



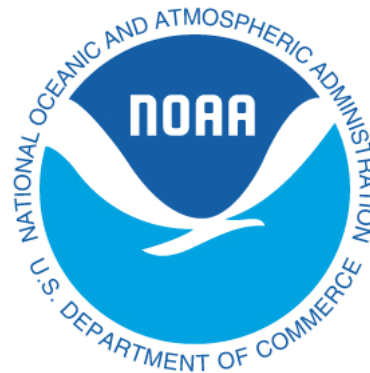
NOAA
Coast Survey

H13754

45 NM Southeast
of Masonboro Inlet

OPR-F324-FH-24
Approaches to Wilmington
North Carolina

Responsible Party
DOC/NOAA/NOS/OCS -- Office of Coast Survey
Contact Information
HSD.Chief@noaa.gov
Field Unit
NOAA Ship Ferdinand Hassler (S250)
Survey Dates
June 06, 2024 - June 26, 2024
License Information
CC0-1.0
Approver
CDR William G. Winner, NOAA



Platform and Sonar Equipment
NOAA Ship Ferdinand R. Hassler (S250) <i>Kongsberg Maritime EM 2040</i>

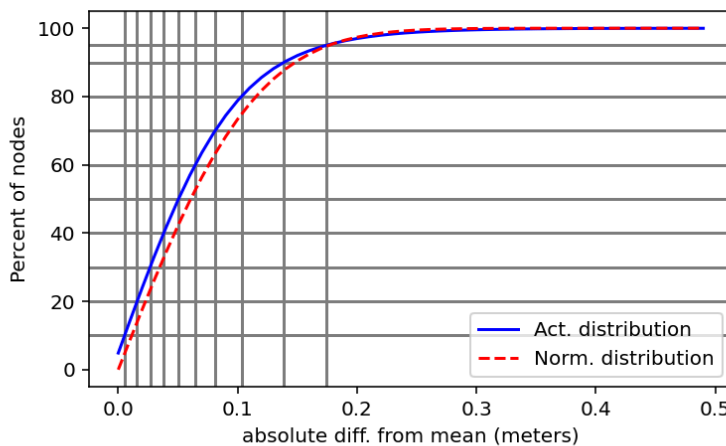
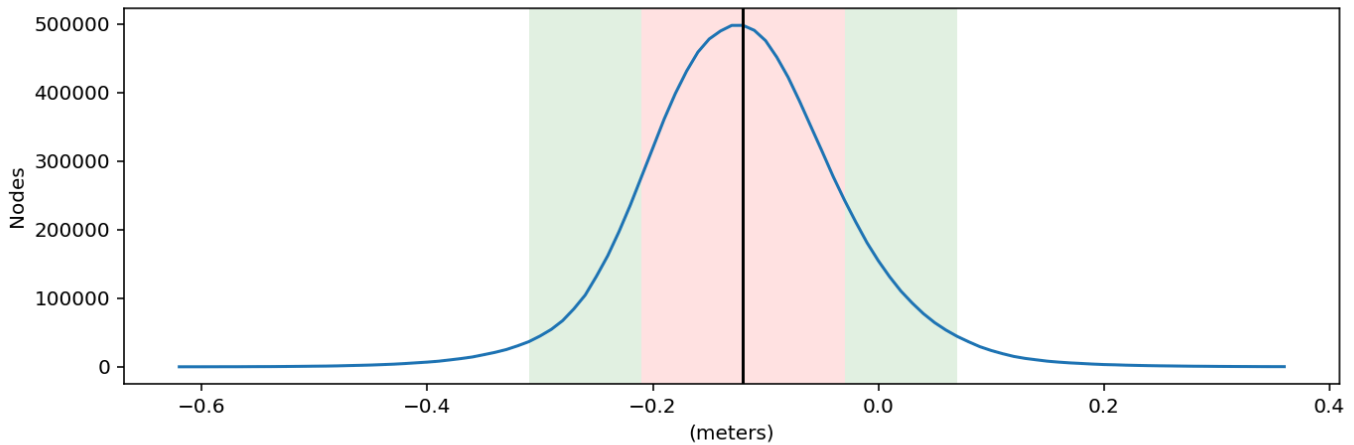
Bathymetry Grid		
H13754_MB_1m_MLLW_1of1 North American Datum 1983 (2011) Projected UTM 18, Mean Lower Low Water		
Sounding Technique: Multibeam	Full Seafloor Coverage: Yes	Feature Detection Size: 2.0m 10%
Features Detected: Yes	Bathymetric Coverage: Yes	Uncertainty Horizontal: 1m N/A
Least Depth Detected: Yes	Interpolated: No	Uncertainty Vertical: 0.15m 0.75%

Quality Control Procedure

Crosslines

Crosslines were collected, processed, and compared to mainscheme in accordance with Section 5.9 of the 2024 HSSD. To evaluate the crosslines, a 1m Single Resolution (SR) Combined Uncertainty and Bathymetry Estimator (CUBE) surface using strictly mainscheme data and a 1m SR CUBE surface of strictly crossline data were created. From these two surfaces, a 1m difference surface (mainscheme - crosslines = difference surface) was generated using the Compare Grids tool in Pydro. Pydro is a suite of software maintained by NOAA's Hydrographic Systems and Technology Branch (HSTB), which contains various tools that aid in the analysis and quality control of hydrographic data. The results of this comparison indicate that 99.99% of grid-node comparisons between the two surfaces are within the Fraction of Allowable Error for depth/height, exceeding the specification of 95% stipulated by NOAA's 2024 Hydrographic Surveys Specifications and Deliverables (HSSD). The mean difference between these surfaces is -0.12m, with a standard deviation of 0.09m, verifying the consistency of the data.

H13754_MB_1m_MLLW_1of1_MS-H13754_MB_1m_MLLW_1of1_XL
 Mean: -0.12 | Mode: -0.12 | One Standard Deviation: 0.09 | Bin size: 0.01



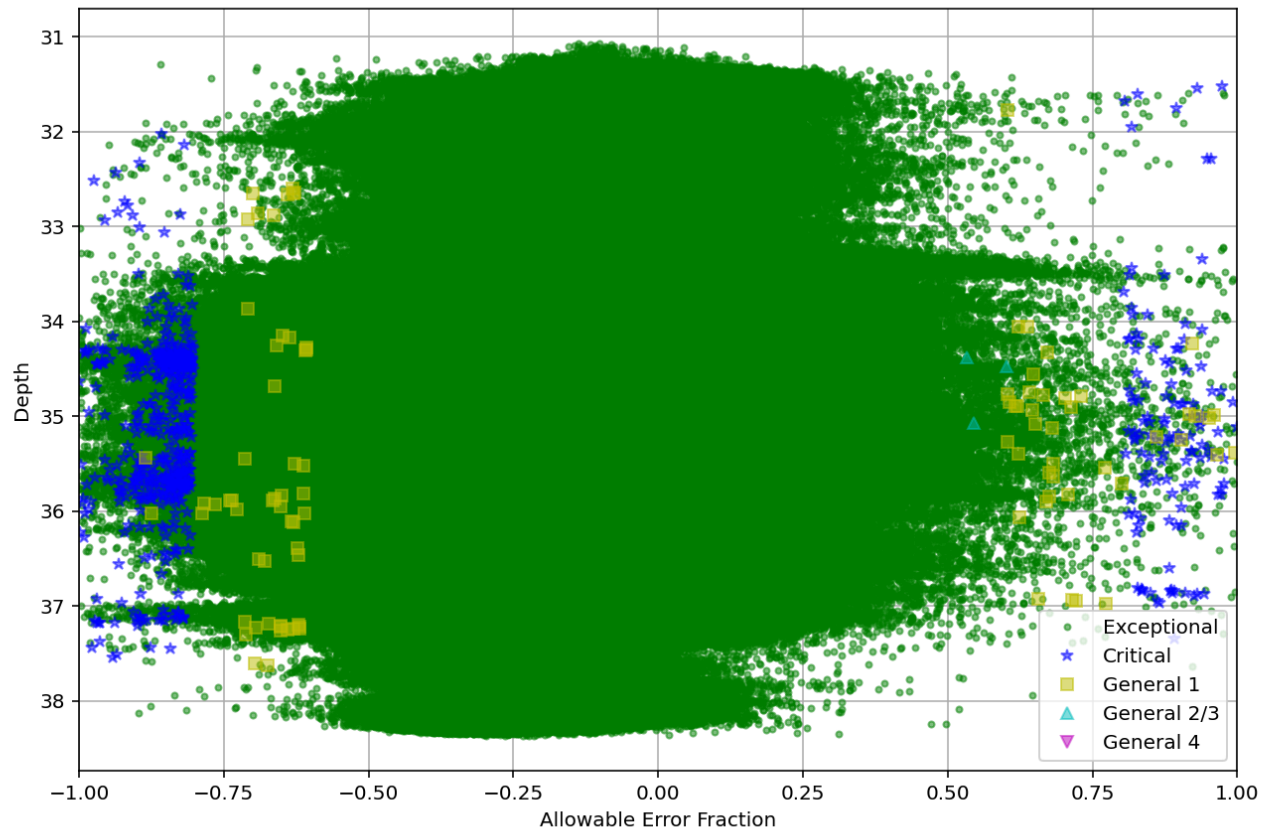
Percent of nodes	Deviation (m)
50%	+/- 0.05
60%	+/- 0.06
70%	+/- 0.08
80%	+/- 0.10
90%	+/- 0.14
95%	+/- 0.17

H13754 Crossline Comparison Statistics

Node Depth vs. Allowable Error Fraction

Total comparisons 10239270

Passed States: Exceptional=99.99%, Critical=100.00%, General 1=100.00%, General 2/3=100.00%, General 4=100.00%,



H13754 Crossline Node Depth vs Allowable Error

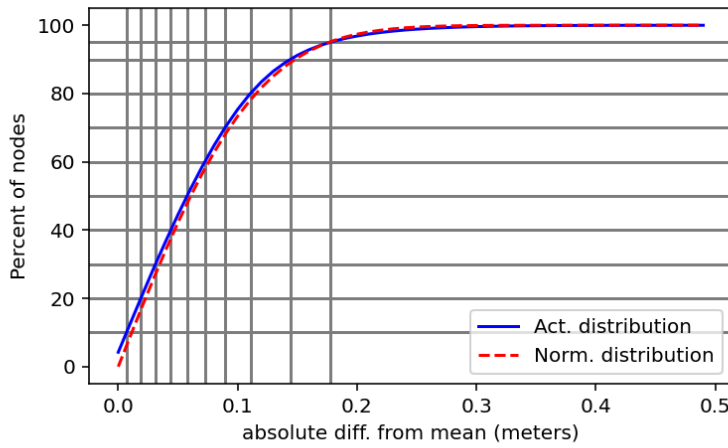
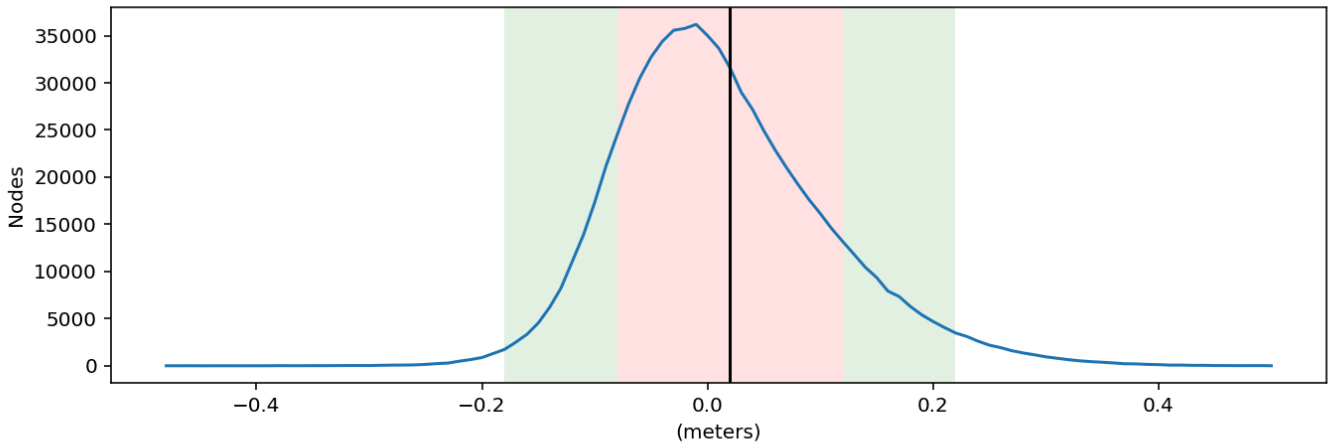
Junction Overlap

To evaluate the junction between H13754 and adjacent surveys, the H13754 1m SR finalized CUBE surface was compared to the finest resolution grid from the adjacent survey using the Pydro Compare Grids tool. This generates a difference surface (H13754 - Junction Surface = Difference Surface) and associated statistics. Survey H13754 junctions with prior surveys H13750 and H13749.

A comparison between the final 1m SR CUBE surface of survey H13754 and the final 2m SR surface of survey H13749 was completed. The mean difference between the surfaces was 0.02m, with a standard deviation of 0.09m. The results indicate that 100% of grid-nodes are within the Fraction of Allowable Error standards for depth/height, exceeding the specification of 95% stipulated by the 2024 HSSD.

A comparison between the final 1m SR CUBE surface of survey H13754 and the final 1m SR surface of survey H13750 was completed. The mean difference between the surfaces was 0.06m, with a standard deviation of 0.08m. The results indicate that 99.99% of grid-nodes are within the Fraction of Allowable Error standards for depth/height, exceeding the specification of 95% stipulated by the 2024 HSSD.

H13754_MB_1m_MLLW_1of1_Final-H13749_MB_2m_MLLW_Final
 Mean: 0.02 | Mode: -0.01 | One Standard Deviation: 0.09 | Bin size: 0.01



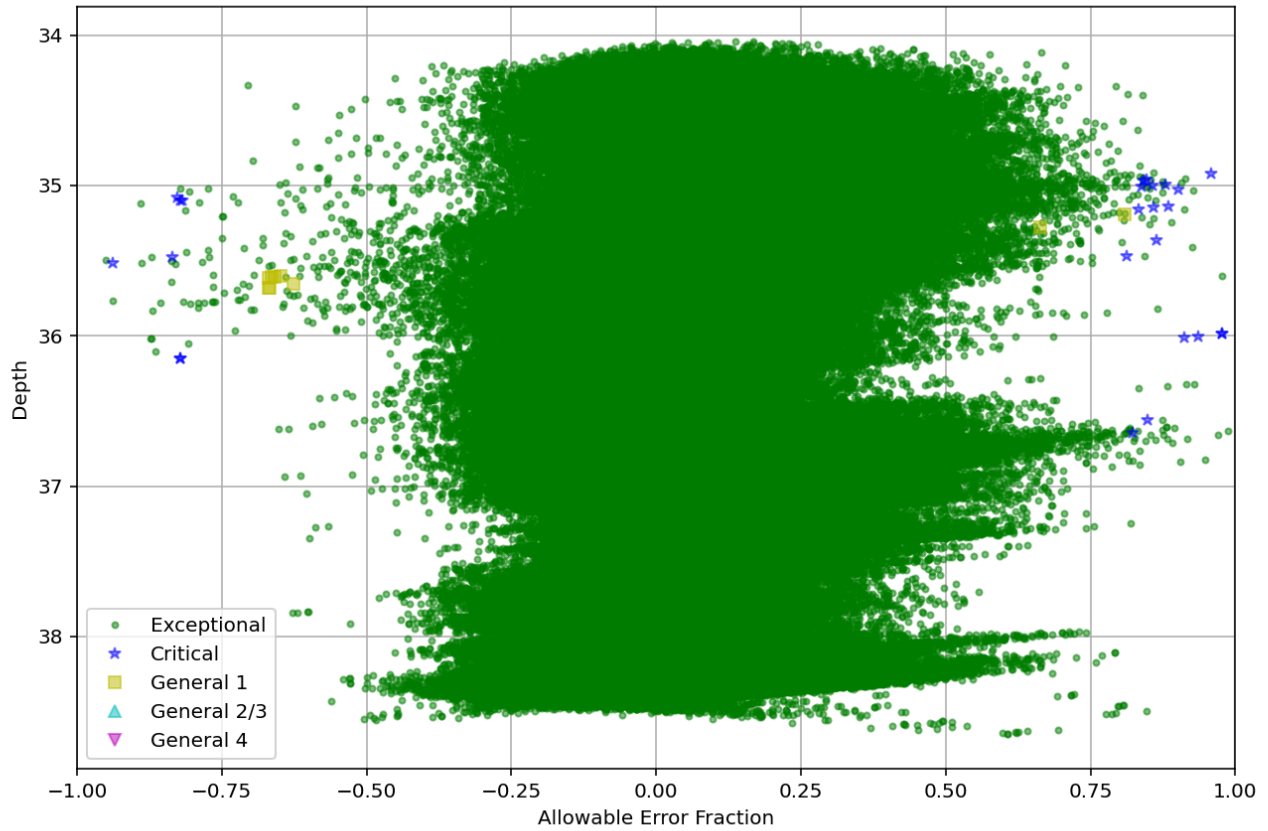
Percent of nodes	Deviation (m)
50%	+/- 0.06
60%	+/- 0.07
70%	+/- 0.09
80%	+/- 0.11
90%	+/- 0.14
95%	+/- 0.18

H13754 to H13749 Junction Comparison Statistics

Node Depth vs. Allowable Error Fraction

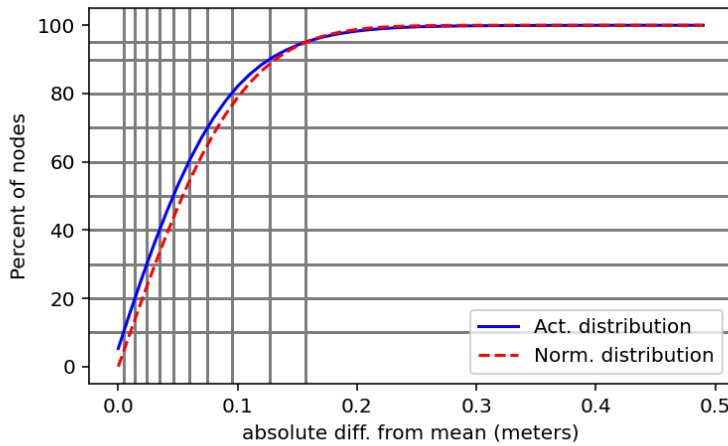
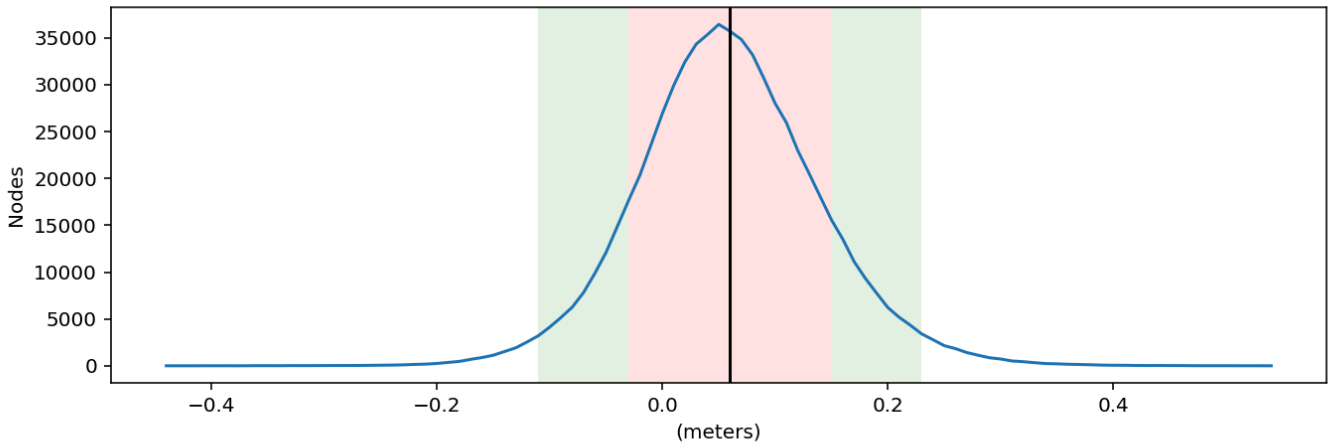
Total comparisons 747955

Passed States: Exceptional=100.00%, Critical=100.00%, General 1=100.00%, General 2/3=100.00%, General 4=100.00%,



H13754 to H13749 Junction Fraction of Allowable Error Statistics

H13754_MB_1m_MLLW_1of1_Final-H13750_MB_1m_MLLW_Final
 Mean: 0.06 | Mode: 0.05 | One Standard Deviation: 0.08 | Bin size: 0.01



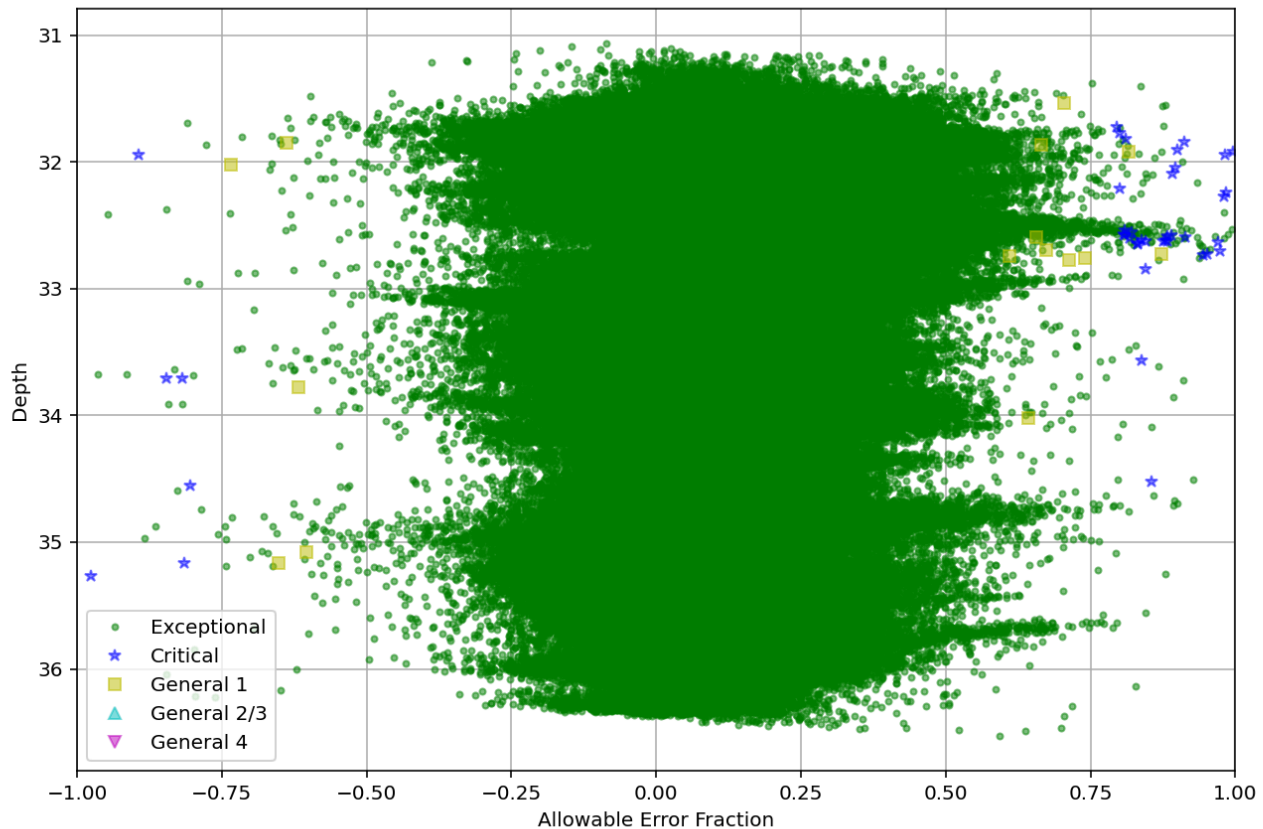
Percent of nodes	Deviation (m)
50%	+/- 0.05
60%	+/- 0.06
70%	+/- 0.07
80%	+/- 0.09
90%	+/- 0.13
95%	+/- 0.16

H13754 to H13750 Junction Comparison Statistics

Node Depth vs. Allowable Error Fraction

Total comparisons 670780

Passed States: Exceptional=99.99%, Critical=100.00%, General 1=100.00%, General 2/3=100.00%, General 4=100.00%,



H13754 to H13750 Junction Fraction of Allowable Error Statistics

Statistical Analysis

Ferdinand R. Hassler's primary bathymetric data review and quality control tool is the CARIS CUBE surface. The CUBE algorithm generates a surface consisting of multiple hypotheses that represent the possible depths at any given position. The CUBE surface is a grid of estimation nodes where depth values are computed based on the horizontal and vertical uncertainty of each contributing sounding. 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. Uncertainty values for tide and sound speed must be entered for each vessel during TPU computation. Ferdinand R. Hassler is currently using the following uncertainty values:

- GPS tide uncertainty is unique to the separation model in use and is supplied by the project manager.
- Measured sound speed uncertainty was set to a value of 2 m/s as recommended by the NOAA Field Procedures Manual when a minimum of 1 cast is taken every 4 hours.
- Surface sound speed value is dependent on the manufacturer specifications of the unit utilized to measure surface SV values for refraction corrections to flat-faced transducers. A value of 0.5 m/s is used for surface sound speed uncertainty.

All other error estimates are read from the Hydrographic Vessel File (HVF). The HVF contains all offsets and system biases for the survey vessel and its systems, as well as error estimates for latency, sensor

offset measurements, attitude and navigation measurements, and draft measurements. The HVF also specifies which type of sonar system the vessel is using. In addition to the usual a priori estimates of uncertainty, some real-time and post-processed uncertainty sources were incorporated into the depth estimates. Real-time uncertainties from the Kongsberg EM2040 dual-dual were recorded and applied in post-processing. Applanix TrueHeave files are recorded, which include an estimate of the heave uncertainty, and are applied during post processing. Uncertainties associated with vessel roll, pitch, gyro, and navigation are applied in CARIS HIPS and SIPS via a Smoothed Best Estimate of Trajectory (SBET) and RMS files generated in Applanix POSPac.

Statistical analysis of grid layers was conducted to assess the quality of the bathymetry. The "GridQA" program contained within Pydro's QC Tools 4 was used to assess grid density, resolution, and uncertainty against allowable standards specified in the 2024 HSSD. This survey was assigned quality metrics of General 1 and the delivered grids exceed the specified standards. The uncertainty metrics reported in the Metadata section of this report reflect the highest Quality Metric that was achieved for the survey (Exceptional).

Directed Editing

The CUBE surface child layers: uncertainty, standard deviation, hypothesis count, and node standard deviation were used to help focus directed editing to soundings that were negatively affecting the BASE surface. Another method to check the quality of sounding data prior to submission is the Pydro QC Tools 4 "Flier Finder." This software scans the CUBE surface for potential anomalous grid data. Lowering the flier height value increases the sensitivity of Flier Finder, resulting in more nodes being flagged. Fliers are then exported as .000 S-57 files that can be imported into CARIS HIPS and SIPS to aid in further cleaning. If desired, the user can set a new tolerance ("Flier Height") and rerun Flier Finder.

0 fliers remain in H13754.

On occasion, the resolution of the CUBE surface may not be sufficient to capture the shoalest point of a feature. In less than 20m of water, a feature is considered inadequately captured by the CUBE surface when the most probable accurate sounding is shoaler than the CUBE surface by greater than one half the allowable OCS Quality Metrics for Uncertainty. In greater than 20m of water, this allowable error is expanded to the full OCS Quality Metric at that depth. Although missed shoal points may occur on irregular shoals or rock pinnacles, man-made features such as piles and wrecks are of particular concern. These features have very slender high points that extend far above the surrounding seafloor as well as the CUBE surface. To ensure that these features are properly represented, the shoalest point is flagged "designated" in CARIS. During the "finalization" process, the CUBE surface is forced to honor all soundings which have been flagged "designated." In the case of a survey where the high points of many features (i.e. a boulder field) are not being captured by the CUBE surface, the hydrographer may decide to produce higher resolution CUBE surfaces to ensure that these features are being honored.

0 designated soundings exist in H13754.

Holiday Identification

Most holidays are identified and addressed while in the field collecting mainscheme. During night processing, Pydro QC Tools' "Holiday Finder" is used to detect holidays not addressed in the field. This tool scans the grid, and any empty nodes surrounded by populated nodes are identified. In the event any

holidays are found, small polygons are made in HIPS to direct data acquisition to fill them in. The ship then returns to the sheet and acquires these identified holidays.

56 holidays remain in H13754.

Ferdinand R. Hassler had a scheduled repair period that resulted in survey acquisition ending prematurely, without completion of the holidays. A .hob file with the remaining holidays is located in QC>holiday_finder folder. While holidays exist that meet the technical definition, the hydrographer believes that significant features are unlikely to exist.

Survey Adequacy

Other than the aforementioned holidays, there are no other factors that affect the survey's adequacy and accuracy. This entire survey is adequate to supersede previous data in the area.

Imagery Coverage

Imagery coverage assessment was not performed for this survey

Data Interpolation

Data interpolation was not performed for this survey

Backscatter

Calibration Method

Relative

Dynamic Range

The EM2040 Dual-Dual system was cross calibrated between heads (essentially a vessel-to-vessel comparison) using QPS' FMGT program to assess intensity differences at each depth mode for 200 and 300 kHz. The resulting values are placed in the backscatter projects during processing to remove any sonar head dependent biases. The EM2040s have the dynamic range to accommodate the relatively homogeneous survey area. On H13754, the frequency was held constant at 300 kHz.

Acquisition Configuration

There were instances when the Kongsberg EM2040 experienced dropped pings and significantly reduced ping rates. Some of these dropouts could be seen during acquisition, but most were not found until post-processing. This resulted in an increased number of holidays. While troubleshooting these dropouts, EM2040 was taken out of auto depth mode, and fixed in the medium depth mode. No additional special techniques were used outside of normal considerations for quality data acquisition for a bathymetric survey.

Environmental Variable

Sound speed profiles were acquired at a minimum of once every four hours in order to apply appropriate absorption coefficients during acquisition. Backscatter data was paired with cleaned HDCS data in QPS' FMGT program further reducing any potential environmental effects.

Acquisition Output

Please refer to Section 4.3.2.1.2 Acoustic Backscatter Imagery of the Field Procedures Manual for the backscatter post processing workflow. Backscatter data was processed daily as a part of night

processing allowing the quality to be evaluated and potential bottom sample locations to be evaluated. The data was paired to HDCS data after the bathymetric data was cleaned.

Report of Survey

Uncertainty Source

Total Propagated Uncertainty (TPU) values for H13754 were derived from a combination of fixed values for equipment and vessel characteristics, as well as field assigned values for sound speed uncertainties. The uncertainty for the VDatum model was provided to the field by the project manager. In addition to the usual a priori estimates of uncertainty, some real time and post processed uncertainty sources were also incorporated into the depth estimates of the survey. Real-time uncertainties from the Kongsberg MBES sonars were incorporated and applied during post processing. Uncertainties associated with vessel roll, pitch, gyro, navigation, and heave were applied during post-processing. All of the aforementioned uncertainties were applied in CARIS HIPS/ SIPS. H13754 is an ellipsoidally referenced survey (ERS) and the tidal component was accomplished with a VDATUM separation model. There are two places in CARIS where the user directly defines uncertainty values to calculate TPU values, in the HVF and during the application of SV and GPS model values during the TPU computation portion of the georeferencing process. TPU values for all motion, navigation position and timing values are taken directly from Appendix IV (Uncertainty values for use in CARIS with vessels equipped WITH an attitude sensor) of the FPM. All timing values were set to 0.001 seconds as outlined for setups with Ethernet connections and precise timing. All offset values were chosen to be 0.02 meters based on the accuracy provided by professional surveys. Reference the vessel HVF for specific uncertainty values used for data processing for H13754.

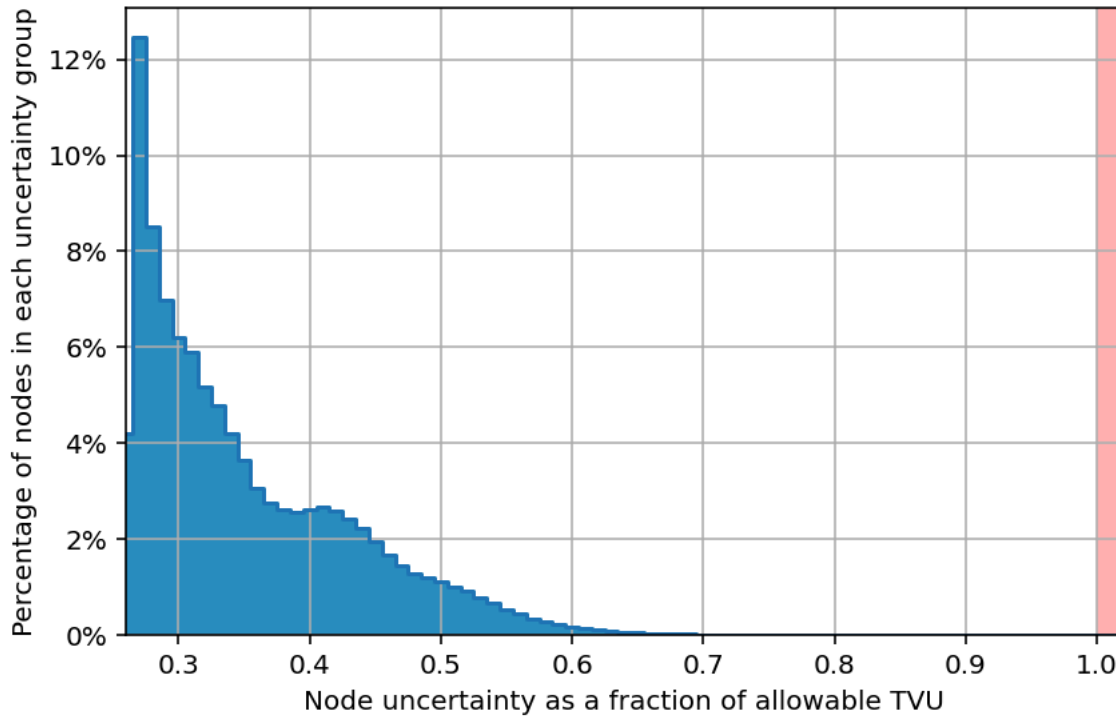
The bathymetric surface of survey H13754 exceeds uncertainty standards stipulated in the 2024 HSSD. The Uncertainty Standards plots depicted here were generated using the "Grid QA" tool in the Pydro QC Tools 4 suite. The results illustrate that over 98% of nodes in the H13754 MBES surface comply with NOAA General 1, Critical, and Exceptional quality metrics for uncertainty.

Uncertainty Standards - NOAA General 1

Grid source: H13754_MB_1m_MLLW_1of1_Final

99.5+% pass (153,386,623 of 153,387,108 nodes), min=0.26, mode=0.27, max=33.08

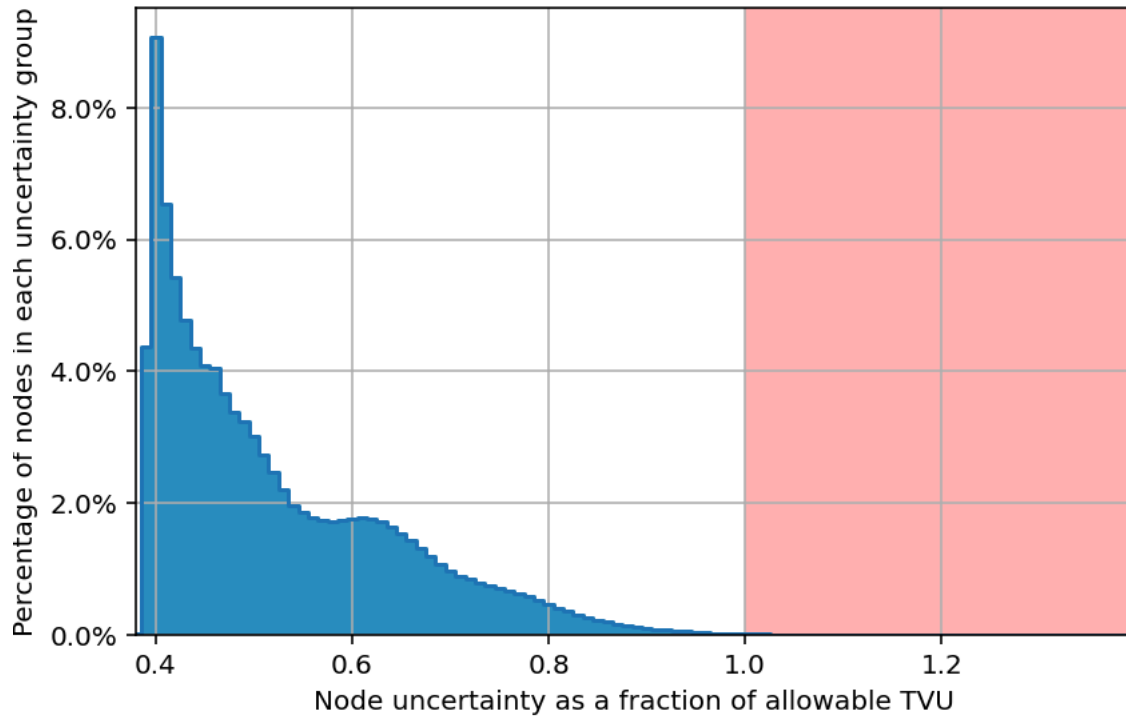
Percentiles: 2.5%=0.26, Q1=0.28, median=0.33, Q3=0.40, 97.5%=0.54



H13754 Uncertainty Statistics, General 1

Uncertainty Standards - NOAA Critical Grid source: H13754_MB_1m_MLLW_1of1_Final

99.5+% pass (153,281,629 of 153,387,108 nodes), min=0.38, mode=0.40, max=49.45
Percentiles: 2.5%=0.39, Q1=0.42, median=0.49, Q3=0.60, 97.5%=0.81



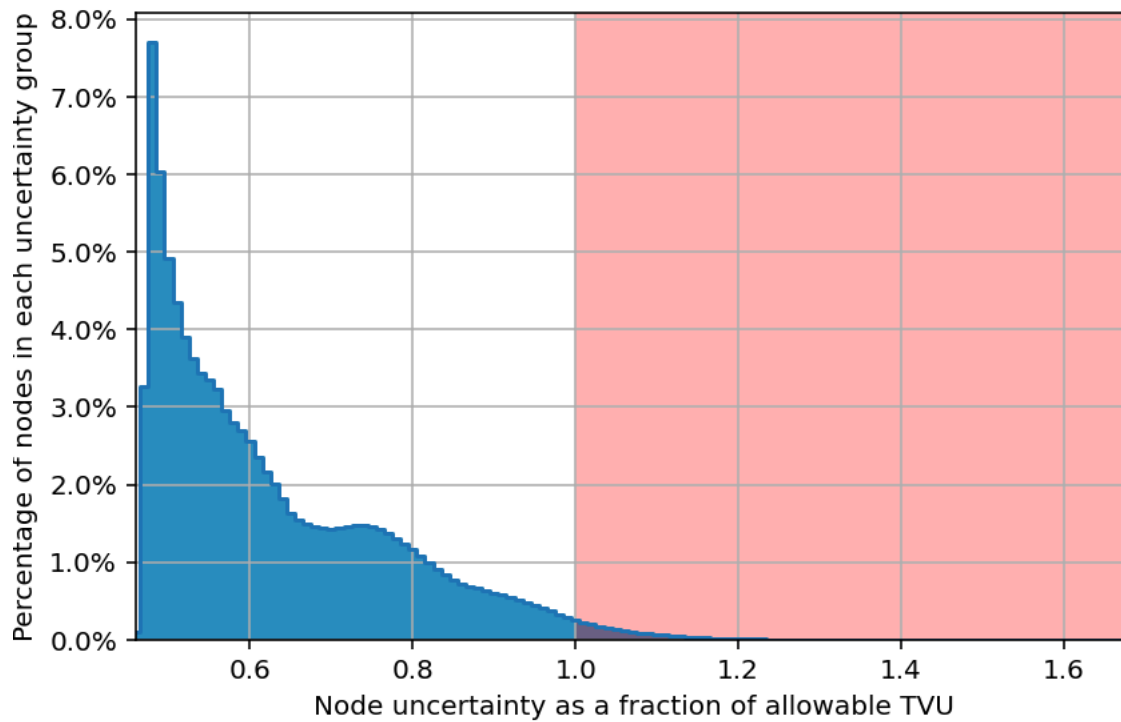
H13754 Uncertainty Statistics, Critical

Uncertainty Standards - NOAA Exceptional

Grid source: H13754_MB_1m_MLLW_1of1_Final

98% pass (150,570,077 of 153,387,108 nodes), min=0.46, mode=0.48, max=59.37

Percentiles: 2.5%=0.47, Q1=0.51, median=0.59, Q3=0.72, 97.5%=0.98



H13754 Uncertainty Statistics, Exceptional

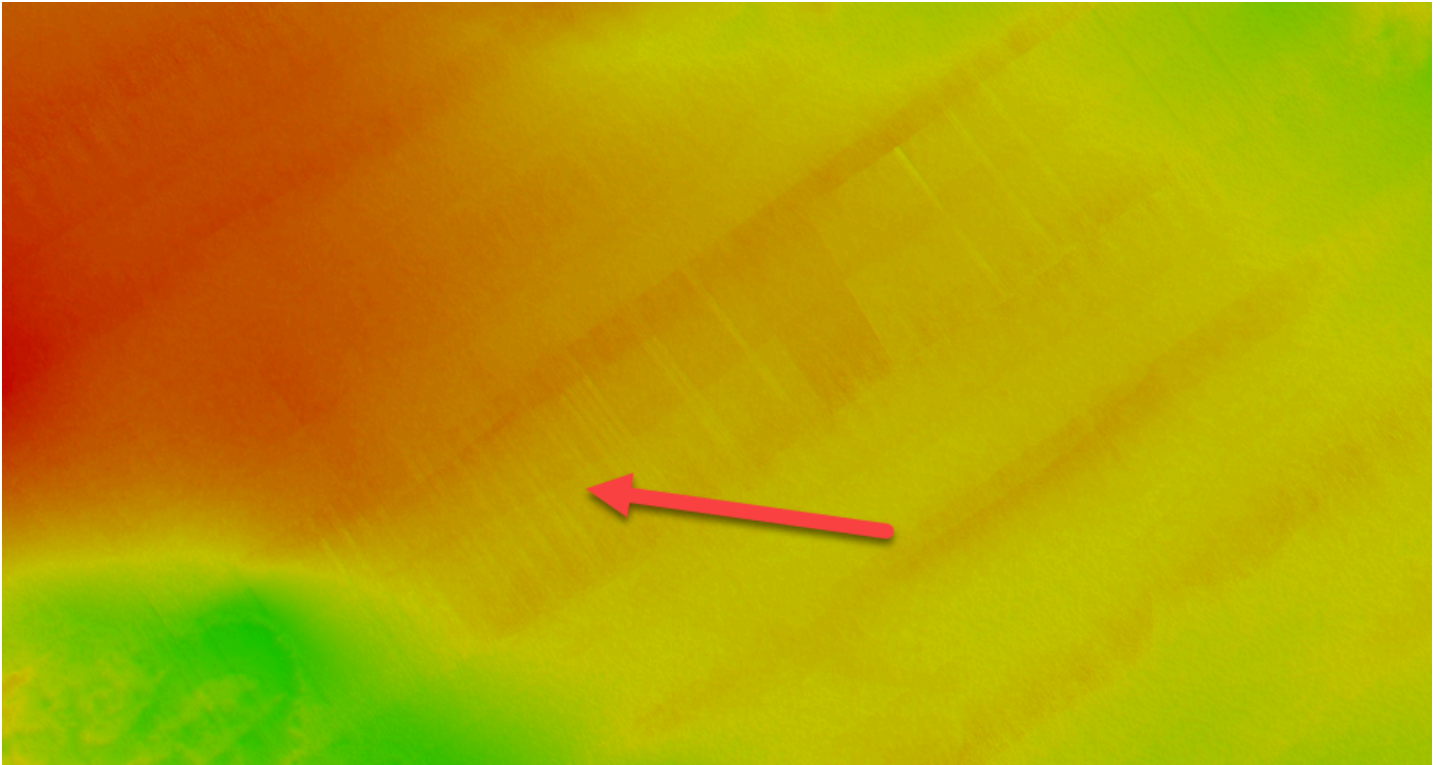
Error Source

Bathymetric grids are evaluated for systematic and random errors using the child layers in CARIS including uncertainty, node standard deviation, and hypothesis count, among others. These layers highlight areas of potentially erroneous data for the hydrographer to evaluate. In addition, Flier Finder and Grid QA in Pydro's QC Tools 4 aid in the direct editing of the grids. A data log is used to ensure that all correctors were properly applied to the multibeam lines. Any errors encountered were investigated and corrected if possible. Anomalous soundings that could not be corrected were rejected from the data set and any data gaps were reacquired.

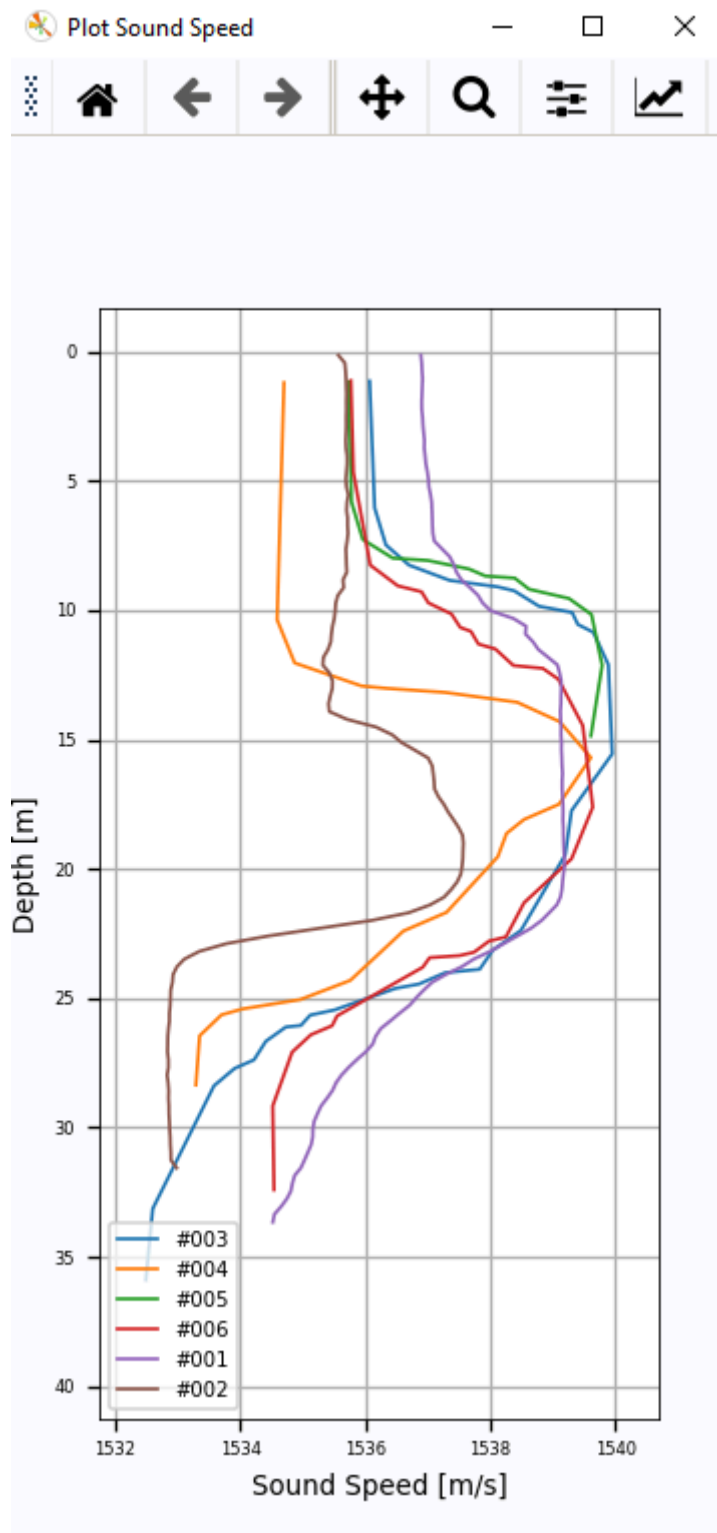
Sound Velocity Issues: Some multibeam data on H13754 contains evident outer beam spreading visible primarily as "smiles/frowns" in the data subset. This is likely caused by sound speed variations in the area that were not evident in the SIS surface sound speed comparison and not captured by a Moving Vessel Profiler (MVP) cast. The most probable cause is dynamic currents in the area. In areas where the beam spreading was obvious, rather than the true seafloor, the spurious soundings were rejected and surfaces recomputed. After cleaning, these areas meet or exceed the uncertainty requirements for an Exceptional survey.

In the first few days of acquisition, large sound velocity variation was observed in the 8-16m depth range, with a difference of up to 5m/s. SIS did not flag this difference, as surface sound velocity remained between the 2m/s threshold. As depth increased beyond the 8-16m range, the difference in sound velocity evened out to within 2m/s again. This can be seen in the second attached image below. Gulf stream eddies and/or

currents around Frying Pan Shoals could have caused this large sound velocity difference. Once this was realized, cast frequency increased and the issue was resolved.



Example of SV related wobble, seen between lines 158 and 160.



Large SV variation between 8-16m depth.

Additional Information

This sheet is incomplete. A scheduled maintenance period and essential regulatory testing ran over the estimated time frame, forcing the cancellation of the last leg for this project. A .hob file with the remaining holidays is located in QC>holiday_finder folder.

Ancient paleochannels seen in previous sheets of this project were also seen in the Southeast region of H13754.

PI Alteration

No modifications were made to the project instructions for H13754.

Supplementals

- Final Survey Outline (*Aug 15, 2024*)
- NCEI Sound Speed Data (*Aug 14, 2024*)
- Trained Marine Mammal Observers list (*Aug 14, 2024*)
- Coast Pilot Report (*Jul 03, 2024*)

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 and approved all data and metadata. The survey meets or exceeds requirements as set forth in the Project Instructions and NOS Hydrographic Surveys Specifications and Deliverables. The survey is complete and no additional work is required with the exception of any deficiencies noted in the Report of Survey.

Approver Name	Approver Title	Approver Certification
CDR William G. Winner, NOAA	Chief of Party	

Personnel

Name	Title	Certification
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Full Equipment List						
Equipment Type	Manufacturer and System	Model Number	Serial Number	Calibration Date	Frequency	Accuracy Check Date
NOAA Ship Ferdinand R. Hassler (S250)						
Positioning and Attitude System	Applanix POS MV 320 v5	POS MV V5	5807	2024-03-21	NA	NA
Multibeam	Kongsberg Maritime EM 2040	Dual-Dual	40144	2024-03-21	200-400kHz	2024-03-25
Sound Speed System	Teledyne RESON SVP 70	N/A	0217026	2023-06-19	N/A	2023-06-19
Sound Speed System	Teledyne RESON SVP 70	N/A	3722084	2023-08-15	N/A	2023-08-15
CTD	SonTek CastAway-CTD	N/A	CC2335016	2023-09-13	N/A	2024-03-13
CTD	AML Oceanographic MVP200	MVP-X2	9196	2023-06-29	N/A	2024-03-13