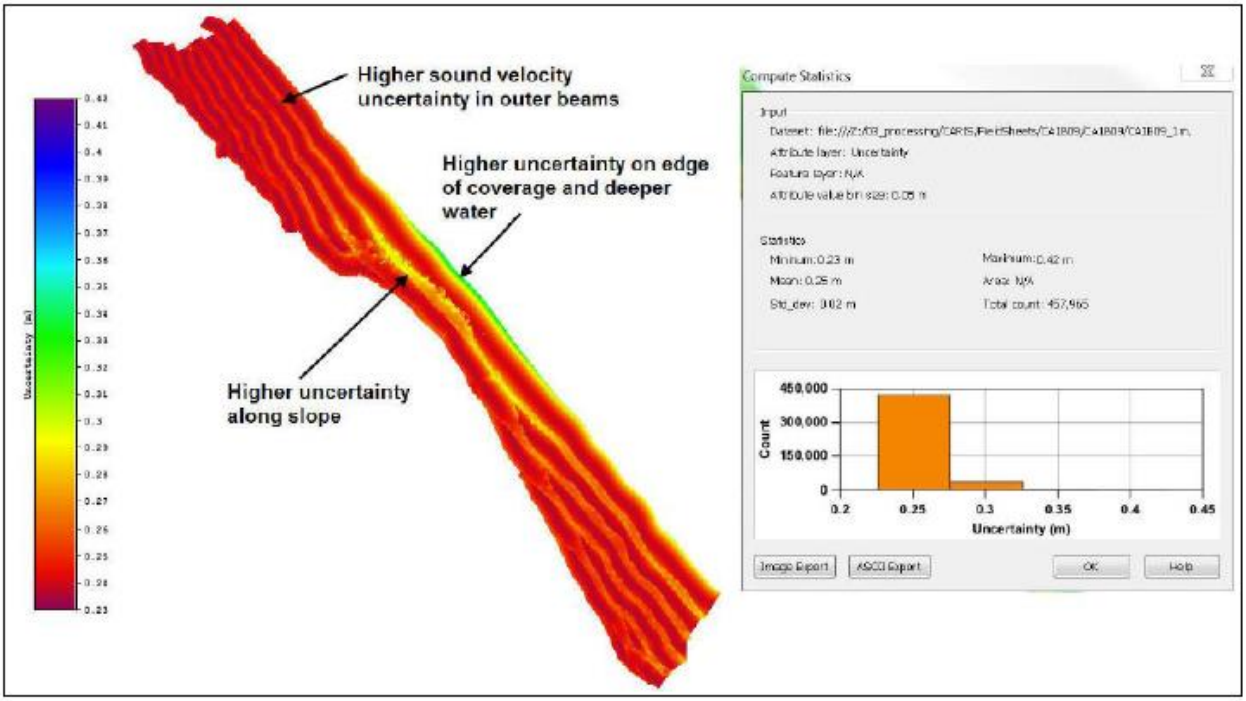

Figure 9: Block CA1B09 Uncertainty

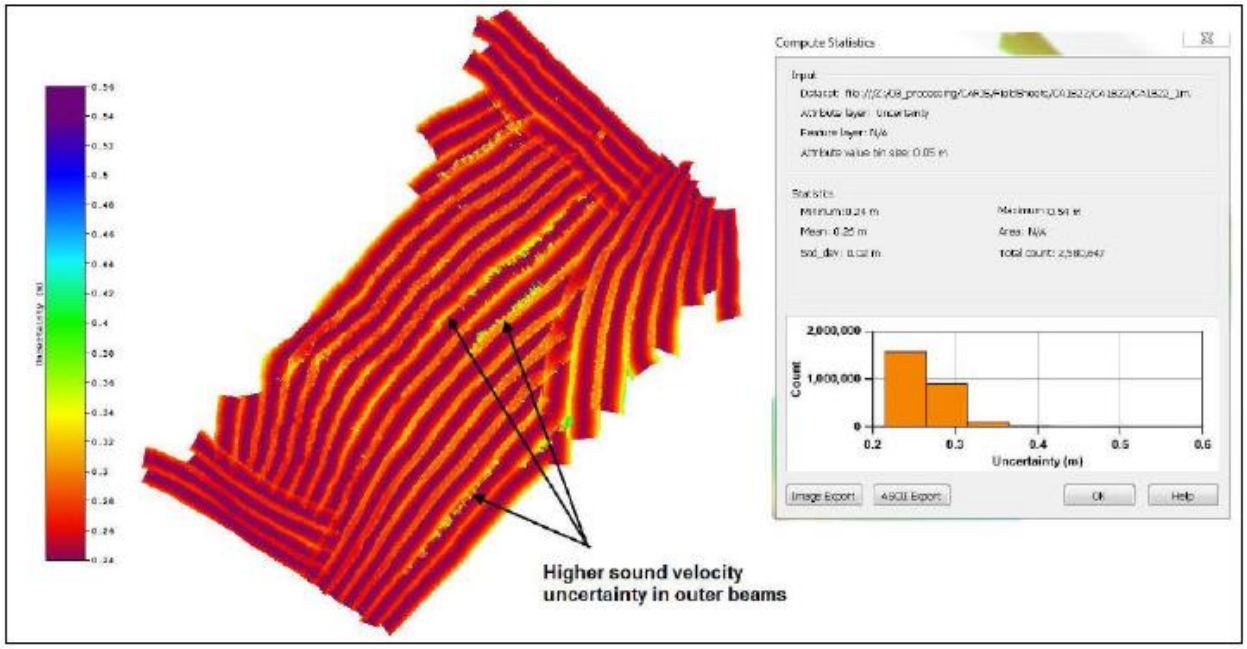

Figure 10: Block CA1B22 Uncertainty

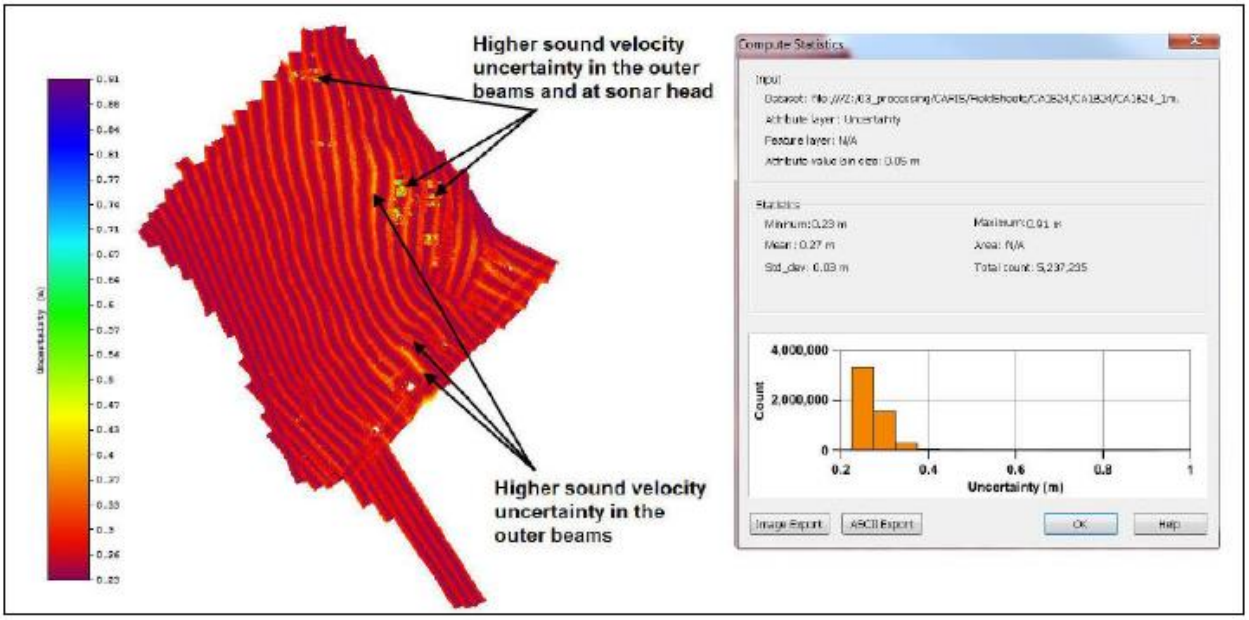

Figure 11: Block CA1B24 Uncertainty

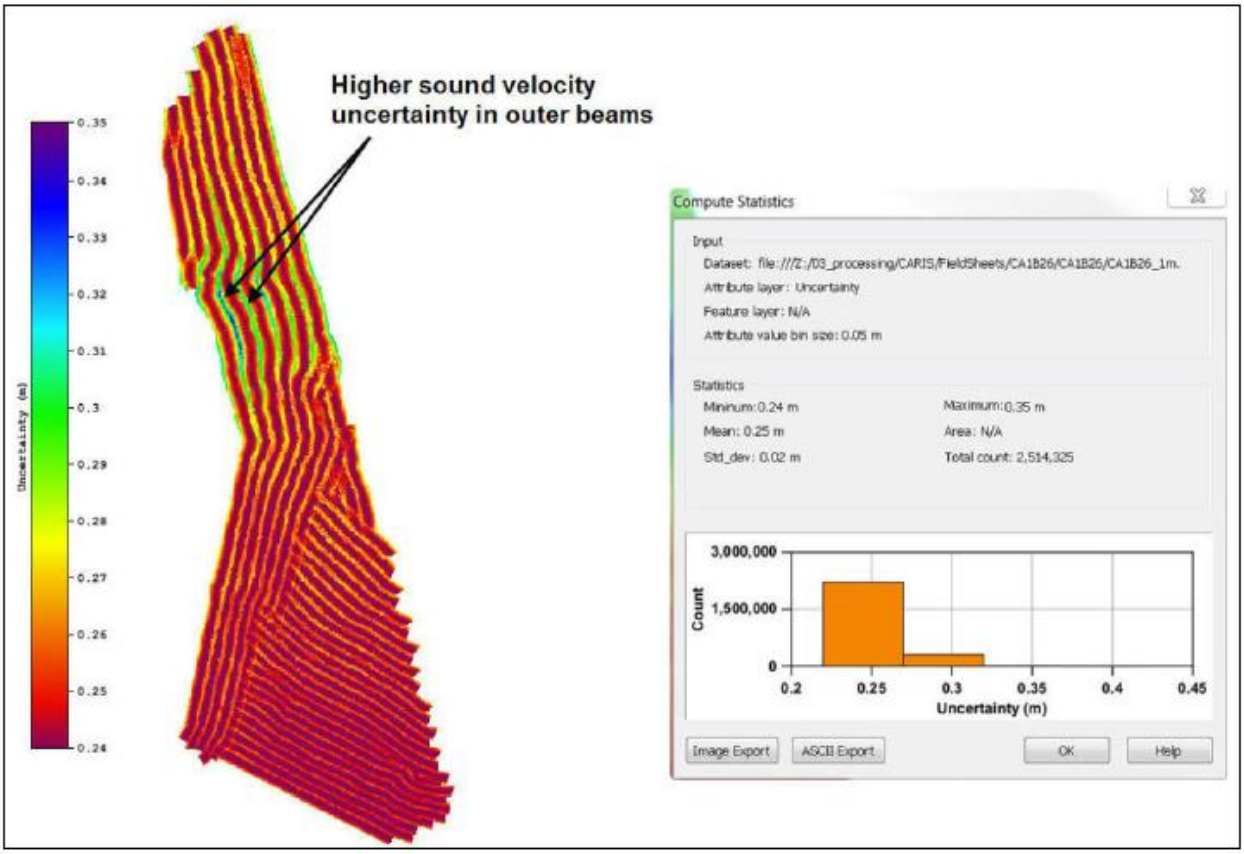

Figure 12: Block CA1B26 Uncertainty

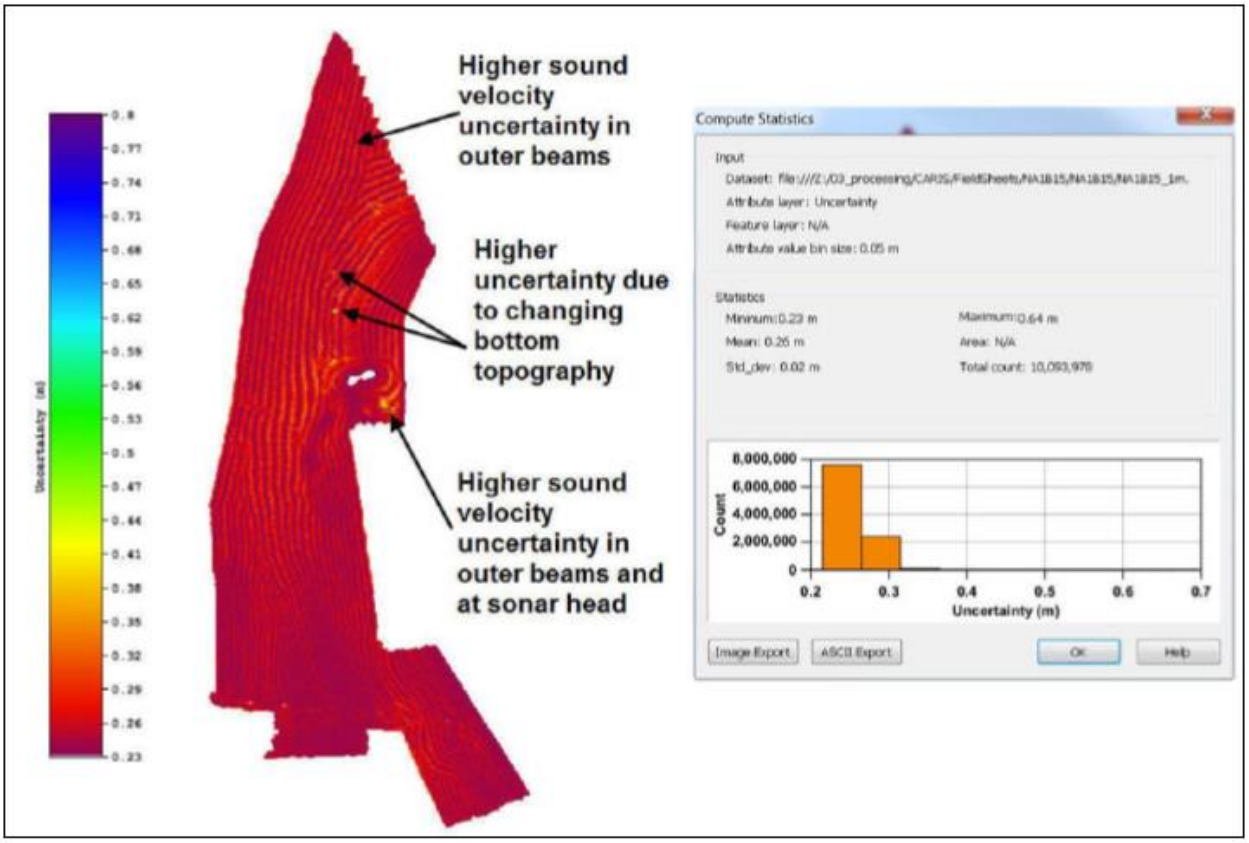

Figure 13: Block NA1B15 Uncertainty

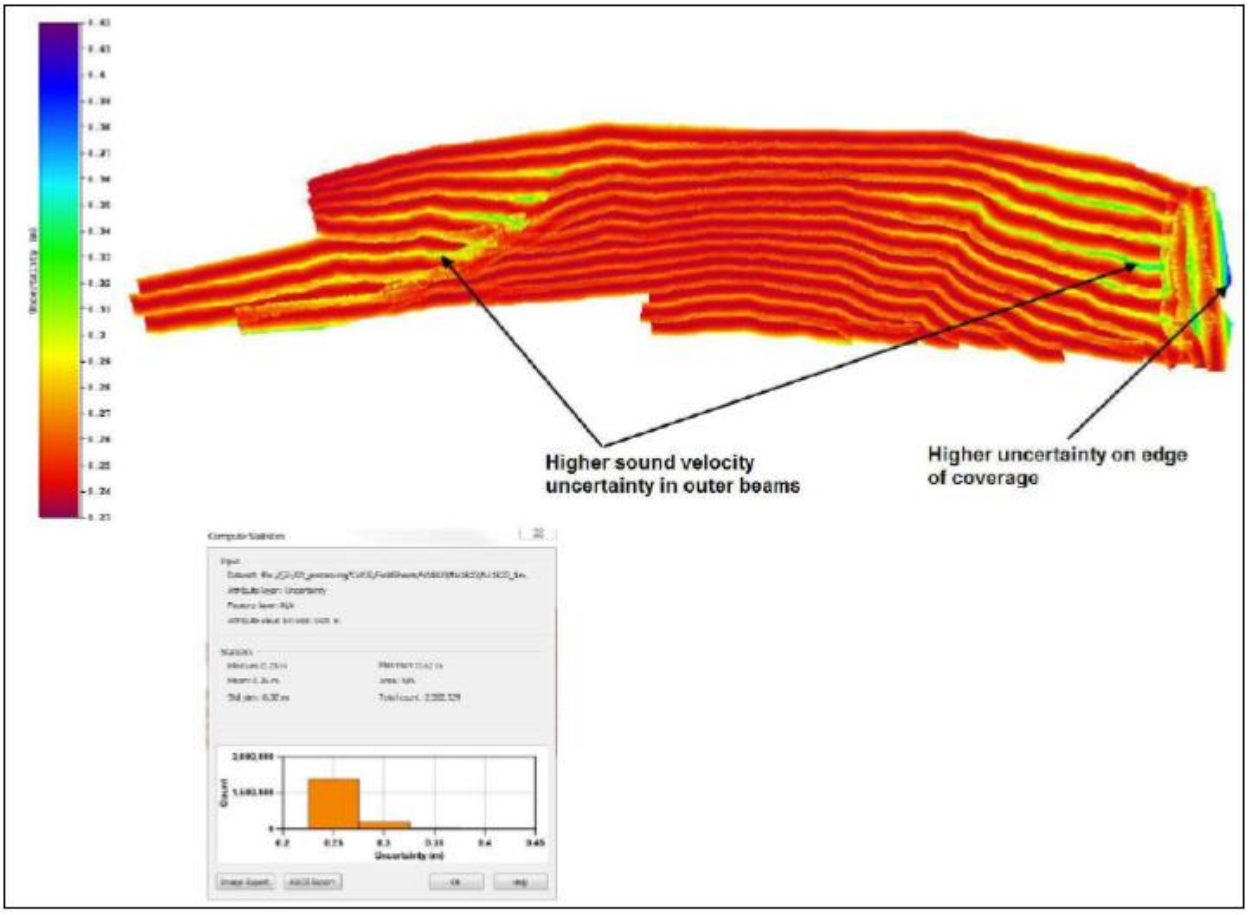

Figure 14: Block NA1B23 Uncertainty

Junctions

No survey junctions were assigned for this project.

Data Density

Though data density was not a requirement for this project, the multibeam data from the Reson 7101 was analyzed to determine that it met the HSSD specifications for multibeam density, mandating that 95% of all nodes to be populated with at least five soundings.
As no specific survey sheets were assigned for this project, the multibeam survey blocks were divided according to the Statement of Work. Seven survey blocks were designated for collection via multibeam. It was decided that these multibeam blocks would be delivered at a 1-meter grid resolution, regardless of water depth. As most of these blocks ranged in depth from 20 meters to 40 meters, the 1-meter CUBE surface was not a suitable test of data density. Instead, the 1-meter surface was used to check for density where water depths ranged from 0 to 20 meters. A 2-meter CUBE surface was used to check for density where water depths ranged from 18 to 40 meters. For all seven of the multibeam blocks, the HSSD specification of 5 soundings per node was

achieved. The images below display the data density surface from CARIS HIPS.

Detection requirements were met by minimizing vessel speed when necessary, using sonar range scales appropriate to the water depth to maximize ping rates, and maximizing swath overlap. These variables were adjusted in real-time by the online acquisition crew based on the WinFrog QC and coverage displays. In-fill lines were run as necessary.

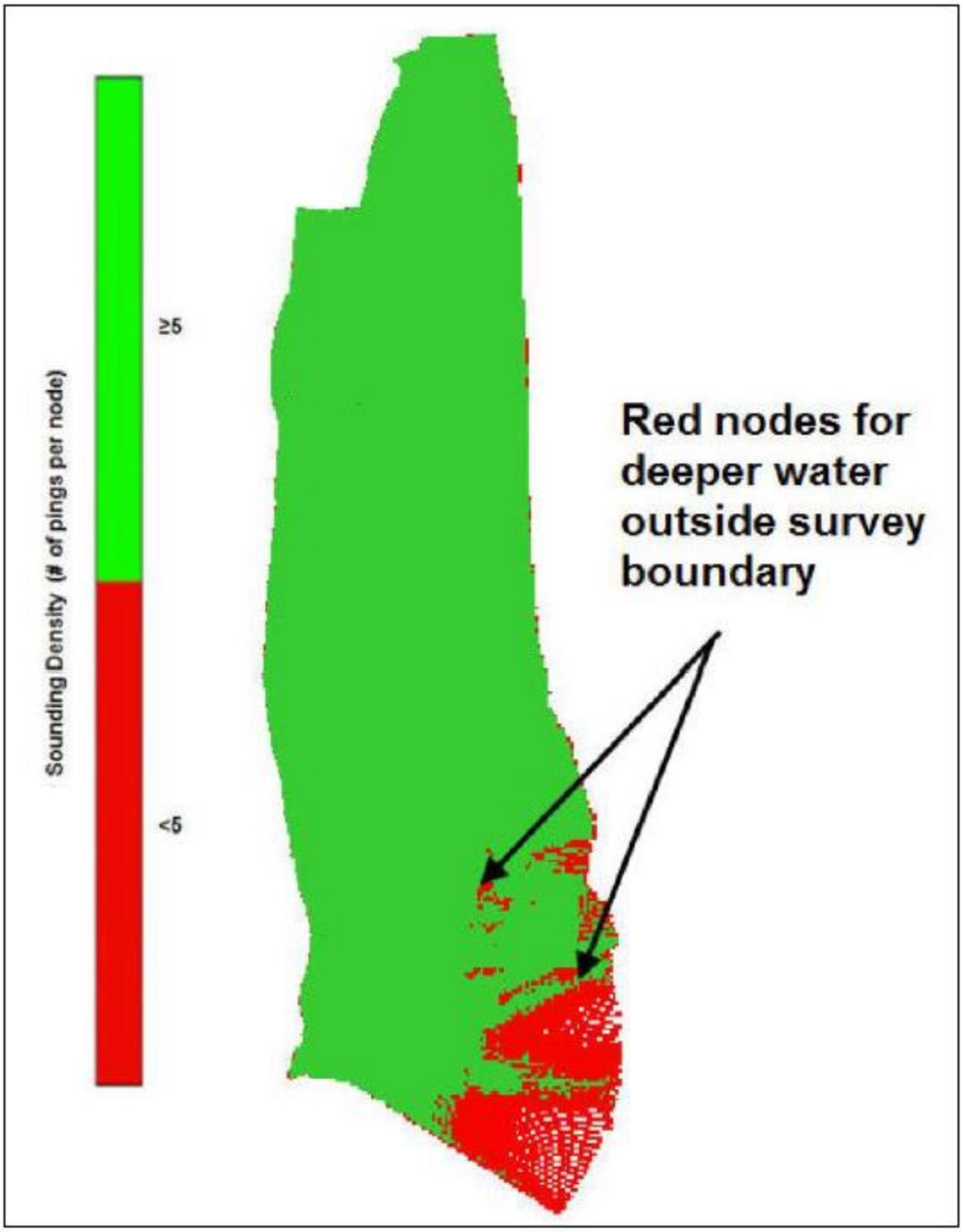

Figure 15: Block CA1B08 Data Density

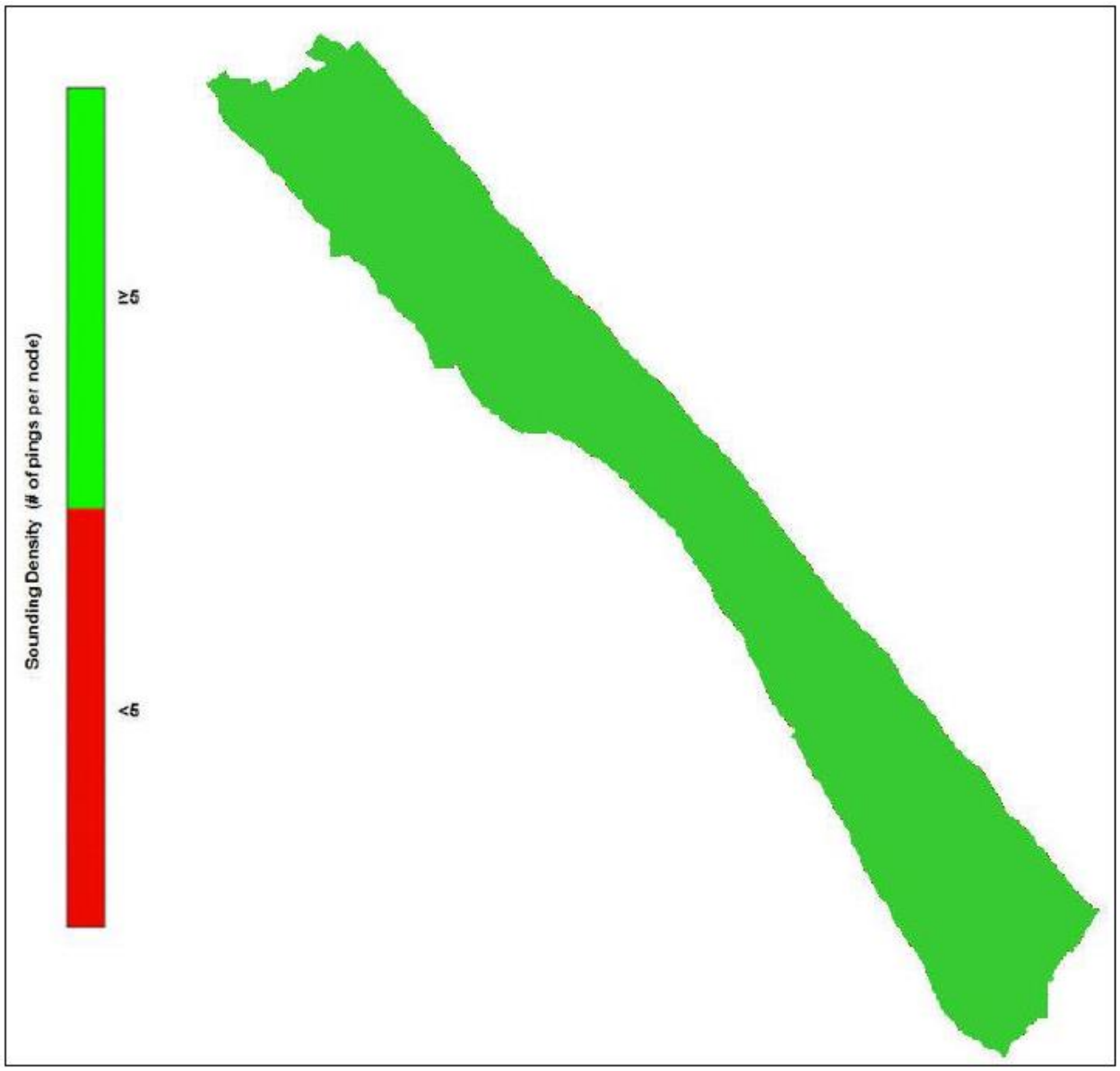

Figure 16: Block CA1B09 Data Density

Figure 17: Block CA1B22 Data Density

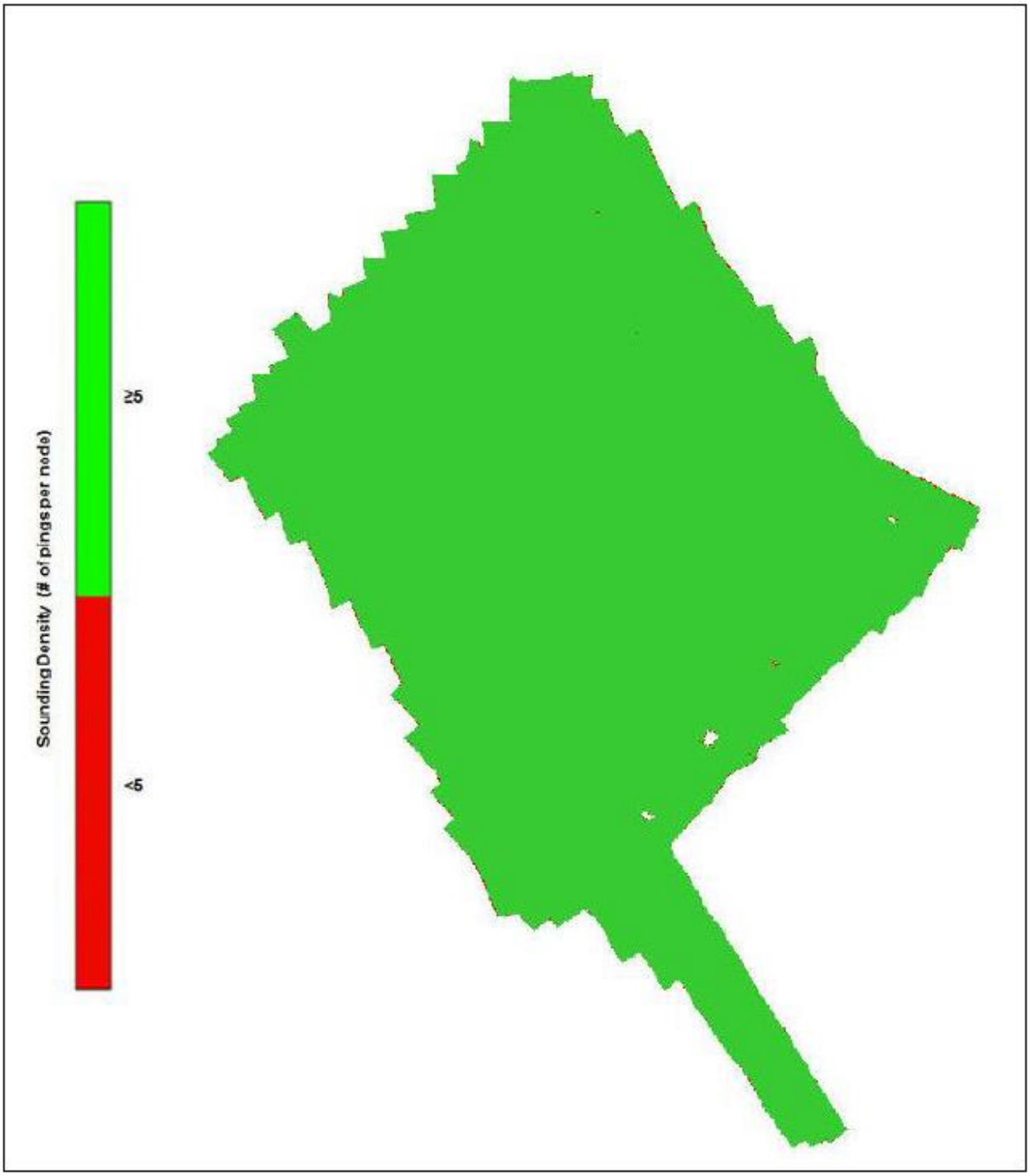

Figure 18: Block CA1B24 Data Density

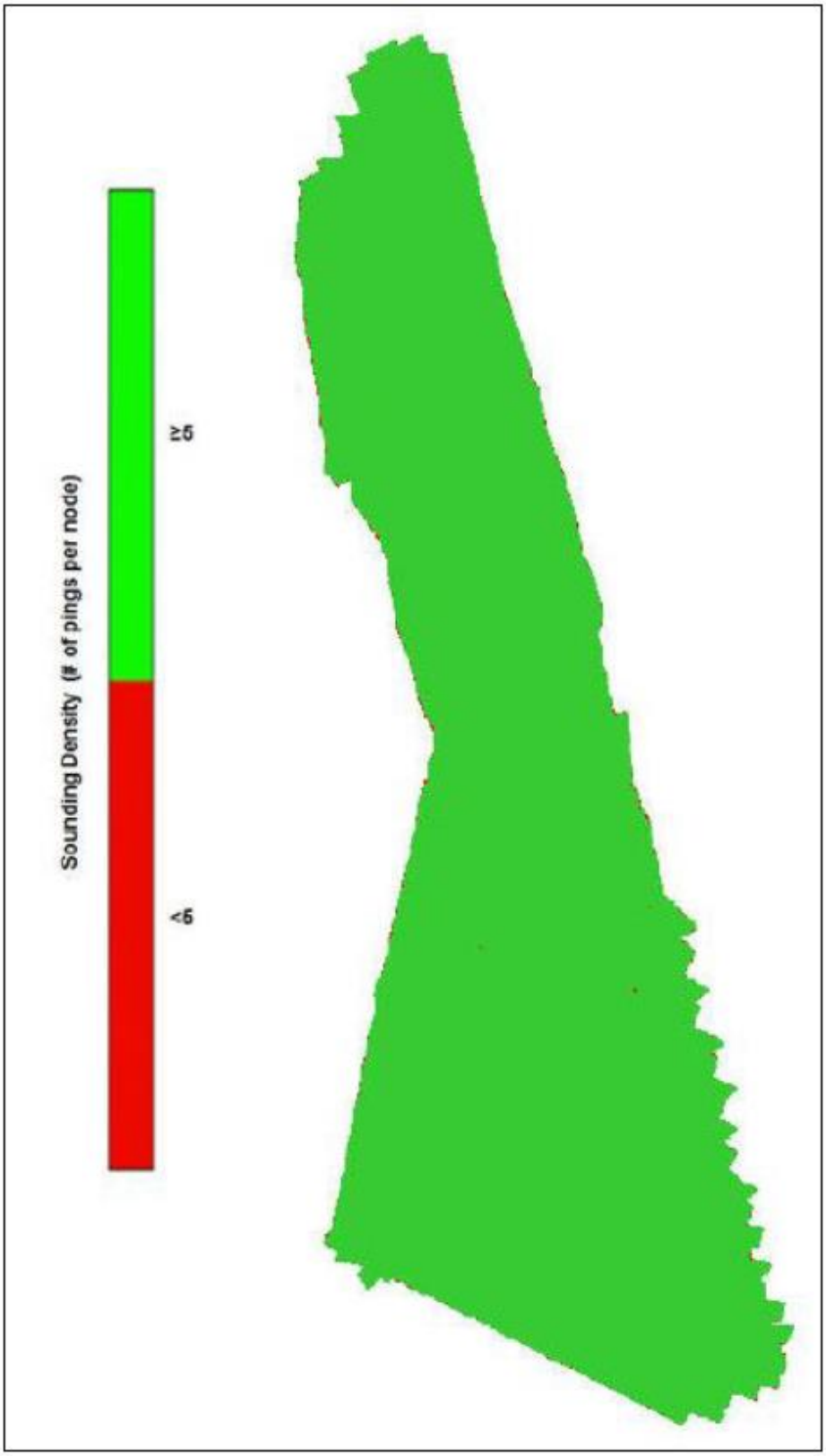

Figure 19: Block CA1B26 Data Density

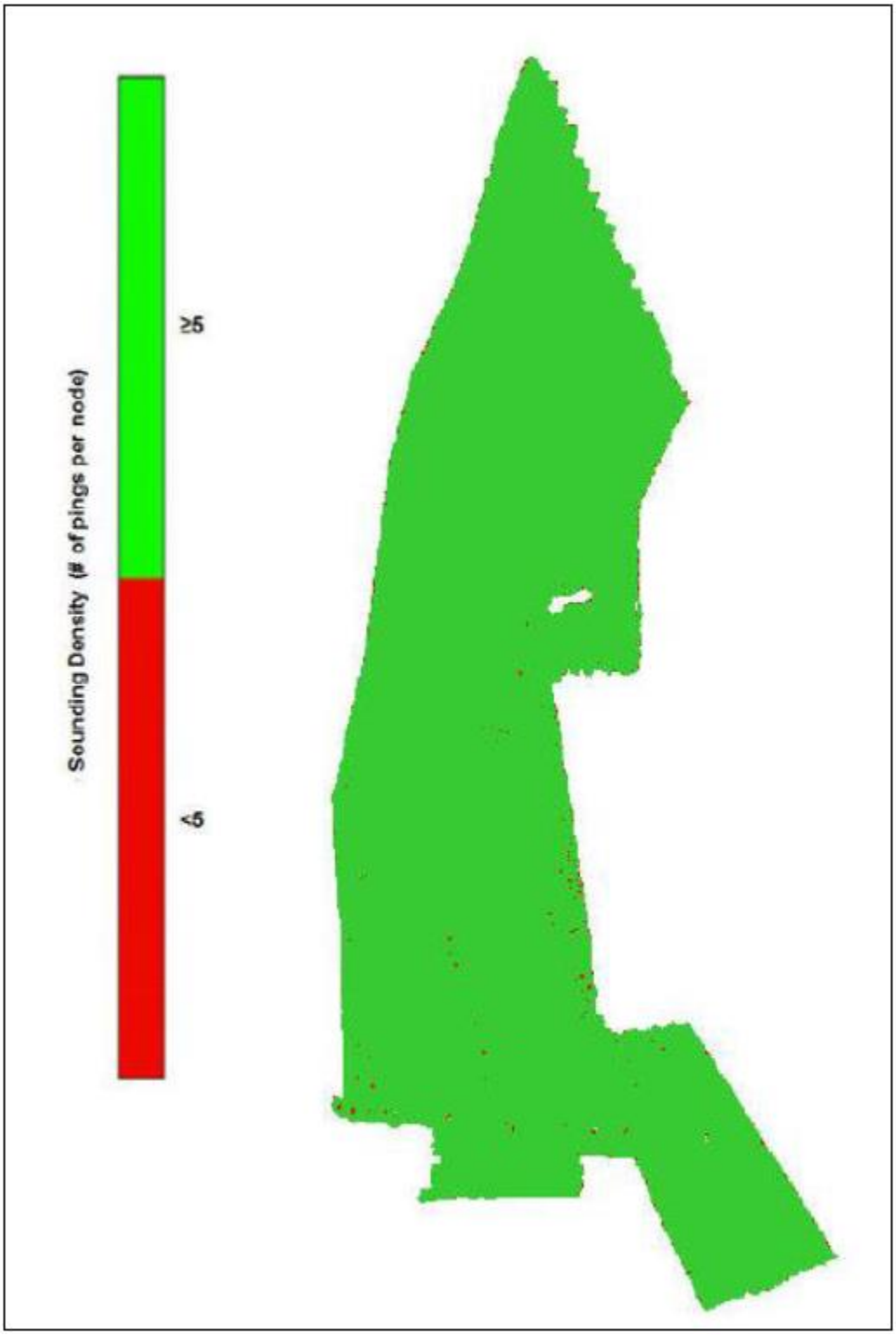

Figure 20: Block NA1B15 Data Density

Figure 21: Block NA1B23 Data Density

Survey Block Overlap for Area A versus Area B Blocks

Two independent organizations acquired data for Area A and Area B survey blocks. Thus, a comparison was performed of the CUBE surfaces in areas of overlap to ensure no systematic errors were present in either Area.

Pair-wise comparisons of 1-meter resolution CUBE surfaces from Areas A1 and A2 against those from Area B were made using the CARIS HIPS Difference Surfaces tool. The overlap between Area A and B surfaces occurred due to oversampling beyond the borders of each block surveyed. The mean difference of the overlapping surface nodes compared across all blocks was 0.019 ± 0.144 m (mean ± SD). The close agreement between surfaces generated completely independently (different vessels, sonars, operators, processors, etc.) strongly validates the approach used in this project. Only 8.4% of nodes compared differed more than ±0.50 m, and the majority of these locations were in relatively deeper water, around pier and bridge pilings, and/or in areas where sediment changes may have occurred between surveys.

B.3 Backscatter

For the multibeam blocks in Area A1, backscatter and beam imagery snippet data from the Reson 7101 multibeam system was logged and stored in the s7k files. All beam imagery snippet data was logged in the s7k file for the project. Multibeam backscatter that was collected by the Locator was processed using Fugro Pelagos Geocoder Version 4.1.0.0 software.

Interferometric side-scan sonar imagery data was collected by both vessels in areas A1 and A2 using the Edgetech 6205 system. Data were processed using CARIS SIPS version 9.0.10.

Interferometric side-scan sonar imagery data was collected in sxr format by both vessels in Area B using the Bathyswath-H system. Interferometric backscatter data were post-processed with Bathyswath Swath Processor to produce sxp files, which were processed in Chesapeake Technology Inc.'s SonarWiz software to conduct Empirical Gain Equalization and produce mosaics. Additionally, the interferometric side scan imagery data were post-processed using CARIS SIPS version 9.1.3 to create additional mosaic products.

Mosaics of the multibeam backscatter and interferometric side scan are provided electronically for this survey, as part of the final set of deliverables. No contacts were identified or analyzed as part of this survey. Likewise, no bottom classification was performed as part of this survey.

B.4 Data Processing

Refer to the Data Acquisition and Processing Report for a detailed description of the processing flow.

Software Updates

There were no software configuration changes after the DAPR was submitted.

Surfaces

No H sheets were assigned to any areas for this project.

All CUBE surfaces for areas A1 and A2 were created at 1-meter resolutions using CARIS HIPS and SIPS.

All CUBE surfaces for area B were created at 1- and 2-meter resolutions using CARIS HIPS and SIPS.

C. Horizontal and Vertical Control

Refer to the Horizontal and Vertical Control Report for a detailed description of the horizontal and vertical control used on this survey. No deviations from the report occurred. A summary of the project's horizontal and vertical control follows.

C.1 Horizontal Control

The horizontal datum for this project is NAD83 (2011). The projection used for this project is UTM 10N. Applanix Smartbase post-processed kinematic (PPK) methods were used for horizontal control. The use of Smartbase PPK solutions is discussed in the Horizontal and Vertical Control Report.

The following Continuously Operating Reference Stations (CORS) were used for horizontal control:

HVCR Site ID	Base Station ID
Tiburon Peninsula, CA	TIBB
Briones Reservoir Lafayette, CA	BRIB
Farrallon Islands, CA AI4511	FARB
Monument Peak BARD AJ1889	MONB
Ohlone Park, CA	OHLN
Mills Creek CN2007	P176
CoDe Tierra CN2008	P177
San Mateo CCCN2007	P178
Miller Knox CN2005	P181
Petalum Air CN2004	P198
Rodgers Crk CN2005	P199
Sonoma Crk CN2005	P200
SanAntonioCN2007	P221
Coyote Hill SCN2004	P222
ChabotParkCN2007	P223
SibleyVolcCN2005	P224
CULLCANYONCN2005	P225
ReidHillVWCN2006	P226
Hunter Hill CN2004	P261
SLAC BARD CN2002	SLAC
St. Vincents	SVIN
UC San Francisco	UCSF
WIN2 BARD CN2008	WIN2
WINT BARD CN1991	WINT
Oakland WAAS 1	ZOA1
Oakland WAAS 2	ZOA2

Table 6: CORS Base Stations Used in Smartbase PPK

C.2 Vertical Control

The vertical datum for this project is NAVD88.

D. Results and Recommendations

D.1 Chart Comparison

This project was not a standard NOAA charting project. The project Statement of Work specified that the vertical datum shall be NAVD88; however, existing NOAA nautical charts use the Mean Lower Low Water (MLLW) datum. Thus, no comparisons of chart bathymetry were performed.

D.2 Additional Results

Aids to Navigation

No damaged or malfunctioning Aids to Navigation were noted for the survey.

Shoreline Features

Shoreline investigation was not assigned in the Statement of Work.

Bottom Samples

No bottom samples were assigned for this survey.

Construction and Dredging

Present and/or planned construction or dredging exists within the survey limits, but was not investigated. The survey team was made aware of potential dredging in the northern section of the survey area, in San Pablo Bay. However, the extents of the proposed dredging work were not known to the survey team.

E. Approval Sheet

As Chief of Party, Field operations for this hydrographic survey were conducted under my direct supervision, with frequent personal checks of progress and adequacy. I have reviewed the attached survey data and reports.

All field sheets, this Descriptive Report, and all accompanying records and data are approved. All records are forwarded for final review and processing.

The survey data meets or exceeds requirements as set forth in the project's Statement of Work. These multibeam data are adequate to supersede charted data in their common areas. This survey is complete and no additional work is required with the exception of any deficiencies noted in the Descriptive Report.

Approved and forwarded,

Chris Esposito
Project Manager
Fugro Pelagos, Inc.
June 16, 2016

6/16/2016

X 

Chris Esposito
Project Manager
Signed by: Esposito, Christopher

APPENDIX I – TIDE MODEL

The GPS tide model (i.e., separation model) used for processing the bathymetry is provided as separate documents in folder *Appendix I (Tide Model)*.