H13013

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

DESCRIPTIVE REPORT

Type of Survey:	Basic Hydrographic Survey
Registry Number:	H13013

LOCALITY

State(s):	Maine
General Locality:	Penobscot Bay
Sub-locality:	Vicinity of Swans Island

2017

CHIEF OF PARTY
Dean Moyles

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Date:

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

REGISTRY NUMBER:

HYDROGRAPHIC TITLE SHEET

H13013

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):	**Maine**
General Locality:	**Penobscot Bay**
Sub-Locality:	**Vicinity of Swans Island**
Scale:	**10000**
Dates of Survey:	**06/27/2017 to 10/07/2017**
Instructions Dated:	**05/23/2017**
Project Number:	**OPR-A366-KR-17**
Field Unit:	**Fugro Pelagos, Inc.**
Chief of Party:	**Dean Moyles**
Soundings by:	**Multibeam Echo Sounder LiDAR SHOALS-1000T**
Imagery by:	**Multibeam Echo Sounder Backscatter Prosilica GX3300**
Verification by:	**Atlantic Hydrographic Branch**
Soundings Acquired in:	**meters at Mean Lower Low Water**

Remarks:

Per the Project Instructions, Project # OPR-A366-KR-17 is a navigable area survey, and not a basic hydrographic survey as noted above. 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 WGS84 UTM 19N, MLLW/MHW. All references to other horizontal or vertical datums in this report are applicable to the processed hydrographic data provided by the field unit.

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Descriptive Report to Accompany Survey H13013

Project: OPR-A366-KR-17

Locality: Penobscot Bay

Sublocality: Vicinity of Swans Island

Scale: 1:10000

June 2017 - October 2017

Fugro Pelagos, Inc.

Chief of Party: Dean Moyles

A. Area Surveyed

H13013 (Sheet ID 3) is located in Penobscot Bay, ME and encompasses approximately 25 SNM of Swans Island and vicinity.

A.1 Survey Limits

Data were acquired within the following survey limits:

Northwest Limit	Southeast Limit
44° 12' 17.28" N 68° 34' 49.87" W	44° 6' 0.14" N 68° 25' 8.11" W

Table 1: Survey Limits

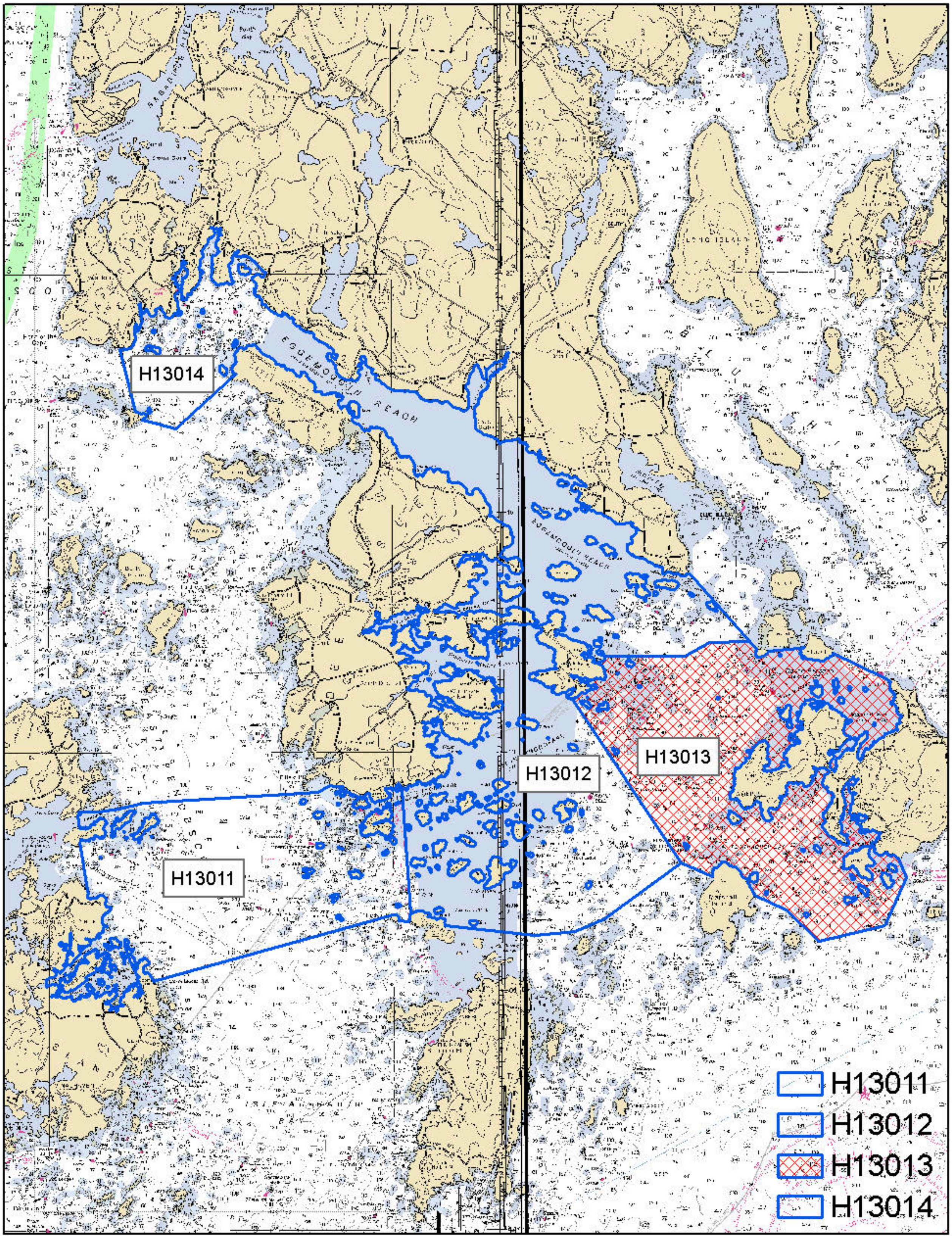

Figure 1: H13013 Sheet 3 Limits

Survey limits were acquired in accordance with the requirements in the Project Instructions and the HSSD.

A.2 Survey Purpose

The purpose of this project is to provide contemporary surveys to update National Ocean Service (NOS) nautical charting products. This project area is located in the highly trafficked areas of Penobscot and Jericho Bays and will cover approximately 89 SNM of Navigationally Significant area as identified in the 2012 NOAA Hydrographic Survey Priorities. Priority Area 3 encompasses approximately 25 SNM in the Swans Island area.

A.3 Survey Quality

The entire survey is adequate to supersede previous data.

Additional discussions regarding survey quality or data quality can be found in the Quality Control and Additional Results sections of this XML DR.

A.4 Survey Coverage

The following table lists the coverage requirements for this survey as assigned in the project instructions:

Water Depth	Coverage Required
Inshore limit to 8 meters water depth	5 by 5 meter LiDAR augmented by MBES
Greater than 8 meters water depth	Complete coverage Multibeam with backscatter

Table 2: Survey Coverage

Survey coverage was in accordance with the requirements listed above and in the HSSD.

Figure 2: H13013 Survey Coverage

A.6 Survey Statistics

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

	HULL ID	*1217549*	*1231991*	*N94AR*	*Total*
LNM	**SBES Mainscheme**	0	0	0	0
	MBES Mainscheme	538.73	446.41	0	985.14
	Lidar Mainscheme	0	0	1737.16	1737.16
	SSS Mainscheme	0	0	0	0
	SBES/SSS Mainscheme	0	0	0	0
	MBES/SSS Mainscheme	0	0	0	0
	SBES/MBES Crosslines	17.98	27.29	0	45.27
	Lidar Crosslines	0	0	40.35	40.35
Number of Bottom Samples					14
Number Maritime Boundary Points Investigated					0
Number of DPs					0
Number of Items Investigated by Dive Ops					0
Total SNM					24.99

Table 3: Hydrographic Survey Statistics

The following table lists the specific dates of data acquisition for this survey:

Survey Dates	Day of the Year
06/26/2017	177
06/27/2017	178

Survey Dates	Day of the Year
06/28/2017	179
06/29/2017	180
06/30/2017	181
08/21/2017	233
08/22/2017	234
08/23/2017	235
08/24/2017	236
08/25/2017	237
08/26/2017	238
08/27/2017	239
08/28/2017	240
08/29/2017	241
08/30/2017	242
08/31/2017	243
09/01/2017	244
09/02/2017	245
09/03/2017	246
09/04/2017	247
09/05/2017	248
09/06/2017	249
09/08/2017	251
09/09/2017	252
09/10/2017	253
09/11/2017	254
09/12/2017	255
09/13/2017	256
09/14/2017	257
09/16/2017	259
09/17/2017	260
09/19/2017	262
09/24/2017	267
09/25/2017	268

Survey Dates	Day of the Year
09/27/2017	270
09/28/2017	271
09/29/2017	272
10/07/2017	280

Table 4: Dates of Hydrography

The area was not divided into separate surveys for LiDAR acquisition, but five smaller blocks for data management purposes. For this reason, the LiDAR survey statistics are for the entire project and not just for H13013.

The LiDAR program was proposed and planned for 100% of the area to be flown with a five by five (or better) spot spacing. A reconnaissance coverage survey would be used from the inshore limit to the 8-meter water depth.

The percentage of LiDAR mainscheme lines to LiDAR crosslines are not within the HSSD 2017 specification, this was due to the LiDAR portion being a reconnaissance-type survey.

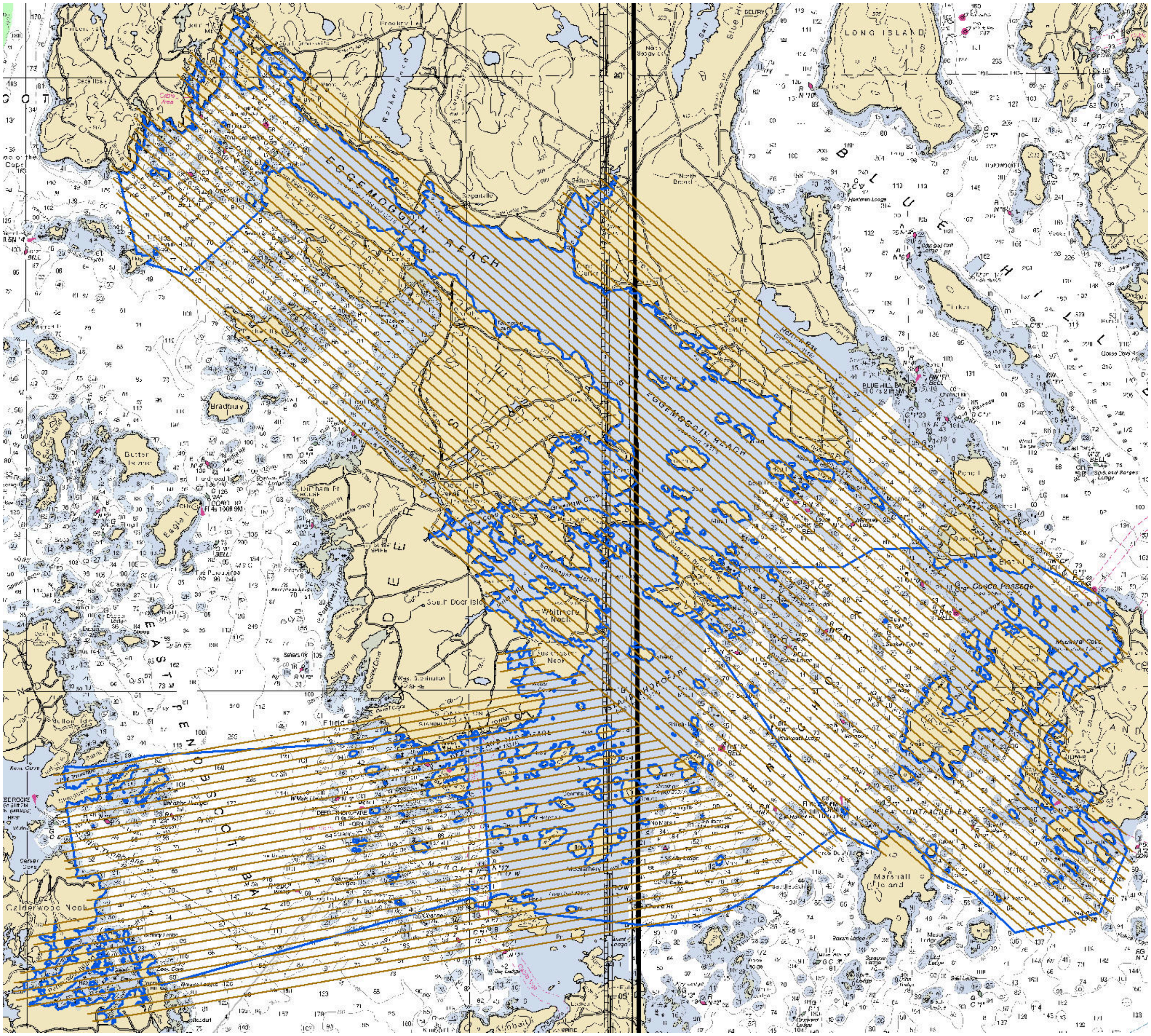

Figure 3: Proposed LiDAR Line Plan

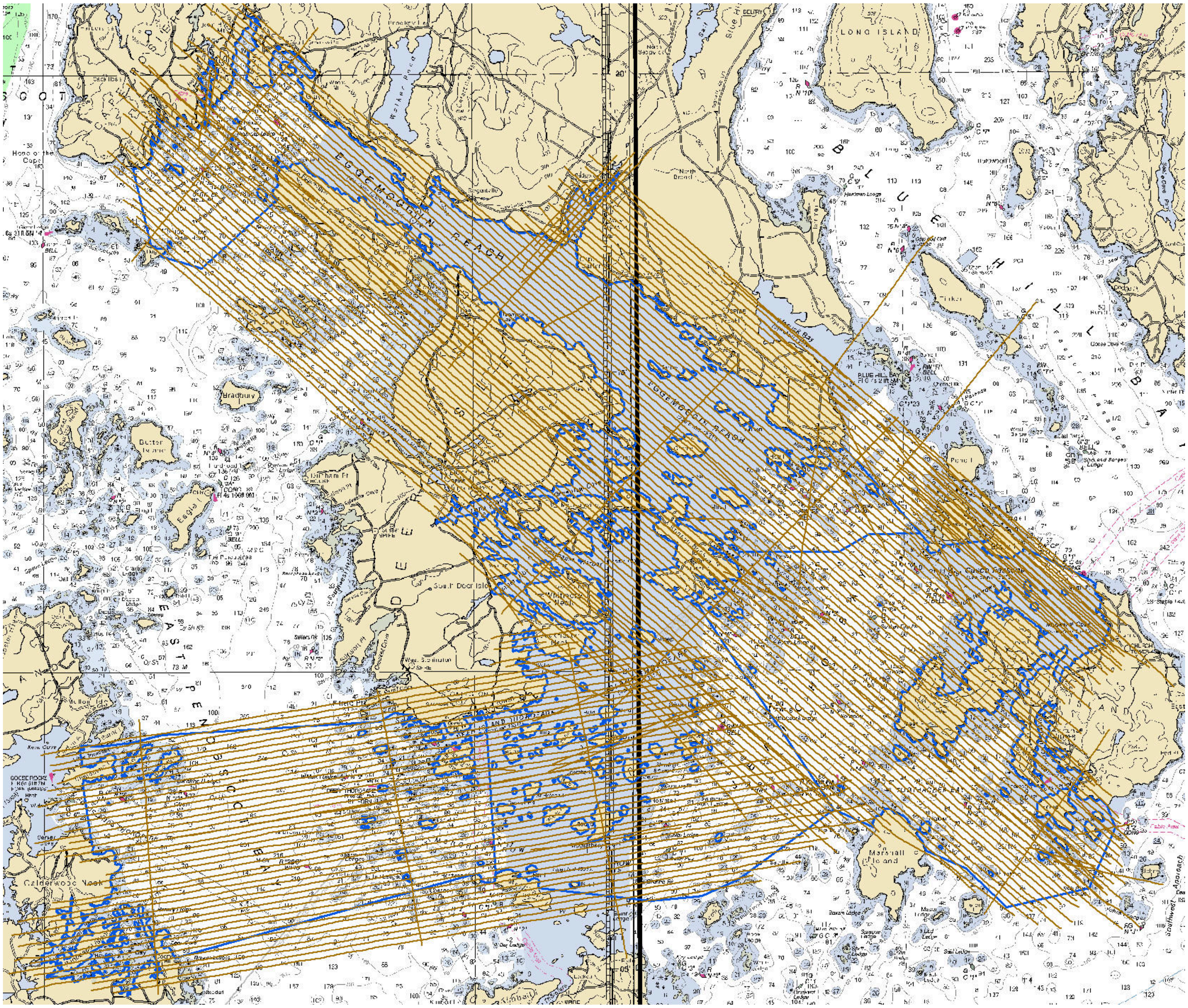

Figure 4: Actual LiDAR Line Plan

Review of the submitted data show the first date of field work submitted as part of the required grid deliverables to be associated with the SHOALS topo-bathy lidar acquired on 6/27/2017 (DN 178). Not 6/26/2017 (DN 177) as noted in Table 3: Hydrographic Survey Statistics.

B. Data Acquisition and Processing

B.1 Equipment and Vessels

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.1.1 Vessels

The following vessels were used for data acquisition during this survey:

Hull ID	***1217549***	***1231991***	***N94AR***
LOA	37 feet	44 feet	15.8 meters
Draft	2.5 feet	2 feet	0 meters

Table 5: Vessels Used

Figure 5: RV Theory

Figure 6: RV Westerly

Figure 7: N94AR Twin Otter

Fugro Pelagos, Inc. (Fugro) mobilized two catamaran-style jet drive survey boats (Theory and Westerly), which were equipped with an over-the-stern pole that housed an underwater IMU and dual-head Reson 7125 multibeam sonars (dual meaning two independent systems). The Reson systems and IMU were installed on a special mount, where each Reson 7125 was rotated approximately 15 degrees and the IMU was centered above the 7125s. These vessels were used to survey in water depths greater than 8 meters, and to augment the LiDAR collection effort in the 3-meter to 8-meter water depth range. In addition to the two vessels, a small aircraft was fitted with a SHOALS-1000T Airborne LiDAR Bathymetry (ALB) system to map data inshore of the 8-meter contour. An Allied Prosilica GX3300 down-look camera and VQ-820-G (RIEGL) LiDAR sensor were also installed. These extra systems were not part of the project instructions or a requirement, but were installed to aid with feature verification and detection.

B.1.2 Equipment

The following major systems were used for data acquisition during this survey:

Manufacturer	Model	Type
Applanix	POS MV 320 v4	Positioning and Attitude System
Applanix	POS MV 320 v5	Positioning and Attitude System
Applanix	POS A/V Version 6	Positioning and Attitude System
Applied Micro-Systems	SV&P	Sound Speed System
Teledyne RESON	SeaBat 7125 SV2	MBES
Teledyne RESON	SVP 70	Sound Speed System
Optech	SHOALS-1000T	Lidar System
Allied	Prosilica GX3300	Down-Look Camera
RIEGL	VQ-820-G	Topo-Lidar System

Table 6: Major Systems Used

Both the R/V Theory and the R/V Westerly were equipped with dual head Reson 7125 sonars, which were operated in the full rate dual head (FRDH) mode in the Reson topside. The Allied Prosilica GX3300 down-look camera and VQ-820-G (RIEGL) LiDAR sensor were not part of the project instructions or a requirement, but were installed to aid with feature verification and detection. By-products of these extra systems include the orthomosaic, SHOALS-1000T reflectance, and RIEGL topo data and will be included as part of the final data deliverable. Kathryn Pridgen approved these to be included in the sonar folder, under a seperate folder named RIEGL.

B.2 Quality Control

B.2.1 Crosslines

Multibeam/single beam echo sounder/side scan sonar crosslines acquired for this survey totaled 4.60% of mainscheme acquisition.

Lidar crosslines acquired for this survey totaled 2.32% of mainscheme acquisition.

Multibeam crosslines were planned and well distributed throughout the survey to ensure adequate quality control. Total crossline length surveyed was 45.27 nautical miles or 4.60 percent of the total mainscheme line length. Depending on depth, each crossline was compared to the entire mainscheme line plan through a 1m, 2m, or 4m CUBE surface using the CARIS HIPS QC report routine.

All of the QC Reports fall well within the required accuracy specifications.

LiDAR crosslines were planned and well distributed throughout the survey to ensure adequate quality control. A total of 10 specific crosslines were planned and flown perpendicular to the mainscheme survey lines.

A difference analysis between the crosslines and the main survey lines was performed using the Crosscheck program within Fledermaus. A surface grid was created from the production lines at a bin size of approximately 3 meters. The crossline points were then compared to the surface, and point-to-surface statistics generated. The crossline comparison documents illustrate that elevated standard deviation of the differences occurs over rocky and high gradient seabed. In relatively featureless areas of seabed, the differences present a much lower variability.

Quality Control Results are located in Separate II Digital Data.

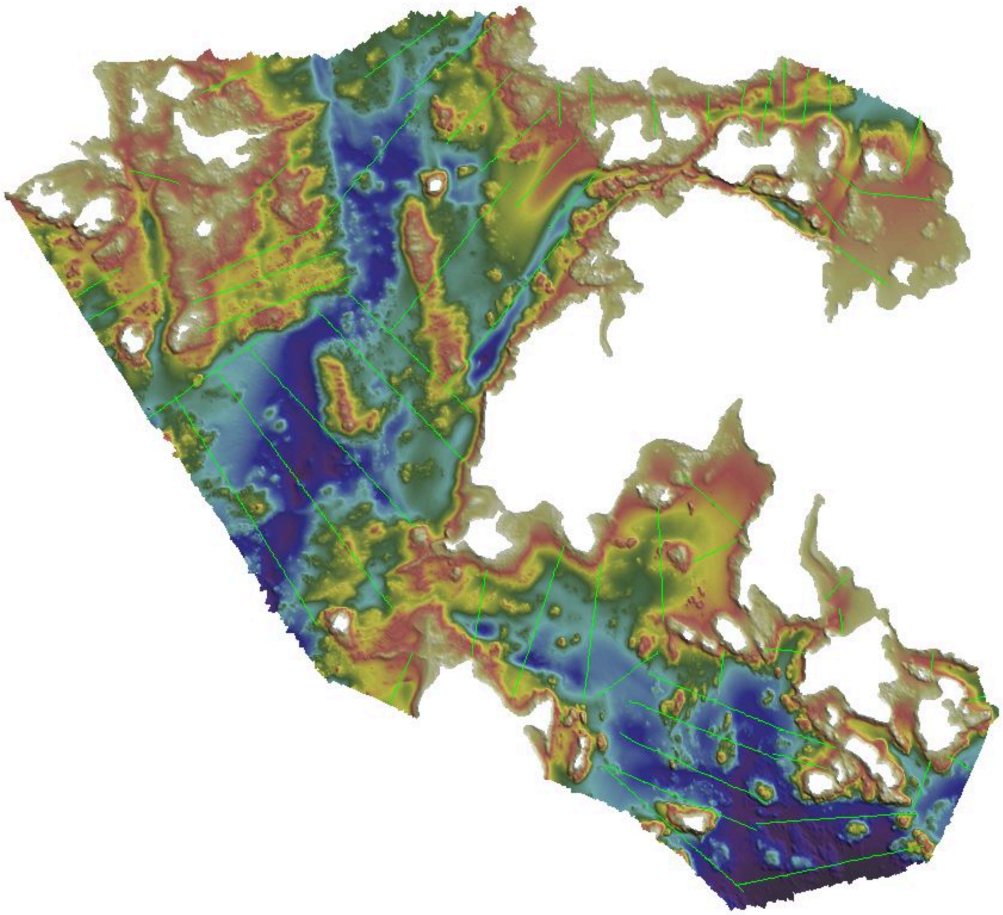

Figure 8: H13013 MB Crossline Overview

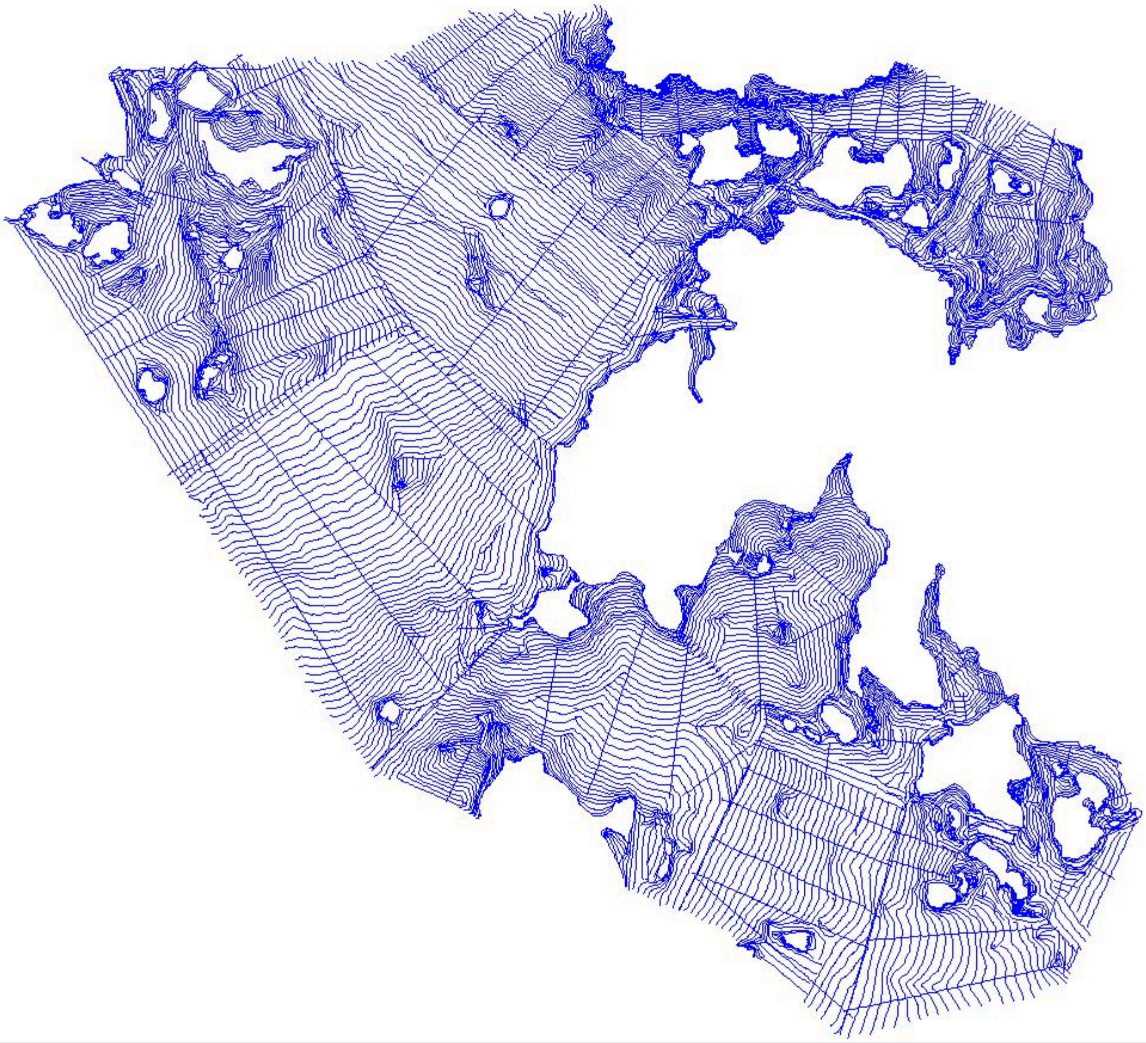

Figure 9: H13013 MB Mainscheme and Crosslines

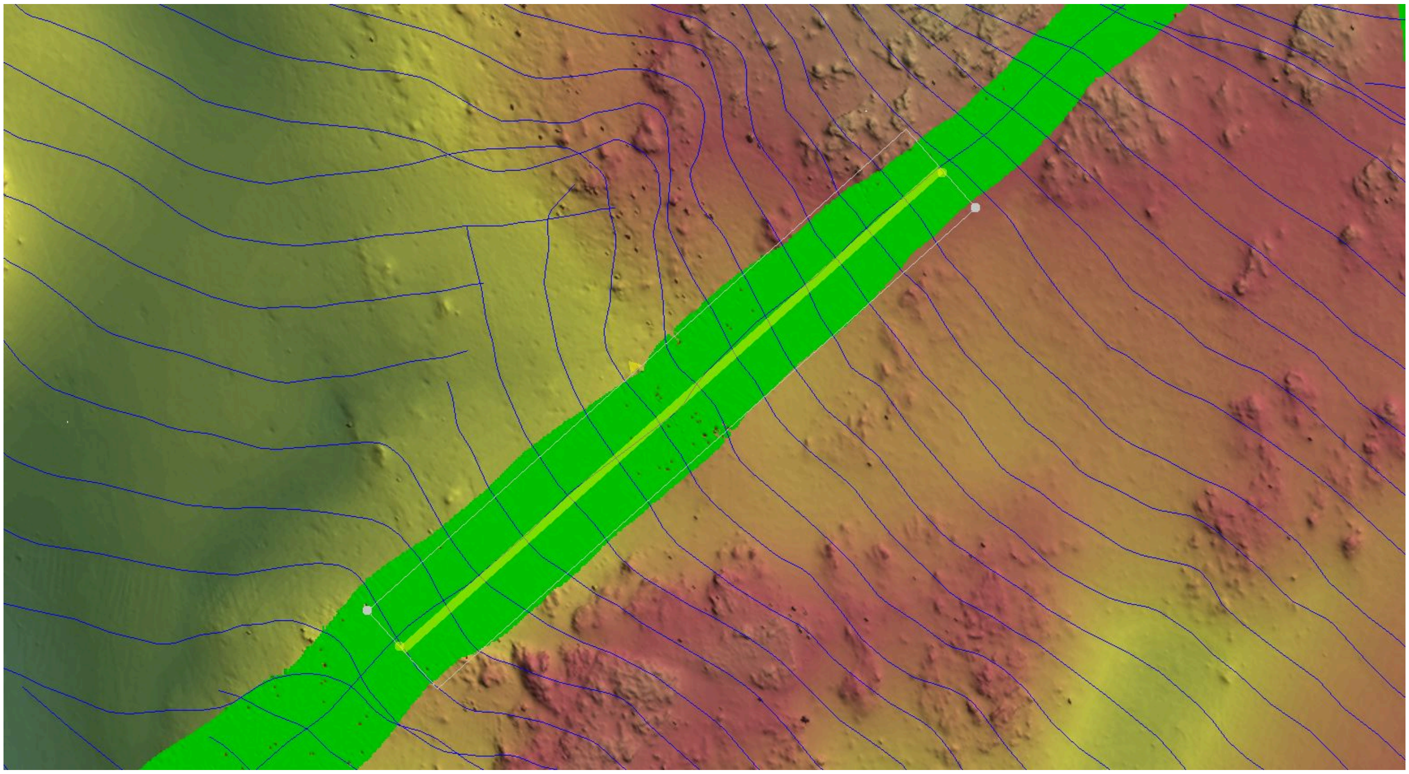

Figure 10: 2P3B10-TIE05 Subset Overview

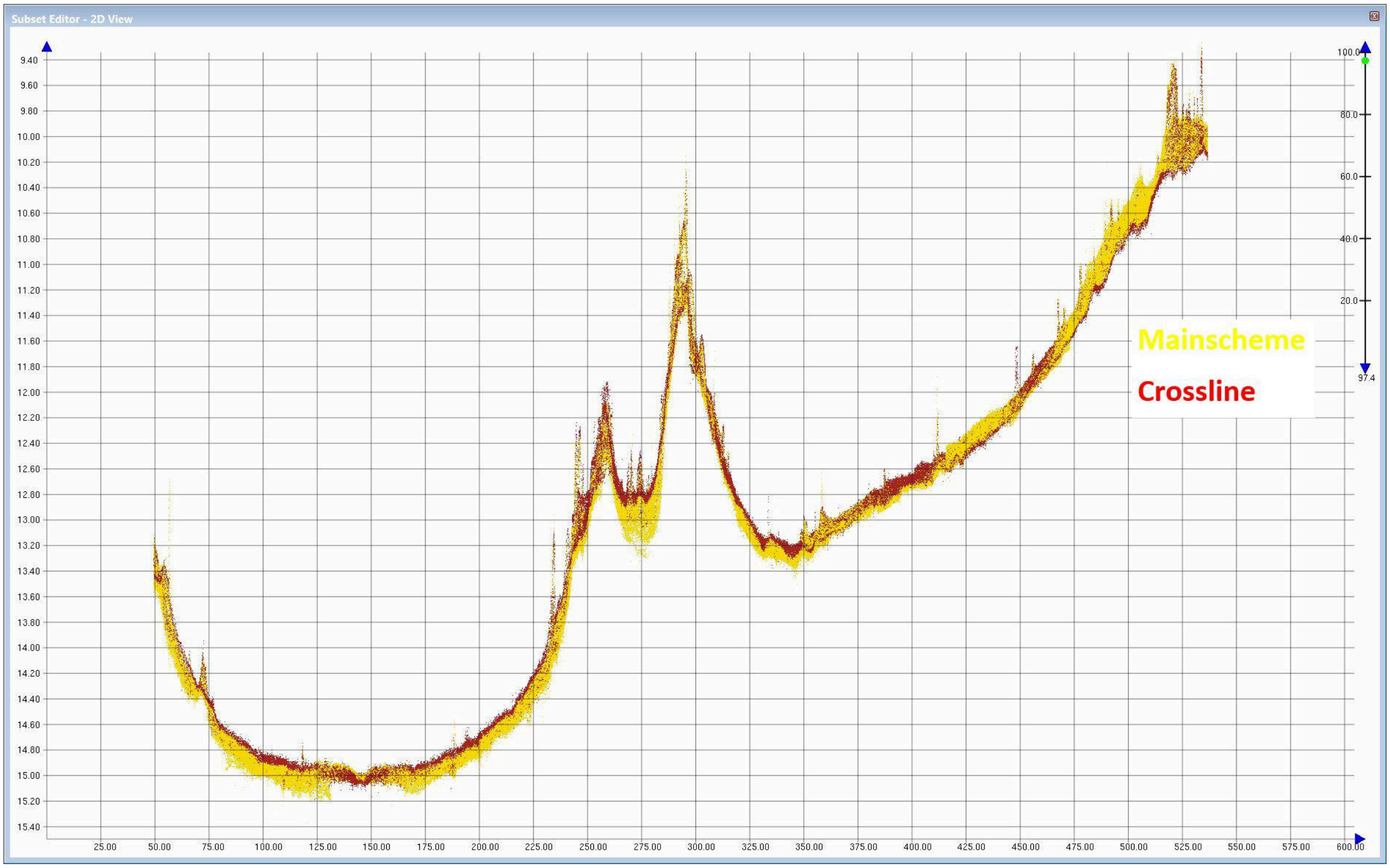

Figure 11: 2P3B10-TIE05 Subset View

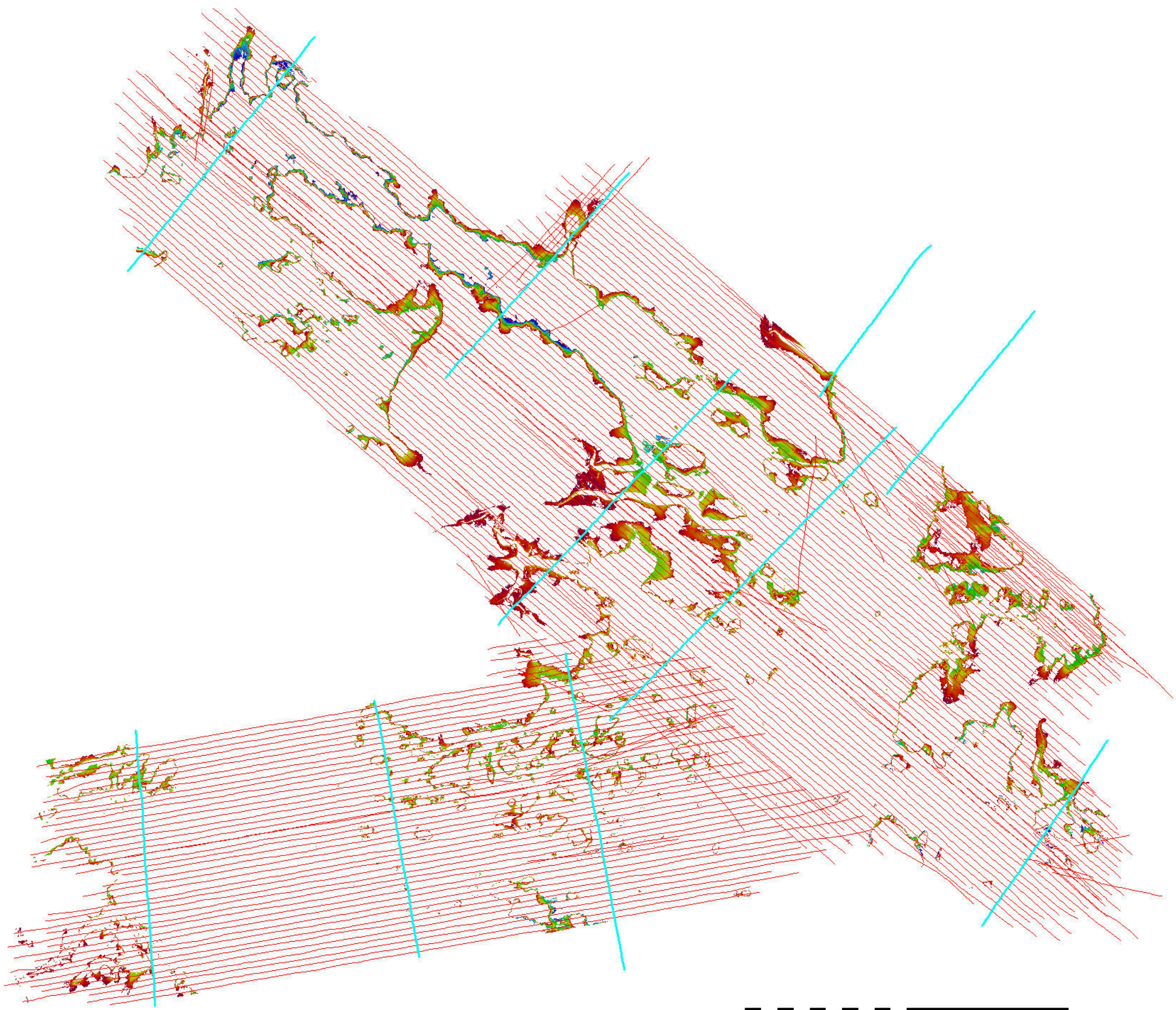

Figure 12: LiDAR Crossline Overview

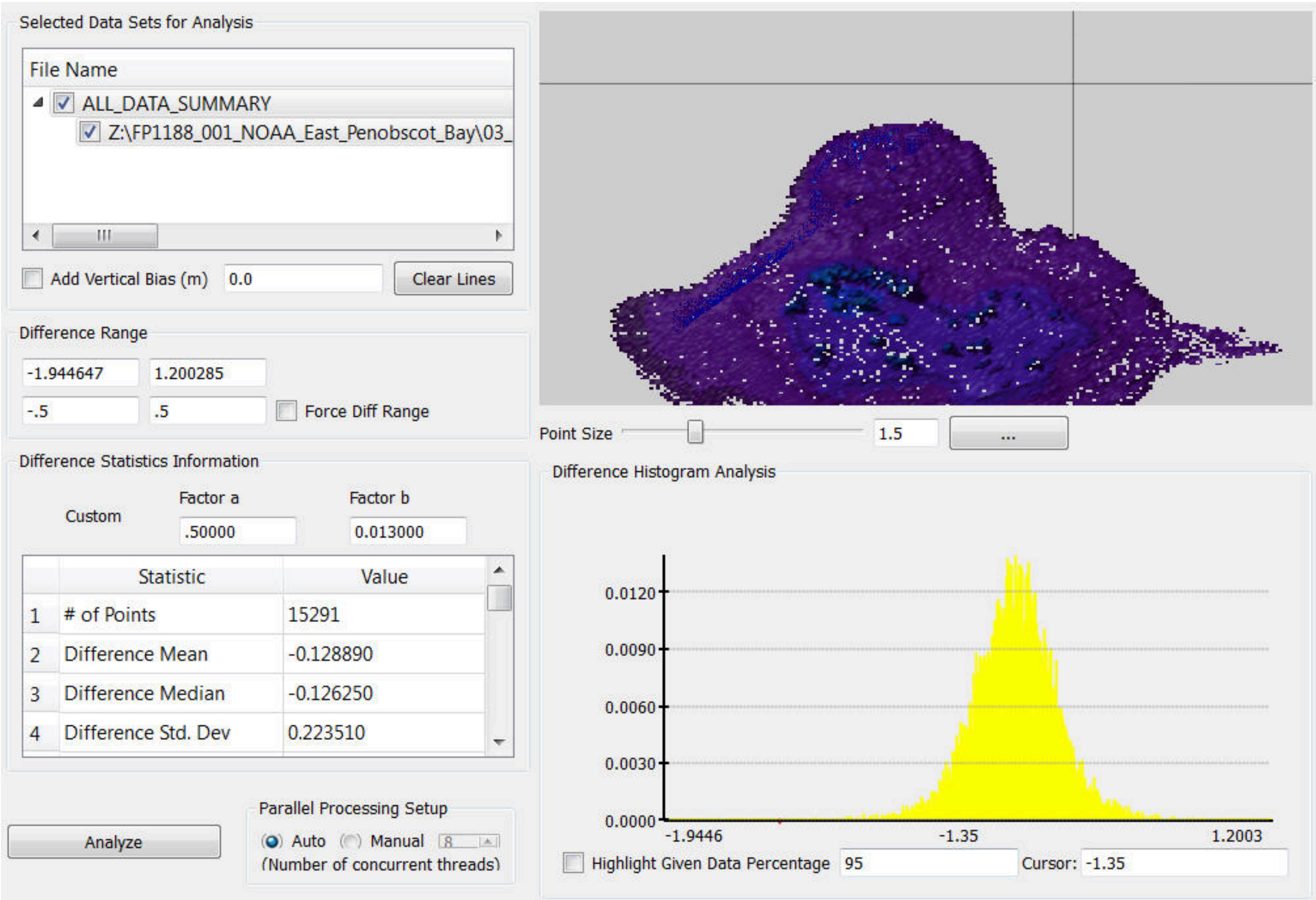

Figure 13: Flight Line 170628_1509_A_02041 QC

	Statistic	Value
1	# of Points	15291
2	Difference Mean	-0.128890
3	Difference Median	-0.126250
4	Difference Std. Dev	0.223510

Figure 14: Flight Line 170628_1509_A_020 QC

B.2.2 Uncertainty

The following survey specific parameters were used for this survey:

Real time uncertainty values were calculated by TCARI grid

Hull ID	Measured - CTD	Measured - MVP	Surface
1217549	2.56 meters/second	0 meters/second	0.25 meters/second
1231991	3.20 meters/second	0 meters/second	0.25 meters/second

Table 7: Survey Specific Sound Speed TPU Values.

The majority of the data fell within IHO Order 1a accuracy specifications. Nodes that exceeded the allowable specifications were located in areas where the outer beams of the coverage boundaries were the single contributor to the surface, with a small portion of the nodes exceeding specifications attributable to rapid topographical changes such as rock outcrops, etc. TPU was derived in CARIS from a combination of real-time and fixed values for equipment, vessel characteristics, sound speed, and tide and tide zoning. The percentage of nodes within IHO Order 1a, were computed by CARIS using the Surface QC Report utility and are as follows:

Surface	Depth Range (m)	% of nodes within IHO Order1a
H13013_MB_1m_FINAL_MLLW	0-20	100%
H13013_MB_2m_FINAL_MLLW	18-40	100%
H13013_MB_4m_FINAL_MLLW	36-80	100%
H13013_MB_8m_FINAL_MLLW	72-160	100%
H13013_LI_5m_FINAL_MLLW	-3.29-10.56	100%

The uncertainty is generally lowest near the sonar nadir beams (in the sectors where the dual heads overlap) and increases toward the outside of each swath. This is expected and primarily a result of the sonar's device model used within CARIS HIPS for TPU calculations. In general, TPU varies proportionally to water depth. Outer beams also have higher uncertainty values as a function of the bottom-detection algorithms within the sonar.

In addition to using the surface QC report in CARIS to derive the TPU for H13013, HydroOffice QCTools were used to compute the total propagated vertical uncertainty (TVU). Both methods yielded similar results. Regarding LiDAR, in order to accurately determine TVU for all depth data collected as part of the project, a 'TPU' line was designed and flown on seven separate occasions. One area of low gradient seabed was identified across the TPU line. Once all of the depth data had been processed, cleaned, and reduced to datum by a VDatum model, Fugro's LiDAR Total Error (LTE) tool (an extension in ArcGIS) was used to determine SHOALS uncertainty. LTE is a tool implemented in ArcGIS that uses spatial analysis of LiDAR point elevations to determine statistical variance of a significant data sample. The LTE tool application shows the common parameters for data sampling, as well as the water depth ranges being analyzed (or elevation on the ellipsoid). The inputs were the Hydrographic Output Files (HOF) files generated in the SHOALS-GCS processing software. The results of the analysis were tabulated and plotted to derive a depth-dependent model of Total Bottom Uncertainty (TBU). Refer to the Appendix II for the full report.

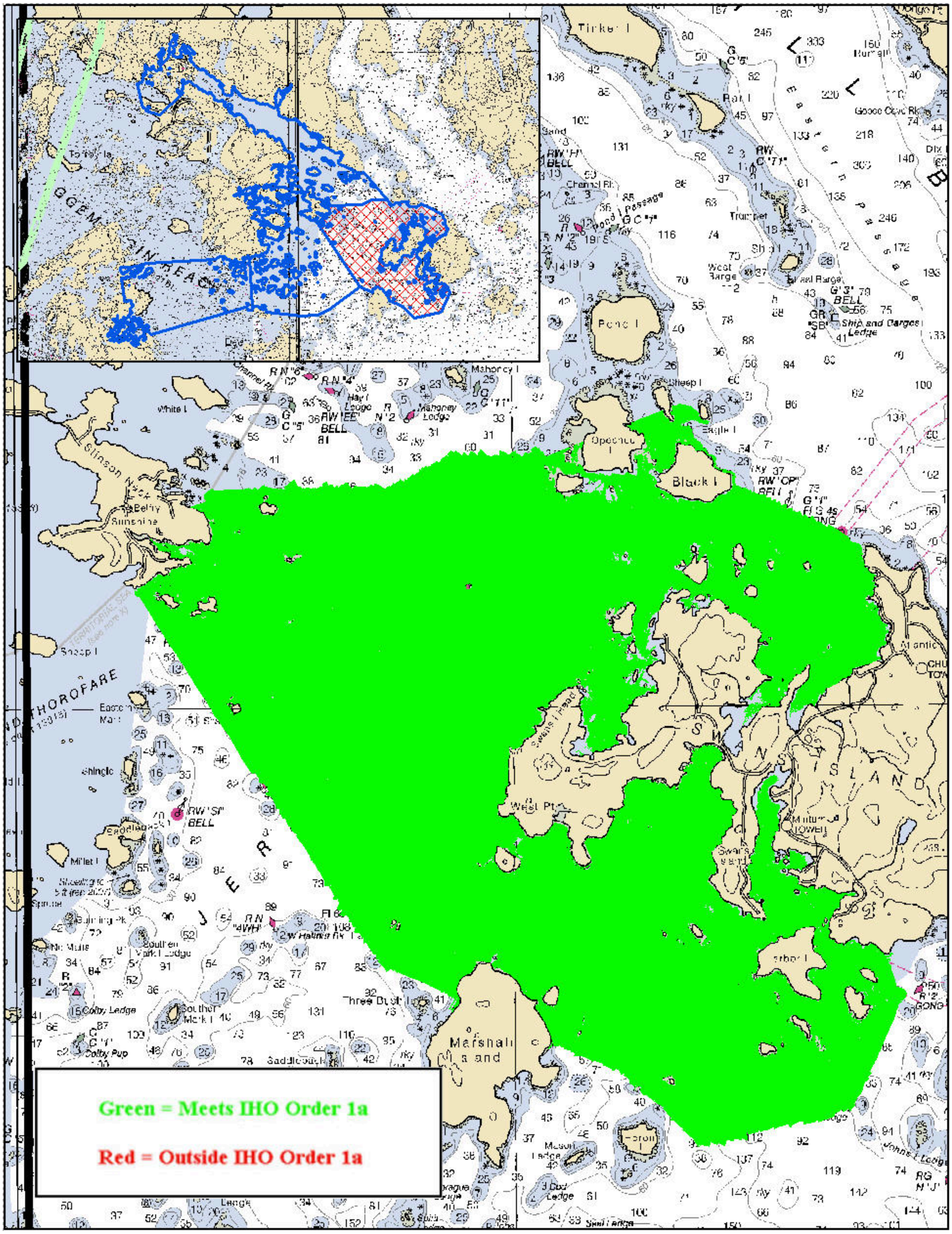

Figure 15: H13013 Uncertainty

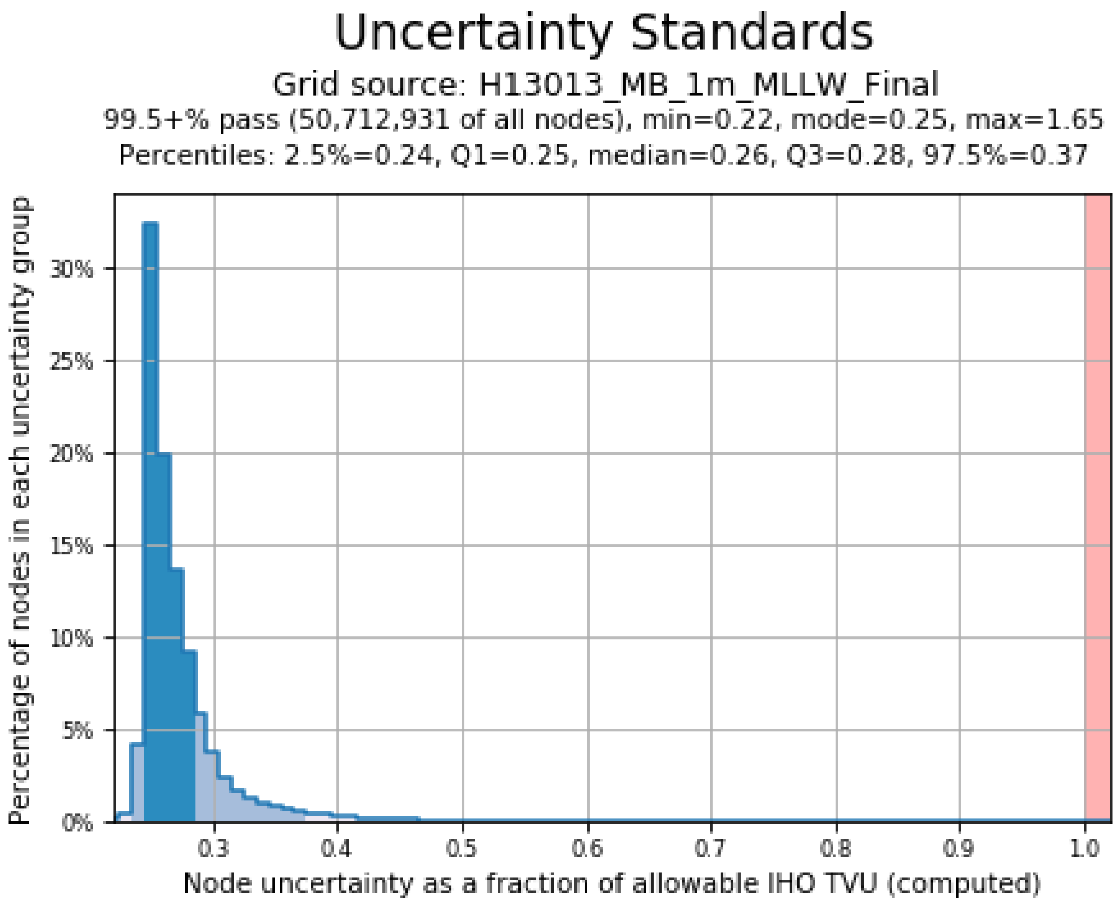

Figure 16: Hydroffice Surface Report H13013 (Priority 3) 1m

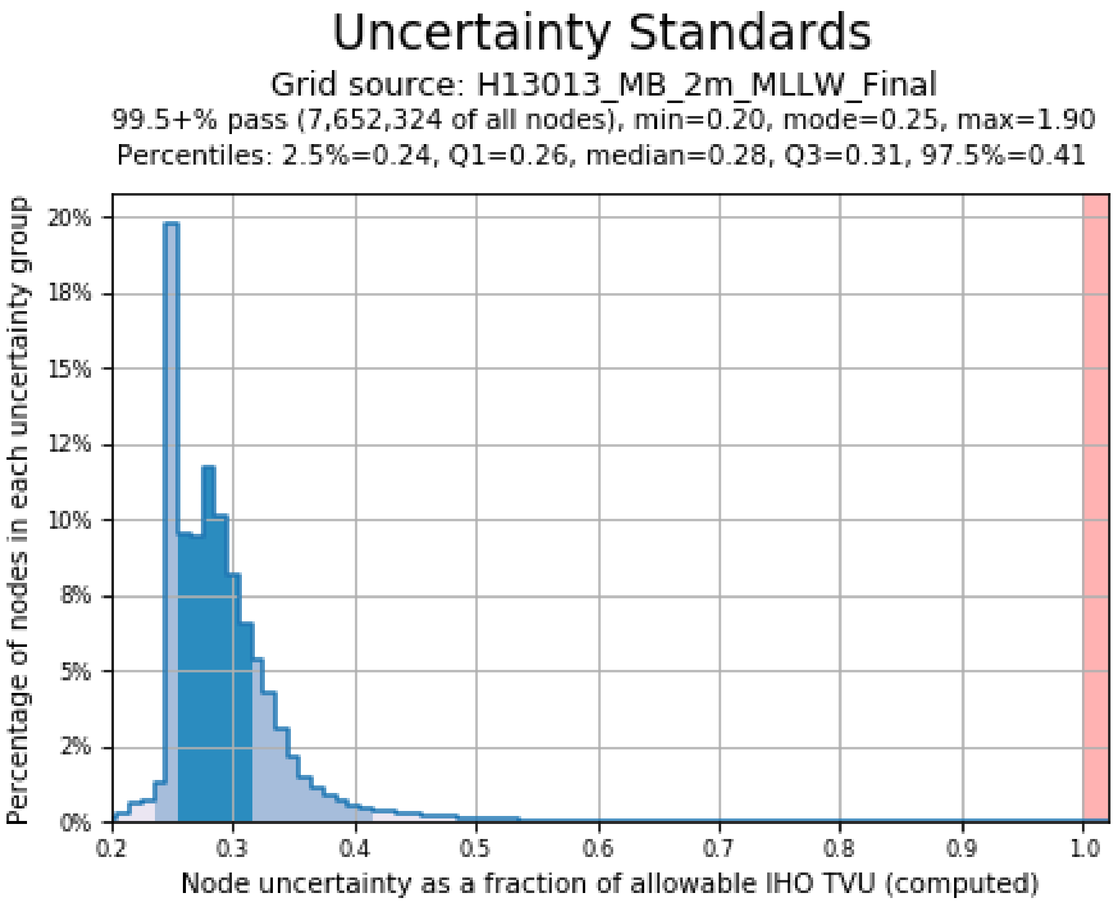

Figure 17: Hydroffice Surface Report H13013 (Priority 3) 2m Final

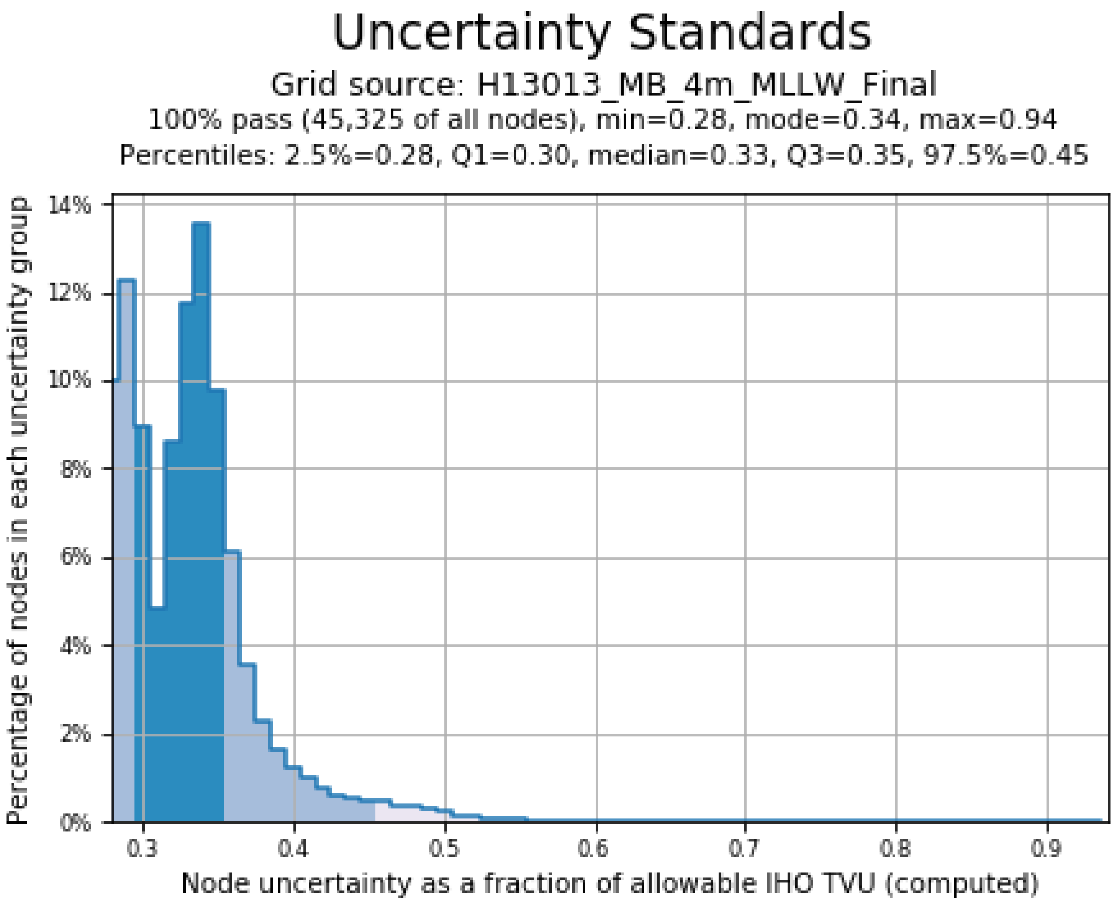

Figure 18: Hydroffice Surface Report H13013 (Priority 3) 4m

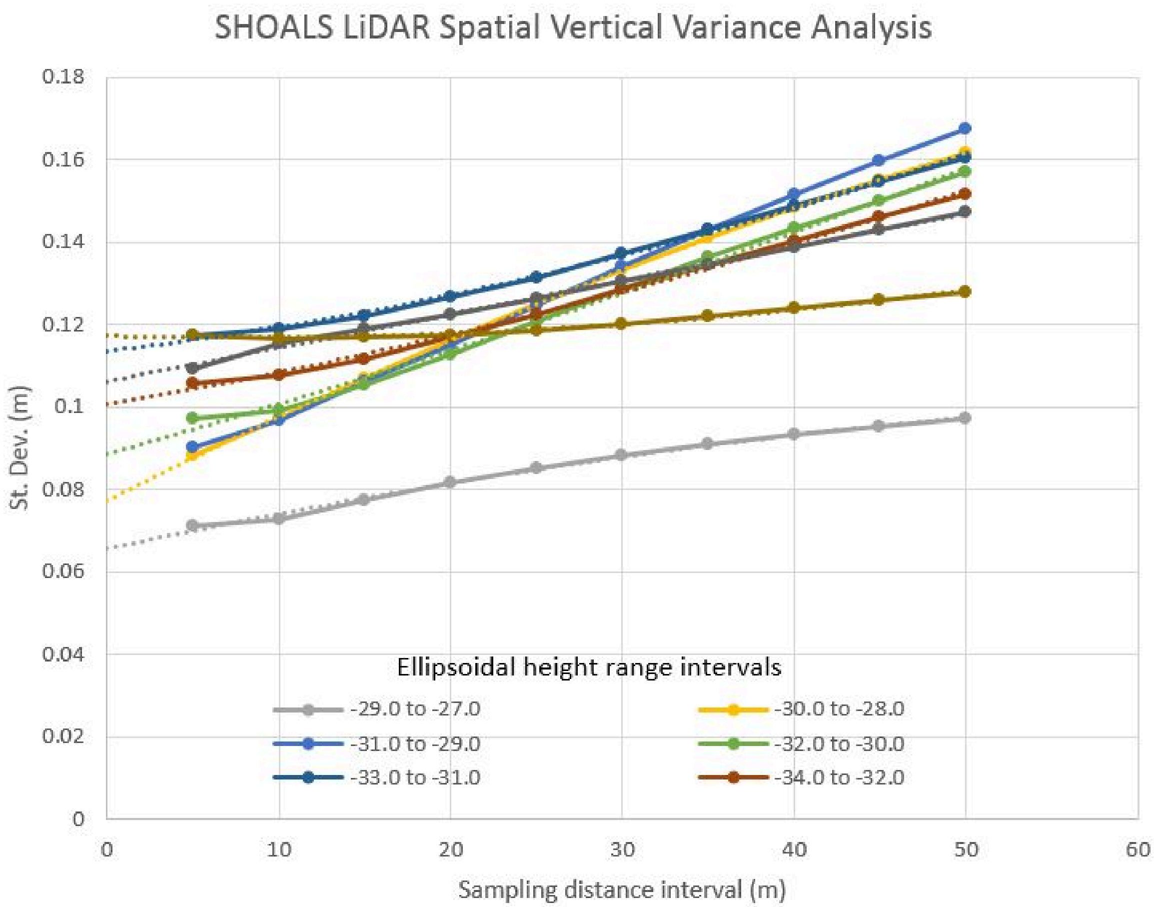

Figure 19: LTE Tool Results

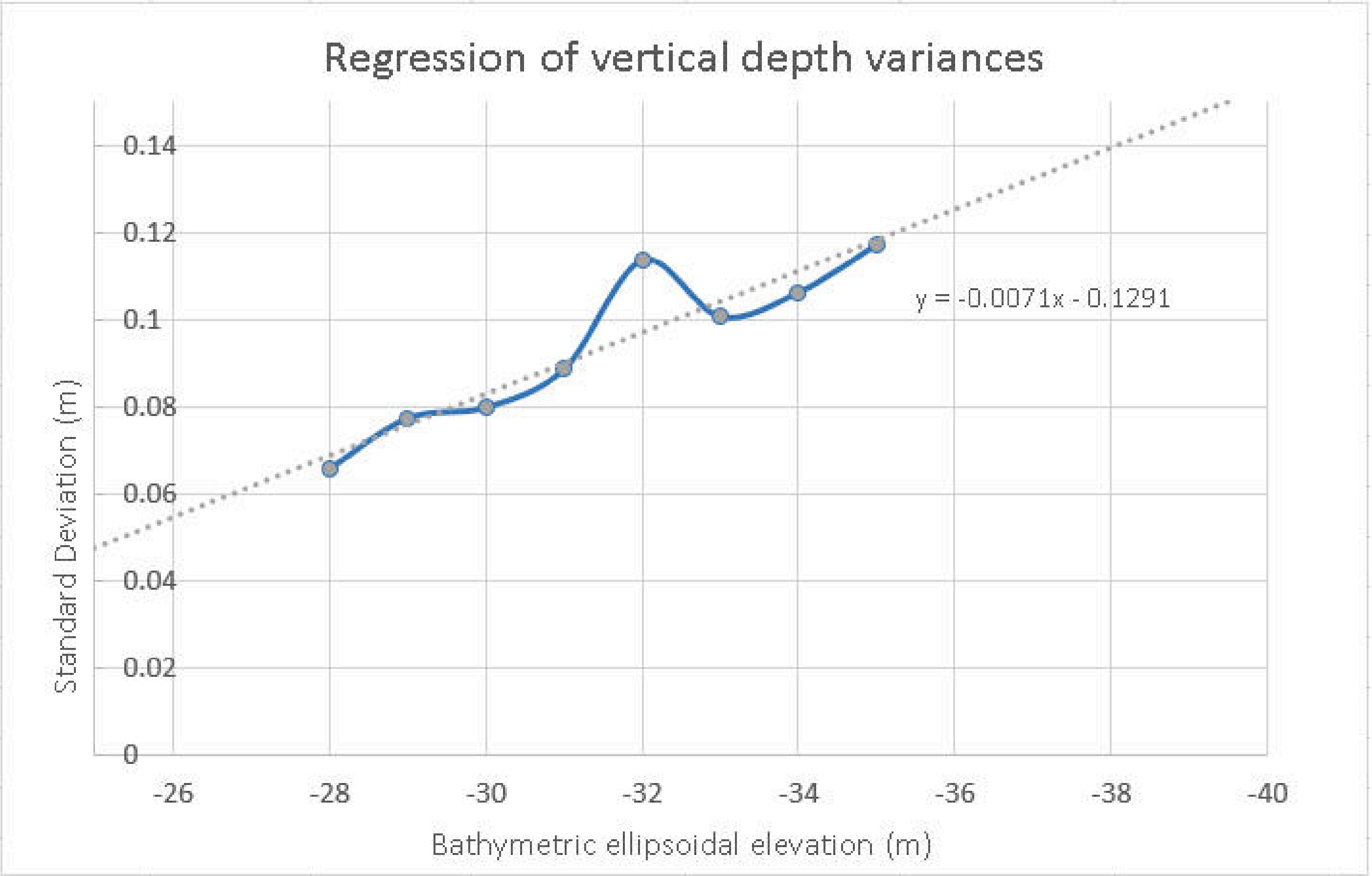

Figure 20: Total Bottom Uncertainty for SHOALS data sample

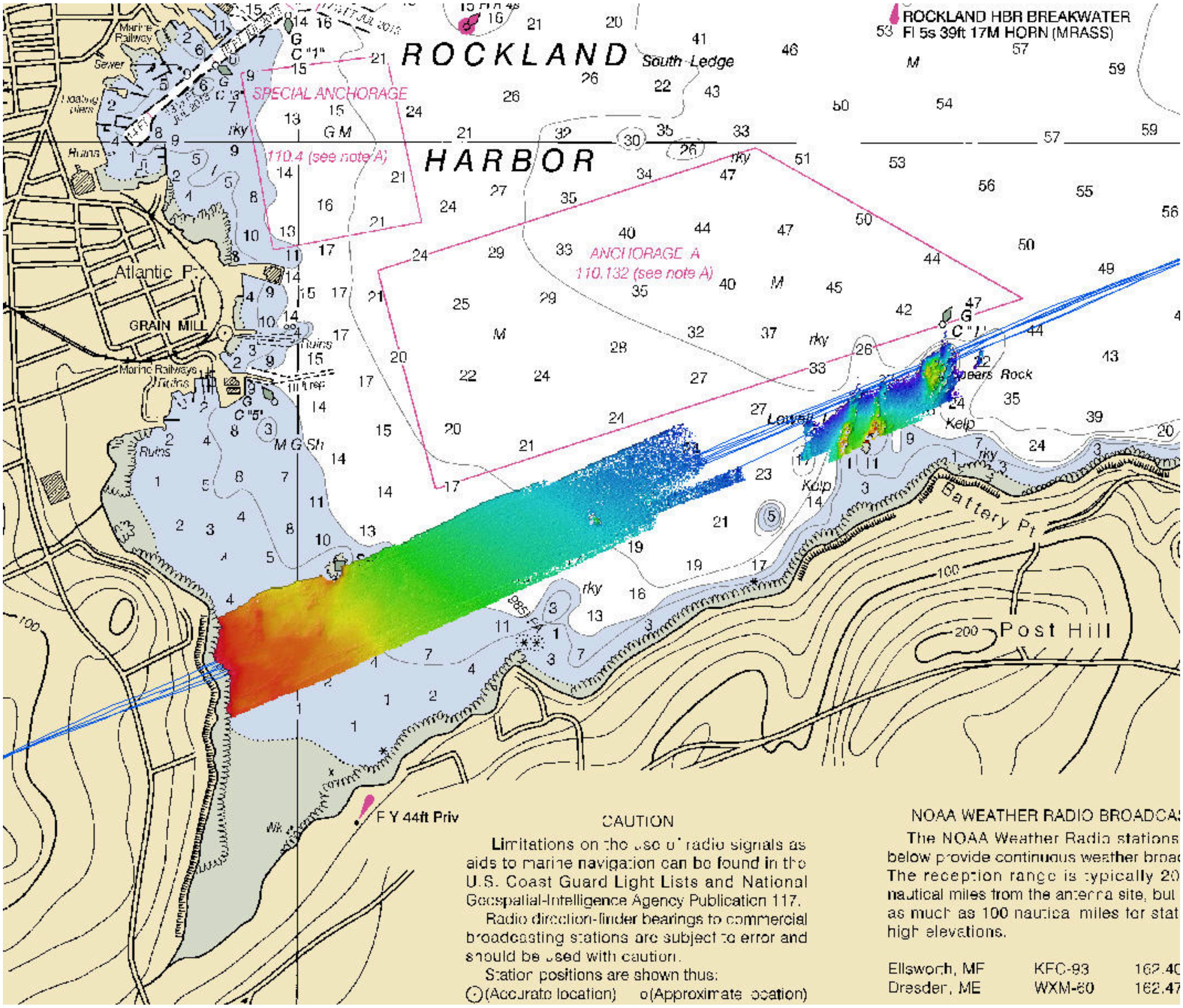

Figure 21: TPU Survey Area

B.2.3 Junctions

Comparisons between H13013 were made with contemporary survey H13012 and the current survey H13014. The results are as follows:

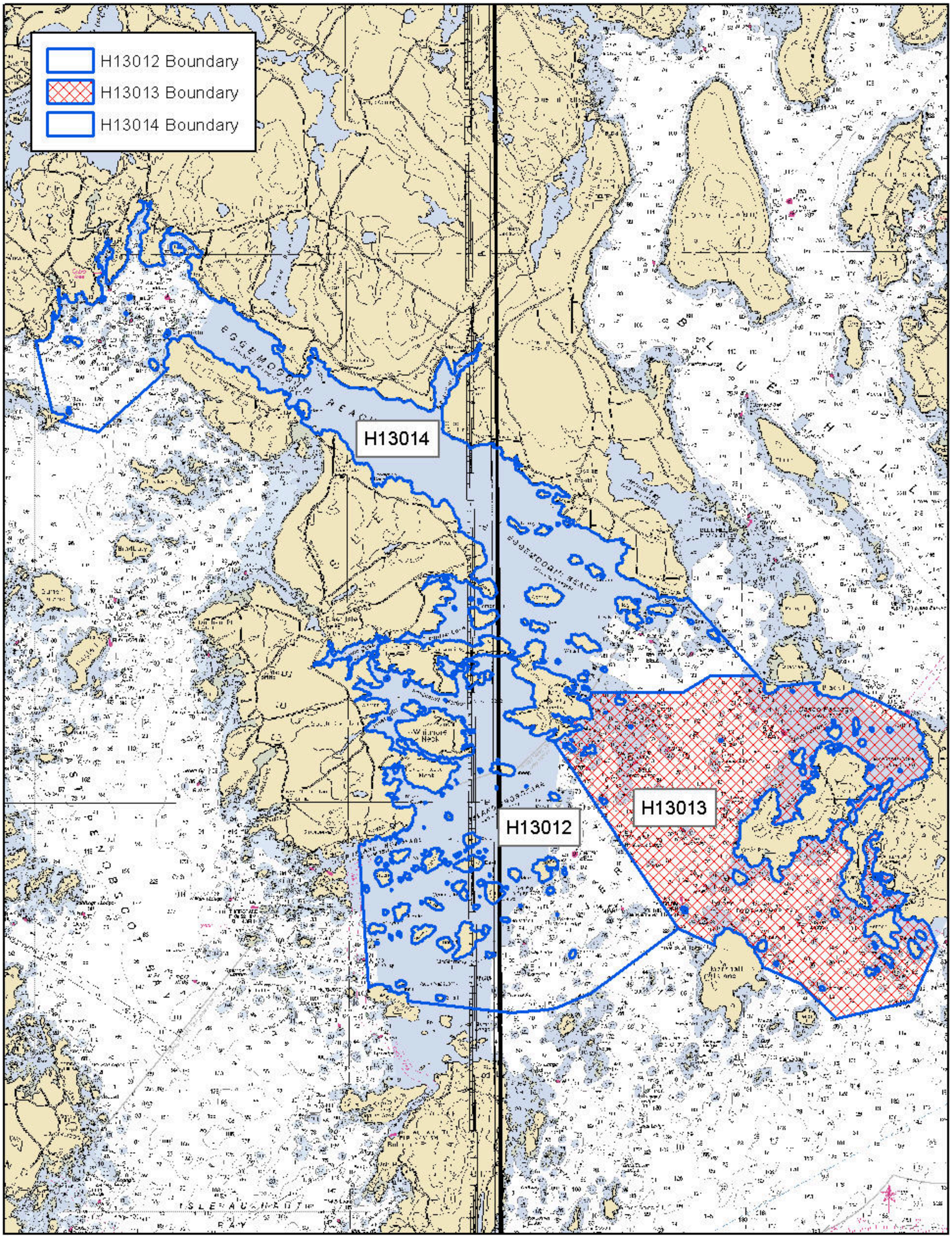

Figure 22: H13013 Junctions Overview

The following junctions were made with this survey:

Registry Number	Scale	Year	Field Unit	Relative Location
H13012	1:10000	2017	Fugro Pelagos, Inc.	W
H13014	1:10000	2017	Fugro Pelagos, Inc.	N

Table 8: Junctioning Surveys

<u>H13012</u>

The conformity between H13013 and the junction with survey H13012 was inspected during processing using the CARIS HIPS Subset Editor routine and finalized as BASE Surfaces. A Difference Surface was generated using the CARIS HIPS Difference Surface function; comparing the depths from the H13013 survey (1 and 2-meter resolution) CUBE surfaces against the H13012 survey. Using the Compute Statistics function in CARIS, the difference surface yielded the following results: a standard deviation of 0.09 meters, and a mean difference of 0.04 meters for the one-meter surface, a standard deviation of 0.12 meters, and a mean difference of 0.04 meters for the two-meter surface. The surveys are in agreement along their common borders and well within the total allowable IHO Order 1a vertical uncertainty. The majority of the difference between the two surveys can be attributed to sound speed refraction and tide error.

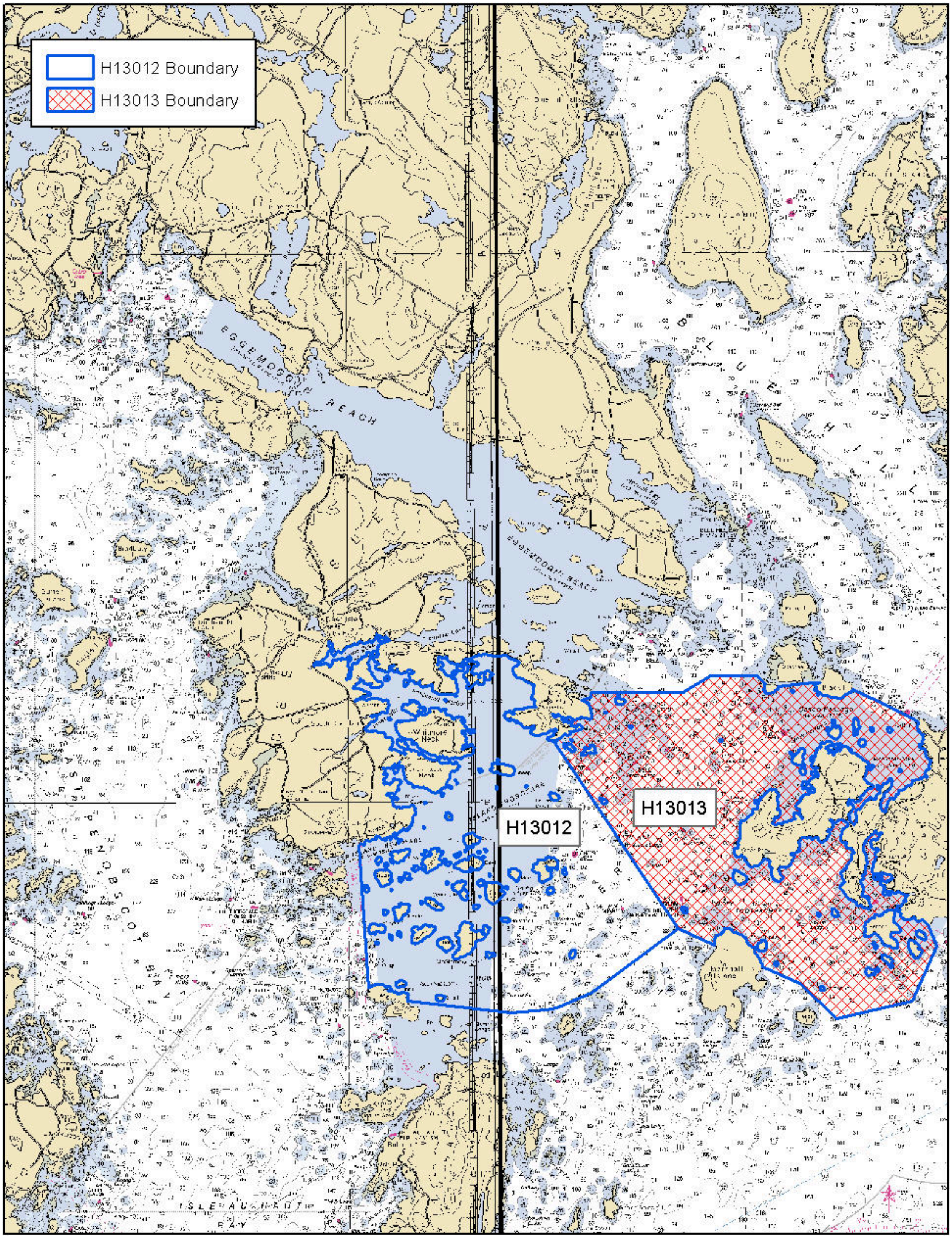

Figure 23: Junction between Survey H13013 and H13012

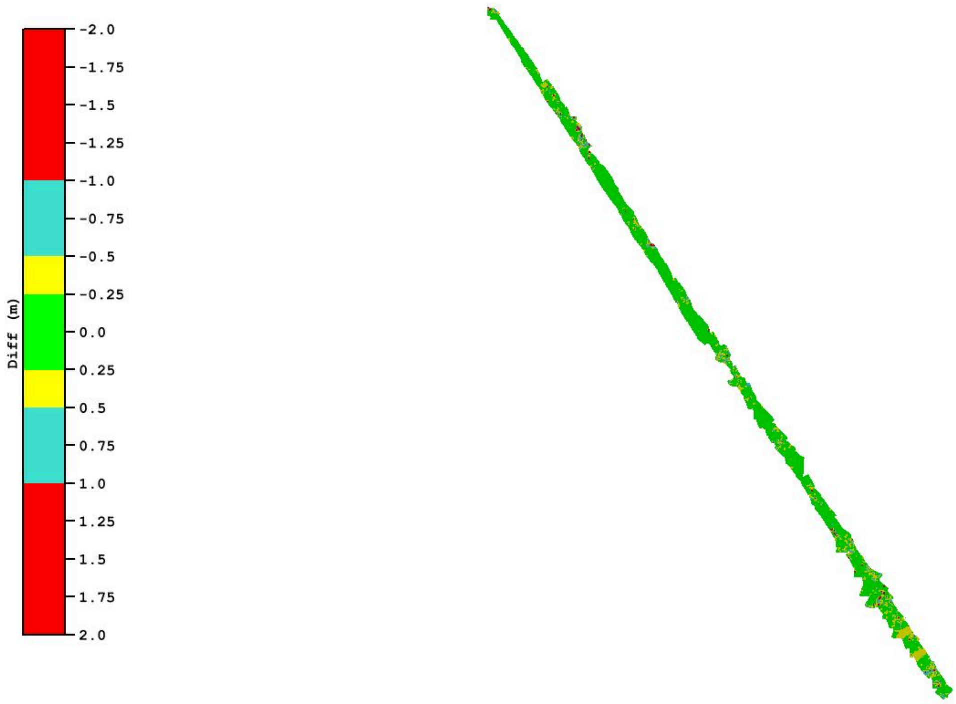

Figure 24: H13012 Minus H13013 1m Difference Surface

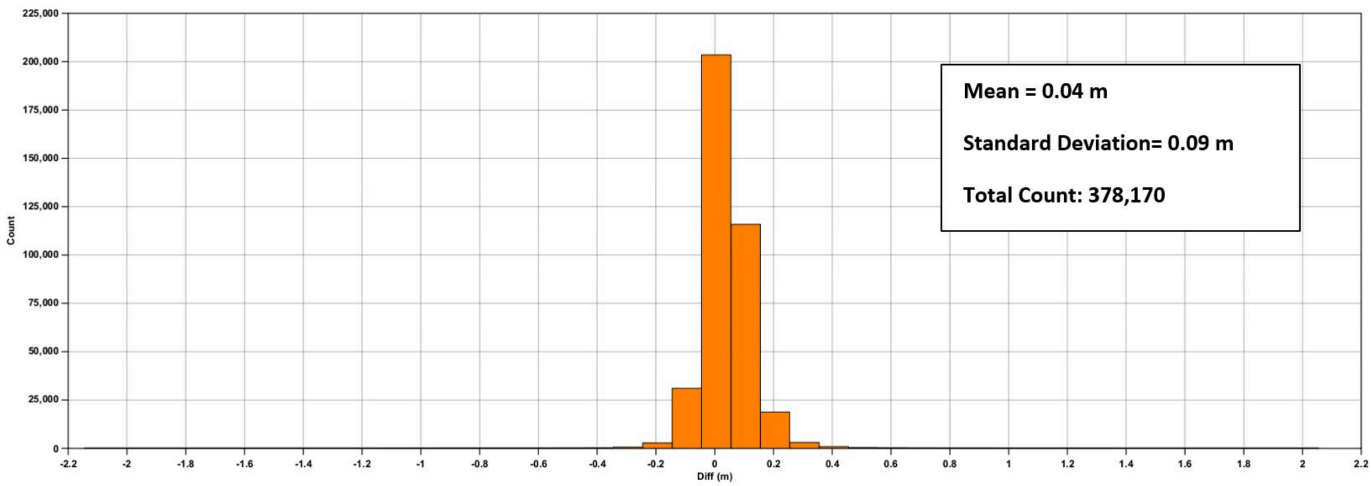

Figure 25: H13012 Minus H13013 1m FINAL Diff Histogram

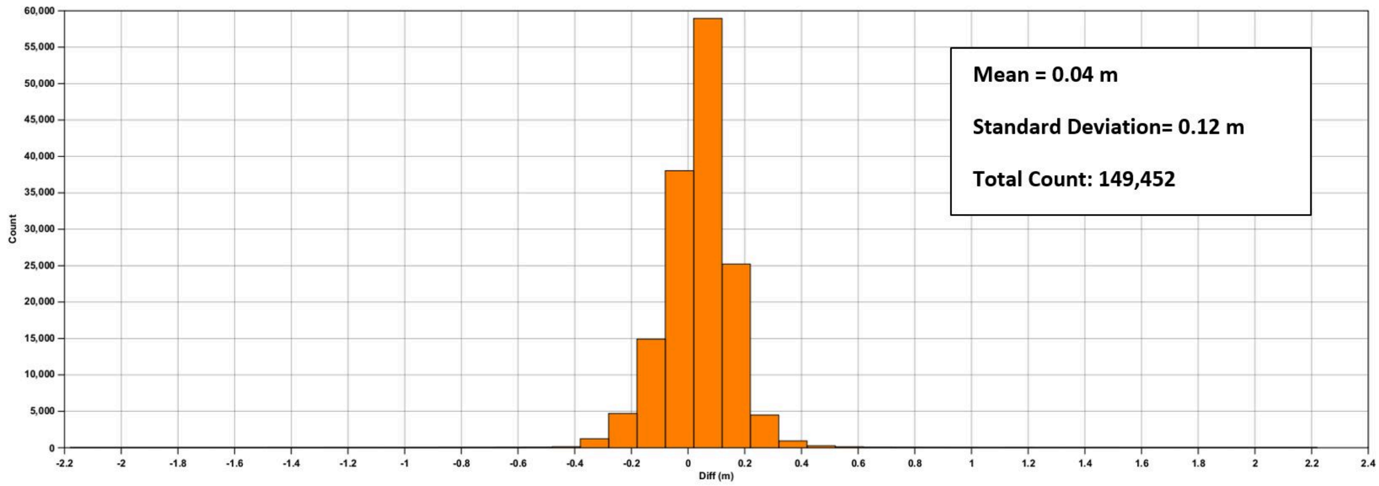

Figure 26: H13012 Minus H13013 2m FINAL Diff Histogram

<u>H13014</u>

The conformity between H13013 and the junction with survey H13014 was inspected during processing using the CARIS HIPS Subset Editor routine and finalized as BASE Surfaces. A Difference Surface was generated using the CARIS HIPS Difference Surface function; comparing the depths from the H13013 survey (1 and 2-meter resolution) CUBE surfaces against the H13014 survey. Using the Compute Statistics function in CARIS, the difference surface yielded the following results: a standard deviation of 0.08 meters, and a mean difference of 0.0 meters for the one-meter surface, a standard deviation of 0.07 meters, and a mean difference of 0.03 meters for the two-meter surface. The surveys are in agreement along their common borders and well within the total allowable IHO Order 1a vertical uncertainty. The majority of the difference between the two surveys can be attributed to sound speed refraction with tide error also accounting for a small portion of that difference.

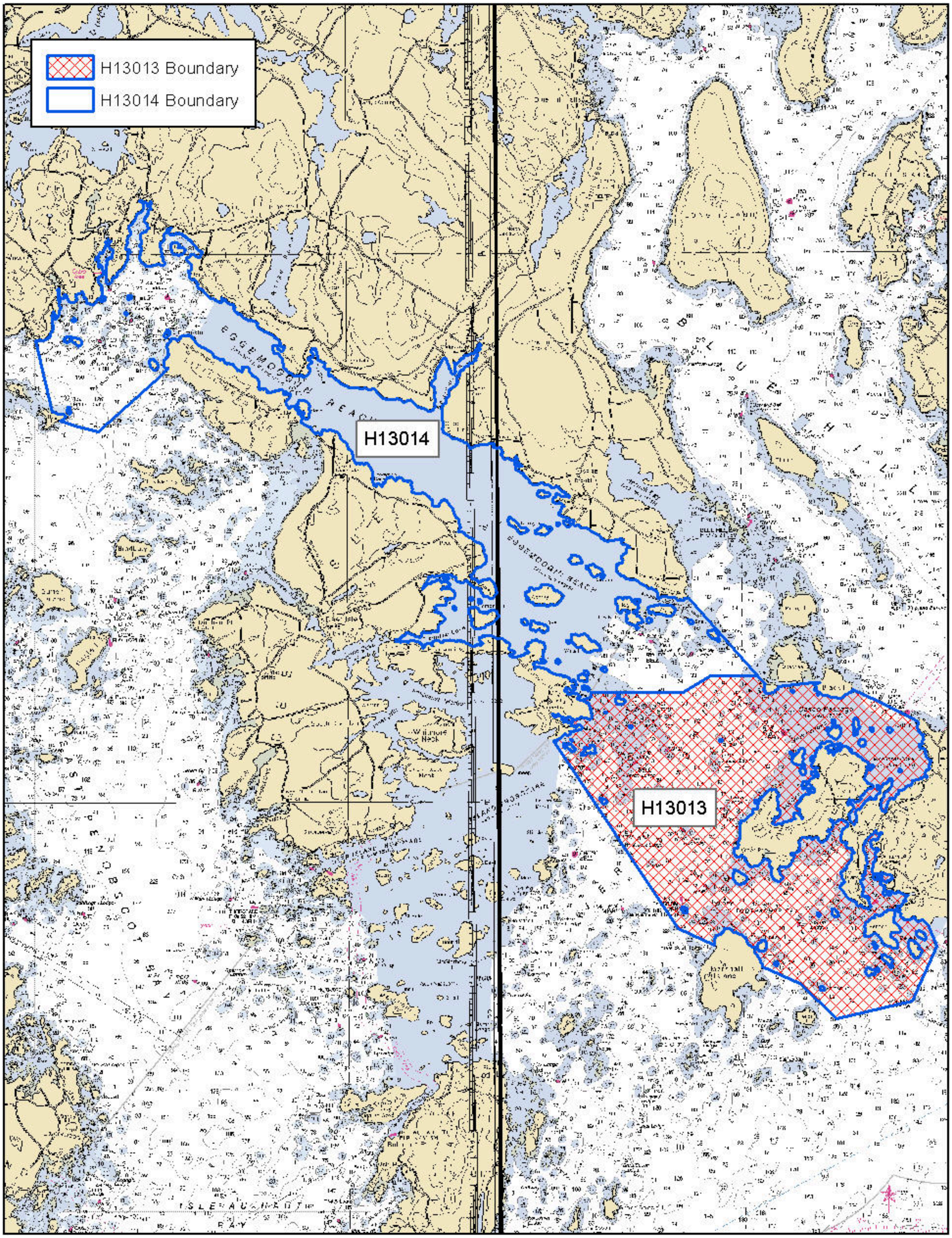

Figure 27: Junction between Survey H13013 and H13014

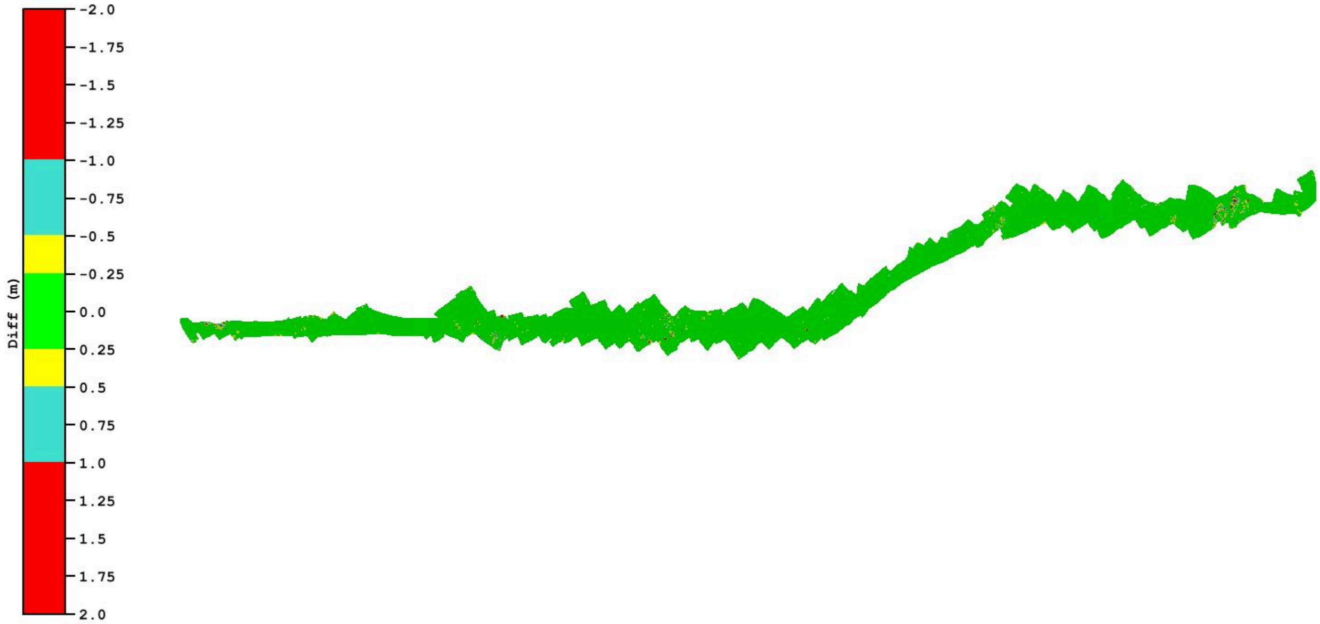

Figure 28: H13013 Minus H13014 1m Difference Surface

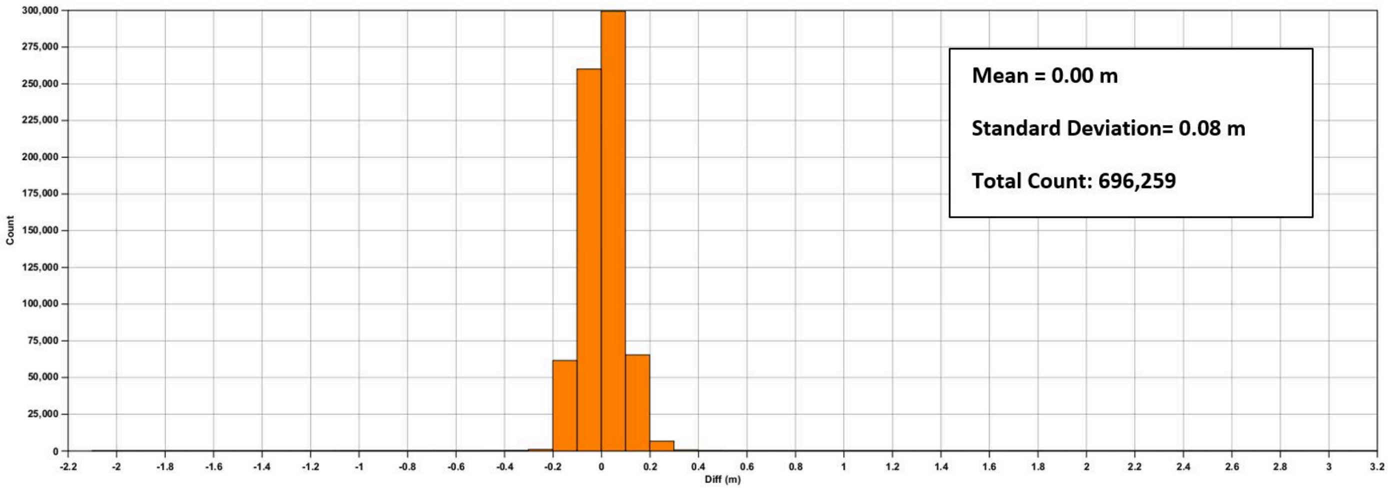

Figure 29: H13013 Minus H13014 1m FINAL Diff Histogram

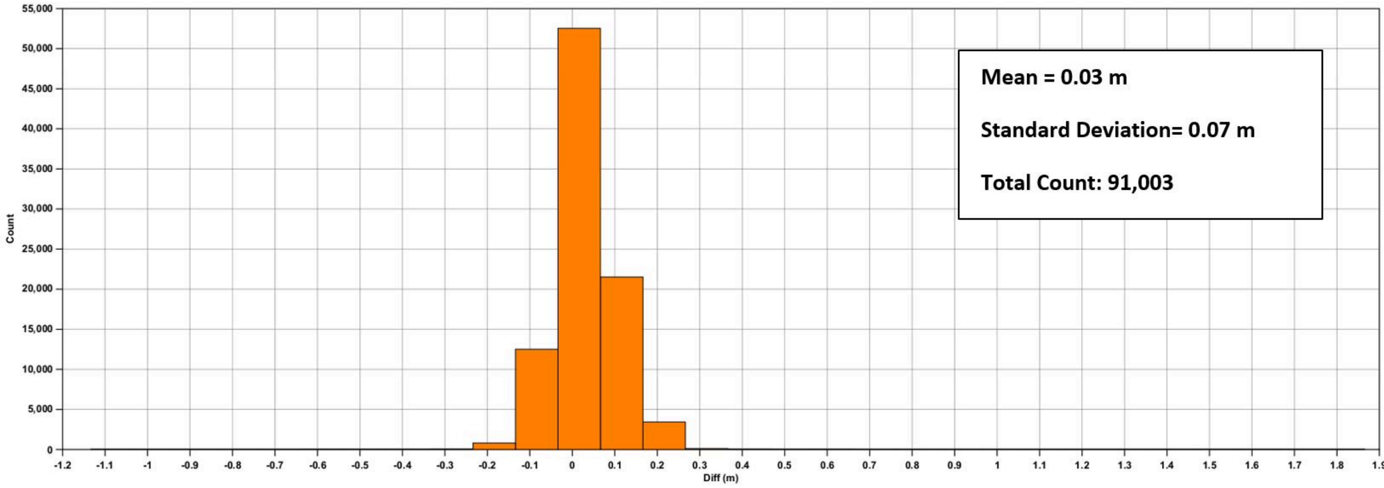

Figure 30: H13013 Minus H13014 2m FINAL Diff Histogram

B.2.4 Sonar QC Checks

Sonar system quality control checks were conducted as detailed in the quality control section of the DAPR.

B.2.5 Equipment Effectiveness

Water Clarity

The greatest contributor to depth performance, seabed coverage, and data quality with a LiDAR system is water clarity. To address this concern, Fugro conducted water clarity assessments across the project area, from the planning phase through to the final flight, using several different techniques. Refer to the DAPR for more details.

From the start of the mission flights on 26 June 2017, Fugro staff undertook water quality assessments along the survey sub-areas. Conditions were documented in many photos and water clarity was, on the whole, found to be relatively poor. Water was seen to be clear in the very shallow depths (likely under four meters) and murky in deeper waters; plumes of sediment swirling around shallow areas near the shoreline and islands were also identified and determined to be in detriment for LiDAR performance.

In general, water clarity in the East Penobscot Bay survey area was less than ideal for ALB acquisition. Clear water was more common in shallow areas, but water in the full eight-meter range of interest was typically murky.

Conditions were similar in the survey area around Eggemoggin Reach, with shallow depths being clearer than the full depth range of interest.

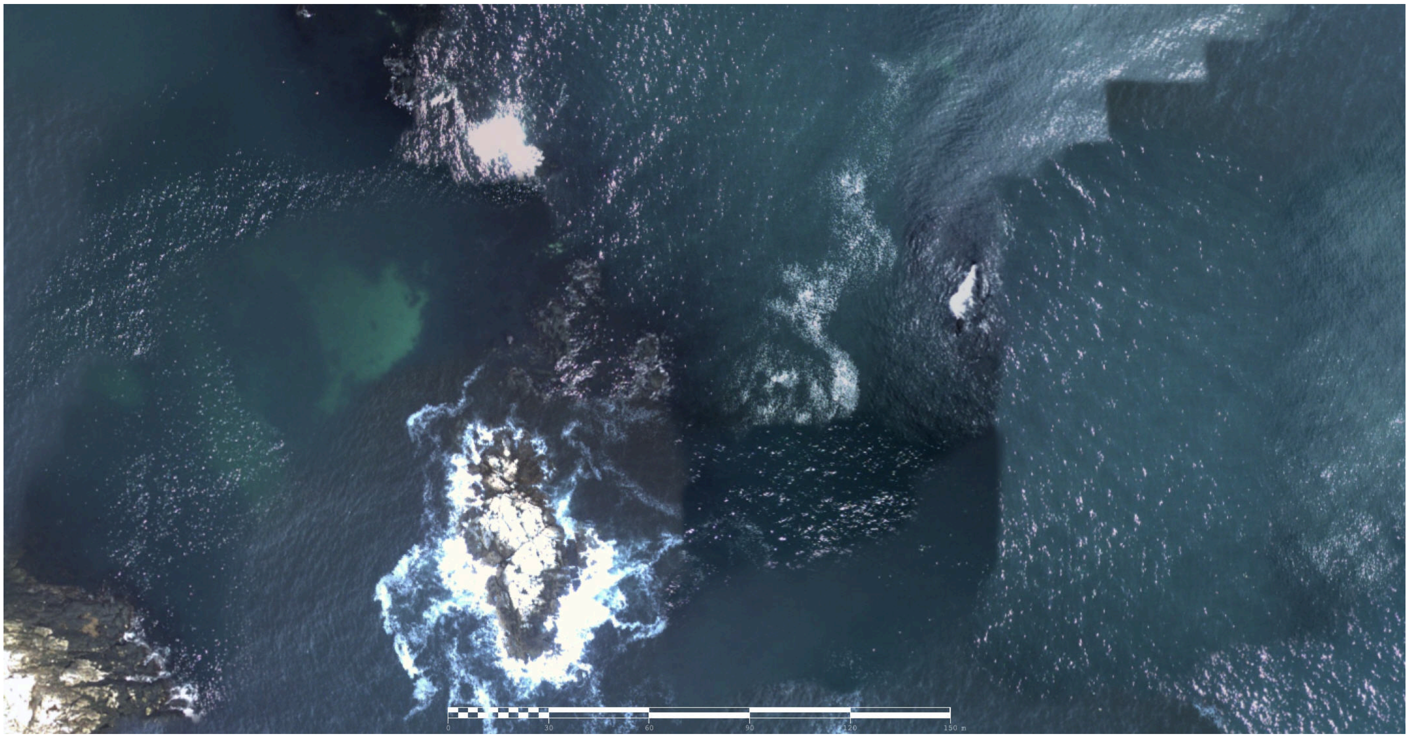

Figure 31: Water Clarity

B.2.6 Factors Affecting Soundings

Sound Speed Refraction (SSR)

A general downward and/or upward cupping is noticeable in the across-track sounding profiles for certain areas. Sound speed refraction errors were seen in the outer beams on the majority of survey lines conducted and were on the order of 0.10 to 0.25 meters. These errors are a result of the strong tidal mixing in the area, which not only carries sediment, but also causes a change in water surface temperature and salinity.

The sound speed profiles conducted throughout the project had an increased inconsistency throughout the water column, much more evident at the surface or near the face of the sonars. In order to mitigate these sound speed errors, the frequency of sound speed casts was increased and the line spacing reduced. Data were examined (and filtered) in CARIS HIPS Subset Editor routine to ensure the data met IHO Order 1a specifications.

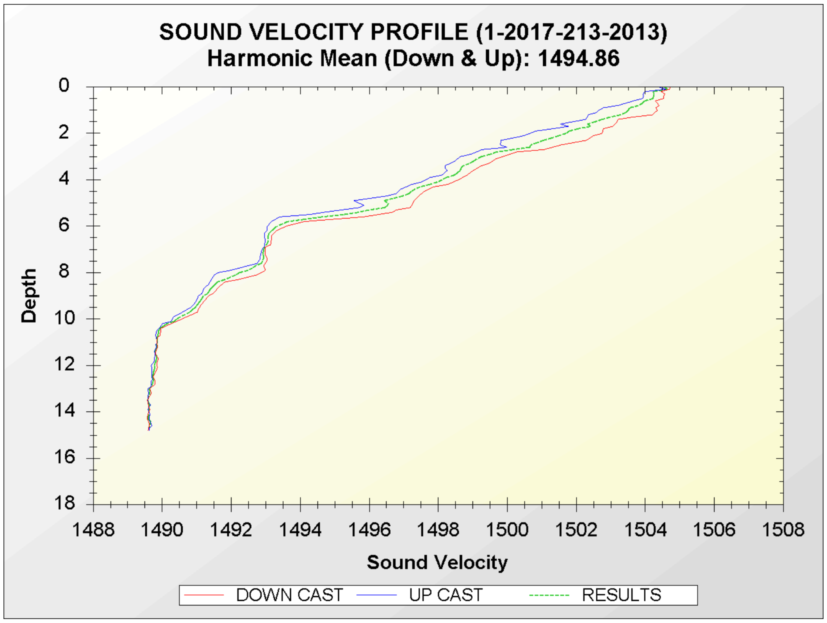

Figure 32: H13013 SVP Cast 1-2017-213-2013

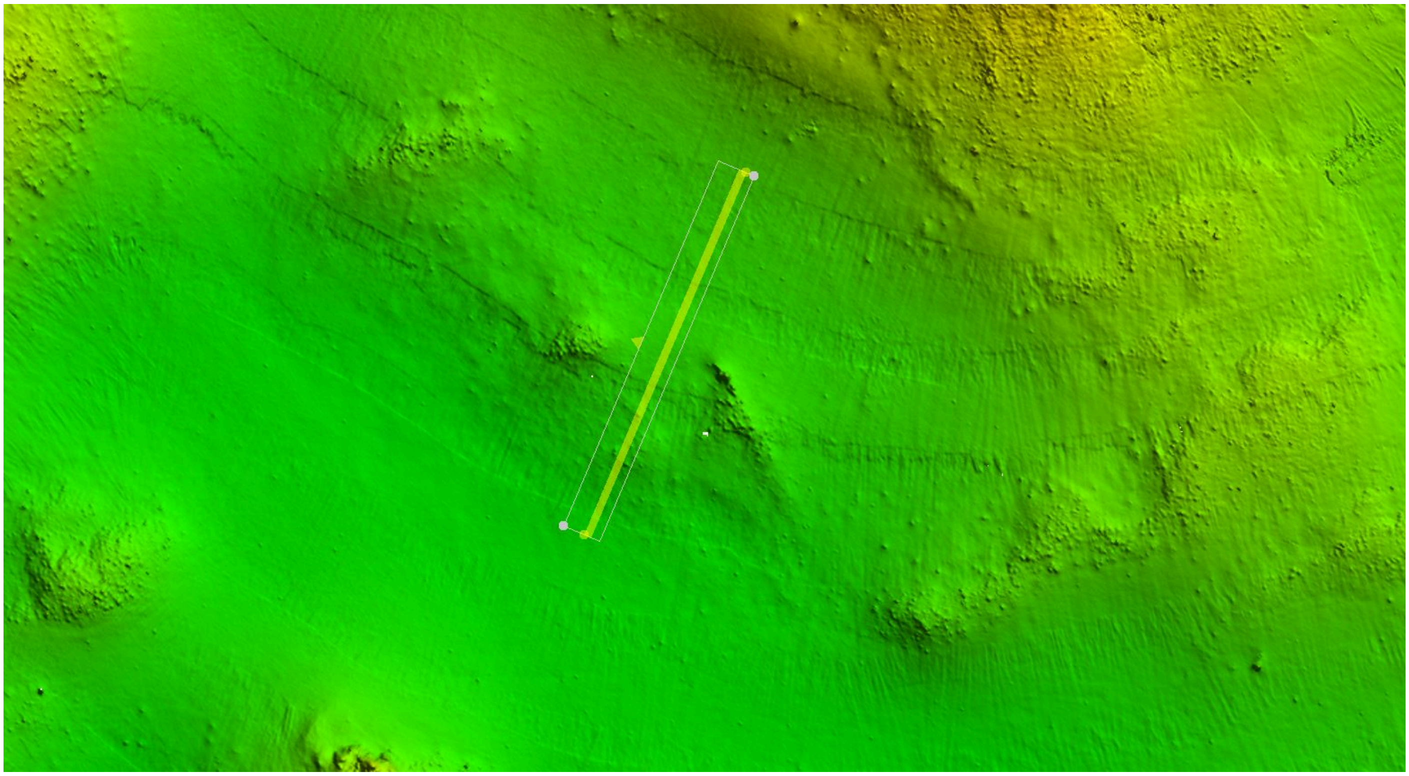

Figure 33: H13013 SSP Refraction Subset Overview

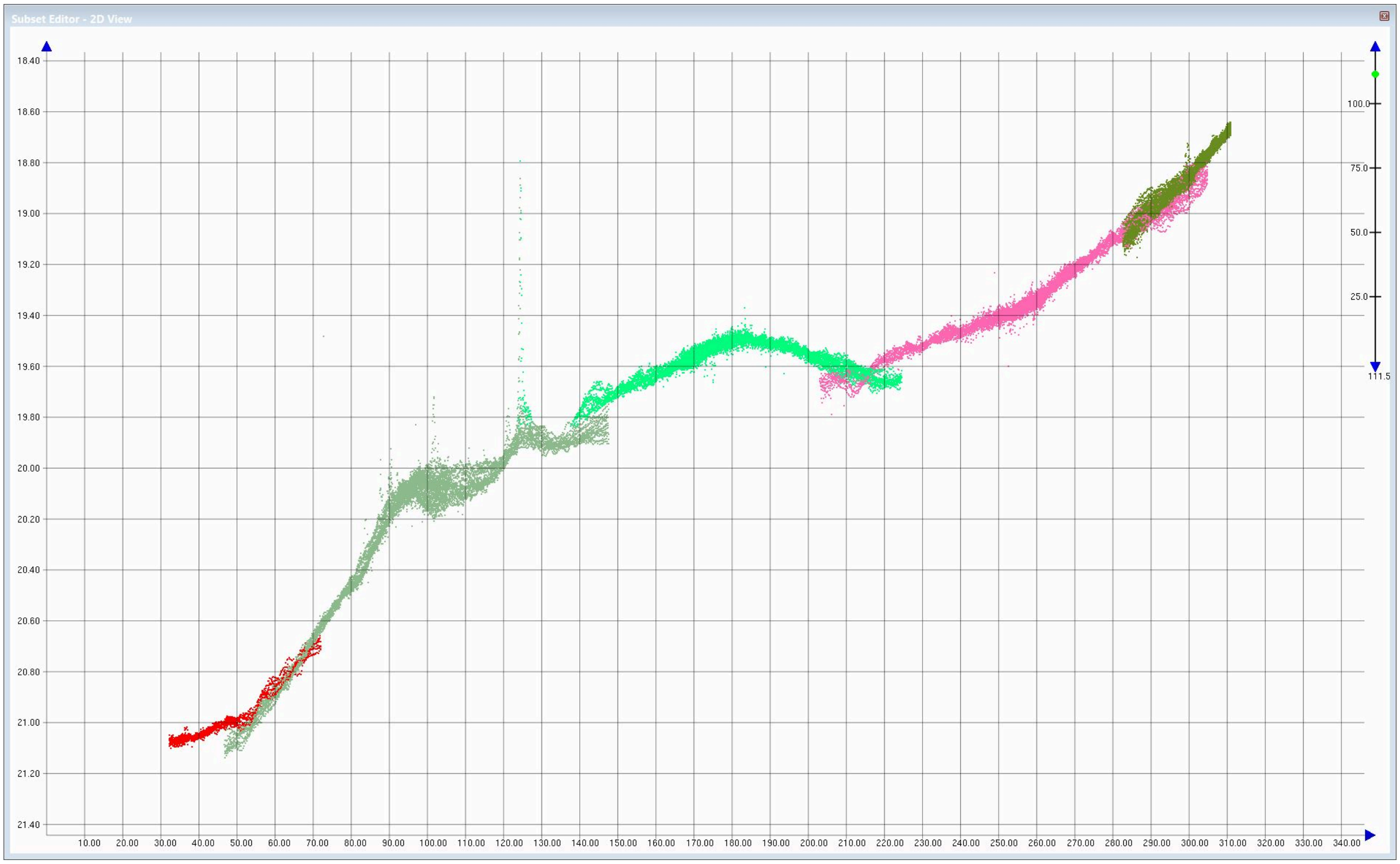

Figure 34: H13013 SSP Refraction Subset View

Fishing Gear

The survey was awarded and conducted during the peak of lobster season, resulting in an extremely high presence of fishing gear (and fishing vessels) in the survey area. This resulted in having to maneuver in and around the surface buoys and fishing vessels causing not only numerous in-fills and re-runs, but increased time spent on manually rejecting erroneous data (fishing gear in the water column) in CARIS HIPS.

Because of the density of fishing gear in the area, vessel speed was at times reduced to near idle. Entanglements between the survey vessel's deployed sonar equipment and fishing gear happened quite often, resulting in a loss of survey time. The risk of entanglement also increased before and after the high tide peaks due to submerged buoys in some areas.

Figure 35: Fishing Gear

Water Clarity

In addition to being an issue in equipment effectiveness, water clarity was a factor affecting soundings. Refer to section B.2.5 for the explanation on water clarity.

Figure 36: Water Clarity

Tidal Bust

Numerous tide busts Tide, on the order of 0.20m to 0.30m were noticed between adjacent mainscheme lines conducted on different days, as well as between mainscheme lines and infills. Survey lines from Julian Day 254 are 0.20 to 0.25 meters deeper than the adjacent data from Julian Day 255. This can be attributed to the overall uncertainly in the gauge data and TCARI Model. All data fell within IHO Order 1a accuracy specifications. Note: GPS Heights were applied to the data set and a GPS Tide Computed (referenced to the WGS84 ellipsoid), but this was for troubleshooting purposes only, mostly to verify tide bust. Final tide corrections for this survey were from the TCARI Model.

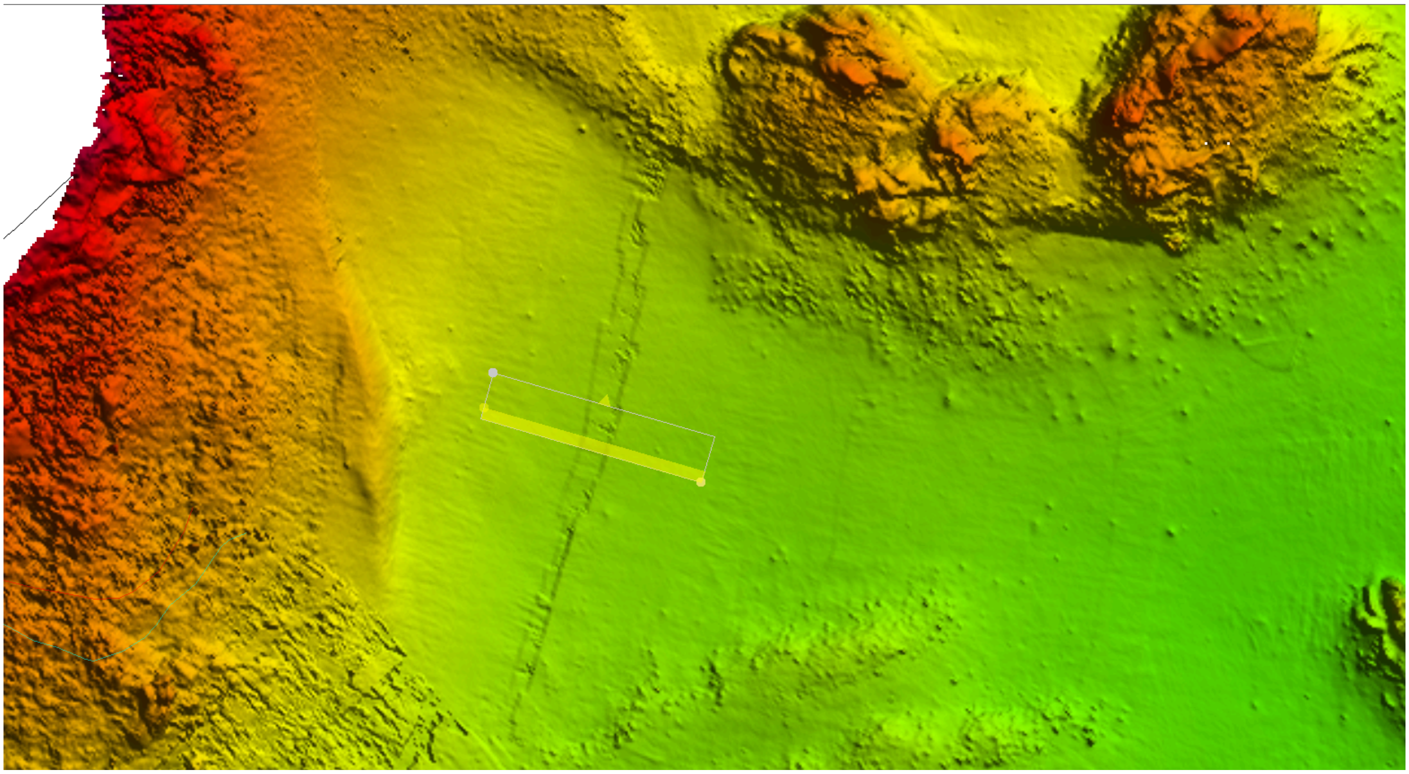

Figure 37: H13013 Tidal Bust TCARI Model Subset Overview

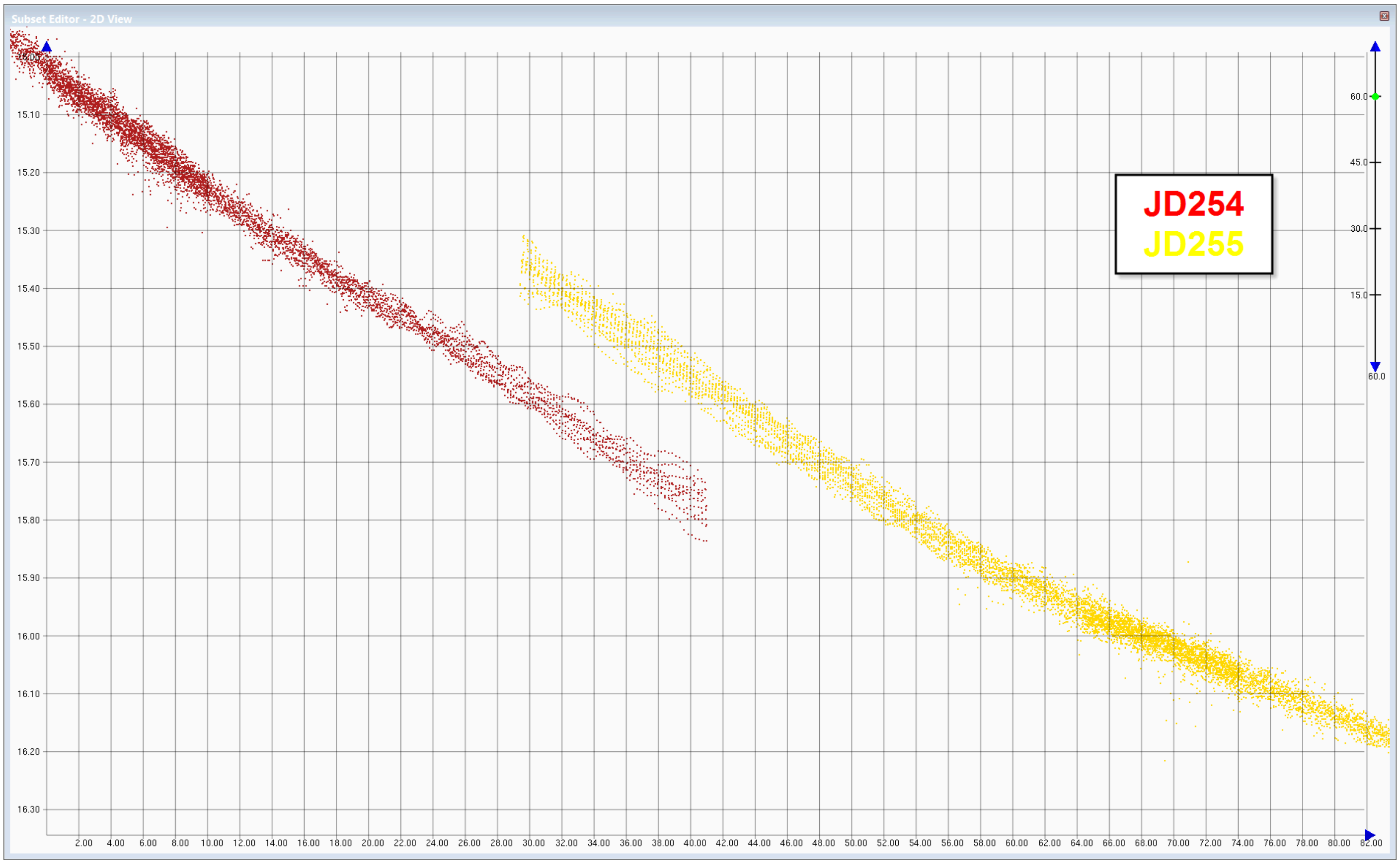

Figure 38: H13013 Tidal Bust TCARI Model JD 2017-254 JD255 Subset View

Marine Life

There was a high presence of marine life in various locations within the survey area. This resulted in not only numerous in-fills and re-runs, but increased time spent on manually rejecting the erroneous data in CARIS HIPS and SIPS.

B.2.7 Sound Speed Methods

Sound Speed Cast Frequency: Sound velocity casts were normally performed every two to three hours on the R/V Theory and R/V Westerly. For each cast, the probes were held at the surface for one to two minutes to achieve temperature equilibrium. The probes were then lowered and raised at a rate of 1 m/s. Between casts, the sound velocity sensors were stored inside the lab or in fresh water to minimize salt-water corrosion and to hold them at ambient water temperature.

Refer to the DAPR for additional information.

R/V Theory and R/V Westerly were equipped with AML 1000 dbar Sound Velocity & Pressure (AML SV&P) Smart Sensors. The AML SV&P directly measures sound velocity through a time of flight calculation, and measures pressure with a temperature compensated semiconductor strain gauge at a 10Hz sample rate. The instrument has a 0.015 m/s resolution with a ± 0.05 m/s accuracy for sound velocity measurements, and a 0.01 dbar resolution and a ±0.5 m dbar accuracy for pressure.

Each vessel was equipped with two AML SV&Ps. The instruments were mounted within a weighted cage and deployed using a hydraulic winch that contained 350 meters of shielded Kevlar reinforced cable via a stern mounted A-Frame.

Sound Speed quality control checks were conducted as per the HSSD 2017, Section 5.2.3.3 and can be found in Separate II.

Figure 39: AML SVP

B.2.8 Coverage Equipment and Methods

All equipment and survey methods were used as detailed in the DAPR.

B.2.9 Data Density

The NOS HSSD, April 2017, require 95% of all nodes to be populated with at least five soundings. Survey H13013 met these project specifications.

Surface	Depth Range (m)	% of nodes with five soundings
H13013_MB_1m_MLLW_Final	0-20	99.91%
H13013_MB_2m_MLLW_Final	18-40	99.96%
H13013_MB_4m_MLLW_Final	36-80	99.84%
H13013_LI_5m_MLLW_Final	0-8	87.09%

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. The processing crew provided feedback after preliminary processing and coverage creation in CARIS HIPS. Infill lines were run as necessary.

The LiDAR program was proposed and planned for 100% of the area to be flown with a five by five (or better) spot spacing. In other words, a reconnaissance coverage survey would be used from the inshore limit to the 8 meter water depth. This explains the percentage of nodes that fall below the five sounding per bin threshold. It should be noted that per the project instructions, the final LiDAR surface was binned at five meters.

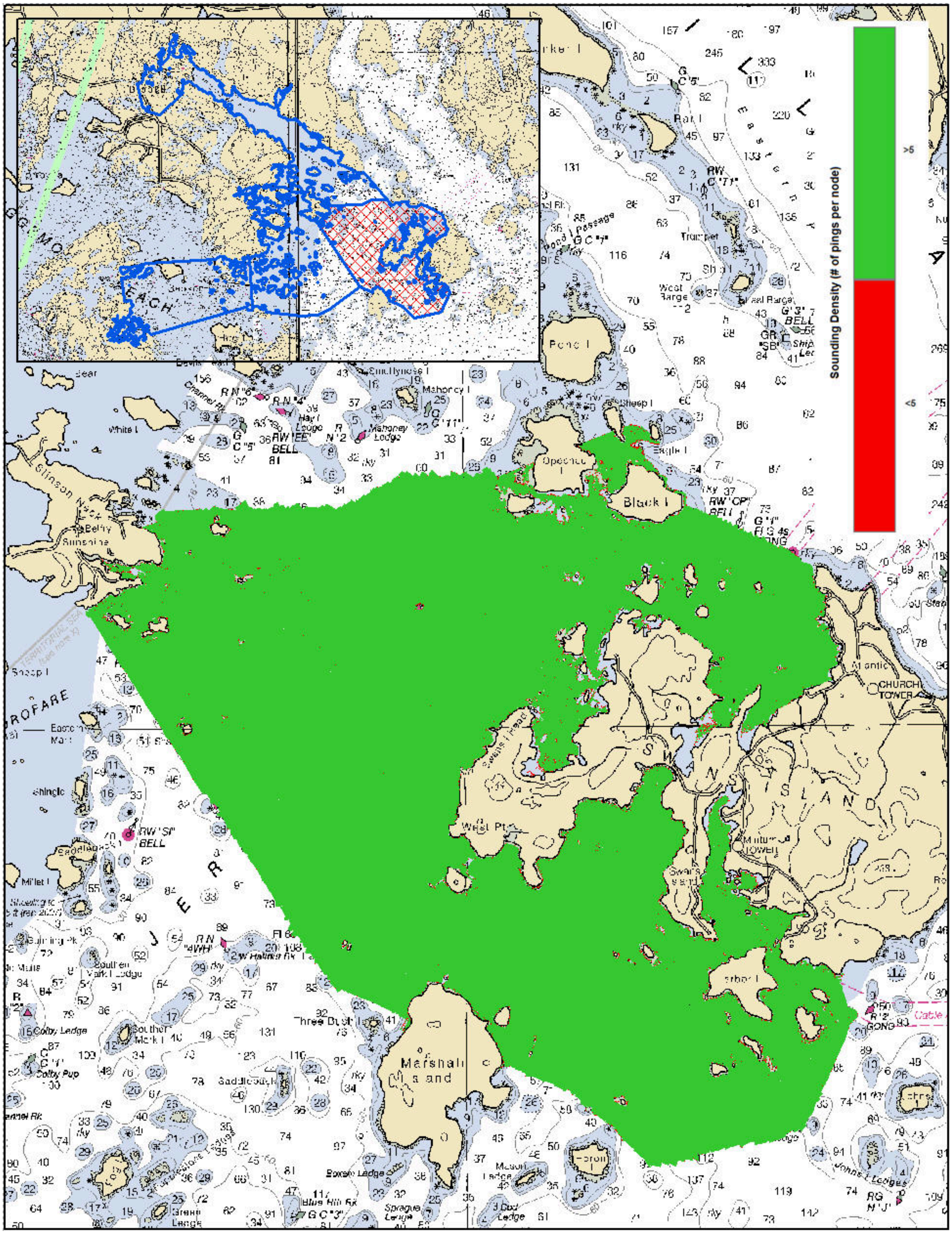

Figure 40: H13013 Final Sounding Density

B.2.10 MB Quality Control Checks

Positioning system confidence checks for the R/V Theory and R/V Westerly were conducted daily using the POS/MV controller software. The controller software had numerous real-time displays that were monitored throughout the survey to ensure the positional accuracies specified in the NOS HSSD were achieved. These include, but are not limited to the following: GPS Status, Position Accuracy, and Receiver Status, which includes Horizontal Dilution of Precision (HDOP) and Position Dilution of Precision (PDOP), and Satellite Status. During periods of high HDOP and/or a low number of available satellites, survey operations were suspended.

Sonar system confidence checks were performed weekly by comparing post processed depth information collected by multiple vessels surveying over a common area. In addition, bar checks were performed to maintain a high confidence level. Sound Velocity Probe confidence checks were conducted weekly by producing comparable sound velocity data between all vessels. This check was carried out by having all sound velocity profiling equipment perform a cast in close proximity to each other in a near simultaneous time period.

B.2.11 LiDAR POS Hold Position Checks

Before each flight, a POS Hold is conducted to ensure Full Nav has been initialized. Once the Position and Orientation System for Airborne Vehicles (POS/AV) system powers up and the “Full Nav” indicator has been reached, the POS initialization hold is started for a minimum of 6 minutes in a static position. After holding the static position, the aircraft can taxi to the takeoff position. Full Nav status indicates that Global Navigation Satellite System (GNSS) position and velocities have been resolved and will aid to initialize the inertial navigation frame, which is the process of aligning the navigation frame with respect to the vertical (leveling) and orientation to North (heading).

B.3 Echo Sounding Corrections

B.3.1 Corrections to Echo Soundings

Two lines in H13013 do not have delayed heave applied. This was due to an interruption in POS logging or a software crash during data acquisition. See affected lines below.

2P3B05-1100
2P3B12-249-SH028

B.3.2 Calibrations

The following calibrations were conducted after the initial system calibration discussed in the DAPR:

Calibration Type	Date	Reason
Multibeam Patch Test	2017-07-06	MBES / IMU polemount repair
Applanix POS MV GAMS Calibration	2017-07-06	MBES / IMU polemount repair

Table 9: Calibrations not discussed in the DAPR.

On July 05, 2017, R/V Westerly struck a submerged object with the sonars. Due to impact a weld on the pole snapped and broke the pole in half. No damage was done to the cables, sonars or the MRU. After the repair of the pole was completed an additional POS MV GAMS calibration and Multibeam Patch Test was performed on July 06, 2017.

B.4 Backscatter

Towed SideScan Sonar (SSS) operations were not required by this contract, but the backscatter and beam imagery snippet data from all multibeam systems were logged and are stored in the s7k files. All beam imagery snippet data was logged in the 7028 record of the s7k file for the project.

To yield the best results when processing the backscatter from the dual head 7125 systems, we recommend utilizing the CARIS SIPS Backscatter routine. Currently, CARIS only uses the Beam Average, but in an upcoming release in v10 CARIS will apply the Time Series backscatter data.

LiDAR reflectance was not part of the project instructions, but was processed and will be included in the final deliverables.

B.5 Data Processing

B.5.1 Primary Data Processing Software

The following software program was the primary program used for bathymetric data processing:

Manufacturer	Name	Version
Teledyne CARIS	HIPS/SIPS	9.1.9

Table 10: Primary bathymetric data processing software

The following software program was the primary program used for bathymetric data processing:

Manufacturer	Name	Version
Teledyne CARIS	HIPS/SIPS	10.2.2

Table 11: Primary bathymetric data processing software

The following Feature Object Catalog was used: NOAA Extended Attribute Files V5_5.

B.5.2 Surfaces

The following surfaces and/or BAGs were submitted to the Processing Branch:

Surface Name	**Surface Type**	**Resolution**	**Depth Range**	**Surface Parameter**	**Purpose**
H13013_MB _1m_MLLW	CARIS Raster Surface (CUBE)	1 meters	-1.22 meters - 40.42 meters	NOAA_1m	Complete MBES
H13013_MB_1m_MLLW_Final	CARIS Raster Surface (CUBE)	1 meters	0 meters - 20 meters	NOAA_1m	Complete MBES
H13013_MB_2m_MLLW	CARIS Raster Surface (CUBE)	2 meters	-1.22 meters - 40.42 meters	NOAA_2m	Complete MBES
H13013_MB_2m_MLLW_Final	CARIS Raster Surface (CUBE)	2 meters	18 meters - 40 meters	NOAA_2m	Complete MBES
H13013_MB_4m_MLLW	CARIS Raster Surface (CUBE)	4 meters	-1.22 meters - 40.37 meters	NOAA_4m	Complete MBES
H13013_MB_4m_MLLW_Final	CARIS Raster Surface (CUBE)	4 meters	36 meters - 80 meters	NOAA_4m	Complete MBES

Surface Name	Surface Type	Resolution	Depth Range	Surface Parameter	Purpose
H13013_LI_5m_MLLW	CARIS VR Surface (CUBE)	5 meters	-66.04 meters - 10.56 meters	N/A	Complete MBES
H13013_LI_5m_MLLW_Final	CARIS Raster Surface (Uncertainty)	5 meters	-3.29 meters - 6.32 meters	N/A	Complete MBES

Table 12: Submitted Surfaces

The surfaces have been reviewed for noisy data or 'fliers' that were incorporated into the gridded solution, causing the surface to be shoaler or deeper than the true seafloor. Spurious soundings that caused the gridded surface to be shoaler or deeper than the reliably measured seabed by greater than the maximum allowable TVU at that depth, have been rejected, and the surface recomputed.

The NOAA CUBE parameters mandated in HSSD were used for the creation of all CUBE BASE surfaces in Survey H13013.

Refer to the OPR-A366-KR-17 DAPR for a detailed description of the processing flow.

MBES grids were originally submitted by the field unit as 1m, 2m, and 4m finalized depth dependent single resolution grids and were accepted by AHB as meeting specifications during the H13013 RSA. After additional review during the SAR, it was found some grids required additional re-computation and re-finalization due to minor revisions of the sounding data and FFF. The reviewer chose to include data originally covered in the 4m depth range (36 to 80 m) in the 2 m resolution grid to reduce the total number of deliverables. The resulting finalized 2m grid passed density and TVU checks with no issues.

The surface type listed for the H13014_LI_5m_MLLW grid is incorrectly documented as CARIS VR (CUBE). In reality, a CARIS single resolution grid using uncertainty weighting was submitted to the Branch and is the deliverable moving forward. Additionally, the depth range for lidar grid was incorrectly depth thresheld to -3.29 m and has been revised to the local MHW value of -3.336 m.

All grids were submitted by the field unit with a horizontal datum of ITRF2000 (WGS84: G1150) and that projection is maintained for submission to NCEI and MCD.

B.5.3 Hydroffice (QCTools version 2.1.0)

QCTools was used to scan each surface for potential fliers. The Detect fliers utility was initially run allowing the software to estimate heights, and it was also run where the Force flier heights value was set manually. This value varied depending on the resolution of the surface being scanned, which on occasion, yielded several false positives. Each finding from the utility was examined and checked for quality assurance.

The Detect holidays, Grid QA, Scan features, and SBDARE checks were also used for the appropriate surface and feature files.

C. Vertical and Horizontal Control

Multibeam:

Multibeam vertical control for OPR-A366-KR-17 was provided by way of a Tidal Constituent And Residual Interpolation (TCARI) grid based on verified tide data from Portland (8418150), and Bar Harbor (8413320), ME.

During field operations, all sounding data were initially reduced to MLLW using a combination of preliminary and verified tidal data along with a zone definition file (ZDF) that was based on tidal data from the Portland, ME station. This station is owned and operated by NOAA's National Ocean Service (NOS) through the Center for Operational Oceanographic Products and Services (CO-OPS). Preliminary and verified tidal data was assembled by CO-OPS and accessed through NOAA's Tides&Currents website (http://tidesandcurrents.noaa.gov/). A cumulative file for the gauge in use was updated daily by appending the new data as it became available. It should be noted that these unverified tides were used in the field for preliminary processing only.

On October 26, 2017, the final TCARI grid was acquired from CO-OPS and applied to all sounding data using the TCARI GUI (version 16.8) and merged in CARIS HIPS. Verified tidal data were used for all final CUBE Surfaces, soundings, and S-57 Feature files.

LiDAR:

LiDAR vertical control for OPR-A366-KR-17 was GPS-derived. POS files logged during data acquisition on each flight were post-processed using Applanix POSPac SmartBase routine to create a smoothed best estimate of trajectory (SBET) file. Following creation, the SmartBase SBETs were then applied to the data in SHOALS GCS, replacing the real-time GPS navigation position with a post-processed GPS position. The separation model was created with NOAA's VDatum v3.6. This model also allowed for topographic data to be referenced to MLLW through the use of DTM-derived interpolation.

Data was initially referenced to the ITRF00 (WGS84) ellipsoid using the Applanix Smart Base routine. A smoothed best estimate of trajectory (SBET) solution was processed using a network of CORS stations, with MEOW, as control. It should be noted that the LiDAR data was maintained on the ellipsoid during processing.

All depth soundings were eventually reduced to MLLW in CARIS using this Fugro-created VDatum model. Topographic heights detected by LiDAR were also related to MLLW through the same method. The model was applied to the data, using the compute GPS tides utility, and then merged.

Additional information discussing the vertical and horizontal control for this survey can be found in the accompanying HVCR.

C.1 Vertical Control

The vertical datum for this project is Mean Lower Low Water.

Traditional Methods Used:

TCARI

The following National Water Level Observation Network (NWLON) stations served as datum control for this survey:

Station Name	Station ID
Portland, ME	8418150
Bar Harbor	8413320

Table 13: NWLON Tide Stations

There was no Water Level file associated with this survey.

File Name	Status
A366KR2017.tc	Final

Table 14: Tide Correctors (.zdf or .tc)

The field supplied separation model included in the Water_Levels folder (EastPenobscotBay_ITRF00_to_MLLW_50m_mod.txt) was found to not provide coverage over small areas of the H13013 sheet extents due to shortcomings in the Vdatum model. Follow up communication with field unit determined they field unit performed additional interpolation of the model to achieve the desired coverage. This deviation was not documented in the DR or DAPR as required. A copy of the report outlining the deviation has now been included in DR Appendix II.

ERS Methods Used:

ERS via VDATUM

Ellipsoid to Chart Datum Separation File:

Interp_ITRF00_to_MLLW
Interp_ITRF00_to_MHW

Additional information discussing the vertical control for this survey can be found in the accompanying HVCR.

C.2 Horizontal Control

The horizontal datum for this project is ITRF2000 (WGS84: G1150).

The projection used for this project is UTM (Zone 19N).

The following PPK methods were used for horizontal control:

Smart Base

Real-time corrections for both the vessels and aircraft, the POS M/V and A/V were configured to accept Fugro's Marinestar G2 corrections. Marinestar G2 service is a real-time GPS and GLObal Navigation Satellite System (GLONASS) Precise Point Positioning (PPP) service providing refined satellite 'clock and orbit' data to any GNSS receiver with a valid subscription. Signals on the L-band with corrections are broadcasted by geo-stationary satellites and are received by the integrated GNSS/L-band antenna. The unit outputs corrected positions at 1 Hz to the POS units where they are integrated with inertial data, and a position for the top-center of the IMU is generated, providing a horizontal accuracy of 10 cm and a vertical accuracy of 15 cm.

This position was logged concurrently with the bathymetry from WinFrog and the POS file using Fugro Pelagos PosMvLogger for the R/V Theory and R/V Westerly. For the multibeam data, the real-time solution was used for the final positioning and no post-processing was required.

Processed LiDAR point positions for the SHOALS system were derived relative to the ITRF00 datum using a Post Processed Kinematic (PPK) solution where primary control coordinates observed the said datum. LiDAR POS files and IMU inertial data, along with concurrently logged onshore dual-frequency base station (CORS stations) data, were post-processed to create a KGPS SBET file.

Refer to the OPR-A366-KR-17 DAPR for additional details.

The following CORS Stations were used for horizontal control:

HVCR Site ID	Base Station ID
Augusta, ME	MEOW
Waldo, ME	MEWA
Penobscot, ME	PNB6
Bar Harbor, ME	BARH
Truro, MA	MATU
U New Hampshire, NH	NHUN

Table 15: CORS Base Stations

D. Results and Recommendations

D.1 Chart Comparison

A comparison of soundings was accomplished by overlaying the latest edition of the largest scale NOS charts and ENCs onto the final BASE surfaces in CARIS HIPS. An additional check was conducted by gridding the ENC sounding data and differencing the ENC *.csar files against the H13013 *.csar files. The general agreement between the charted soundings and H13013 soundings is noted in the Charts section. A more detailed comparison was undertaken for any charted shoals or other dangerous features and is discussed in the Shoals and Hazardous Features section.

D.1.1 Electronic Navigational Charts

The following are the largest scale ENCs, which cover the survey area:

ENC	Scale	Edition	Update Application Date	Issue Date	Preliminary?
US5ME32M	1:20000	6	09/01/2016	09/01/2016	NO
US5ME31M	1:40000	10	01/24/2017	01/24/2017	NO

Table 16: Largest Scale ENCs

US5ME32M

Chart information displayed is based on OPR-A366-KR-17 Project Instructions, however the charts used for final comparison were downloaded on 30 January 2018.

Given that the survey area was ensonified with 100% multibeam coverage, discrepancies were discovered between the charted and surveyed depths.

Sounding agreement between the H13013 BASE surface depths (surveyed depths) and the charted soundings for all applicable ENC charts was within (+/-) 1 meter. Since the survey area was ensonified with 100% multibeam coverage, discrepancies between charted and surveyed depths were discovered; special attention was given to charted and surveyed depths with a difference greater than 2 meters.

Contours in the area were adequate, but the 100% multibeam coverage established discrepancies between charted and observed contours and require revision from the high-resolution data.

Multibeam:

The item is a charted, 1.2-meter sounding in the general vicinity of (44-11-16) (68-32-53). Survey H13013 had a survey depth of 6.2 meters in that general location, but revealed a depth of 4.4 meters, 75 meters to the west.

The item is a charted, 5.1-meter sounding in the general vicinity of (44-10-38) (68-33-49). Survey H13013 had a survey depth of 8.9 meters in that general location, but revealed a depth of 4.5 meters, 85 meters to the east.

The item is a charted, 7.3-meter sounding in the general vicinity of (44-09-55) (68-33-30). Survey H13013 had a survey depth of 8.6 meters in that general location, but revealed a depth of 4.6 meters, 80 meters to the south east.

The item is a charted, 4.8-meter sounding in the general vicinity of (44-11-40) (68-33-39). Survey H13013 had a survey depth of 8.6 meters in that general location, but revealed a depth of 4.7 meters, 72 meters to the west.

The item is a charted, 11.5-meter sounding in the general vicinity of (44-11-52) (68-32-28). Survey H13013 had a survey depth of 12.3 meters in that general location, but revealed a depth of 4.9 meters, 85 meters to the south.

The item is a charted, 6.4-meter sounding in the general vicinity of (44-11-23) (68-33-39). Survey H13013 had a survey depth of 10.2 meters in that general location, but revealed a depth of 5.8 meters, 72 meters to the south.

The item is a charted, 2.4-meter sounding in the general vicinity of (44-11-05) (68-33-55). Survey H13013 had a survey depth of 7.8 meters in that general location, but revealed a depth of 6.3 meters, 42 meters to the south west.

The item is a charted, 10.6-meter sounding in the general vicinity of (44-11-46) (68-32-43). Survey H13013 had a survey depth of 8.4 meters in that general location, but revealed a depth of 6.3 meters, 25 meters to the east.

The item is a charted, 7-meter sounding in the general vicinity of (44-10-57) (68-33-33). Survey H13013 had a survey depth of 10.9 meters in that general location, but revealed a depth of 6.6 meters, 90 meters to the north.

The item is a charted, 6.4-meter sounding in the general vicinity of (44-10-30) (68-34-06). Survey H13013 had a survey depth of 13.1 meters in that general location, but revealed a depth of 6.6 meters, 101 meters to the north.

The item is a charted, 7.9-meter sounding in the general vicinity of (44-11-32) (68-31-53). Survey H13013 had a survey depth of 14.3 meters in that general location, but revealed a depth of 8 meters, 82 meters to the west.

The item is a charted, 8.8-meter sounding in the general vicinity of (44-11-36) (68-31-48). Survey H13013 had a survey depth of 13.2 meters in that general location, but revealed a depth of 8 meters, 31 meters to the east.

The item is a charted, 10.3-meter sounding in the general vicinity of (44-10-32) (68-34-13). Survey H13013 had a survey depth of 13.9 meters in that general location, but revealed a depth of 8.3 meters, 112 meters to the south east.

The item is a charted, 8.5-meter sounding in the general vicinity of (44-10-17) (68-32-12). Survey H13013 had a survey depth of 14.9 meters in that general location, but revealed a depth of 8.8 meters, 71 meters to the south west.

The item is a charted, 9.7-meter sounding in the general vicinity of (44-08-33) (68-31-32). Survey H13013 had a survey depth of 16.9 meters in that general location, but revealed a depth of 10.8 meters, 112 meters to the east.

The item is a charted, 8.5-meter sounding in the general vicinity of (44-10-13) (68-31-58). Survey H13013 had a survey depth of 13.2 meters in that general location, but revealed a depth of 11.3 meters, 32 meters to the west.

The item is a charted, 14-meter sounding in the general vicinity of (44-09-48) (68-32-53). Survey H13013 had a survey depth of 19 meters in that general location, but revealed a depth of 11.6 meters, 67 meters to the south.

The item is a charted, 16.1-meter sounding in the general vicinity of (44-09-46) (68-31-43). Survey H13013 had a survey depth of 19.6 meters in that general location, but revealed a depth of 12.8 meters, 107 meters to the south east.

The item is a charted, 20.7-meter sounding in the general vicinity of (44-11-30) (68-31-44). Survey H13013 had a survey depth of 17.6 meters in that general location, but revealed a depth of 13.5 meters, 66 meters to the south west.

The item is a charted, 9.1-meter sounding in the general vicinity of (44-10-45) (68-34-25). Survey H13013 had a survey depth of 17.6 meters in that general location, but revealed a depth of 13.9 meters, 60 meters to the east.

The item is a charted, 19.2-meter sounding in the general vicinity of (44-12-10) (68-30-12). Survey H13013 had a survey depth of 24.1 meters in that general location, but revealed a depth of 14.6 meters, 130 meters to the east.

The item is a charted, 25.9-meter sounding in the general vicinity of (44-10-06) (68-31-59). Survey H13013 had a survey depth of 22.4 meters in that general location, but revealed a depth of 19.6 meters, 46 meters to the north.

The item is a charted, 21.3-meter sounding in the general vicinity of (40-09-17) (68-32-08). Survey H13013 had a survey depth of 27.5 meters in that general location, but revealed a depth of 25.3 meters, 53 meters to the west.

The item is a charted, 28.3-meter sounding in the general vicinity of (44-09-35) (68-31-50). Survey H13013 had a survey depth of 31.1 meters in that general location, but revealed a depth of 25.7 meters, 200 meters to the north east.

The item is a charted, 35-meter sounding in the general vicinity of (44-09-01) (68-31-53). Survey H13013 had a survey depth of 29 meters in that general location, but revealed a depth of 26.5 meters, 49 meters to the south west.

The item is a charted, 23.1-meter sounding in the general vicinity of (44-09-29) (68-31-59). Survey H13013 had a survey depth of 30.3 meters in that general location, but revealed a depth of 27.2 meters, 115 meters to the north east.

The item is a charted, 28-meter sounding in the general vicinity of (44-09-14) (68-31-48). Survey H13013 had a survey depth of 32.7 meters in that general location, but revealed a depth of 28.2 meters, 123 meters to the south.

The item is a charted, 1.2-meter sounding in the general vicinity of (44-10-14) (68-32-55). Survey H13013 had a survey depth of 5 meters in that general location. There is, however an islet located 78 meters to the south.

The item is a charted, 9.4-meter sounding in the general vicinity of (44-10-44) (68-32-13). Survey H13013 had a survey depth of 17.4 meters in that general location. The hydrographer recommends replacement.

Lidar:

The item is a charted, 1.5-meter sounding in the general vicinity of (44-11-30) (68-28-28). Survey H13013 had a survey depth of 4.3 meters in that general location.

The Hydrographer recommends that soundings within the survey limits of H13013 supersede all prior survey and charted depths.

US5ME31M

Chart information displayed is based on OPR-A366-KR-17 Project Instructions, however the charts used for final comparison were downloaded on 30 January 2018.

Given that the survey area was ensonified with 100% multibeam coverage, discrepancies were discovered between the charted and surveyed depths.

Sounding agreement between the H13013 BASE surface depths (surveyed depths) and the charted soundings for all applicable ENC charts was within (+/-) 1 meter. Since the survey area was ensonified with 100% multibeam coverage, discrepancies between charted and surveyed depths were discovered; special attention was given to charted and surveyed depths with a difference greater than 2 meters.

Multibeam:

The item is a charted, 4.2-meter sounding in the general vicinity of (44-07-01) (68-26-28). Survey H13013 had a survey depth of 7.6 meters in that general location, but revealed a depth of 4.5 meters, 28 meters to the south.

The item is a charted, 4.5-meter sounding in the general vicinity of (44-10-39) (68-30-36). Survey H13013 had a survey depth of 9.3 meters in that general location, but revealed a depth of 5.8 meters, 85 meters to the north.

The item is a charted, 5.1-meter sounding in the general vicinity of (44-08-08) (68-28-04). Survey H13013 had a survey depth of 12.5 meters in that general location, but revealed a depth of 7.5 meters, 112 meters to the east.

The item is a charted, 5.1-meter sounding in the general vicinity of (44-08-08) (68-28-04). Survey H13013 had a survey depth of 12.5 meters in that general location, but revealed a depth of 7.4 meters, 67 meters to the north.

The item is a charted, 5.1-meter sounding in the general vicinity of (44-07-27) (68-25-51). Survey H13013 had a survey depth of 6.6 meters in that general location, but revealed a depth of 3.8 meters, 53 meters to the north west.

The item is a charted, 5.4-meter sounding in the general vicinity of (44-08-25) (68-30-47). Survey H13013 had a survey depth of 9.1 meters in that general location, but revealed a depth of 5.4 meters, 41 meters to the north east.

The item is a charted, 5.4-meter sounding in the general vicinity of (44-10-46) (68-26-17). Survey H13013 had a survey depth of 6.1 meters in that general location, but revealed a depth of 2.3 meters, 169 meters to the north east.

The item is a charted, 5.4-meter sounding in the general vicinity of (44-07-25) (68-28-13). Survey H13013 had a survey depth of 11.8 meters in that general location, but revealed a depth of 5.9 meters, 22 meters to the east.

The item is a charted, 6-meter sounding in the general vicinity of (44-08-27) (68-29-02). Survey H13013 had a survey depth of 8.8 meters in that general location, but revealed a depth of 5.2 meters, 63 meters to the north.

The item is a charted, 6.4-meter sounding in the general vicinity of (44-08-37) (68-27-34). Survey H13013 had a survey depth of 6.8 meters in that general location, but revealed a depth of 4.7 meters, 32 meters to the south.

The item is a charted, 6.4-meter sounding in the general vicinity of (44-11-07) (6825-31). Survey H13013 had a survey depth of 7.5 meters in that general location, but revealed a depth of 3.7 meters, 80 meters to the south.

The item is a charted, 6.4-meter sounding in the general vicinity of (44-07-59) (68-26-42). Survey H13013 had a survey depth of 11 meters in that general location, but revealed a depth of 6 meters, 42 meters to the north west.

The item is a charted, 6.7-meter sounding in the general vicinity of (44-07-28) (68-26-43). Survey H13013 had a survey depth of 9.4 meters in that general location, but revealed a depth of 6.8 meters, 45 meters to the north.

The item is a charted, 7-meter sounding in the general vicinity of (44-08-13) (68-26-31). Survey H13013 had a survey depth of 8 meters in that general location, but revealed a depth of 4.7 meters, 110 meters to the north.

The item is a charted, 7.3-meter sounding in the general vicinity of (44-06-54) (68-26-25). Survey H13013 had a survey depth of 11.7 meters in that general location, but revealed a depth of 6.8 meters, 28 meters to the north.

The item is a charted, 7.6-meter sounding in the general vicinity of (44-08-51) (68-28-03). Survey H13013 had a survey depth of 7.4 meters in that general location, but revealed a depth of 5.5 meters, 21 meters to the south.

The item is a charted, 8.2-meter sounding in the general vicinity of (44-06-41) (68-28-18). Survey H13013 had a survey depth of 13.9 meters in that general location, but revealed a depth of 8.8 meters, 44 meters to the north east.

The item is a charted, 8.8-meter sounding in the general vicinity of (44-09-25) (68-31-15). Survey H13013 had a survey depth of 14.9 meters in that general location, but revealed a depth of 8.5 meters, 75 meters to the east.

The item is a charted, 9.1-meter sounding in the general vicinity of (44-09-04) (68-28-27). Survey H13013 had a survey depth of 8.5 meters in that general location, but revealed a depth of 5.8 meters, 80 meters to the north west.

The item is a charted, 9.7-meter sounding in the general vicinity of (44-07-26) (68-27-08). Survey H13013 had a survey depth of 14.1 meters in that general location, but revealed a depth of 10.7 meters, 38 meters to the north.

The item is a charted, 10.3-meter sounding in the general vicinity of (44-12-10) (68-30-55). Survey H13013 had a survey depth of 18.8 meters in that general location, but revealed a depth of 14.4 meters, 205 meters to the north.

The item is a charted, 10.3-meter sounding in the general vicinity of (44-12-10) (68-30-54). Survey H13013 had a survey depth of 18.9 meters in that general location, but revealed a depth of 14.4 meters, 204 meters to the north.

The item is a charted, 10.9-meter sounding in the general vicinity of (44-08-41) (68-31-14). Survey H13013 had a survey depth of 15.9 meters in that general location, but revealed a depth of 10.9 meters, 90 meters to the east.

The item is a charted, 11.2-meter sounding in the general vicinity of (44-08-52) (68-27-17). Survey H13013 had a survey depth of 11.5 meters in that general location, but revealed a depth of 7.8 meters, 100 meters to the south east.

The item is a charted, 11.8-meter sounding in the general vicinity of (44-07-01) (68-27-46). Survey H13013 had a survey depth of 15.9 meters in that general location, but revealed a depth of 11.7 meters, 60 meters to the north.

The item is a charted, 12.1-meter sounding in the general vicinity of (44-08-32) (68-30-52). Survey H13013 had a survey depth of 15 meters in that general location, but revealed a depth of 10.4 meters, 11.2 meters to the north east.

The item is a charted, 12.4-meter sounding in the general vicinity of (44-08-10) (68-30-01). Survey H13013 had a survey depth of 15 meters in that general location, but revealed a depth of 12.5 meters, 161 meters to the east.

The item is a charted, 13.1-meter sounding in the general vicinity of (44-09-54) (68-30-37). Survey H13013 had a survey depth of 18.1 meters in that general location, but revealed a depth of 11.7 meters, 143 meters to the south east.

The item is a charted, 13.3-meter sounding in the general vicinity of (44-06-48) (68-26-32). Survey H13013 had a survey depth of 16.9 meters in that general location, but revealed a depth of 11.2 meters, 144 meters to the north east.

The item is a charted, 13.7-meter sounding in the general vicinity of (44-11-01) (68-30-56). Survey H13013 had a survey depth of 26 meters in that general location, but revealed a depth of 18.5 meters, 110 meters to the east.

The item is a charted, 14-meter sounding in the general vicinity of (44-07-21) (68-26-57). Survey H13013 had a survey depth of 16.7 meters in that general location, but revealed a depth of 13.1 meters, 45 meters to the south west.

The item is a charted, 14.1-meter sounding in the general vicinity of (44-09-27) (68-30-11). Survey H13013 had a survey depth of 19 meters in that general location, but revealed a depth of 14.1 meters, 70 meters to the east.

The item is a charted, 14.3-meter sounding in the general vicinity of (44-09-27) (68-30-10). Survey H13013 had a survey depth of 19 meters in that general location, but revealed a depth of 15.8 meters, 65 meters to the south east.

The item is a charted, 15-meter sounding in the general vicinity of (44-11-45) (68-31-27). Survey H13013 had a survey depth of 18.2 meters in that general location, but revealed a depth of 14.5 meters, 122 meters to the east.

The item is a charted, 15.2-meter sounding in the general vicinity of (44-11-45) (68-31-27). Survey H13013 had a survey depth of 18.3 meters in that general location, but revealed a depth of 14.4 meters, 125 meters to the east.

The item is a charted, 15.5-meter sounding in the general vicinity of (44-09-06) (68-30-49). Survey H13013 had a survey depth of 17.9 meters in that general location, but revealed a depth of 15.6 meters, 55.6 meters to the south west.

The item is a charted, 16.1-meter sounding in the general vicinity of (44-08-51) (68-31-11). Survey H13013 had a survey depth of 20.4 meters in that general location, but revealed a depth of 15.5 meters, 87 meters to the west.

The item is a charted, 16.7-meter sounding in the general vicinity of (44-11-55) (68-31-12). Survey H13013 had a survey depth of 19.3 meters in that general location, but revealed a depth of 13.8 meters, 177 meters to the north.

The item is a charted, 16.7-meter sounding in the general vicinity of (44-11-55) (68-31-12). Survey H13013 had a survey depth of 19.3 meters in that general location, but revealed a depth of 14.1 meters, 202 meters to the north.

The item is a charted, 17.3-meter sounding in the general vicinity of (44-09-22) (68-30-46). Survey H13013 had a survey depth of 19.7 meters in that general location, but revealed a depth of 15.5 meters, 85 meters to the west.

The item is a charted, 17.3-meter sounding in the general vicinity of (44-09-19) (68-31-08). Survey H13013 had a survey depth of 20.7 meters in that general location, but revealed a depth of 19.6 meters, 25 meters to the west.

The item is a charted, 17.3-meter sounding in the general vicinity of (44-09-22) (68-30-46). Survey H13013 had a survey depth of 19.7 meters in that general location, but revealed a depth of 16.4 meters, 105 meters to the west.

The item is a charted, 17.9-meter sounding in the general vicinity of (44-10-00) (68-31-29). Survey H13013 had a survey depth of 21.5 meters in that general location, but revealed a depth of 17.7 meters, 185 meters to the south.

The item is a charted, 18.2-meter sounding in the general vicinity of (44-10-07) (68-30-45). Survey H13013 had a survey depth of 20.5 meters in that general location, but revealed a depth of 17.7 meters, 80 meters to the south.

The item is a charted, 23.7-meter sounding in the general vicinity of (44-09-04) (68-31-14). Survey H13013 had a survey depth of 26.4 meters in that general location, but revealed a depth of 21.4 meters, 139 meters to the south west.

The item is a charted, 25.6-meter sounding in the general vicinity of (44-10-36) (68-31-10). Survey H13013 had a survey depth of 28.6 meters in that general location, but revealed a depth of 23.4 meters, 115 meters to the north east.

The item is a charted, 25.9-meter sounding in the general vicinity of (44-06-15) (68-26-54). Survey H13013 had a survey depth of 30.7 meters in that general location, but revealed a depth of 23.1 meters, 80 meters to the north west.

The Hydrographer recommends that soundings within the survey limits of H13013 supersede all prior survey and charted depths.

D.1.2 Maritime Boundary Points

No Maritime Boundary Points were assigned for this survey.

D.1.3 Charted Features

All charted features were included in the assigned features of the Composite Source File and are addressed in the final feature file (FFF).

D.1.4 Uncharted Features

No uncharted features exist for this survey.

D.1.5 Shoal and Hazardous Features

The following DTON reports were submitted:

DTON Report Name	Date Submitted
H13013_DTON_Report_1	09-20-2017
H13013_DTON_Report_2	09-27-2017

Dangers to Navigation (DTON's) are included in the FFF and have images associated with them. The DTON files listed above were submitted to MCD via AHB are included in Appendix II.

A comparison of soundings was accomplished by overlaying the latest edition of the largest scale NOS charts and ENCs onto the final BASE surfaces in CARIS HIPS. An additional check was conducted by gridding the ENC sounding data and differencing the ENC *.csar files against the H13013 *.csar files. The results from this method highlight areas that differed and warranted extra attention. A unique color range pallet was developed to highlight these areas, for example, if the agreement was +/- 2 meters, the difference surface was colored green. Areas greater than +/- 2 meters were colored orange and red was used for extreme differences.

The following are shoal features that differed, but did not warrant a danger to navigation submittal. Other Shoals and Hazardous Features exist in the survey area and were submitted as dangers to navigation; a total of 13 dangers were accepted by AHB.

Chart:
ENC No.: US5ME32M

Multibeam:

The item is a charted, 7.6-meter sounding in the general vicinity of (44-10-15) (68-32-50). Survey H13013 had a survey depth of 8.1 meters in that general location, but revealed a depth of 0.8 meters, 100 meters to the south.

The item is a charted, 3.3-meter sounding in the general vicinity of (44-11-05) (68-33-49). Survey H13013 had a survey depth of 5.9 meters in that general location, but revealed a depth of 0.9 meters, 62 meters to the east.

The item is a charted, 1.1-meter sounding in the general vicinity of (44-10-09) (68-32-46). Survey H13013 had a survey depth of 8.9 meters in that general location, but revealed a depth of 1.1 meters, 130 meters to the north west.

The item is a charted, 4.5-meter sounding in the general vicinity of (44-11-04) (68-32-32). Survey H13013 had a survey depth of 5 meters in that general location, but revealed a depth of 1.4 meters, 114 meters to the south east.

The item is a charted, 3.3-meter sounding in the general vicinity of (44-11-09) (68-34-31). Survey H13013 had a survey depth of 3.7 meters in that general location, but revealed a depth of 1.5 meters, 45 meters to the south west.

The item is a charted, 3.3-meter sounding in the general vicinity of (44-11-09) (68-34-31). Survey H13013 had a survey depth of 3.7 meters in that general location, but revealed a depth of 1.5 meters, 51 meters to the south.

The item is a charted, 0.6-meter sounding in the general vicinity of (44-11-08) (68-44-37). Survey H13013 had a survey depth of 3.4 meters in that general location, but revealed a depth of 1.6 meters, 85 meters to the east.

The item is a charted, 2.7-meter sounding in the general vicinity of (44-11-11) (68-26-47). Survey H13013 had a survey depth of 2.9 meters in that general location, but revealed a depth of 1.7 meters, 130 meters to the east.

The item is a charted, 1.8-meter sounding in the general vicinity of (44-11-10) (68-34-21). Survey H13013 had a survey depth of 4.4 meters in that general location, but revealed a depth of 1.8 meters, 38 meters to the south west.

The item is a charted, 7.9-meter sounding in the general vicinity of (44-11-31) (68-33-33). Survey H13013 had a survey depth of 6.5 meters in that general location, but revealed a depth of 1.9 meters, 61 meters to the north.

The item is a charted, 4.5-meter sounding in the general vicinity of (44-11-04) (68-34-37). Survey H13013 had a survey depth of 4.7 meters in that general location, but revealed a depth of 2 meters, 31 meters to the east.

The item is a charted, 12.4-meter sounding in the general vicinity of (44-10-56) (68-34-34). Survey H13013 had a survey depth of 12.5 meters in that general location, but revealed a depth of 2 meters, 95 meters to the north.

The item is in the general vicinity of (44-10-58.87) (68-34-33.66). Survey H13013 had a survey depth of 2.1 meters in that general location.

The item is a charted, 4.5-meter sounding in the general vicinity of (44-11-04) (68-34-37). Survey H13013 had a survey depth of 4.7 meters in that general location, but revealed a depth of 2.2 meters, 28 meters to the east.

The item is a charted, 4.8-meter sounding in the general vicinity of (44-11-10) (68-26-57). Survey H13013 had a survey depth of 5.3 meters in that general location, but revealed a depth of 2.7 meters, 45 meters to the south.

The item is a charted, 3.9-meter sounding in the general vicinity of (44-10-59) (68-33-02). Survey H13013 had a survey depth of 7.1 meters in that general location, but revealed a depth of 3.2 meters, 186 meters to the south east.

The item is a charted, 5.1-meter sounding in the general vicinity of (44-11-07) (68-34-05). Survey H13013 had a survey depth of 5.6 meters in that general location, but revealed a depth of 3.4 meters, 85 meters to the south west.

Lidar:

The item is a charted, 2.1-meter sounding in the general vicinity of (44-10-05) (68-33-38). Survey H13012 had a survey depth of 6.1 meters in that general location, but revealed a depth of 1.6 meters, 20 meters to the north east.

The item is a charted, 0.6-meter sounding in the general vicinity of (44-11-21) (68-28-23). Survey H13012 had a survey depth of 3.3 meters in that general location, but revealed a depth of 1.1 meters, 63 meters to the north east.

ENC No.: US5ME31M

Multibeam:

The item is a charted, 0.9-meter sounding in the general vicinity of (44-07-33) (68-26-07). Survey H13013 had a survey depth of 4 meters in that general location, but revealed a depth of 0.4 meters, 28 meters to the north east.

The item is a charted, 0.9-meter sounding in the general vicinity of (44-07-33) (68-26-07). Survey H13013 had a survey depth of 4 meters in that general location, but revealed a depth of 1 meters, 31 meters to the north east.

The item is a charted, 1.2-meter sounding in the general vicinity of (44-10-41) (68-26-18). Survey H13013 had a survey depth of 6.1 meters in that general location, but revealed a depth of 2.1 meters, 23 meters to the north.

The item is a charted, 1.2-meter sounding in the general vicinity of (44-07-40) (68-25-53). Survey H13013 had a survey depth of 5.7 meters in that general location, but revealed a depth of 1.4 meters, 33 meters to the north.

The item is a charted, 1.2-meter sounding in the general vicinity of (44-10-32) (68-25-35). Survey H13013 had a survey depth of 4.7 meters in that general location, but revealed a depth of 1.4 meters, 41 meters to the east.

The item is a charted, 1.8-meter sounding in the general vicinity of (44-10-58) (68-25-33). Survey H13013 had a survey depth of 5.1 meters in that general location, but revealed a depth of 2.1 meters, 24 meters to the east.

The item is a charted, 2.4-meter sounding in the general vicinity of (44-07-47) (68-26-06). Survey H13013 had a survey depth of 5.3 meters in that general location, but revealed a depth of 2.2 meters, 26 meters to the east.

The item is a charted, 2.4-meter sounding in the general vicinity of (44-10-09) (68-29-34). Survey H13013 had a survey depth of 9.9 meters in that general location, but revealed a depth of 0.8 meters, 91 meters to the south.

The item is a charted, 2.4-meter sounding in the general vicinity of (44-07-48) (68-26-06). Survey H13013 had a survey depth of 5.3 meters in that general location, but revealed a depth of 2.6 meters, 24 meters to the east.

The item is a charted, 2.4-meter sounding in the general vicinity of (44-07-10) (68-29-29). Survey H13013 had a survey depth of 5.6 meters in that general location, but revealed a depth of 2.3 meters, 32 meters to the south.

The item is a charted, 2.7-meter sounding in the general vicinity of (44-10-28) (68-25-45). Survey H13013 had a survey depth of 5.3 meters in that general location, but revealed a depth of 3.3 meters, 39 meters to the south east.

The item is a charted, 3.3-meter sounding in the general vicinity of (44-10-21) (68-29-15). Survey H13013 had a survey depth of 10 meters in that general location, but revealed a depth of 2.9 meters, 81 meters to the south east.

The item is a charted, 4.2-meter sounding in the general vicinity of (44-10-33) (68-28-46). Survey H13013 had a survey depth of 6.1 meters in that general location, but revealed a depth of 1.9 meters, 88 meters to the south east.

Lidar:

The item is a charted, 4.2-meter sounding in the general vicinity of (44-10-00) (68-28-56). Survey H13013 had a survey depth of 1.5 meters in that general location, but revealed a depth of 0.3 meters, 94 meters to the south west.

The item is a charted, 0.9-meter sounding in the general vicinity of (44-10-05) (68-28-51). Survey H13013 had a survey depth of 3.2 meters in that general location, but revealed a depth of 2.1 meters, 74 meters to the north east.

The item is a charted, 2.1-meter sounding in the general vicinity of (44-09-31) (68-27-37). Survey H13013 had a survey depth of 4.2 meters in that general location, but revealed a depth of 1.7 meters, 68 meters to the north.

The item is a charted, 0.6-meter sounding in the general vicinity of (44-08-46) (68-26-45). Survey H13013 had a survey depth of 2.6 meters in that general location, but revealed a depth of 0.9 meters, 71 meters to the north.

The item is a charted, 1.5-meter sounding in the general vicinity of (44-11-11) (68-26-18). Survey H13013 had a survey depth of 3.9 meters in that general location, but revealed a depth of 1.9 meters, 37 meters to the north.

The item is a charted, 0.9-meter sounding in the general vicinity of (44-07-33) (68-26-07). Survey H13013 had a survey depth of 3.4 meters in that general location, but revealed a depth of 1 meters, 42 meters to the north.

The item is a charted, 1.2-meter sounding in the general vicinity of (44-07-40) (68-25-53). Survey H13013 had a survey depth of 6.1 meters in that general location, but revealed a depth of 1.5 meters, 35 meters to the north.

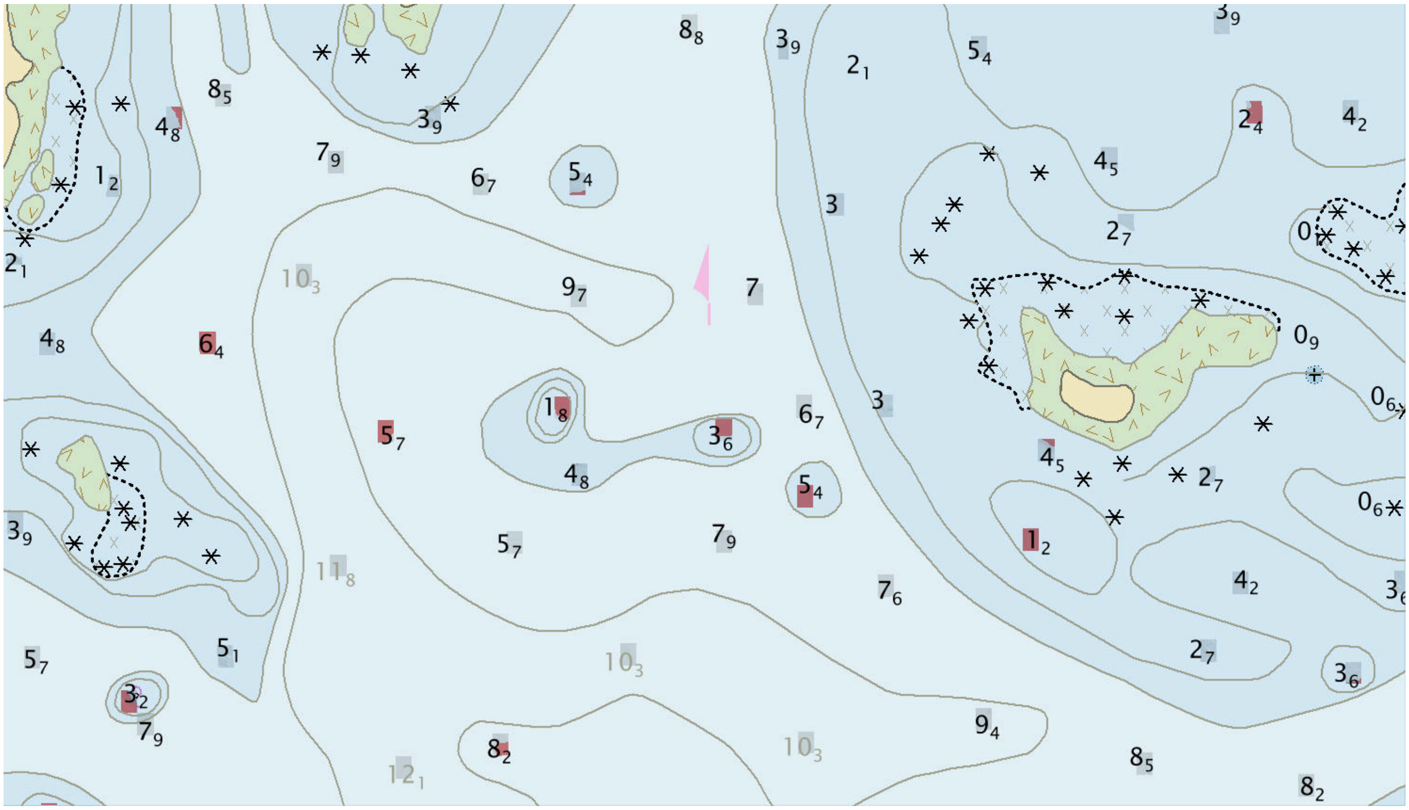

Figure 41: Sample of difference surface of H13013 and ENC

D.1.6 Channels

No channels exist for this survey. There are no designated anchorages, precautionary areas, safety fairways, traffic separation schemes, pilot boarding areas, or channel and range lines within the survey limits.

D.1.7 Bottom Samples

Samples were taken with a Van Veen grab sampler and positions and information were recorded with WinFrog Multibeam and CARIS Notebook 3.1. Samples retrieved were analyzed and then encoded with the appropriate S-57 attributes. Positions and descriptions of bottom samples for survey H13013 are found in the “H13013_FFF.000” file.

No SBDARE items were in the CSF, therefore were not investigated during field operations. Bottom samples were conducted in accordance with the project instructions and HSSD 2017. All 14 samples were discarded after the sample information was recorded.

D.2 Additional Results

D.2.1 Shoreline

Limited shoreline verification was conducted using the composite source file (CSF). All features with the attribute ‘asgnmt’ were address and can be found in the final feature file (FFF).

D.2.2 Prior Surveys

No prior survey comparisons exist for this survey.

D.2.3 Aids to Navigation

There were no Aids to Navigation (ATONs) specifically assigned for this project, but all ATONs within the survey limits were verified and serve their intended purpose, and are noted in the final feature file (FFF).

D.2.4 Overhead Features

No overhead features exist for this survey.

D.2.5 Submarine Features

The only submarine feature within the limits of H13013 was an existing cable, which was located within the charted Cable Area. Portions of the charted Cable Area within the limits of H13013 were surveyed with 100% MB coverage. The cable trench is not apparent in the final surfaces. Refer to the following graphics.

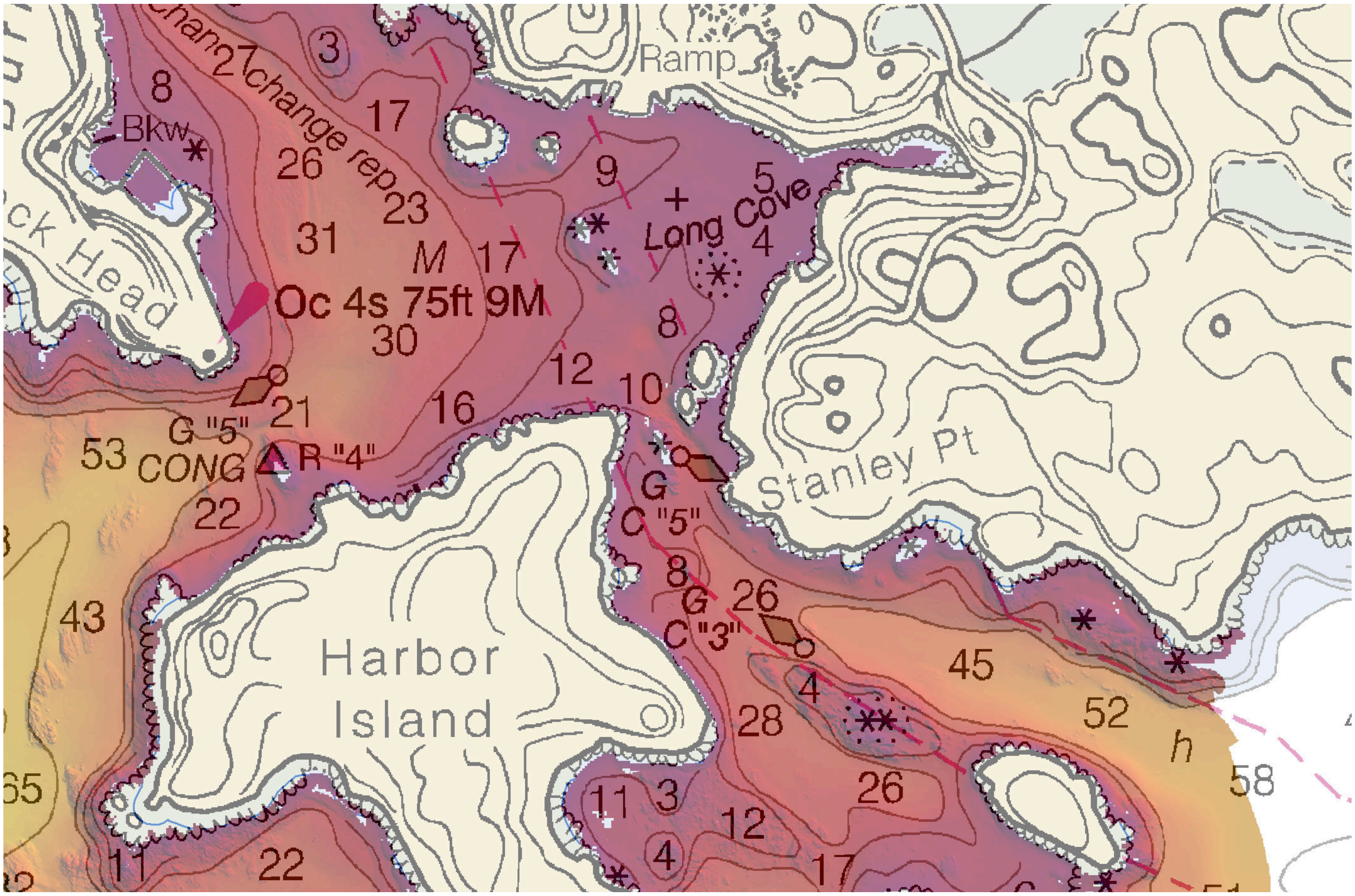

Figure 42: Existing Cable Area 1 in H13013

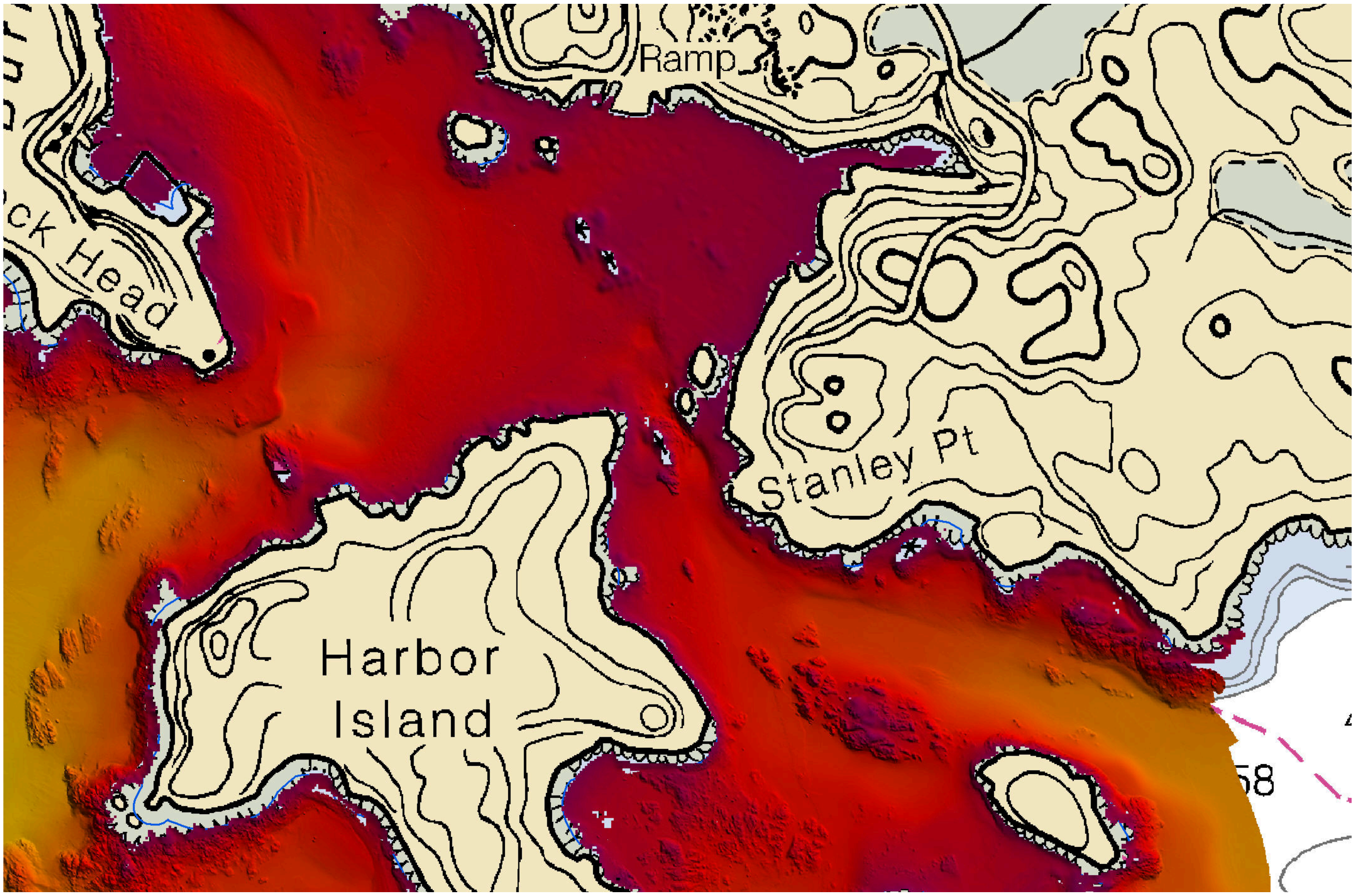

Figure 43: Coverage of Cable Area 1 in H13013

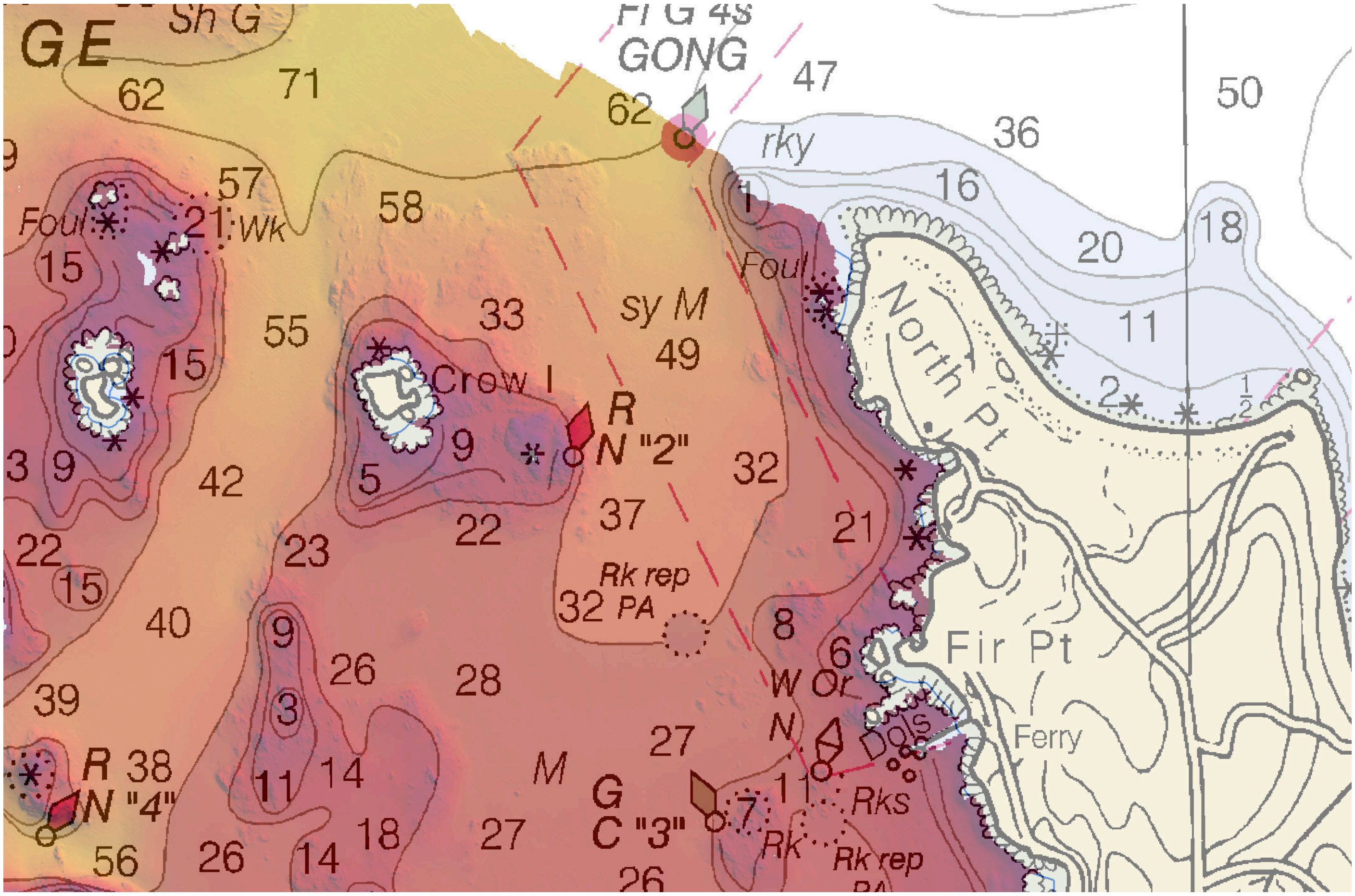

Figure 44: Existing Cable Area in 2 H13013

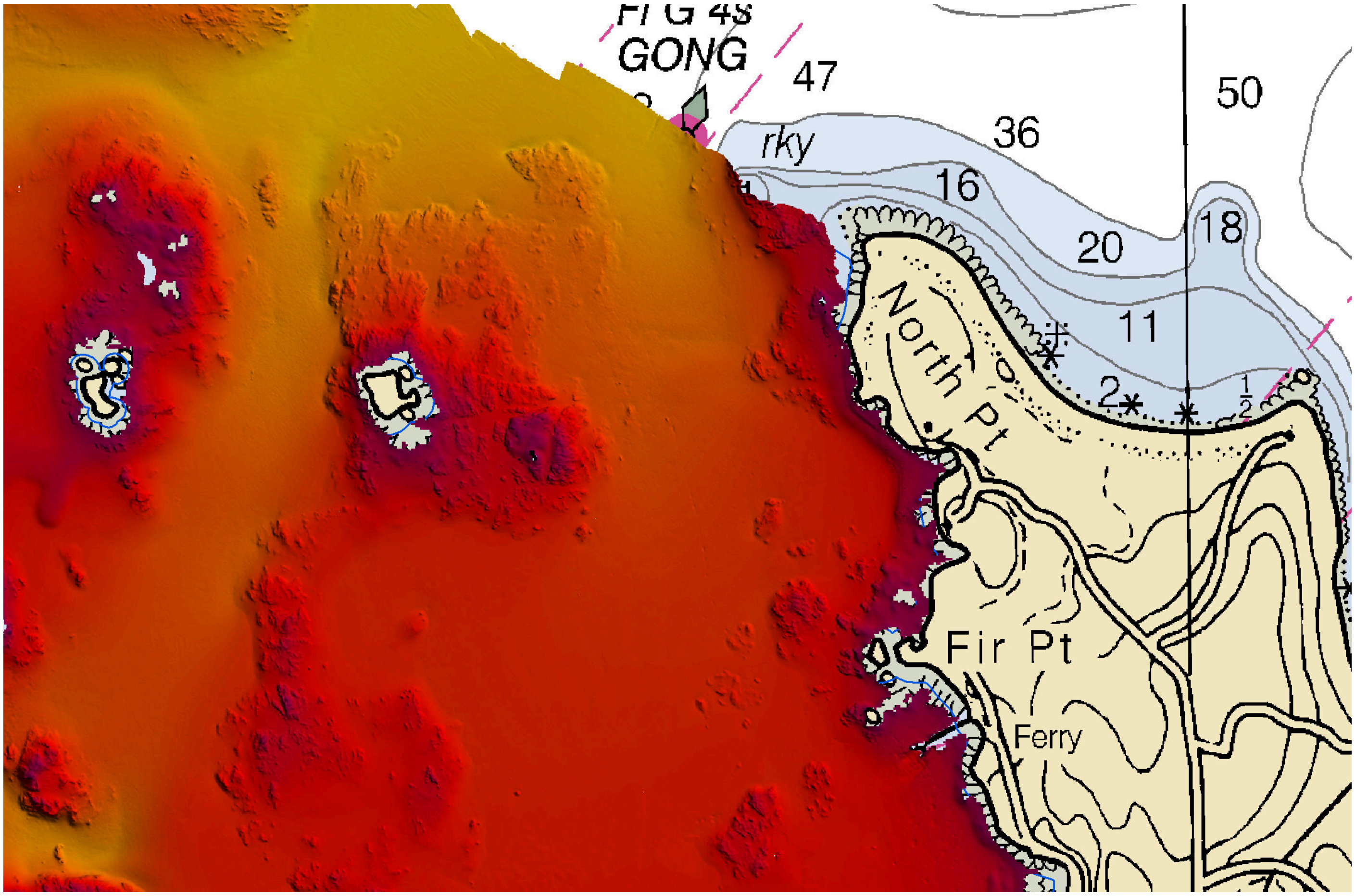

Figure 45: Coverage of Cable Area 2 in H13013

D.2.6 Platforms

No platforms exist for this survey.

D.2.7 Ferry Routes and Terminals

No ferry routes or terminals exist for this survey.

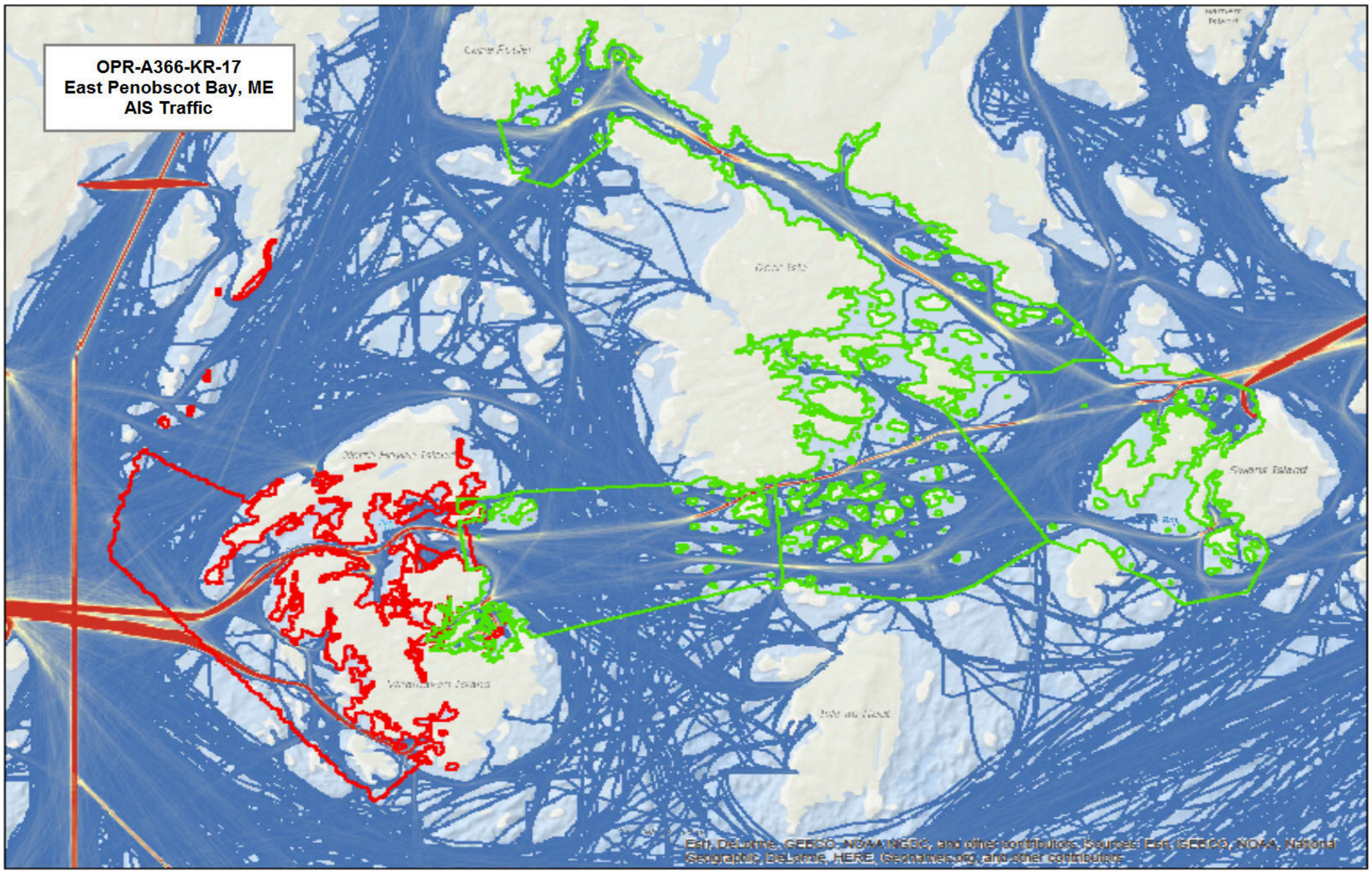

Figure 46: AIS Traffic in H13013

D.2.8 Abnormal Seafloor and/or Environmental Conditions

Abnormal seafloor and/or environmental conditions were not observed for this survey.

D.2.9 Construction and Dredging

No present or planned construction or dredging exist within the survey limits.

D.2.10 New Survey Recommendation

No new surveys or further investigations are recommended for this area.

D.2.11 Final Features File

Fugro conducted limited shoreline verification using the CSF. All features with the assigned attribute were addressed in accordance with the HSSD 2017. There were a total of 702 assigned features (which included the Charted Features) in the CSF provided by NOAA. All features were addressed as required with S-57 attribution and recorded in the H13013 FFF to best represent the features at chart scale.

Features that do not exist or were determined to be a duplicate were given a “delete” value in the “descrp” attribute. Features that were positioned incorrectly were also given the “delete” value in the “descrp” attribute, and a new feature with a “new” value in the “descrp” attribute was added in its correct location. The “primsec” field was used to distinguish deleted features from newly positioned features. For survey H13013, most of the assigned features were verified or identified in the LiDAR bathy data or ortho-mosaic. These items were labelled with “LiDAR investigations” in the “Special Feature Type” attribute. The TECSOU field was populated with the “found by multi-beam attribute” for any feature verified by multibeam.

To determine the VALSOU or ELEVAT for features investigated by LiDAR, the National VDatum software developed by NOAA was used to reduce LiDAR data to MLLW. LiDAR data was then clipped to the extents of each of the survey priorities and overlaid with Fugro-acquired ortho-imagery and assigned CSF features. The LiDAR grid was then used to determine the VALSOU attribute using the height or depth on the actual features and not the height or depth of the corresponding assigned CSF features. In order to determine which features should be considered islets, a difference surface corresponding to mean high water (MHW) was created for all survey priorities. Islet elevations were derived by taking the difference between the highest SHOALS topo point and the MHW grid. See the NOS HSSD 2017, Appendix F. WATLEV Attribution encoding guidelines were used for determining points above and below MHW.

Riegl data was acquired simultaneously with the SHOALS dataset during the LiDAR reconnaissance survey for the 2017 survey. This data was used to help verify the assigned features along with the SHOALS data and Ortho-Imagery. The Riegl dataset is broken into two classes or layers: a class zero; which is data above the water surface at the time of collection, and class twenty-six; which is data below the water surface at the time of collection. Both classes were reduced to MLLW using a VDatum grid in the same manner as the SHOALS data set. The Riegl data were only cleaned in areas the Riegl was used as the source for the new VALSOU attribute in UWTROC and Obstruction features. Due to the multiple classes the VALSOU could have been taken from either the class zero or class twenty-six. These features (features derived from the Riegl) are specifically labeled in the office notes and contain, but were not limited to the following phrases: “DS – Riegl” or “DS - Riegl - Rock not seen in SHOALS data”, etc. Riegl data provided a more detailed reference for feature attribution, particularly in extremely shallow areas. Where possible, SHOALS data was given priority, except in situations where it was determined that the SHOALS system was not the best source for the feature development, either due to a positional or water level difference with the original feature, or because it was determined that the SHOALS data was not the best source of the least depth. These situations are clearly marked in the office notes.

Assigned seabed areas were updated to follow the Zero contour as created from the SHOALS LiDAR surface. Riegl data was used to assist this function, particularly in the very shallow near shore tidal areas.

All images if not shown with a color scale bar use the following scale bar to attribute features visually for water level. Tan is always uncovered based on a -3.53 limit against MLLW, Grey covers and uncovers with values -0.305 to -3.353, awash is pink with values -0.305 to 0.305; everything deeper than this value is rainbow, tiered down to blue at five meters, then changing to purple for the remainder of the data.

The final S-57 file for this project is called "H13013_FFF.000". This file contains the object and metadata S-57 objects as required in the HSSD 2017.

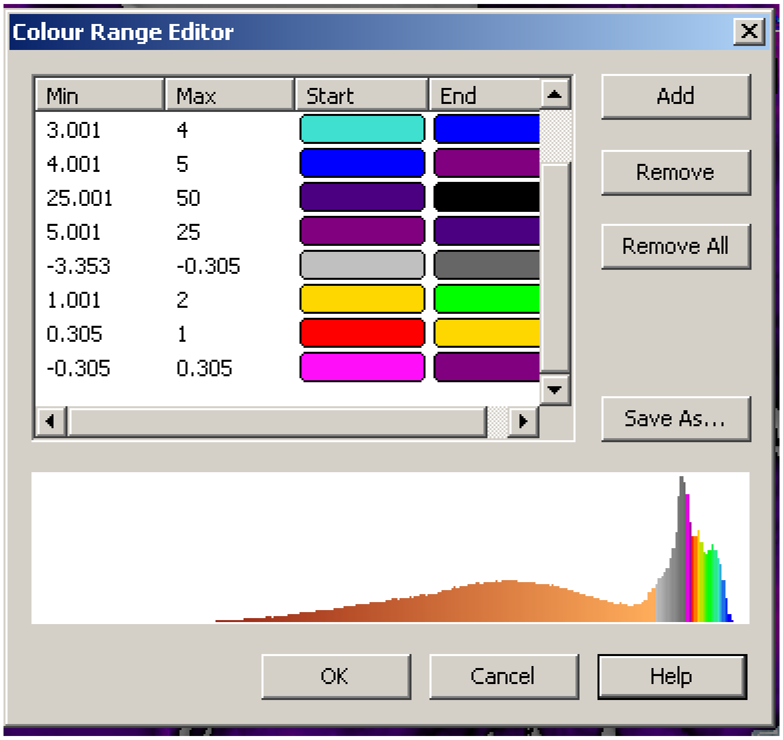

Figure 47: H13013 Scale bar representing water levels

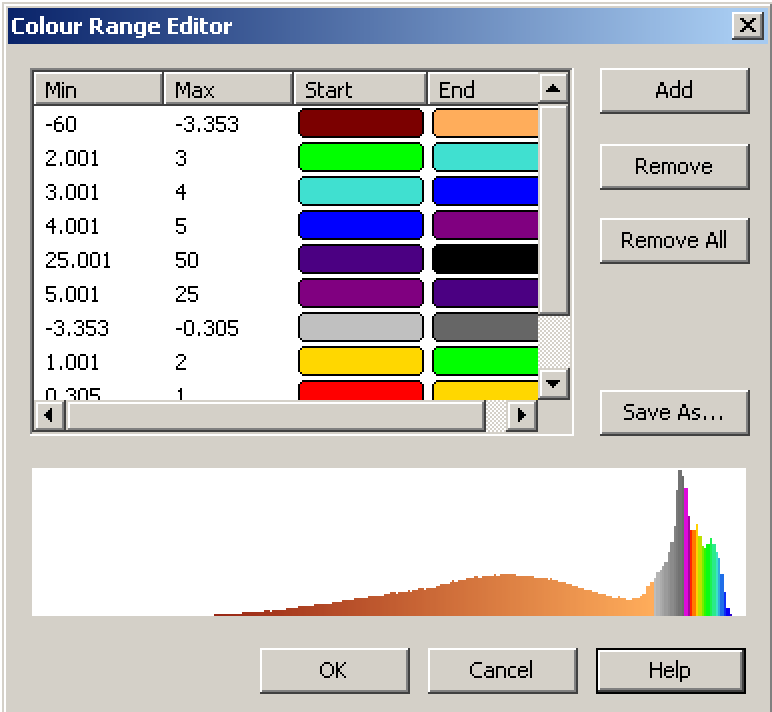

Figure 48: H13013 Scale bar representing water levels

D.2.12 Inset Recommendation

No new insets are recommended for this area.

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 to the Processing Branch.

The survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys and Specifications Deliverables, Field Procedures Manual, Letter Instructions, and all HSD Technical Directives. These 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 deficiencies noted in the Descriptive Report.

Report Name	Report Date Sent
Data Acquisition and Processing Report	2018-05-01
Horizontal and Vertical Control Report	2018-02-22
Coast Pilot Report	2018-02-21

Approver Name	Approver Title	Approval Date	Signature
Dean Moyles	Senior Hydrographer (ACSM Cert. No. 226)	05/01/2018	Moyles, Dean Digitally signed by Moyles, Dean DN: dc=com, dc=fugro, l=america, ou=fpi, ou=people_fpi, 0.9.2342.19200300.100.1.1=moylesd, cn=Moyles, Dean, email=dmoyles@fugro.com Date: 2018.05.01 18:00:56 -02'30'

F. Table of Acronyms

Acronym	Definition
AHB	Atlantic Hydrographic Branch
AST	Assistant Survey Technician
ATON	Aid to Navigation
AWOIS	Automated Wreck and Obstruction Information System
BAG	Bathymetric Attributed Grid
BASE	Bathymetry Associated with Statistical Error
CO	Commanding Officer
CO-OPS	Center for Operational Products and Services
CORS	Continually Operating Reference Staiton
CTD	Conductivity Temperature Depth
CEF	Chart Evaluation File
CSF	Composite Source File
CST	Chief Survey Technician
CUBE	Combined Uncertainty and Bathymetry Estimator
DAPR	Data Acquisition and Processing Report
DGPS	Differential Global Positioning System
DP	Detached Position
DR	Descriptive Report
DTON	Danger to Navigation
ENC	Electronic Navigational Chart
ERS	Ellipsoidal Referenced Survey
ERZT	Ellipsoidally Referenced Zoned Tides
FFF	Final Feature File
FOO	Field Operations Officer
FPM	Field Procedures Manual
GAMS	GPS Azimuth Measurement Subsystem
GC	Geographic Cell
GPS	Global Positioning System
HIPS	Hydrographic Information Processing System
HSD	Hydrographic Surveys Division
HSSD	Hydrographic Survey Specifications and Deliverables

Acronym	Definition
HSTP	Hydrographic Systems Technology Programs
HSX	Hypack Hysweep File Format
HTD	Hydrographic Surveys Technical Directive
HVCR	Horizontal and Vertical Control Report
HVF	HIPS Vessel File
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
ITRF	International Terrestrial Reference Frame
LNM	Linear Nautical Miles
MCD	Marine Chart Division
MHW	Mean High Water
MLLW	Mean Lower Low Water
NAD 83	North American Datum of 1983
NAIP	National Agriculture and Imagery Program
NALL	Navigable Area Limit Line
NM	Notice to Mariners
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NRT	Navigation Response Team
NSD	Navigation Services Division
OCS	Office of Coast Survey
OMAO	Office of Marine and Aviation Operations (NOAA)
OPS	Operations Branch
MBES	Multibeam Echosounder
NWLON	National Water Level Observation Network
PDBS	Phase Differencing Bathymetric Sonar
PHB	Pacific Hydrographic Branch
POS/MV	Position and Orientation System for Marine Vessels
PPK	Post Processed Kinematic
PPP	Precise Point Positioning
PPS	Pulse per second
PRF	Project Reference File

Acronym	Definition
PS	Physical Scientist
PST	Physical Science Technician
RNC	Raster Navigational Chart
RTK	Real Time Kinematic
SBES	Singlebeam Echosounder
SBET	Smooth Best Estimate and Trajectory
SNM	Square Nautical Miles
SSS	Side Scan Sonar
ST	Survey Technician
SVP	Sound Velocity Profiler
TCARI	Tidal Constituent And Residual Interpolation
TPE	Total Propagated Error
TPU	Topside Processing Unit
USACE	United States Army Corps of Engineers
USCG	United Stated Coast Guard
UTM	Universal Transverse Mercator
XO	Executive Officer
ZDA	Global Positiong System timing message
ZDF	Zone Definition File

UNITED STATES DEPARMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Silver Spring, Maryland 20910

PROVISIONAL TIDE NOTE FOR HYDROGRAPHIC SURVEY

DATE : October 16, 2017

HYDROGRAPHIC BRANCH: Atlantic
HYDROGRAPHIC PROJECT: OPR-A366-KR-2017
HYDROGRAPHIC SHEET: H13014
LOCALITY: Eggemoggin Reach, Penobscot Bay, ME
TIME PERIOD: July 12 - October 7, 2017

TIDE STATION USED: 841-3320 Bar Harbor, ME
Lat. 44° 23.5'N Long. 68° 12.3' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 3.336 meters

TIDE STATION USED: 841-8150 Portland, ME
Lat. 43° 39.4'N Long. 70° 14.8' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 2.886 meters

REMARKS: RECOMMENDED GRID Please use the TCARI grid "A366KR2017.tc" as the final grid for project OPR-A366-KR-2017, H13014, during the period between July 12 and October 7, 2017.

Refer to attachments for zoning information.

Note 1: Provided time series data are tabulated in metric units(meters), relative to MLLW and on Greenwich Mean Time on the 1983-2001 National Tidal Datum Epoch (NTDE).

Note 2: Annual leveling for Porltand, ME (841-8150) was not completed in FY17. A review of the verified leveling records from October 2006 to 2016 shows the tide station benchmark network to be stable within an allowable 0.009 m tolerance. This Tide Note may be used as final stability verification for survey OPR-A366-KR-2017, H13014. CO-OPS will immediately provide a revised Tide Note should subsequent leveling records indicate any benchmark network stability movement beyond the allowable 0.009 m tolerance.

HOVIS.GERALD.THOMAS.JR.1365860250

Digitally signed by HOVIS.GERALD.THOMAS.JR.1365860250
Date: 2017.10.19 13:09:14 -04'00'

CHIEF, PRODUCTS AND SERVICES BRANCH

From:	OCS NDB - NOAA Service Account
To:	Castle E Parker
Cc:	Briana Welton; Kathryn Pridgen - NOAA Federal; Corey Allen; Moyles, Dean; David Vejar - NOAA Federal; Emily Clark - NOAA Federal; _NOS OCS PBA Branch; _NOS OCS PBB Branch; _NOS OCS PBC Branch; _NOS OCS PBD Branch; _NOS OCS PBE Branch; _NOS OCS PBG Branch; James M Crocker; Matt Kroll; NSD Coast Pilot; Pearce Hunt; PHB Chief; Tara Wallace
Subject:	Fwd: H13013 DtoN #1 Submission to NDB
Date:	Friday, September 22, 2017 6:52:59 PM
Attachments:	H13013_DtoN_1.zip

DD-28815 has been registered by the Nautical Data Branch and directed to Products Branch C for processing.

The DtoNs reported are several shoal soundings in Penobscot Bay, ME, in the vicinity of Swans Island.

The following charts are affected:
13315 kapp 2013

13313 kapp 2015

13316 kapp 2011

13312 kapp 2016

The following ENCs are affected:

US5ME32M

US5ME31M

US4ME30M

References:
H13013
OPR-A366-KR-17

This information was discovered by a NOAA contractor and was submitted by AHB.

Nautical Data Branch/Marine Chart Division/
Office of Coast Survey/National Ocean Service/
Contact: ocs.ndb@noaa.gov

---------- Forwarded message ----------
From: **Castle Parker - NOAA Federal** <castle.e.parker@noaa.gov>
Date: Thu, Sep 21, 2017 at 1:13 PM
Subject: H13013 DtoN #1 Submission to NDB
To: OCS NDB - NOAA Service Account <ocs.ndb@noaa.gov>
Cc: Briana Hillstrom - NOAA Federal <Briana.Hillstrom@noaa.gov>, Kathryn Pridgen - NOAA Federal <kathryn.pridgen@noaa.gov>, Corey Allen - NOAA Federal <corey.allen@noaa.gov>, "Moyles, Dean" <dmoyles@fugro.com>, David Vejar - NOAA Federal <david.vejar@noaa.gov>, Emily Clark - NOAA Federal <emily.clark@noaa.gov>

Good day,

Please find attached zip file associated with survey H13013 DtoN #1 for submission to Nautical Data Branch (NDB) and Marine Chart Division (MCD). This danger submission contains thirteen shoal depths that warrant chart application.

The information attached originates from NOAA contract field unit and was submitted to the Atlantic Hydrographic Branch (AHB) for review and processing. The contents of the attached WinZip file were generated at AHB. The attached zip file contains a DtoN Letter (PDF), associated image files, and a Pydro XML file.

If you have any questions, please direct them back to me via email or phone 757-364-7472.

Thank you for your assistance with this matter.

Regards,

Gene Parker

Castle Eugene Parker

NOAA Office of Coast Survey

Atlantic Hydrographic Branch

Hydrographic Team Lead / Physical Scientist

castle.e.parker@noaa.gov

office (757) 364-7472

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Marine and Aviation Operations
NOAA Ship *Fairweather* (S220)
1010 Stedman Street, Ketchikan, Alaska 99901

Date June, 26, 2017

MEMORANDUM FOR: Kathryn Pridgen
Project Manager, OPR-A366-KR-17
Hydrographic Surveys Division Operations Branch

FROM: Dean Moyles
Project Manager/Senior Hydrographer
Fugro

SUBJECT: Waiver request – Horizontal Datum

Fugro requests a waiver of the HTD 2017 requirement from Section 2.2 Horizontal Datum. Leidos requests to use ITRF00 instead of NAD83 for all horizontal positions in the final surface deliverable. The vertical position will be determined using TCARI.

Justification

Fugro uses Marinestar (G2 solution) in the field during acquisition for their horizontal position corrections. The POS M/V units utilize the *Fugro's* Marinestar correctors and the computed position from the POS M/V will be in ITRF00. The delta X and Y are low compared to the allowable IHO order 1a horizontal error budget. The Delta Z is high, but the GPS height will not be applied to the data since we are using TCARI.

Decision

Waiver is: Granted ______ Denied ______

cc: Chief, HSD OPS

File Home Insert Page Layout Formulas Data Review View

PROTECTED VIEW Be careful—files from the Internet can contain viruses. Unless you need to

B19

	A	B	C	D
1	https://www.youtube.com/watch?v=KKo3r1yVBBA			
2	Name	Company	Date completed	
3	Marshall Blackbourn	Fugro Marine GeoServices, Inc.	6/13/2017	
4	Kevin Kline	Fugro Marine GeoServices, Inc.	6/13/2017	
5	Ezrah Schraven	Fugro Marine GeoServices, Inc.	6/14/2017	
6	Dean Moyles	Fugro Marine GeoServices, Inc.	6/14/2017	
7	Juan Lopez	Fugro Marine GeoServices, Inc.	6/14/2017	
8	Brandy Geiger	Fugro Marine GeoServices, Inc.	6/14/2017	
9	David Dietzler	Fugro Marine GeoServices, Inc.	6/15/2017	
10	Scott Ramsey	Fugro Marine GeoServices, Inc.	7/16/2017	
11	Ried Cody	Contractor	6/15/2017	
12	Brayton Pointner	Contractor	6/15/2017	
13	Ryan Braget	Contractor	6/15/2017	
14	Todd Beach	Contractor	7/15/2017	
15	Sean Akins	Contractor	8/29/2017	
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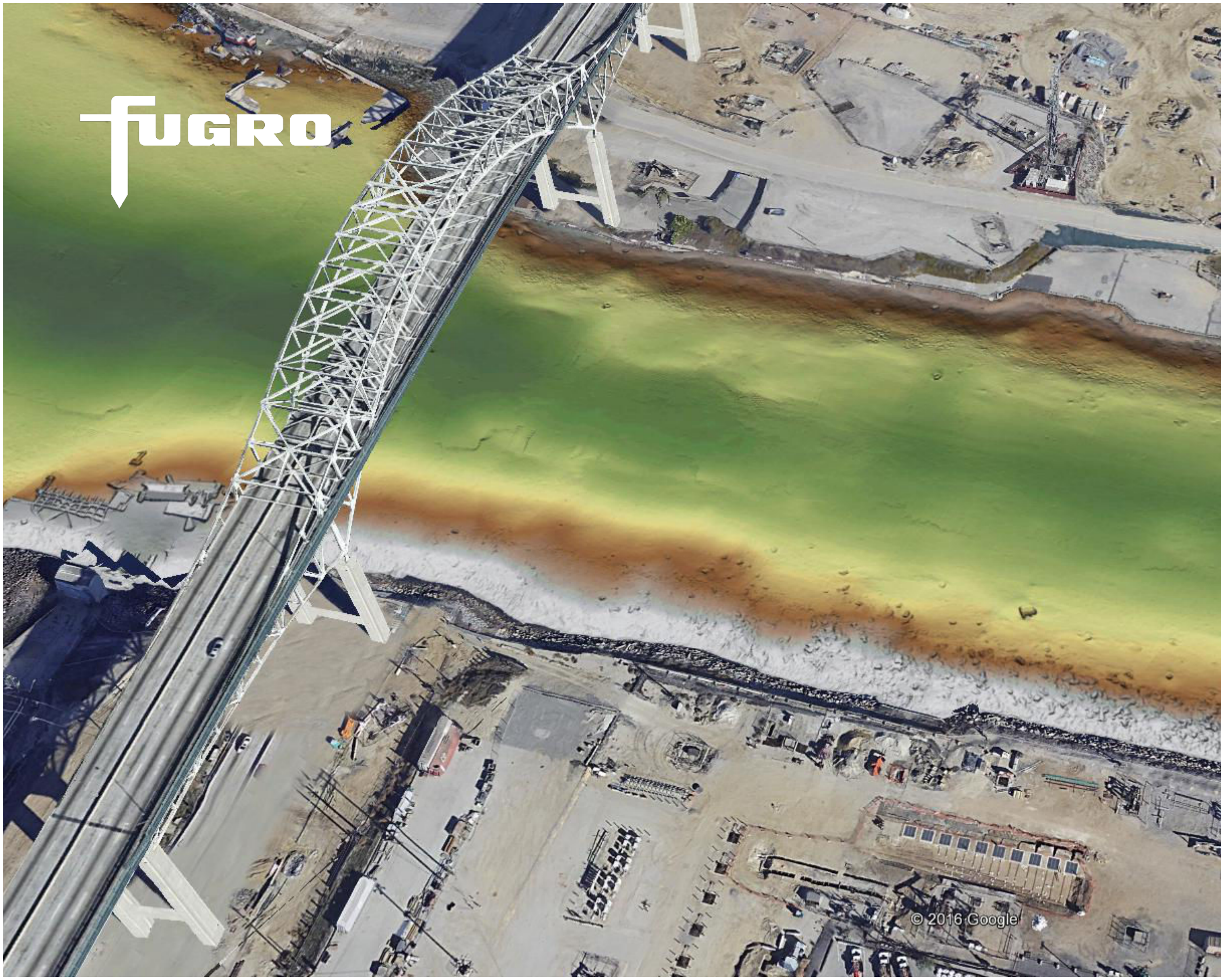


Separation Model for SHOALS 1000 Lidar Data

Memo | FP1188_001_NOAA_East_Penobscot_Bay

Rev. 1 | 30 June 2020

NOAA

Client Logo Here

Project Details

Client Name	NOAA Hydrographic Office	Issue Date	June 30th 2020
Client Contact		Fugro Contact(s)	Dean Moyles
Location			
Objective	Explanation on the use of Separation Model for SHOALS 1000 Lidar Data		
Scope of Work			

1. FP1188_001_NOAA_East_Penobscot_Bay Separation Model

"The separation model was generated with VDatum for a region that included all the survey area boundary extents. However, VDatum conversion from NAD83 2011 ellipsoidal heights to MLLW is geographically limited to include only land areas up to 700 m inland from a coarse depiction of the coastline; inlets and small bays may not be covered by this limit, as it was the case for small sections in the survey area and surveyed by bathymetric lidar (Figure 1 below).

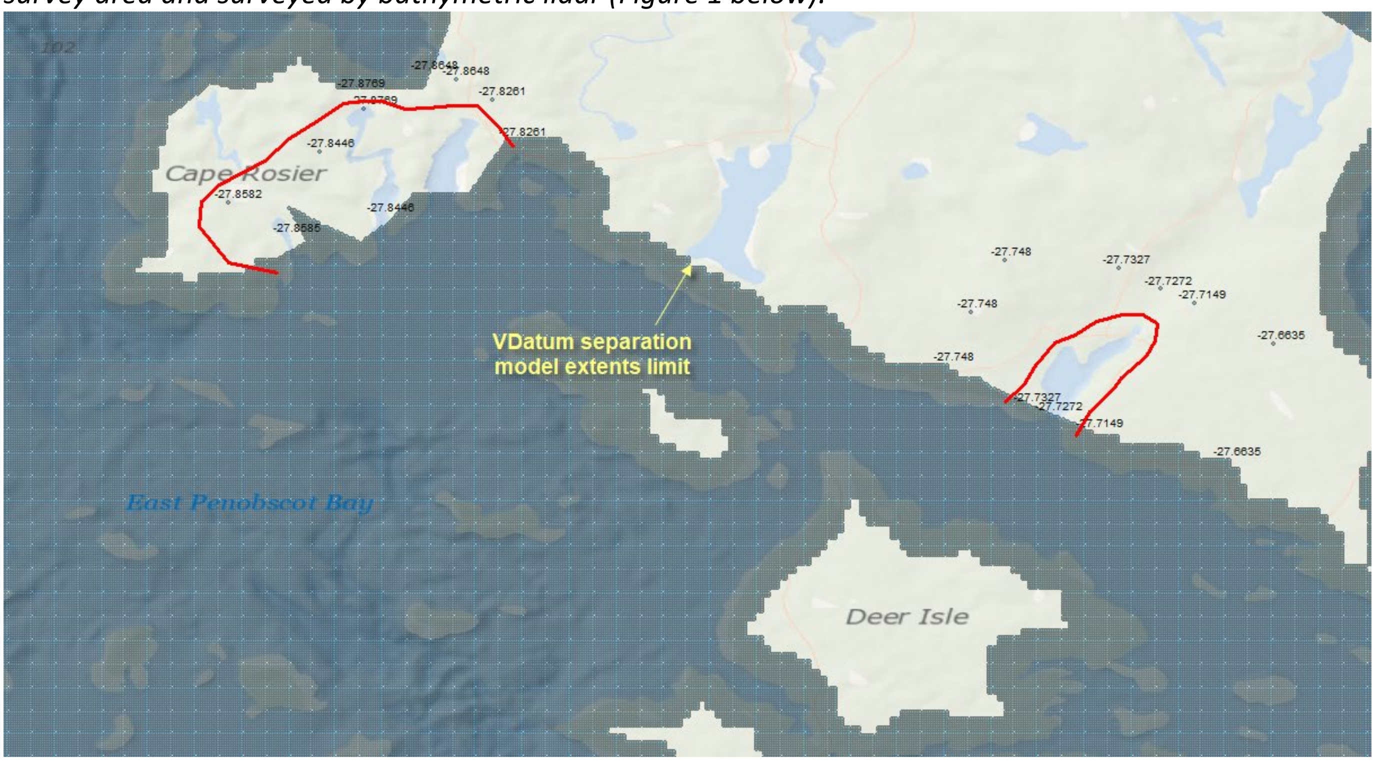


Figure 1. VDatum separation model extents and the areas surveyed by bathymetric lidar not covered by it (in red).

In order to reduce lidar ellipsoidal elevations to MLLW datum on these sections, it was decided to extrapolate a number of points at the edge of the model further inland. This was done at the discretion of the hydrographer with the only consideration given to point values that were closest to the selected extrapolated location, as seen in the two graphics in Figure 2. The separation variations in these small areas are at centimeter-level (4-8 cm), thus potential uncertainty introduced on the bathymetric lidar data could be in same magnitude; it was not evaluated but considered to be within the overall MLLW depth reduction uncertainty using separation model.

Figure 2. Extrapolation of separation model value at edge limit to include survey area (in red)

The modified separation model was then imported into Caris HIPS and SIPS v9.x where the datum conversion tools reads the point data file and perform interpolation across existing model points."

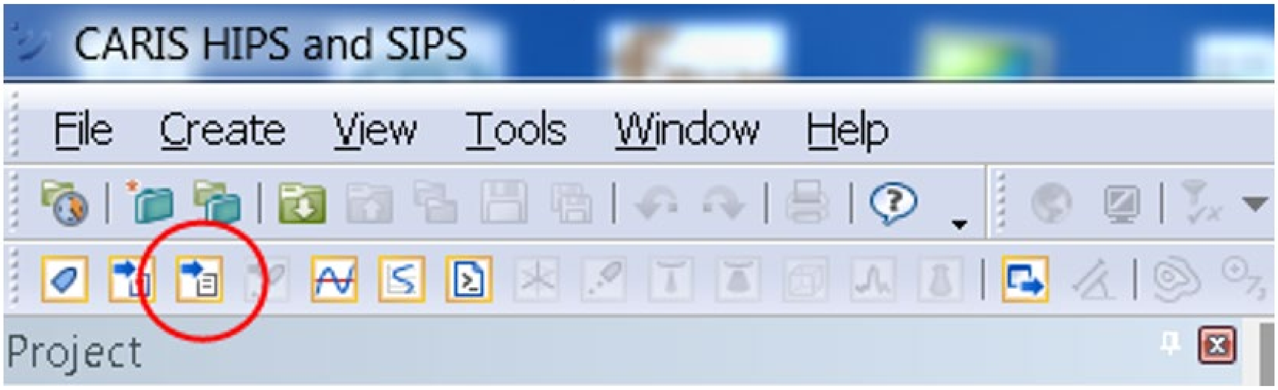
1.1 Apply Separation Model using CARIS HIPS & SIPS

In order to apply a separation model for Lidar data in CARiS 9.x, the next process was followed:

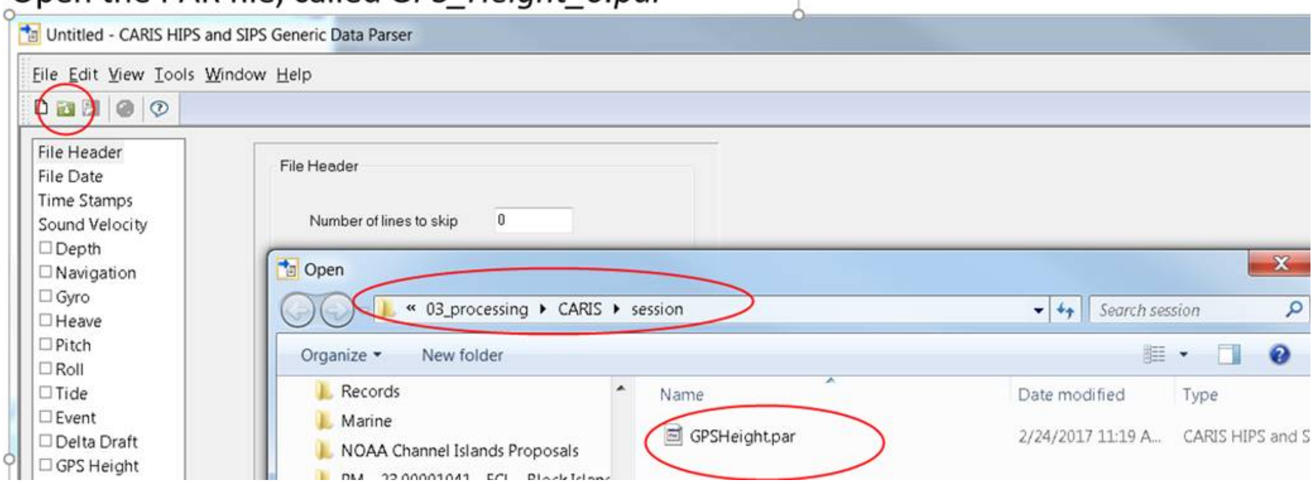
A zero GPS tide time series was added to the data through Generic Data Parser (GDP), that is basically an ASCII comma delimited file with the next format: yyyy/mm/dd hh:mm:ss, ZeroTide.
Once the Zero GPS height have been added to the Lidar HDCS Data, next step was to compute GPS tide, then in order to apply the separation model added through the computed GPS tide, all Datasets need to be merged.
After all this processing flow was completed, Datasets need to be QC to ensure the Separation model was applied correctly.

See below for a schematic processing flow:

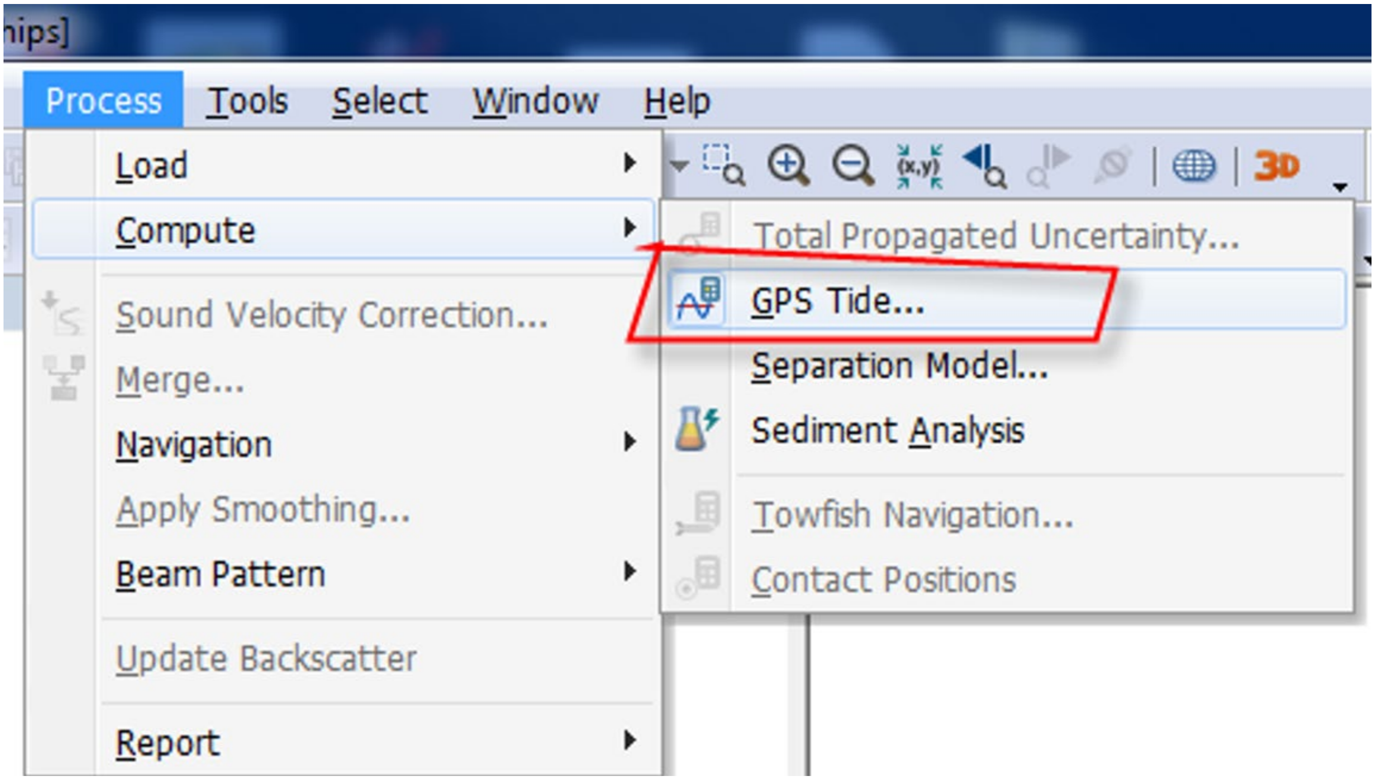
1. Click on GDP icon in CARIS



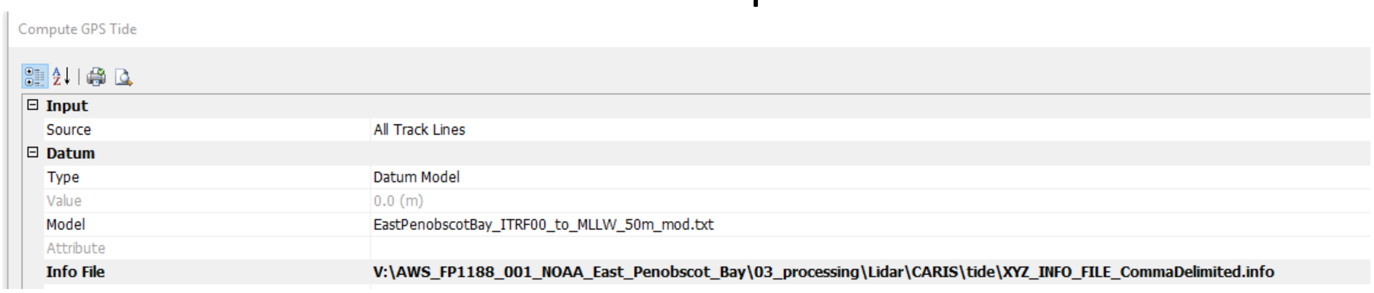
2. Open the PAR file, called *GPS_Height_0.par*



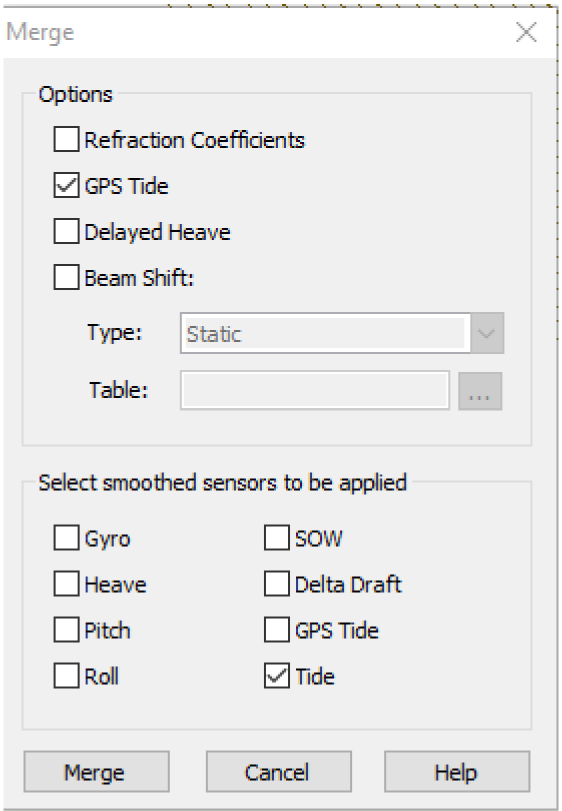
3. Once the zero GPS tide have been applied, next step is to apply the separation model with the Compute GPS tide process:



4. Browse to the location of the Separation model text file



5. After GPS Tide is computed, It needs to be applied to the Data sets through the merge process:



6. Next step is to check the data sets to ensure the separation model was applied correctly.

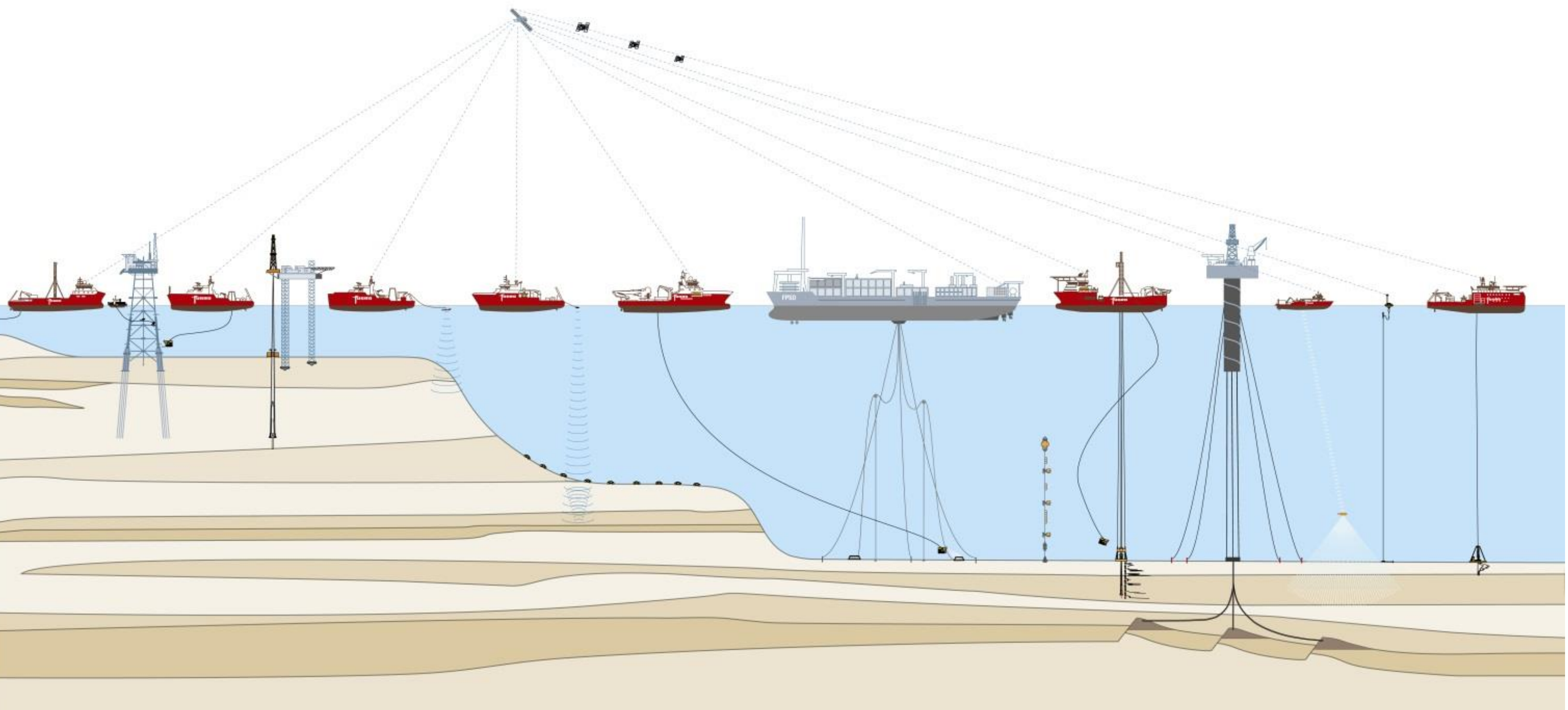
FUGRO

SHOALS LiDAR TPU Determination
OPR-A366-KR-16
Registry No. H13011, H13012, H13013 & H13014

Fugro Document No.: FP1188-RPT-SHOALS_TPU

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

Version 1 – 01 October 2017



SHOALS LiDAR TPU Determination
OPR-A366-KR-17
Registry No. H13011, H13012, H13013 & H13014

Fugro Document No.: FP1188-RPT-SHOALS_TPU
Volume 1 of 1

Prepared for: National Oceanic and Atmospheric Administration
National Ocean Service
Office of Coast Survey
Silver Spring, Maryland 20910-3282

01	Issued for reporting	JM			1 Oct 2017
Issue	**Report Status**	**Prepared**	**Checked**	**Approved**	**Date**

EXECUTIVE SUMMARY

This document summarizes the process to determine vertical and Horizontal TPU estimates for the SHOALS airborne LiDAR system employed for the acquisition of bathymetric data.

The vertical TPU (vTPU) is summarized as the uncertainty contributions from the LIDAR sensor measurements and the navigation trajectory for positioning solution. Horizontal TPU (hTPU) was determined using historic dynamic positioning QC analysis.

The SHOALS bathymetric LIDAR data was analyzed with spatial analysis methods, Fugro's LiDAR TPU Estimation tool (LTE), that observes the results of the LIDAR sensor measurements over a number of data samples collected over the period of data acquisition.

The following sections describe the analyses, results and final TPU estimates that have been applied to SHOALS LiDAR points in the Caris HDCS data.

CONTENTS

FIGURES

1. VERTICAL TPU ESTIMATON

Vertical TPU (vTPU) can be simplified as the uncertainty contributions of the LiDAR sensor and vertical positioning for the trajectory solution. The Fugro's LTE (LiDAR TPU Estimation tool - extension in ArcMap) was used to determine SHOALS uncertainty.

This method requires flying lines over a benchmark seabed area where bathymetry is smooth and slopes gently over water depth ranges expected in the survey area. Several passes over the bathymetric benchmark are and desirable to increase the data volume of the sampled data. The more data is collected over varying water conditions through time, the more representative the vTPU model will be for all data collected. Figure 1 shows the bathymetry coverage over the selected benchmark area where at least 6 flightlines collected acceptable LiDAR soundings for the water depth range required (at least 6 meters depth referenced to chart datum).

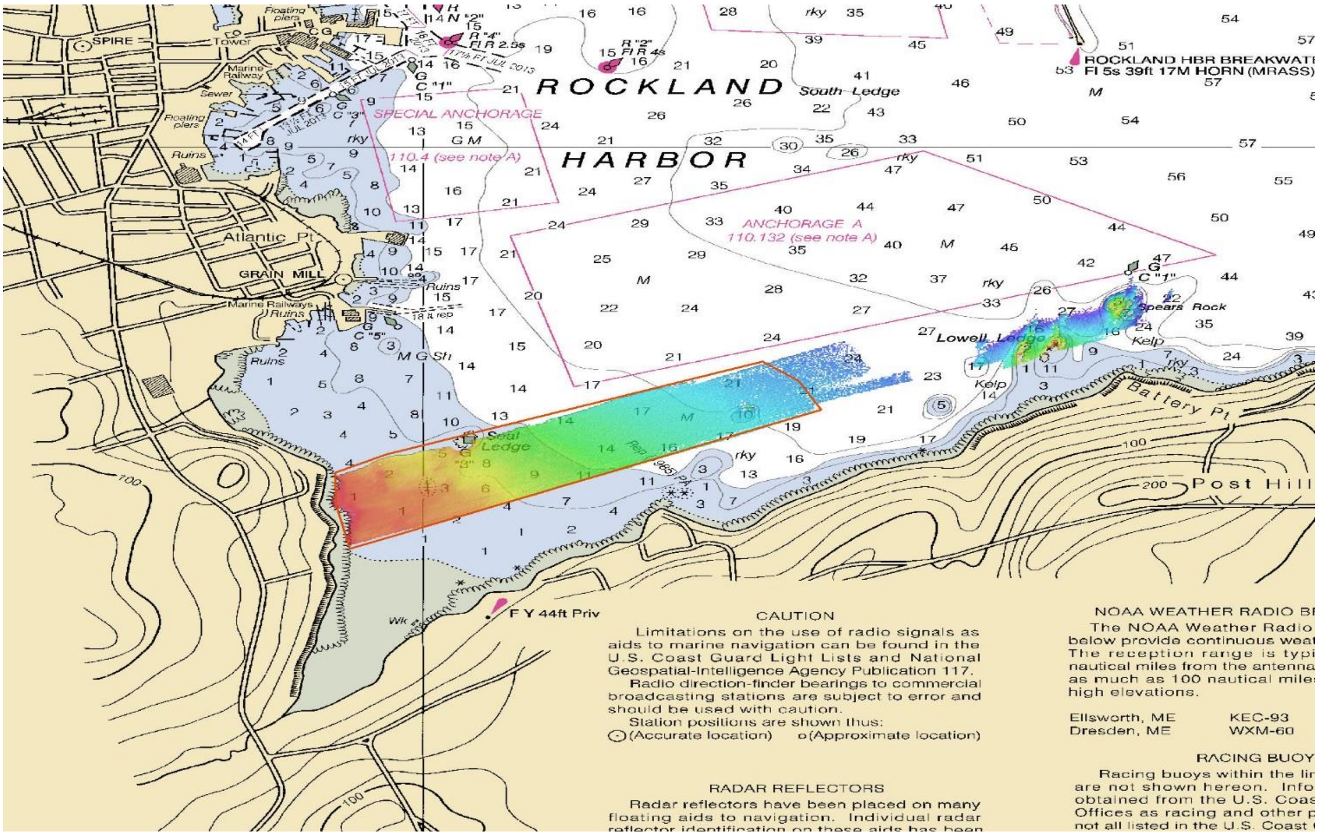


Figure 1. Bathymetry over selected benchmark area.

1.1 SHOALS Vertical Uncertainty

LTE is a tool implemented in ArcGIS that uses spatial analysis of LIDAR point elevations to determine statistical variance of a significant data sample. The principles of this tool's method are detailed on Lockhart, et al [2008][1]. The LTE tool application in Figure 2 shows the common parameters for data

[1] Lockhart, C, D. Lockhart, J. Martinez. 2008. Comparing LiDAR and Acoustic Bathymetry Using Total Propagated Uncertainty (TPU) and the Combined Uncertainty and Bathymetry Estimator (CUBE) Algorithm. Proceedings of the Canadian Hydrographic Conference and National Surveyors Conference 2008. Paper 3A-1. Victoria, BC, Canada May 5th-8th, 2008.

sampling, as well as the water depth ranges being analysed (or elevation on the ellipsoid). The inputs are the HOF files generated in SHOALS-GCS processing software.

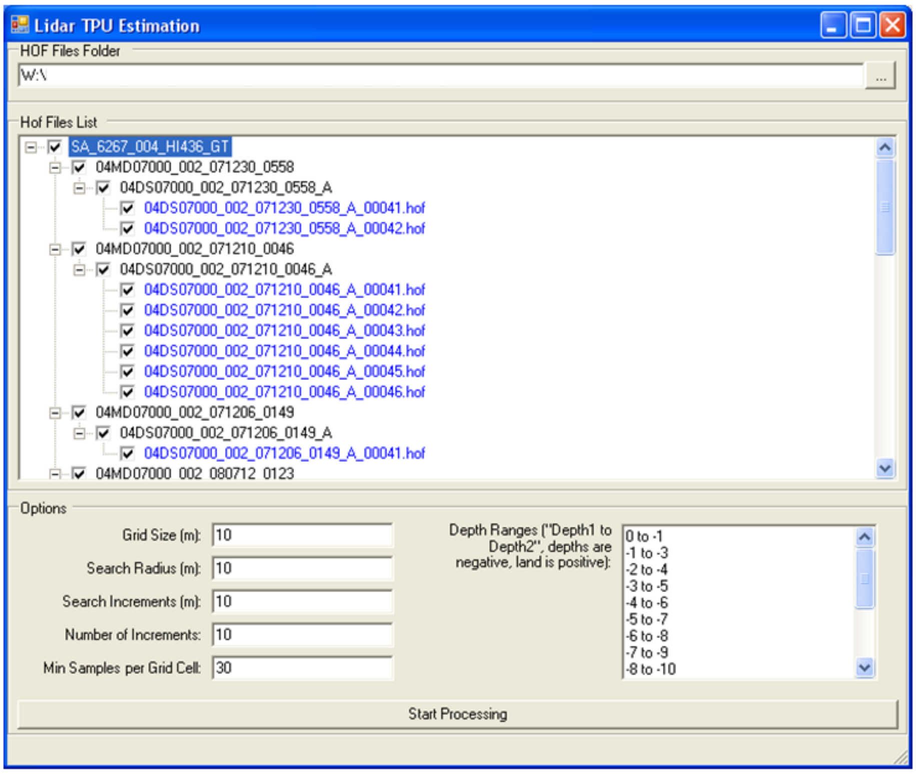


Figure 2. ArcGIS LTE tool.

The results of LTE tool lists a table of depth's standard deviation at grid nodes per depth range and initial sampling radius size; the radius then increases by a constant and standard deviation is calculated again with all-inclusive sample depths. The process continues as many times as sampling intervals are necessary to obtain the data behavior shown in the graph in Figure 3 below. Note that only the existing water depth ranges in the data sampling location are tabulated and plotted. A polynomial regression is used to find the value where the x-axis crosses the y-axis, which cannot be determined directly. This value, known as a nugget, denotes the vertical uncertainty for the depth range defined and sampled.

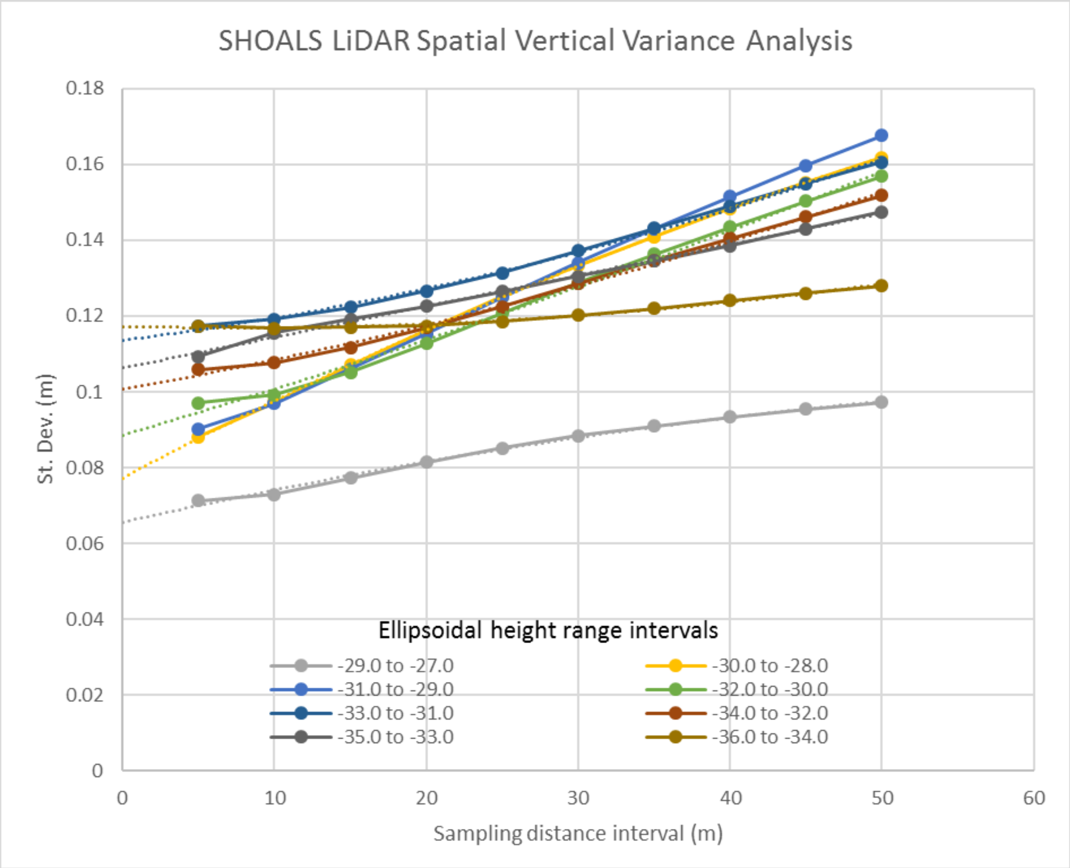


Figure 3. LTE tool results example

The results of the analysis were tabulated and plotted to derive a depth-dependent model of Total Bottom Uncertainty (TBU) (Figure 4). The linear regression represents an uncertainty model from the analyzed data that also aids to calculate *TBU* for depths were sampling data was insufficient (gaps in coverage).

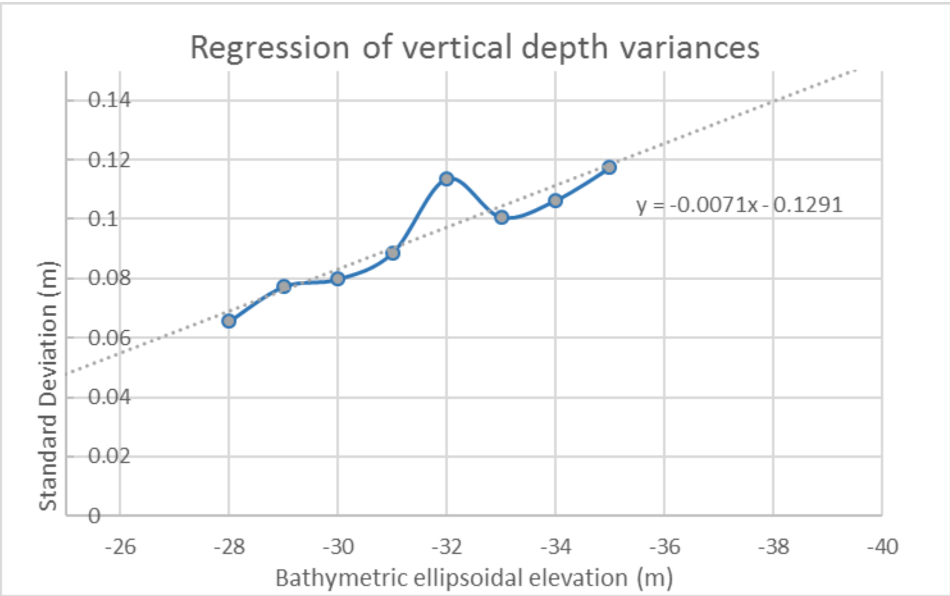


Figure 4. Total Bottom Uncertainty for SHOALS data sample.

TBU contains variance introduced by the SHOALS sensor measurements and the natural seafloor bottom (slope and roughness). In order to isolate the SHOALS LIDAR Sensor uncertainty (LSU) from seafloor Bottom Variability (BV), modeling was conducted on synthetic seafloor depths to replicate the potential components of slope and roughness. Modeled *BV* over relative featureless synthetic bottom has been found to be 0.015 m (1σ) (Lockhart et al, *op cit.*); then *BV* is subtracted from the *TBU* to obtain *LSU* in the form:

$$LSU = \sqrt{TBU^2 - BV^2}$$

The *LSU* is the main component of vTPU, the other being the uncertainty of the depth reduction (separation model, tides, tidal model, etc.). The SHOALS LiDAR elevations were reduced to chart datum using VDatum. The estimated uncertainty for VDatum vertical conversions for the Maine region is 0.134 m (1-σ), therefore, the total vTPU estimates can be calculated as:

$$vTPU = \sqrt{LSU^2 - VDatumU^2}$$

1.2 vTPU Results

The results of the vTPU estimation are presented in Table 2 and illustrated in Figure 5. The IHO SP44 Order 1 standard for accuracy is also included for comparison.

Table 1. Vertical TPU for SHOALS system and VDatum depth reduction (units in meters)

Depth	LiDAR Unc. (LSU)	VDatum Unc.	vTPU 1σ	vTPU 2σ (95%)	IHO Order 1
-200	0.045	0.134	0.141	0.277	na
-2.0	0.055	0.134	0.145	0.284	0.500
-1.0	0.062	0.134	0.148	0.290	0.500
0.0	0.069	0.134	0.151	0.296	0.500
2.0	0.076	0.134	0.154	0.302	0.501
4.0	0.087	0.134	0.160	0.313	0.503
6.0	0.105	0.134	0.170	0.333	0.506
9.0	0.122	0.134	0.181	0.356	0.514
11.0	0.140	0.134	0.194	0.380	0.520
14.0	0.158	0.134	0.207	0.406	0.532
16.0	0.175	0.134	0.221	0.433	0.542
19.0	0.193	0.134	0.235	0.461	0.558
21.0	0.211	0.134	0.250	0.489	0.574

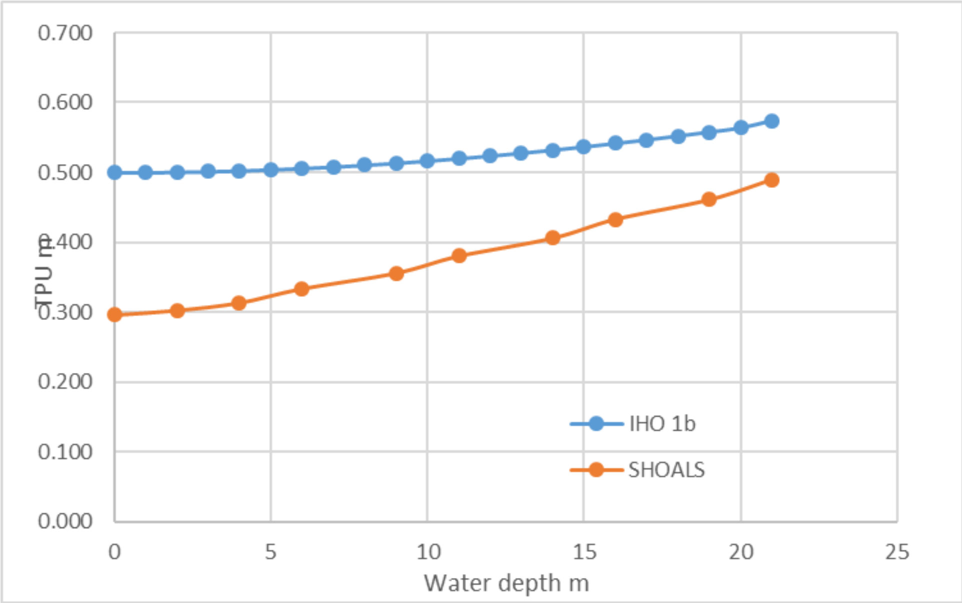


Figure 5. vTPU for SHOALS system with VDatum depth reduction

2. HORIZONTAL TPU ESTIMATION

The horizontal TPU (hTPU) component was calculated using historic Dynamic Navigation Checks, which consist on determining the closest LiDAR positions acquired in a normal airborne acquisition mode to the surveyed corners of a prominent building. The horizontal separation between surveyed points and LIDAR points are calculated and the statistical difference interpreted as the overall system uncertainty to measure the horizontal position of a target. The hTPU has the combined errors of the navigation trajectory solution and the LiDAR system measurements, the latter considered to be the largest component.

Table 2 shows the mean difference and standard deviation of the of the Dynamic Navigation Checks for both SHOALS LIDAR sensor, and the estimated hTPU.

Table 2. Horizontal check analysis summary for SHOALS

Analysis Check Statistics	SHOALS
Mean Diff (bias):	2.295 m
St. dev.:	1.200 m
hTPU (m+1.96σ @95% c.l.):	4.499 m

3. TPU APPLICATION IN CARIS

After SHOALS data in converted to CARIS HIPS format, a small application within in CARIS HIPS (createTPU.exe) is used to apply the estimated TPU. The utility requires a look-up table with depth, vTPU and hTPU as it solely fields. The TPU values populate the corresponding fields in the HIPS data according to final processed depth. The Final TPU look-up table is presented in Table 3.

Table 3. Final CARIS HIPS TPU LUT (depths, positive down)

Depth (m)	vTPU (m)	hTPU (m)
-200	0.277	4.499
-2	0.284	4.499
-1	0.290	4.499
0	0.296	4.499
2	0.302	4.499
4	0.313	4.499
6	0.333	4.499
9	0.356	4.499
11	0.380	4.499
14	0.406	4.499
16	0.433	4.499

From: Christopher Paver - NOAA Federal
To: Moyles, Dean
Cc: NODC.submissions@noaa.gov; Kathryn Pridgen - NOAA Federal
Subject: Re: Sound Speed Data
Date: Wednesday, February 21, 2018 6:06:10 PM

Hey Dean,
Thanks for the new package. We will start to process it soon. In the future, please add the submission date to the package file name, i.e. OPR-A366-KR-17_20180221.zip.

Thanks,
Chris

On Wed, Feb 21, 2018 at 3:17 PM, Moyles, Dean <dmoyles@fugro.com> wrote:

> Attached is the sound speed data for OPR-A366-KR-17, please let me know if you have any questions.
>
> Kind regards,
>
> Dean Moyles
>
> *Project Manager/Senior Hydrographer (ACSM cert. No. 226)*
>
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>
> email: dmoyles@fugro.com
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> Fugro (USA) Marine Inc.: https://www.fugro.com/
>
> 6100 Hillcroft Street, Houston, TX 77081, USA

--
Chris Paver, Oceanographer
NOAA/NCEI
1315 East-West Hwy
Silver Spring MD 20910
Phone: 301-713-4910
www.ncei.noaa.gov

From:	Brian Mohr - NOAA Federal
To:	Moyles, Dean
Subject:	Re: OPR-A366-KR-17 Survey Outlines
Date:	Tuesday, October 10, 2017 10:06:53 AM

Morning Dean. Any chance you could send these outlines in shp format? We have migrated to an enterprise geodatabase and would find shapefiles much easier to ingest than .000's.

Brian Mohr
Data Manager
Hydrographic Surveys Division
brian.mohr@noaa.gov

On Sun, Oct 8, 2017 at 7:05 PM, Moyles, Dean <dmoyles@fugro.com> wrote:

> Please find the attached survey outlines for OPR-A366-KR-17, please let me know if you have any questions or comments.
>
> Kind regards,
>
> Dean Moyles
>
> *Project Manager/Senior Hydrographer (ACSM cert. No. 226)*
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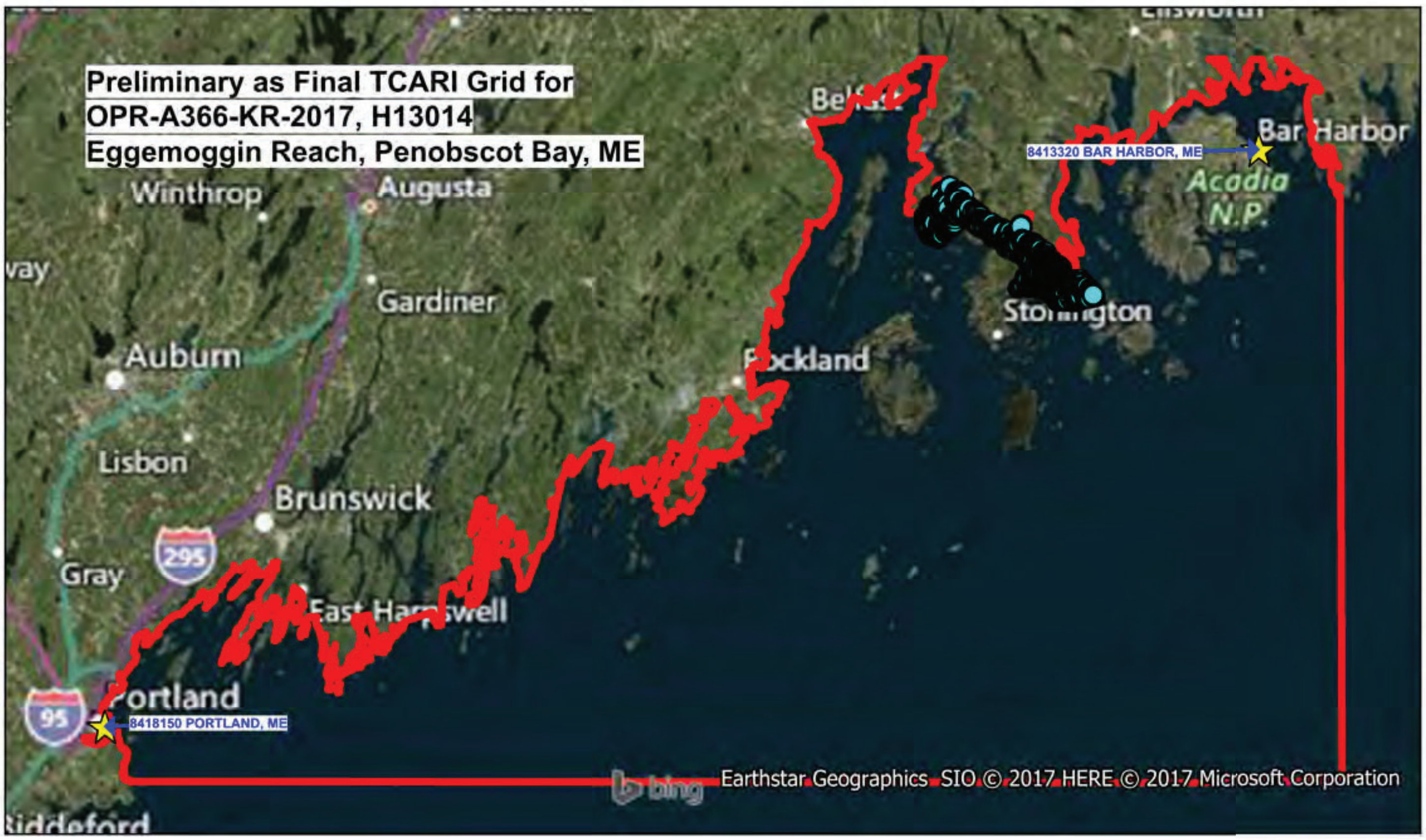
Preliminary as Final TCARI Grid for
OPR-A366-KR-2017, H13014
Eggemoggin Reach, Penobscot Bay, ME
Winthrop
Augusta
Gardiner
Auburn
Lisbon
Brunswick
Gray
295
Portland
95
8418150 PORTLAND, ME
Bar Harbor
8413320 BAR HARBOR, ME
Acadia
N.P.
Earthstar Geographics SIO © 2017 HERE © 2017 Microsoft Corporation

APPROVAL PAGE

H13013

Data meet or exceed current specifications as certified by the OCS survey acceptance review process. Descriptive Report and survey data except where noted are adequate to supersede prior surveys and nautical charts in the common area.

The following products will be sent to NCEI for archive

- Descriptive Report
- Data Acquisition and Processing Report
- Collection of Bathymetric Attributed Grids (BAGs)
- Processed survey data and records
- Geospatial PDF of survey products
- Collection of backscatter mosaics

The survey evaluation and verification have been conducted according to current OCS specifications, and the survey has been approved for dissemination and usage of updating NOAA's suite of nautical charts.

Digitally signed by MCGOVERN.MEGHAN.ELIZABETH.1284020495
Date: 2021.08.20 08:38:40 -04'00'

Approved: ______________________________

Commander Meghan McGovern, NOAA
Chief, Atlantic Hydrographic Branch