H13867

Southern Case Inlet

OPR-N360-RA-24
Central and Southern Puget Sound
Washington

Responsible Party
DOC/NOAA/NOS/OCS -- Office of Coast Survey
Contact Information
NOAA Ship RAINIER OPS
Field Unit
NOAA Ship Rainier (S221)
Survey Dates
May 18, 2024 - June 13, 2024
License Information
CC0-1.0
Approver
Nicholas C. Morgan, CDR/NOAA

Platform and Sonar Equipment

RA-3 (2803)

Kongsberg Maritime EM 2040

RA-6 (2804)

Kongsberg Maritime EM 2040

2902 (2902)

Kongsberg Maritime EM 2040

Bathymetry Grid

H13867_MB_VR_MLLW_Final_1of1 *North American Datum 1983 (2011) Projected UTM 10, Mean Lower Low Water*

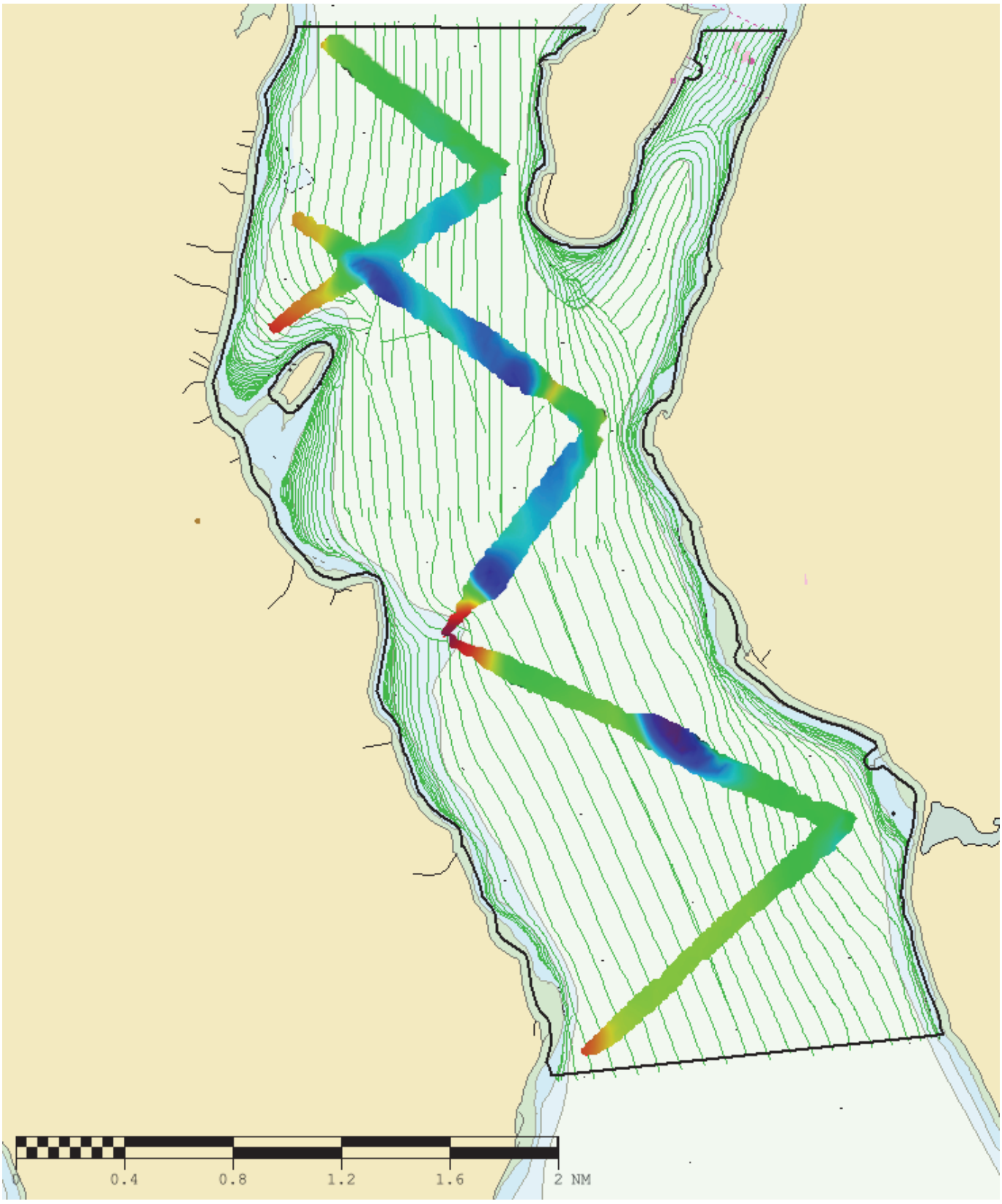
					Fixed	Variable
Sounding Technique:	***Multibeam***	Full Seafloor Coverage:	***Yes***	Feature Detection Size:	***2.0m***	***10%***
Features Detected:	***Yes***	Bathymetric Coverage:	***Yes***	Uncertainty Horizontal:	***1m***	***N/A***
Least Depth Detected:	***Yes***	Interpolated:	***No***	Uncertainty Vertical:	***0.15m***	***1%***

Quality Control Procedure

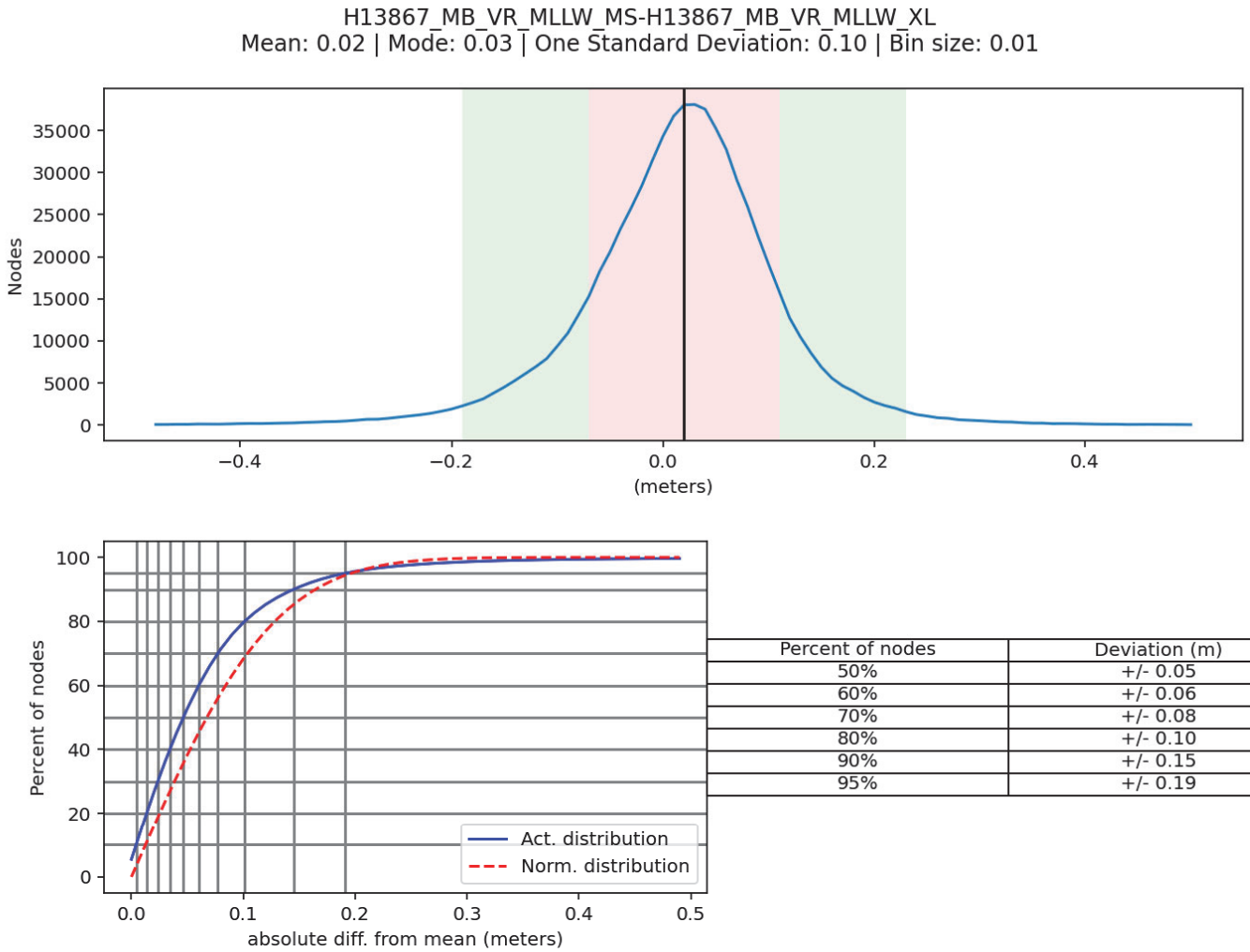
Crosslines

As a quality control measure for each survey, section 5.9 of the HSSD requires approximately 4% (for complete coverage surveys) of the linear nautical mile total of mainscheme multibeam lines be run as crosslines. Following acquisition, a surface containing strictly data from mainscheme lines and a surface containing strictly data from crosslines are generated and analyzed with the Compare Grids tool in Pydro. This tool analyzes the difference between the two grids and outputs a difference surface between the depths, as well as a second surface that contains the fraction of NOAA allowable error represented by that depth difference for each node. Additionally, statistics/distribution summary plots of the difference surface and the fraction of allowable error are generated to provide easily interpretable analyses of the differences between the surfaces.

NOAA Ship RAINIER launches collected 6.96 nautical miles of multibeam crosslines, approximately 4.5 percent, across a range of depths in the maincheme data. The Gridded Surface Comparison (v24.6) function in Pydro Explorer was used to analyze the finalized VR surfaces of H13867 mainscheme only and crossline only data. Pydro determined that 99.99 percent of nodes met allowable uncertainties.

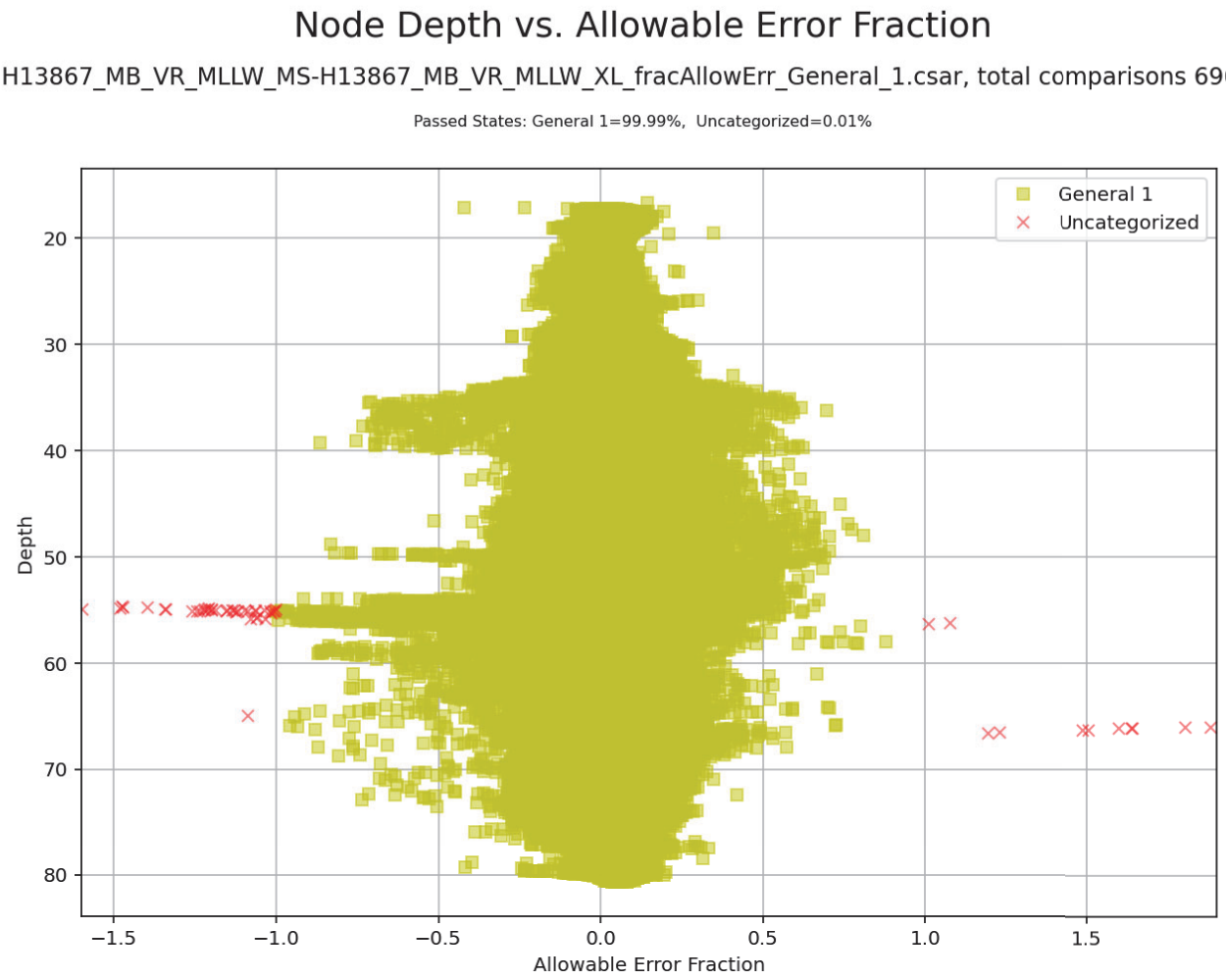


H13867 crossline surface overlaid on mainscheme tracklines. (Chart US4WA11M)



Percent of nodes	Deviation (m)
50%	+/- 0.05
60%	+/- 0.06
70%	+/- 0.08
80%	+/- 0.10
90%	+/- 0.15
95%	+/- 0.19

Pydro derived plot showing abolute difference statistics of H13867 mainscheme to crossline data.

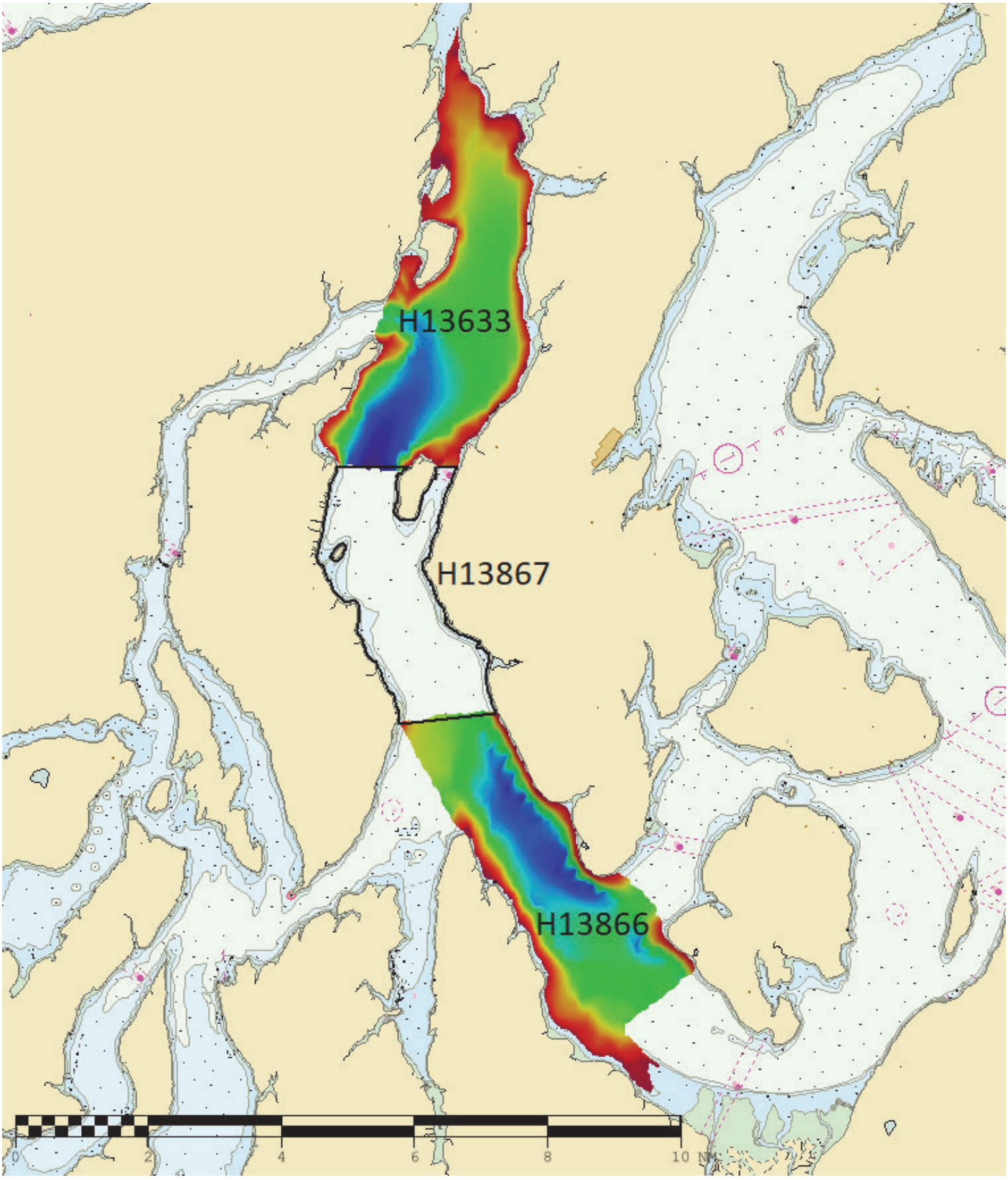


Pydro derived plot showing percentage-pass value of H13867 mainscheme to crossline data.

Junction Overlap

Survey managers perform junction analyses between the current survey and all adjacent contemporary surveys. To ensure proper overlap between surveys, approximately one bathymetric swath of overlap is acquired at each junction. Surface-based and statistical analysis of the junctions is performed through the Compare Grids tool as described in the "Crossline" section of this report.

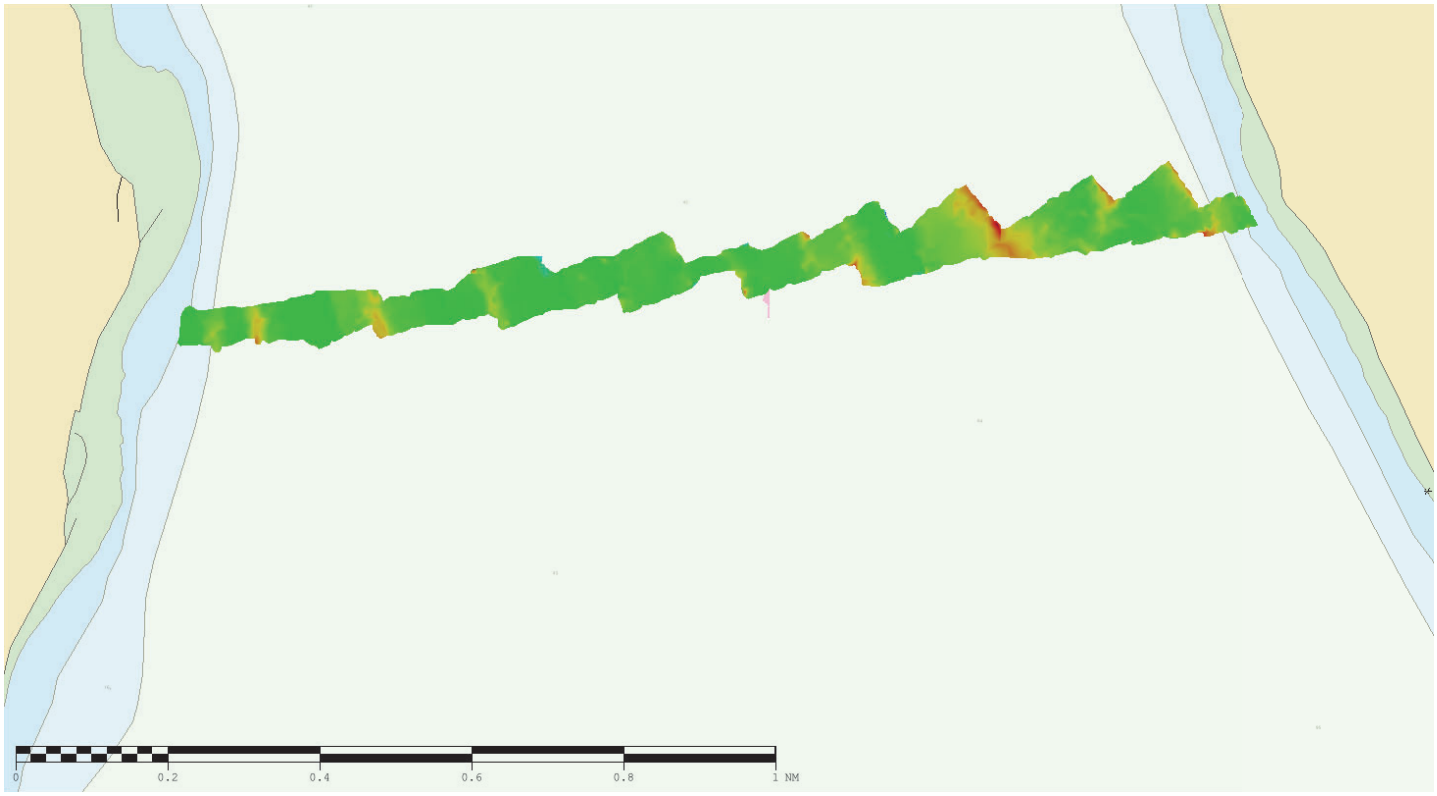
Survey H13867 junctions with two sheets, H13633 and H13866. See the two junctions with H13867 in the image below.



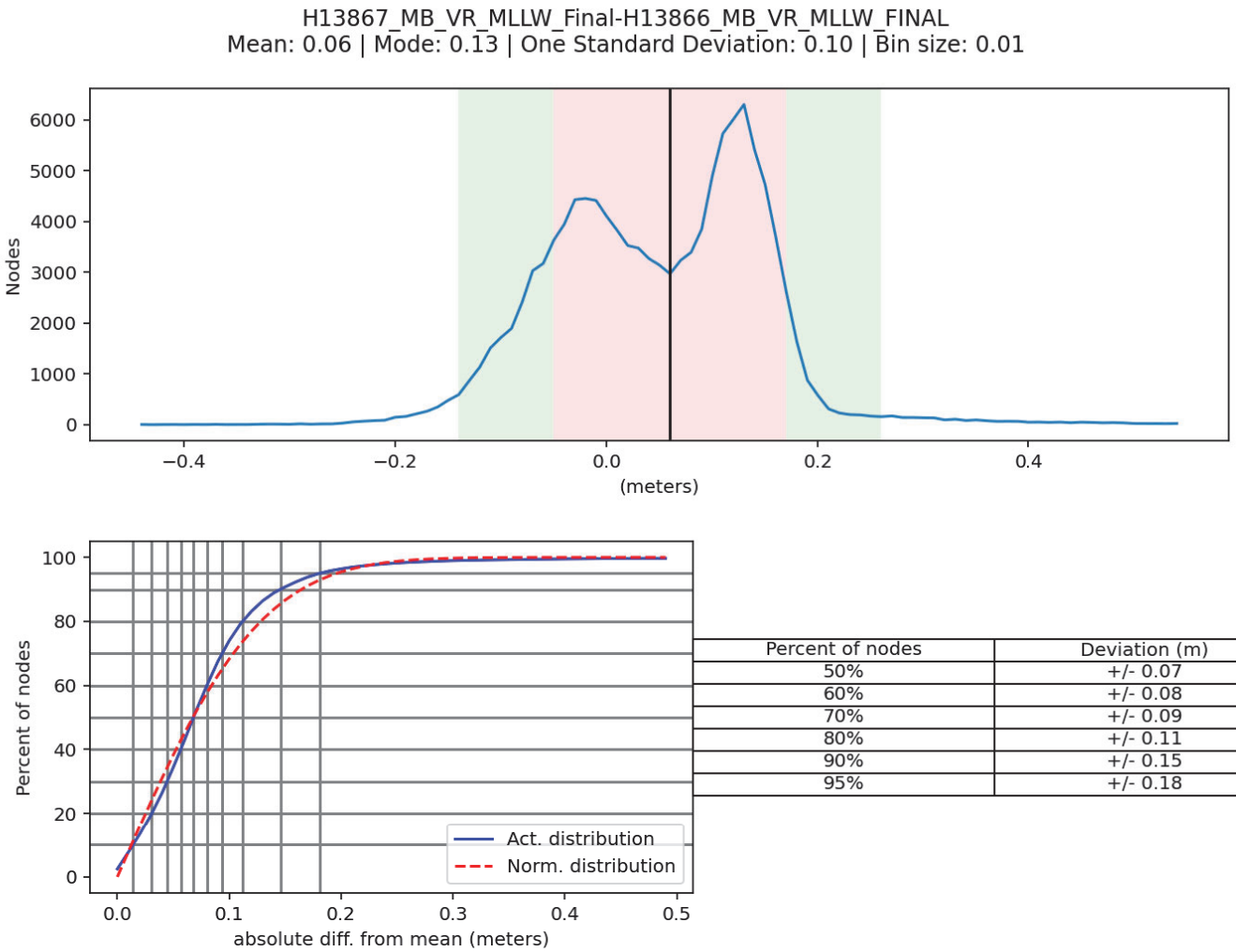
Junction surfaces H13633 and H13866, with H13867 survey extents.

The junction with survey H13866 encompasses approximately 0.076 square nautical miles along the northern border of coverage. The Compare Grids function of Pydro Explorer derived a difference surface from H13867 variable resolution surface and H13866 variable resolution surface. Pydro Compare Grids showed that 100 percent of nodes in the overlapping area met NOAA General 1 allowable error standards.

Analysis of the difference surface indicated that there is a 0.06 meter average difference between the two surveys.

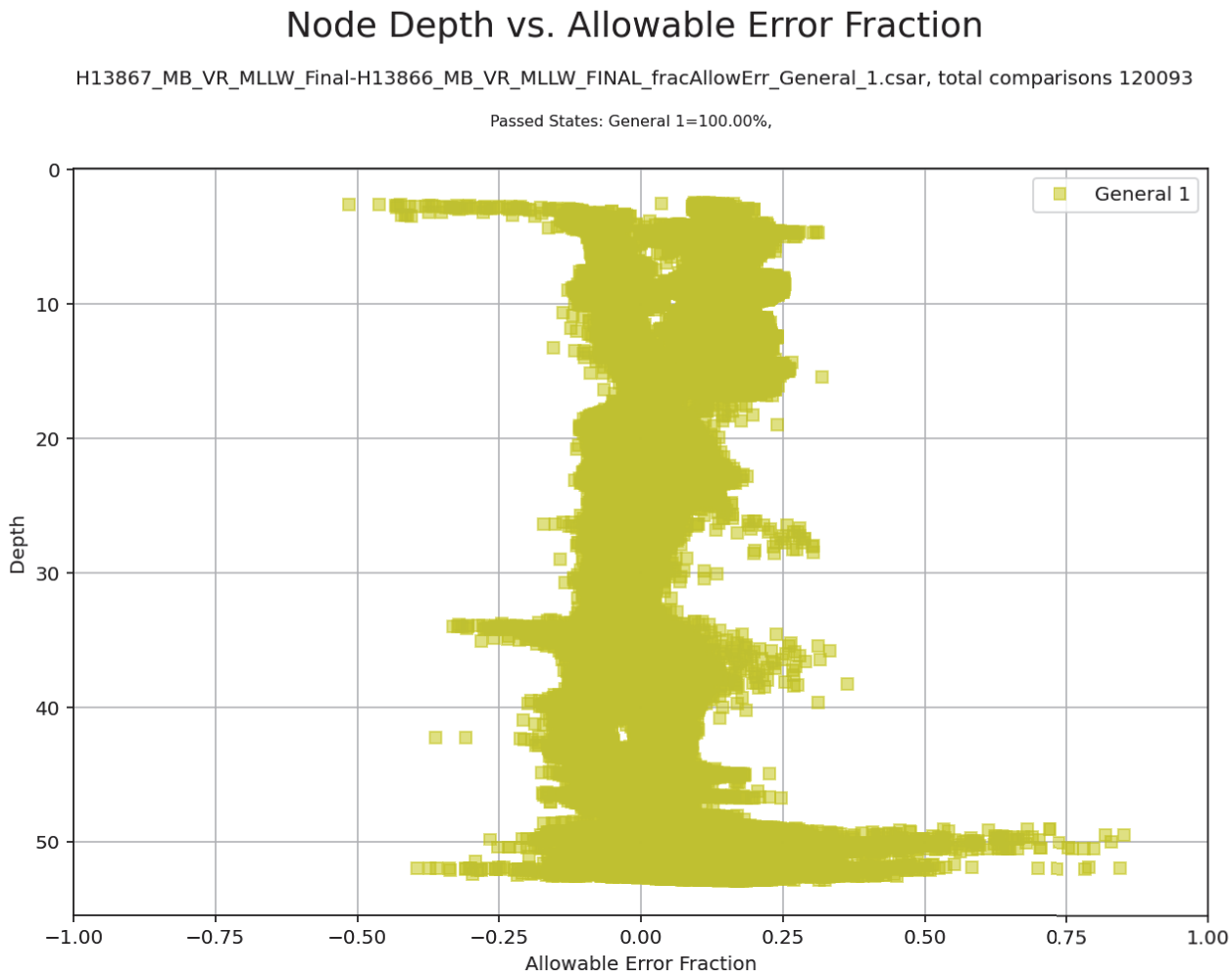


H13867 and H13866 difference of depth surface.



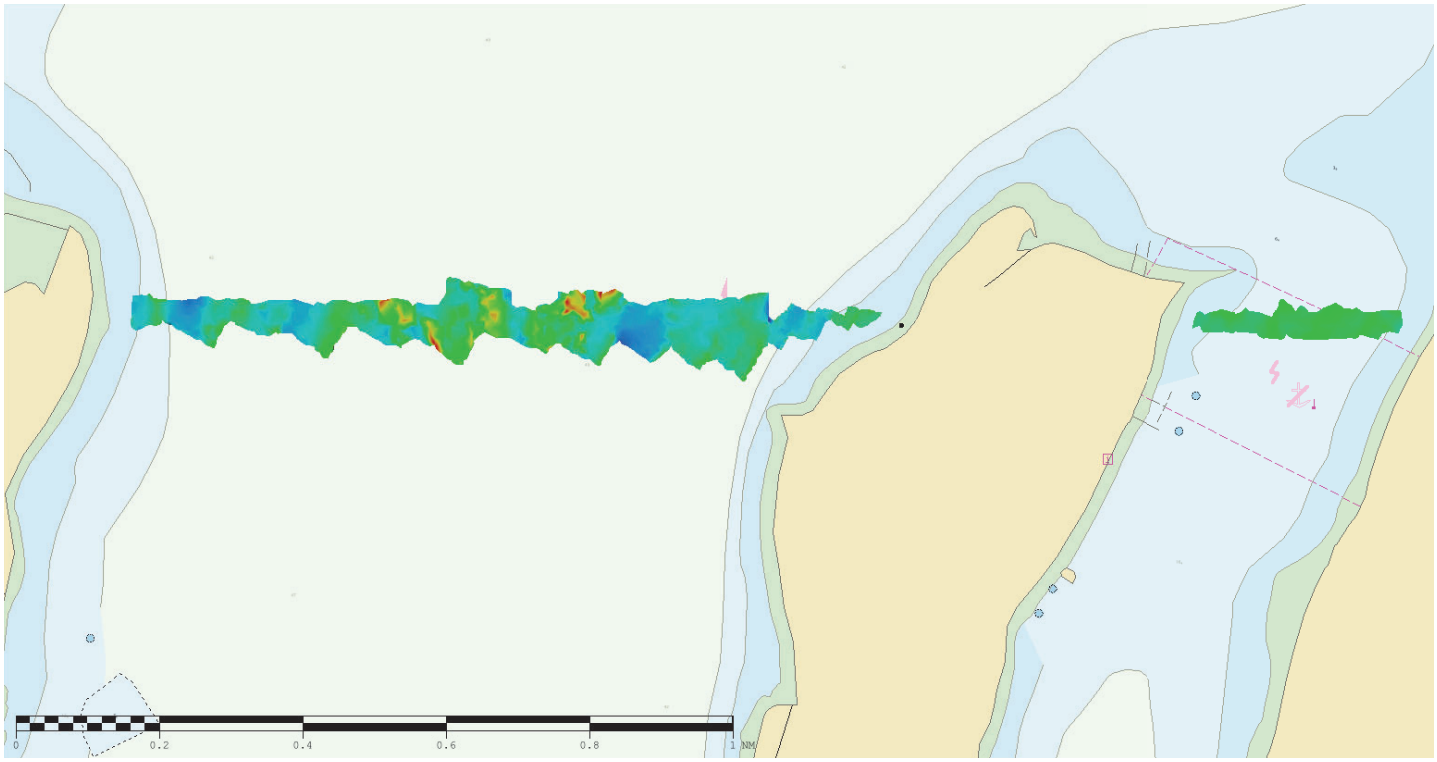
Percent of nodes	Deviation (m)
50%	+/- 0.07
60%	+/- 0.08
70%	+/- 0.09
80%	+/- 0.11
90%	+/- 0.15
95%	+/- 0.18

Pydro derived plot showing absolute difference statistics of the junction between H13867 and H13866 variable resolution surfaces.

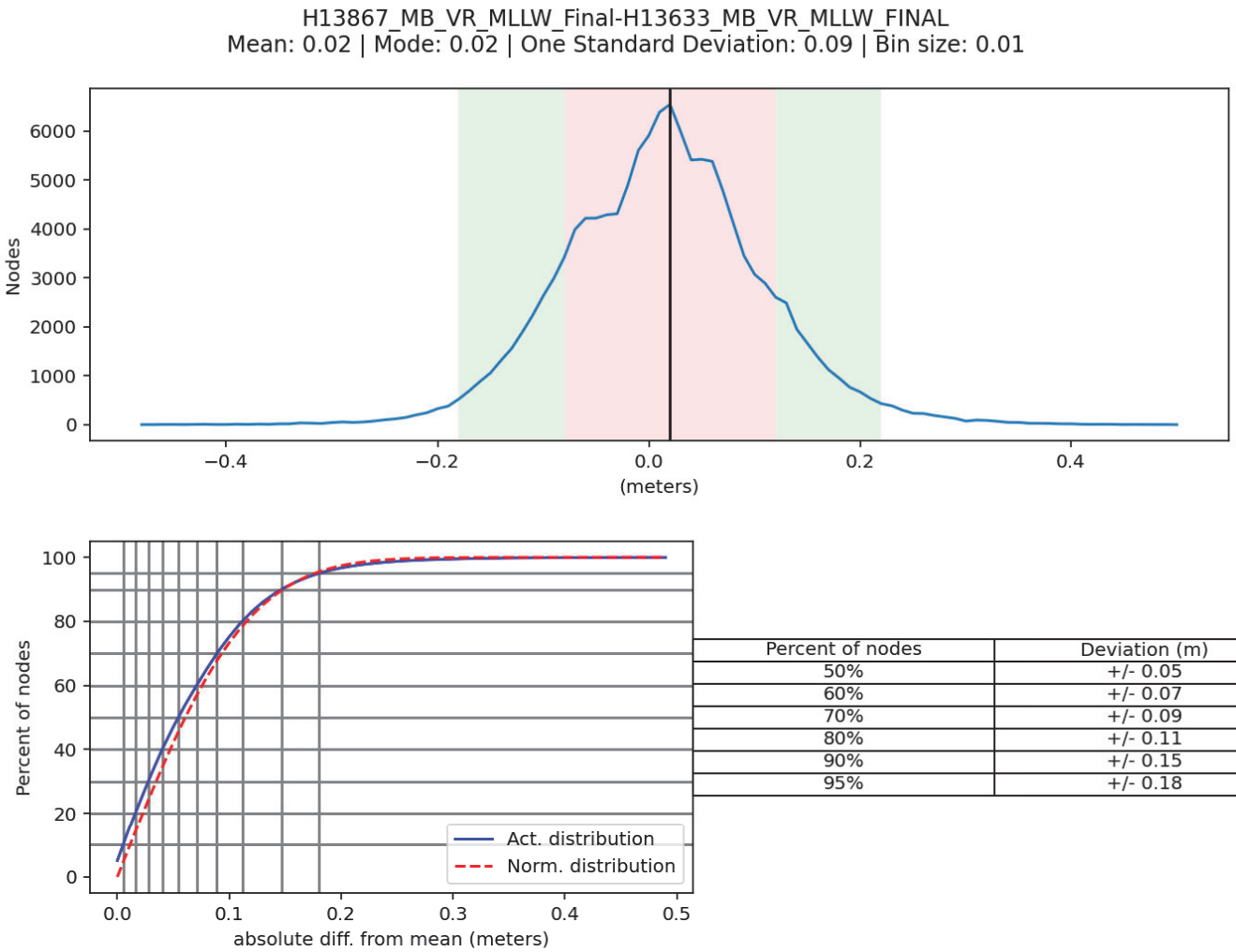


Pydro derived plot showing percentage-pass volume of the junction between H13867 and H13866 variable resolution surfaces.

The junction with survey H13633 encompasses approximately 0.089 square nautical miles along the southern border of coverage. The Compare Grids function of Pydro Explorer derived a difference surface from H13867 variable resolution surface and H13633 variable resolution surface. Pydro Compare Grids showed that 100 percent of nodes in the overlapping area met NOAA General 1 allowable error standards. Analysis of the difference surface indicated that there is a 0.02 meter average difference between the two surveys.

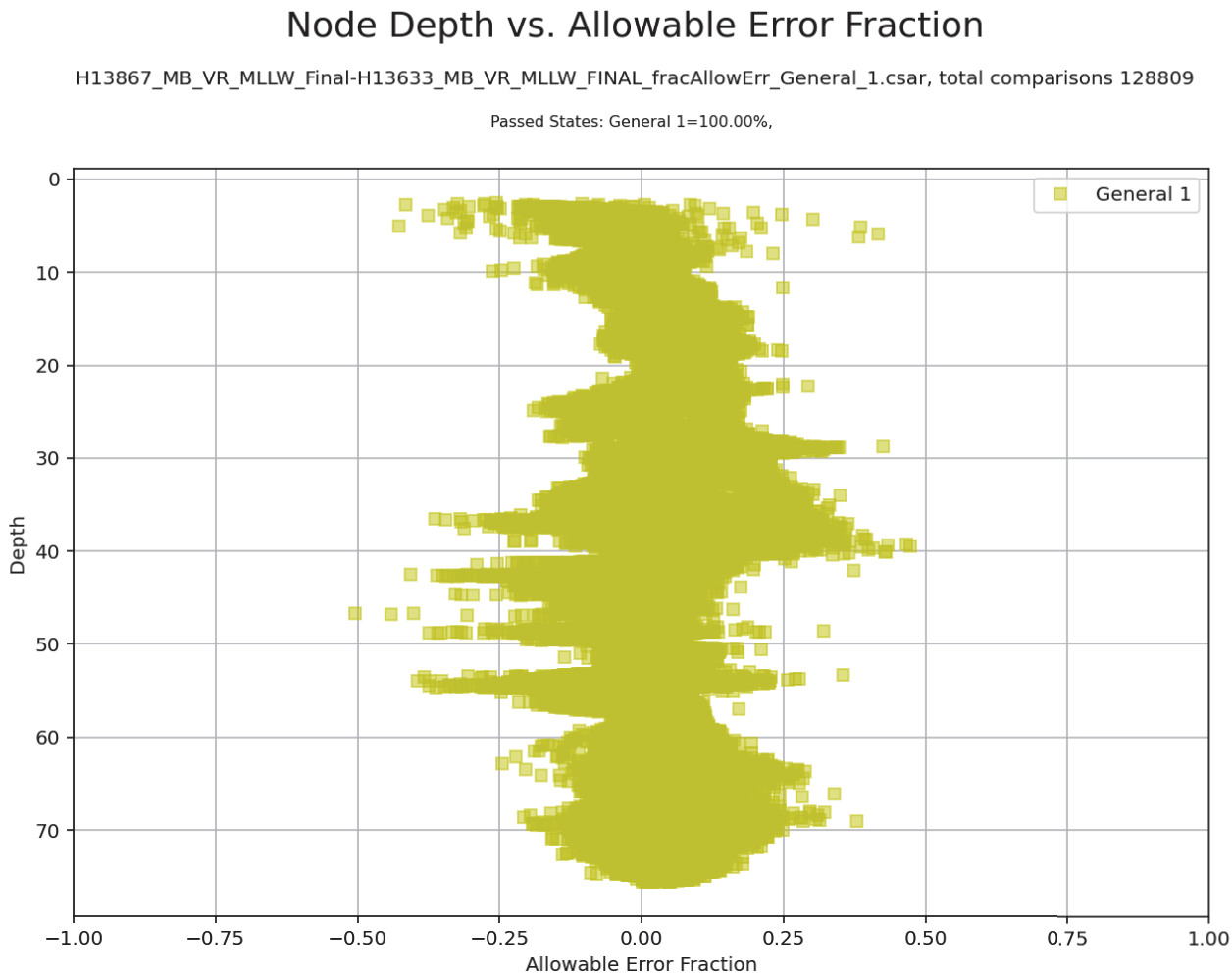


H13867 and H13633 difference of depth surface.



Percent of nodes	Deviation (m)
50%	+/- 0.05
60%	+/- 0.07
70%	+/- 0.09
80%	+/- 0.11
90%	+/- 0.15
95%	+/- 0.18

Pydro derived plot showing absolute difference statistics of the junction between H13867 and H13633 variable resolution surfaces.



Pydro derived plot showing percentage-pass volume of the junction between H13867 and H13633 variable resolution surfaces.

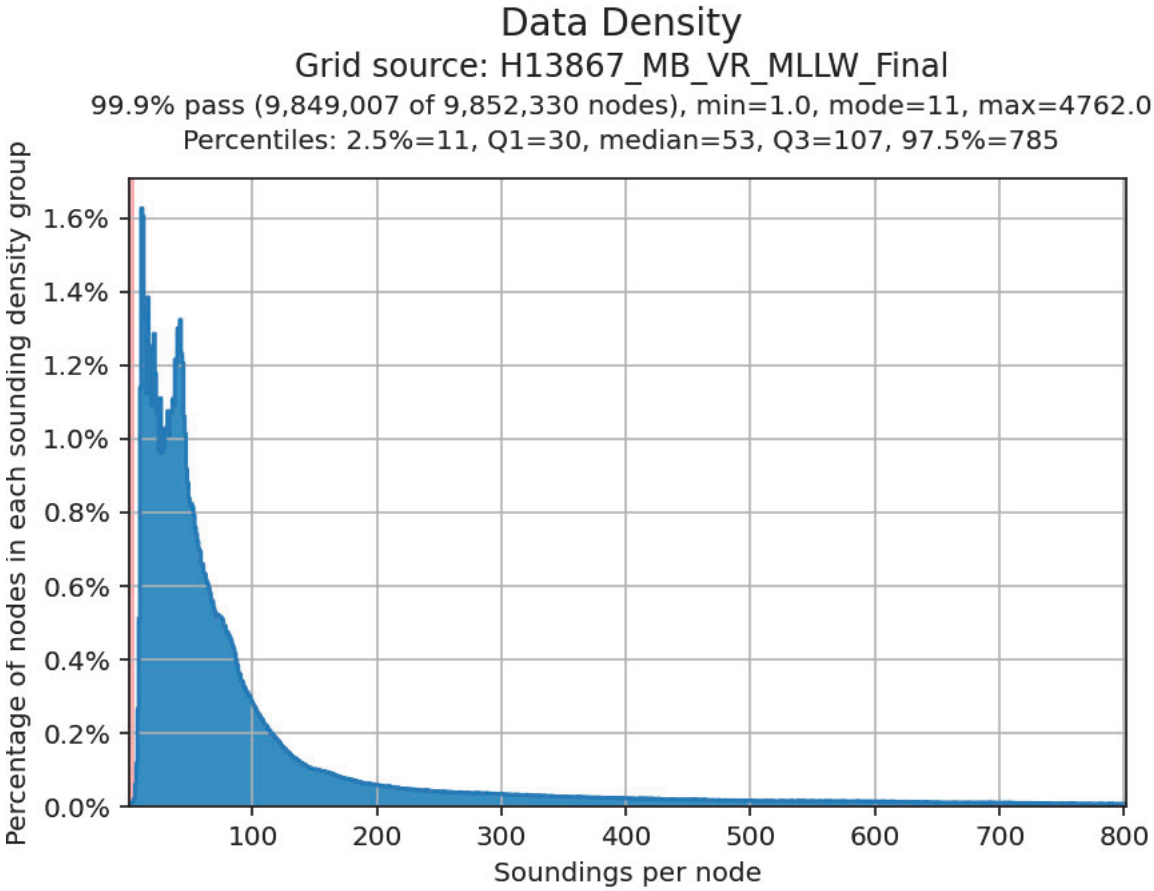
Statistical Analysis

Pydro's QC Tools (v4.3.2) included the tool "Grid QA" which automates the computation of grid statistics to ensure compliance with HSSD's specifications. This tool plots node percentage histograms for resolution requirements, uncertainty standards and data density which demonstrate surface compliance with the standards set forth in the HSSD. Each of these plots includes the percent of nodes that pass the specific test in addition to statistical results such as mode, median and quartile values.

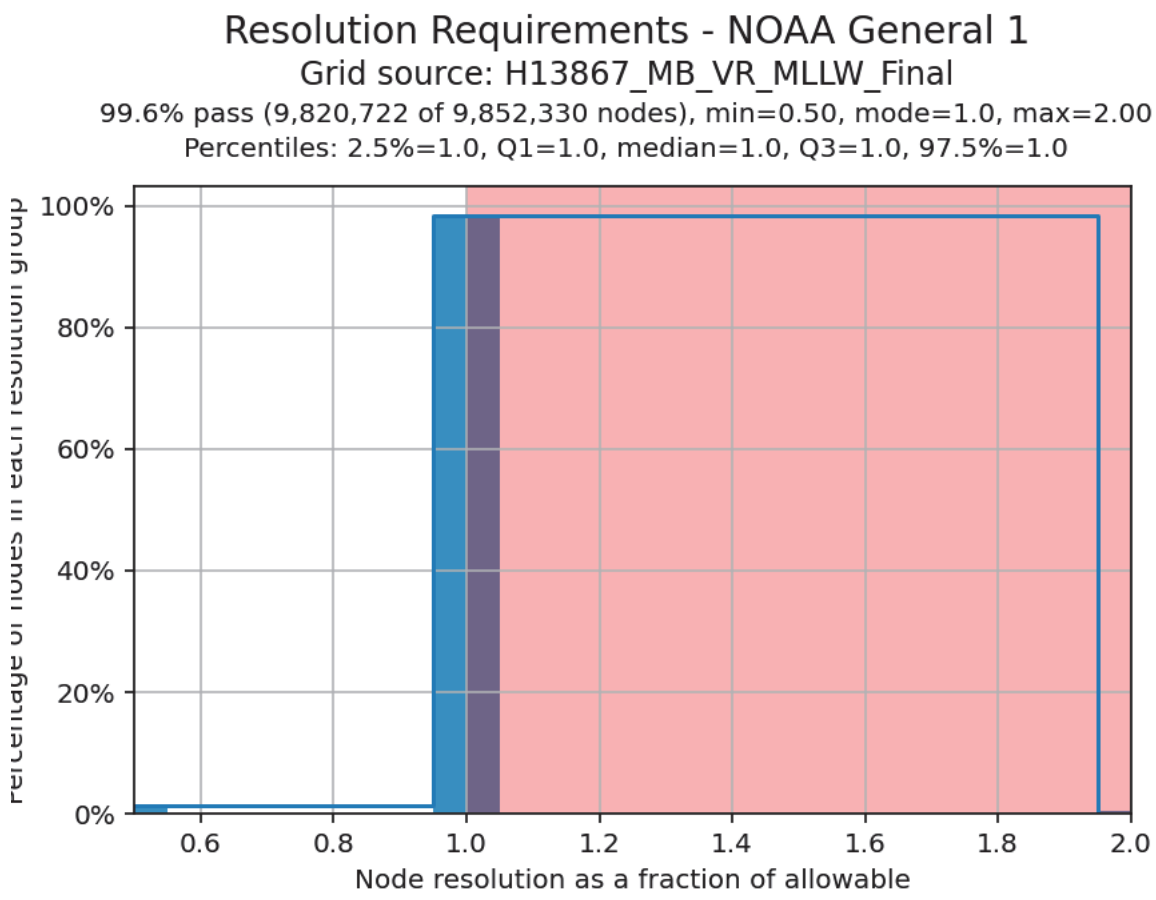
Pydro QC Tools Grid QA (v7) was used to analyze H13867 multibeam echosounder (MBES) data density and data resolution. The submitted H13867 finalized variable-resolution (VR) surface met HSSD General 1 density requirements. Grid QA results determined that over 99.9 percent of H13867 nodes met full density requirements and 99.6 percent of H13867 nodes met data resolution requirements.

Uncertainty values of the submitted finalized grids were calculated in Caris using "Uncertainty" when creating the finalized surface. Grid QA within Pydro QC Tools was used to analyze H13867 TVU compliance. The submitted H13867 finalized variable-resolution (VR) surface met HSSD Exceptional

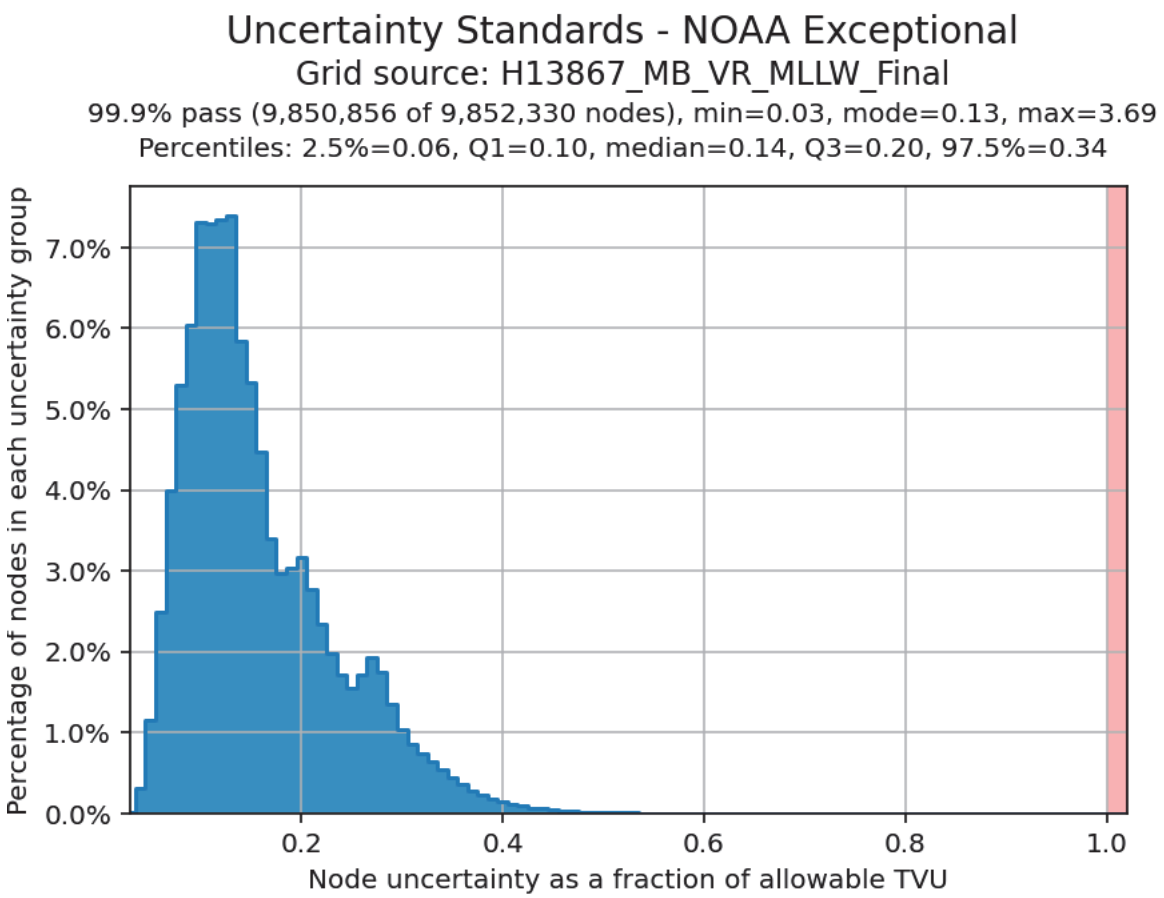
uncertainty standards with over 99.9 percent of grid nodes passing, which is shown in the histogram plot below.



Pydro Grid QA derived histogram plot showing HSSD density requirements of H13867 finalized variable-resolution MBES data.



Pydro Grid QA derived histogram plot showing HSSD resolution requirements of H13867 finalized variable-resolution MBES data.



Pydro Grid QA derived histogram plot showing HSSD uncertainty requirements of H13867 finalized variable-resolution MBES data.

Directed Editing

Directed editing involves an overview examination of the depth layer in addition to the available child layers to find problems with the data. This processing method works under the premise that if a surface “looks good” then the underlying data requires no additional cleaning. The hydrographer is then free to concentrate on trouble spots and make any necessary edits. While good at spotting bursts of noise and disagreement between overlapping lines, directed editing can have issues with finding single sounding fliers that may show up as only a single pixel if at all.

Preliminary data cleaning is performed daily during night processing following acquisition, addressing the most blatant fliers and blowouts. Cleaning is primarily done in Subset Editor, rejecting data that cause fliers in the CUBE grid.

Following this gross cleaning, Flier Finder, part of the QC Tools package in Pydro, is used to assist the search for spurious soundings. Flier Finder is run iteratively until all remaining flagged fliers are deemed to be valid aspects of the steep slopes and dynamic nature of the seafloor. Additionally, the uncertainty, hypothesis count, hypothesis strength, and node standard deviation child layers of the surface in CARIS HIPS are utilized to identify potential problem areas. These child layers may also cause seafloor features with high hypothesis counts or standard deviation such as man-made obstructions or wrecks to be easier identified.

On rare occasions the resolution of the CUBE surface may not be sufficient to capture the conditions throughout the entirety of a survey area. Only as a last resort should the hydrographer designate soundings that are not incorporated in the gridded surface. Detailed designated sounding searches in Subset Editor are only performed in regions expected to contain variation not captured in the standard grid, or when searching for known features. As a rule, sounding designation solely to adjust the surface is frowned upon and rarely used. Rather, sounding designation is typically used when those soundings are of critical importance, such as in the case of Dangers to Navigation (DTONs). In addition, all features found in the bathymetry that the Hydrographer wants included in the Final Feature File (FFF) should be correlated between MBES and S-57 data. This is accomplished by designating the most reliable least depth of the feature in question and importing the designated sounding into the FFF as a feature for additional attribution.

Fliers were edited utilizing subset editor in CARIS. Pydro QC Tools (v4.1.1) Flier finder was used with default settings and found 74 fliers. These fliers were checked and deemed as edge fliers or false fliers.

Holiday Identification

Pydro's "Holiday Finder" tool scans the CUBE surfaces for any empty grid nodes that are surrounded by populated nodes, and flags holidays dependent on the criteria set by the coverage requirements. All flags are then visually inspected to determine the validity of each holiday, and all confirmed holidays are addressed either by acquiring additional data over the gaps, or explaining the cause and likelihood of hazards within each gap.

Pydro QC Tools Holiday Finder (v5) was used with default settings to find holidays in the finalized H13867 VR surface. Holiday Finder detected 1 certain holidays from a final submitted VR surface which was determined to be the result of small blowout that created a gap in coverage. Least depths around the holidays were found.

Survey Adequacy

This survey is adequate to supersede all previous data.

Imagery Coverage

N/A

Data Interpolation

N/A

Backscatter

Calibration Method

Relative

Dynamic Range

Due to variation in depth, the sonar pulse characteristics were automatically adjusted throughout the survey to optimize the quality of the bathymetry measurements. Pulse-characteristic-dependent offsets are visible in the final mosaic.

Acquisition Configuration

Kongsberg EM 2040 Echosounders automatically adjusts power and gain to ensure that the received intensity is within the usable dynamic range of the system.

Environmental Variable

Absorption coefficients were derived from sound velocity casts and integrated in real-time in the sonar acquisition software.

Acquisition Output

Acoustic intensity data was recorded by the sonar, enabling it to be post-processed into the final mosaic.

H13867 backscatter mosaic.

Report of Survey

Uncertainty Source

Any individual sounding's Total Propagated Uncertainty (TPU), is derived from the assumed uncertainty in the echosounder measurement itself, as well as the contributing correctors from sound speed, water levels, position, and attitude. There are two places in CARIS where the user directly defines uncertainty values for use in CARIS to calculate TPU values, in the HVF and the direct input of SV and tide values during the TPU computation.

The TPU section of the HVF captures fixed estimates of uncertainty estimates for latency, sensor offset measurements, attitude and navigation measurements, and draft measurements. These uncertainty values are compiled from manufacturer specification sheets for each sensor, Appendix IV (Uncertainty values for use in CARIS with vessels equipped WITH an attitude sensor) of the 2014 FPM and from those set forth in Section 4.2.9 of the 2020 FPM.

Source of TPU Values: 28-foot Survey Launches

Commonly reported ranges of TPU values for all motion, navigation position and timing values are found in in the FPM. All timing values were set to 0.005 seconds as outlined for setups with Ethernet connections and precise timing. All offset values were chosen to be 0.010 meters based on the accuracy provided by professional surveys. Vessel speed uncertainty was defined as 0.03 m/s plus an average value (assumed to be 0.05 m/s) for currents for a total of 0.08 m/s.

Starting in 2021 Rainier made the decision to analyze the historic record and come up with a single "launch representative value" Loading TPU value (in meters). This single, all-time loading value was determined by averaging together the Loading TPU values determined annually between the years 2012 to 2021. The resulting value is used for both of the 28-foot survey launches utilized by the Rainier field party in 2024.

Starting in 2021 Rainier made the decision to analyze the historic records and come up with a single "launch representative value" for the Draft TPU value (in meters). This single, all-time draft value was determined by averaging together individual Draft TPU values determined annually for each launch between the years 2012 to 2021. The resulting value is used by the 28-foot survey launches utilized by the Rainier field party in 2024.

Vessel delta draft is set at 0.010 meters in the CARIS HVF, a value which falls within the range recommended in FPM.

In the past Roll/Pitch and Yaw uncertainty were determined individually for each launch on an annual basis by using a number of testers to separately determine the pitch, roll, and yaw angular bias correctors. For each bias the standard deviation was also determined. The MRU Align StdDev Roll/Pitch value entered into the CARIS HVF was calculated by finding the square root of the roll standard deviation squared plus the pitch standard deviation squared. The MRU Align StdDev gyro value entered into the CARIS HVF was simply the yaw standard deviation.

Starting in 2021 Rainier made the decision to analyze the historic record and come up with a single "launch representative value" for both roll/pitch and yaw standard deviation. Each launch’s annual pitch, roll, and yaw standard deviation values were found for each year between 2012 to 2021 and weighed by the number of testers (a roll StdDev with 8 testers had twice the influence of a roll StdDev with 4 testers), These weighted standard deviation values were then averaged using data from all 4 Rainier survey launches, to obtain a "launch representative value" for each of the three angular biases. For all 28-foot survey launches utilized by the Rainier field party in 2024, the MRU Align StdDev Roll/Pitch entered into the CARIS HVF is the square root of the "launch representative" roll standard deviation squared plus the "launch representative" pitch standard deviation squared. The MRU Align StdDev gyro entered into the CARIS HVF is simply the "launch representative" yaw standard deviation.

Source of TPU Values: 29-foot Survey Launch

For this project the field party also utilized a 29-foot survey launch normally maintained by MOC-P as training and testbed vessel. Although this launch looks similar to her 28' cousins, her construction is different enough from Rainier's launches that the 28-foot "launch representative" values cannot be used. Instead a HVF supplied by the Hydrographic Systems & Technology Branch with recommended standard deviation values from the FPM was used.

Report of Survey

Uncertainty Source

Four additional TPU values for tide and sound velocity must be manually entered for TPU computation during the Georeference Bathymetry process:

1) Tide values measured uncertainty is now defunct; referring to accuracy of the tide gauges that are no longer used. A value of 0.0 is entered.

2) Tide values zoning uncertainty value once referred to the tidal error contribution to the total survey error budget which included the tidal datum computation and tidal zoning errors. It now contains the separation uncertainty of the VDATUM model. The actual uncertainty value can be found in either the Vertical Control Requirements section of the Project Instructions or in the metadata associated with the VDATUM model supplied. H13867 utilized the branch provided, ellipse-MLLW: "VDatum_Outline_100m_NAD83_2011-MLLW_geoid188" for processing data for GPS vertical adjustment. The separation uncertainty is 13.4 cm.

3) Measured sound speed value error ranges from 0.5 to 4 m/s, dependent on temporal/spatial variability. Although the FPM recommends a value of 4 m/s when one cast is taken every 4-hours, Rainier experience in the field indicates that a value of 3.0 m/s better models this error. If the ship measures sound speed with the MVP, a value of 1.0 m/s is used due to the higher sampling frequency. In cases where XBT casts are used to measure sound speed, the recommended value of 4.0 m/s is used.

4) Surface sound speed value is dependent on the manufacturer specifications of the instrument utilized to measure surface SV values for refraction corrections to flat-faced transducers. The RESON SVP 70 is the only model affixed to Rainier and all her MBES launches and a has a published accuracy of 0. 05 m/s.

In addition to the usual a priori estimates of uncertainty, some real-time and post-processed uncertainty sources are also incorporated. Real-time uncertainties from the Kongsberg EM2040 were recorded and applied in post-processing. Applanix TrueHeave files are recorded on all survey vessels, which include an estimate of the heave uncertainty, and are applied during post-processing. Finally, the post-processed uncertainties associated with navigation and GPS Height applied in CARIS HIPS via an SBET RMS file generated in POSPac.

Supplementals

- Coast Pilot Report *(Feb 28, 2025)*
- Trained Marine Mammal Observers list *(Aug 12, 2024)*
- Final Survey Outline *(Feb 27, 2025)*
- NCEI Sound Speed Data *(Aug 21, 2024)*
- Potentially Sensitive Data Findings *(Feb 27, 2025)*

Approval Statement

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 Specifications and 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.

Approver Name	Approver Title	Approver Certification
Nicholas C. Morgan, CDR/NOAA	Chief of Party	Digitally signed by MORGAN.NICHOLAS.CHARLES.1292288138 Date: 2025.03.13 11:48:55 -10'00'

Personnel

Name	Title	Certification
Justin E. Blancher, LT/NOAA	Field Operations Officer	BLANCHER.JUSTIN.EDWARD.1558114424 Digitally signed by BLANCHER.JUSTIN.EDWARD.1558114424 Date: 2025.03.13 10:43:09 -10'00'
James B. Jacobson	Chief Survey Technician	JACOBSON.JAMES.BRYAN.1269664017 I have reviewed this document 2025.03.13 08:48:09 -10'00'
Thomas A. Murphy	Sheet Manager	MURPHY.THOMAS.ANDREW.1608363633 Digitally signed by MURPHY.THOMAS.ANDREW.1608363633 Date: 2025.03.04 11:29:31 -10'00'

Full Equipment List

Equipment Type	Manufacturer and System	Model Number	Serial Number	Calibration Date	Frequency	Accuracy Check Date
RA-3 (2803)						
Positioning and Attitude System	Applanix POS MV 320 v5	POS MV 320 V5	7272	2024-03-26	NA	NA
Multibeam	Kongsberg Maritime EM 2040	EM2040-07	256	2024-03-26	300 kHz	2024-03-26
Sound Speed System	Teledyne RESON SVP 70	SVP 70	3417109	2018-03-05	20 Hz	2024-03-26
CTD	Sea-Bird Scientific SBE 19plus V2	SBE 19 Plus	4343	2021-11-26	4 Hz	2024-05-31
RA-6 (2804)						
Positioning and Attitude System	Applanix POS MV 320 v5	POS MV 320 V5	7274	2024-03-26	NA	NA
Multibeam	Kongsberg Maritime EM 2040	EM2040-07	257	2024-03-26	300 kHz	2024-03-26
Sound Speed System	Teledyne RESON SVP 70	SVP 70	2817018	2018-03-01	20 Hz	2024-03-26
CTD	Sea-Bird Scientific SBE 19plus V2	SBE Plus	4676	2018-01-31	4 Hz	2024-05-31
2902 (2902)						
Positioning and Attitude System	Applanix POS MV 320 v5	POS MV 320 V5	8198	2024-03-26	NA	NA
Multibeam	Kongsberg Maritime EM 2040	EM2040-07	262	2024-03-26	300 kHz	2024-03-26
Sound Speed System	Teledyne RESON SVP 70	SVP 70	3722013	2023-02-15	20 Hz	2024-03-26
CTD	Sea-Bird Scientific SBE 19plus V2	SBE 19 Plus	4778	2018-02-10	4 Hz	2024-05-31