H13941

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

DESCRIPTIVE REPORT

Type of Survey:	Navigable Area
Registry Number:	H13941

LOCALITY

State(s):	Indiana Michigan
General Locality:	Offshore Chicago and Michigan City
Sub-locality:	Michigan City Harbor

2024

CHIEF OF PARTY
Nicholas Damm, CH

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Date:

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

REGISTRY NUMBER:

HYDROGRAPHIC TITLE SHEET

H13941

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):	**Indiana Michigan**
General Locality:	**Offshore Chicago and Michigan City**
Sub-Locality:	**Michigan City Harbor**
Scale:	**5000**
Dates of Survey:	**07/20/2024 to 09/20/2024**
Instructions Dated:	**06/12/2024**
Project Number:	**OPR-Y393-KR-24**
Field Unit:	**Geodynamics LLC**
Chief of Party:	**Nicholas Damm, CH**
Soundings by:	**Multibeam Echo Sounder**
Imagery by:	**Multibeam Echo Sounder Backscatter**
Verification by:	**Atlantic Hydrographic Branch**
Soundings Acquired in:	**meters at Low Water Datum IGLD-1985**

Remarks: ***Any revisions to the Descriptive Report (DR) applied during office processing are shown in red italic text. The DR is maintained as a field unit product, therefore all information and recommendations within this report are considered preliminary unless otherwise noted. The final disposition of survey data is represented in the NOAA nautical chart products. All pertinent records for this survey are archived at the National Centers for Environmental Information (NCEI) and can be retrieved via https://www.ncei.noaa.gov/.***

Products created during office processing were generated in NAD83 UTM 16N, LWD. 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 H13941

Project: OPR-Y393-KR-24

Locality: Offshore Chicago and Michigan City

Sublocality: Michigan City Harbor

Scale: 1:5000

July 2024 - September 2024

Geodynamics LLC

Chief of Party: Nicholas Damm, CH

A. Area Surveyed

Geodynamics conducted a hydrographic survey in the assigned area of H13941 located within the sublocality of Michigan City Harbor, Southern Lake Michigan. Within H13941, all survey operations were conducted in accordance with the provided Statement of Work (SOW), Hydrographic Survey Project Instructions (PI), and the March 2022 National Ocean Service (NOS) Hydrographic Survey Specifications and Deliverables (HSSD). Any deviations from the aforementioned guidelines have been approved by the National Oceanographic and Atmospheric Administration (NOAA) Hydrographic Survey Division (HSD) Operations (OPS) branch and are documented in the survey correspondences.

A.1 Survey Limits

Data were acquired within the following survey limits:

Northwest Limit	Southeast Limit
41° 50' 46.77" N 87° 5' 0.53" W	41° 40' 35.59" N 86° 52' 11.08" W

Table 1: Survey Limits

Data were acquired to the survey limits in accordance with the requirements listed in the PI and the HSSD.

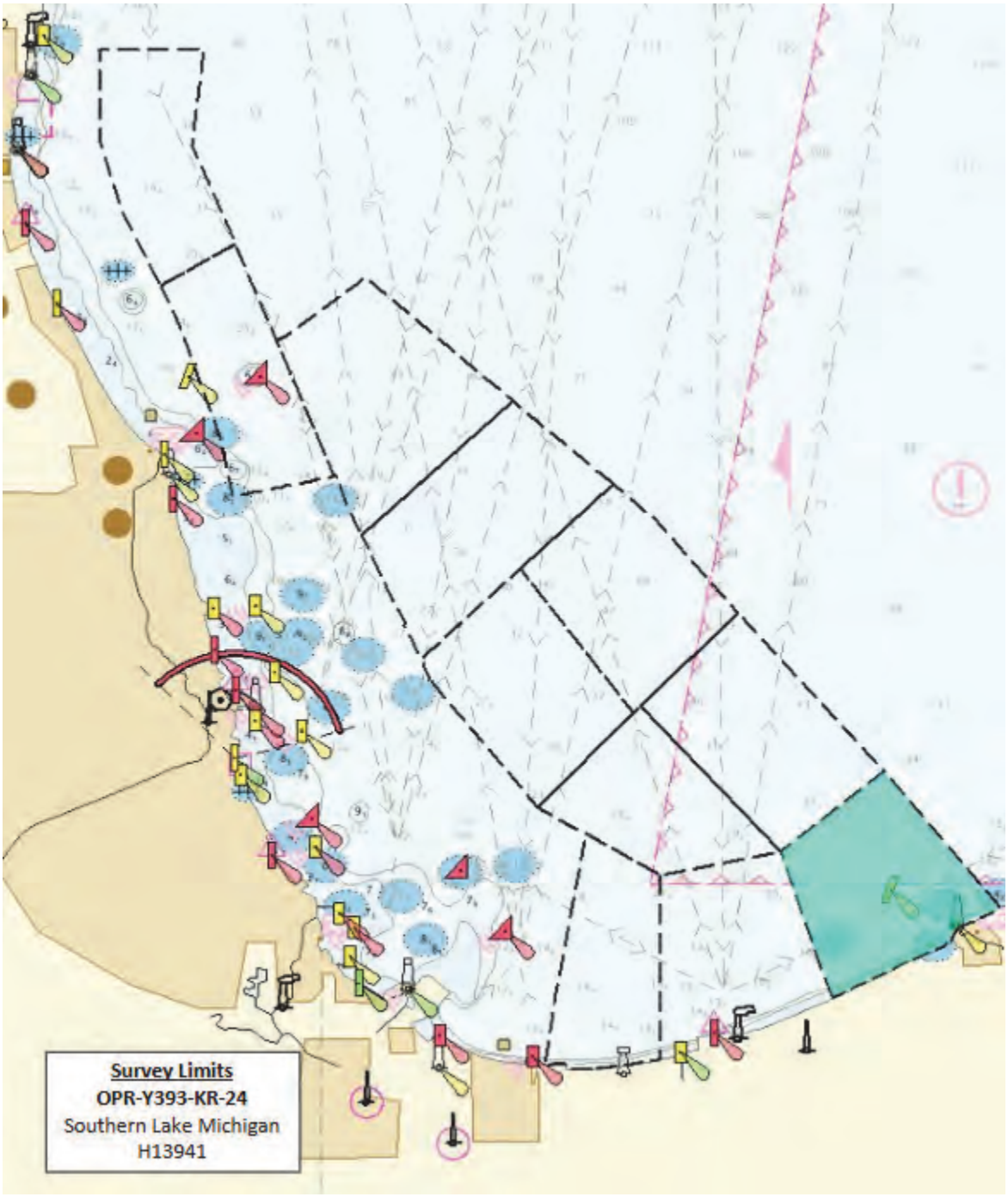


Figure 1: Overview of project survey limits (H13941 shown in blue), overlaid onto Chart US2MI01M

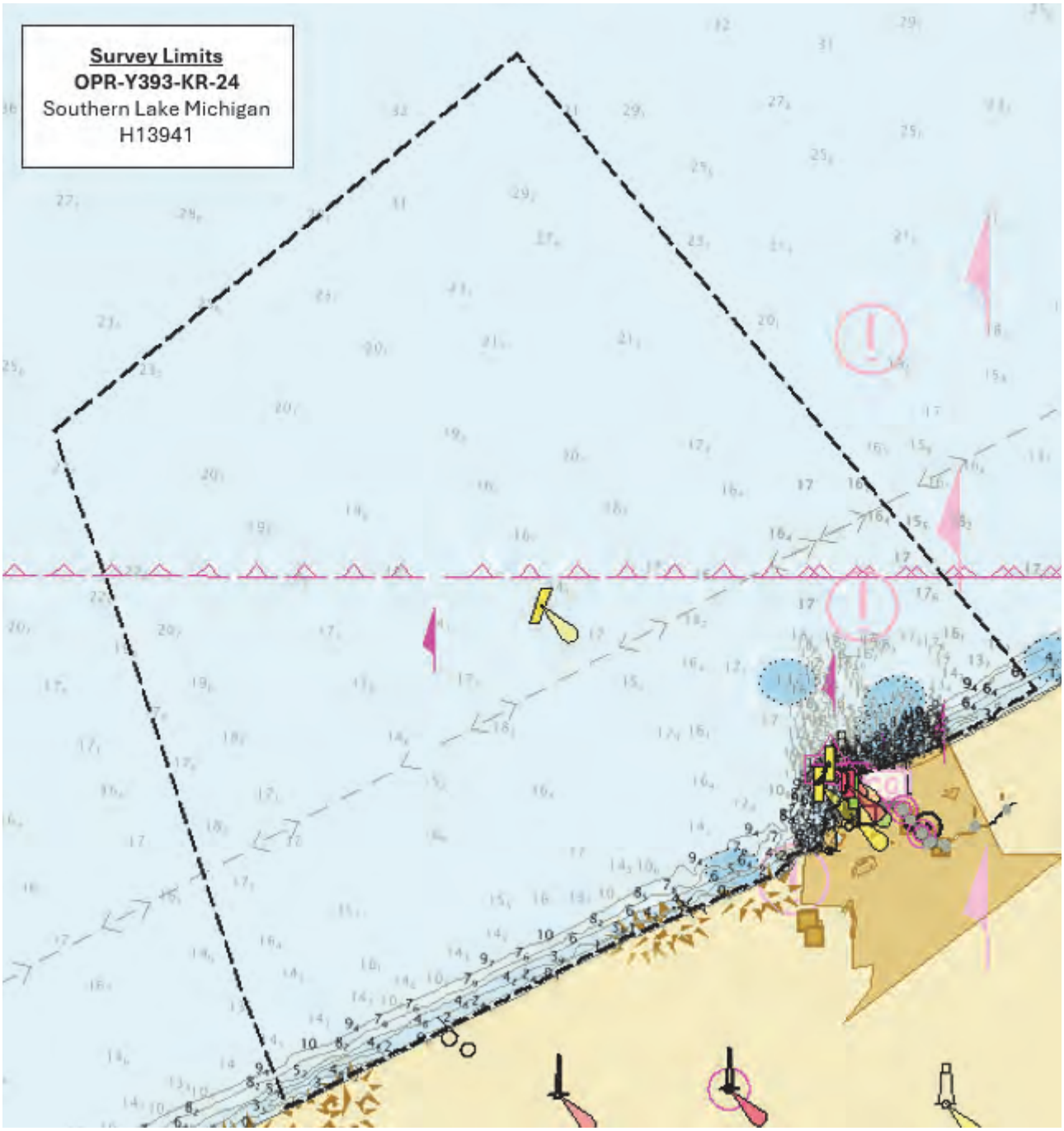


Figure 2: H13941 survey limits overlaid onto Charts US4MI2AM, US4IN1DD, US4IN1CD, US4IN1CE, and US5CHIHV

A.2 Survey Purpose

This project is located in Southern Lake Michigan, northeast of Chicago, Illinois extending to Michigan City, Indiana. The Chicago harbor is the northern entrance to the Mississippi River and has a tremendous amount of local barge traffic moving commodities throughout the year. Much of this 481 SNM survey area

has not been surveyed since the late 1940's, forcing many throughout the Lake Michigan community to predict the hazards and depths associated with the area near shore, including tug and barge operators as well as recreational boaters.

Conducting a modern bathymetric survey in this area will provide critical data for the updating of NOS nautical charting products and services to increase maritime safety near the Michigan, Indiana, and Illinois shoreline. Survey data from this project is intended to supersede all prior survey data in the common area.

A.3 Survey Quality

The entire survey is adequate to supersede previous data.

Survey quality in H13941 meets or exceeds requirements set forth in the HSSD. Survey quality was assessed through visual inspection, the analysis of crosslines, and utilizing QC Tools to assess uncertainty and density. Additionally, junction analyses were conducted between overlapping data collected on this project and existing bathymetric data. For more information on methods and results of the data quality assessments for this survey, refer to Section B.2 of this report.

A.4 Survey Coverage

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

Water Depth	Coverage Required
All waters in survey area	Complete Coverage (HSSD 5.2.2.3)

Table 2: Survey Coverage

The entirety of H13941 was acquired with complete coverage in accordance with Section 5.2.2.3 of the HSSD, as shown in Figure 3.

All efforts were made to acquire survey data to the sheet limits or the Navigable Area Limit Line (NALL), as defined in Section 1.3.2 of the HSSD. Figure 4 provides an example of where survey coverage was defined by NALL. The vessels obtained as much coverage as safely possible in and around charted shoreline construction. It should be noted that special attention was given to the cleaning of MBES data in and around charted shoreline construction areas, to reject the data associated with the baring feature, however, retain submerged riprap leading up to these charted features. See DR Appendix II Supplemental Records for more information regarding the charted shoreline construction cleaning and received guidance from NOAA HSD OPS.

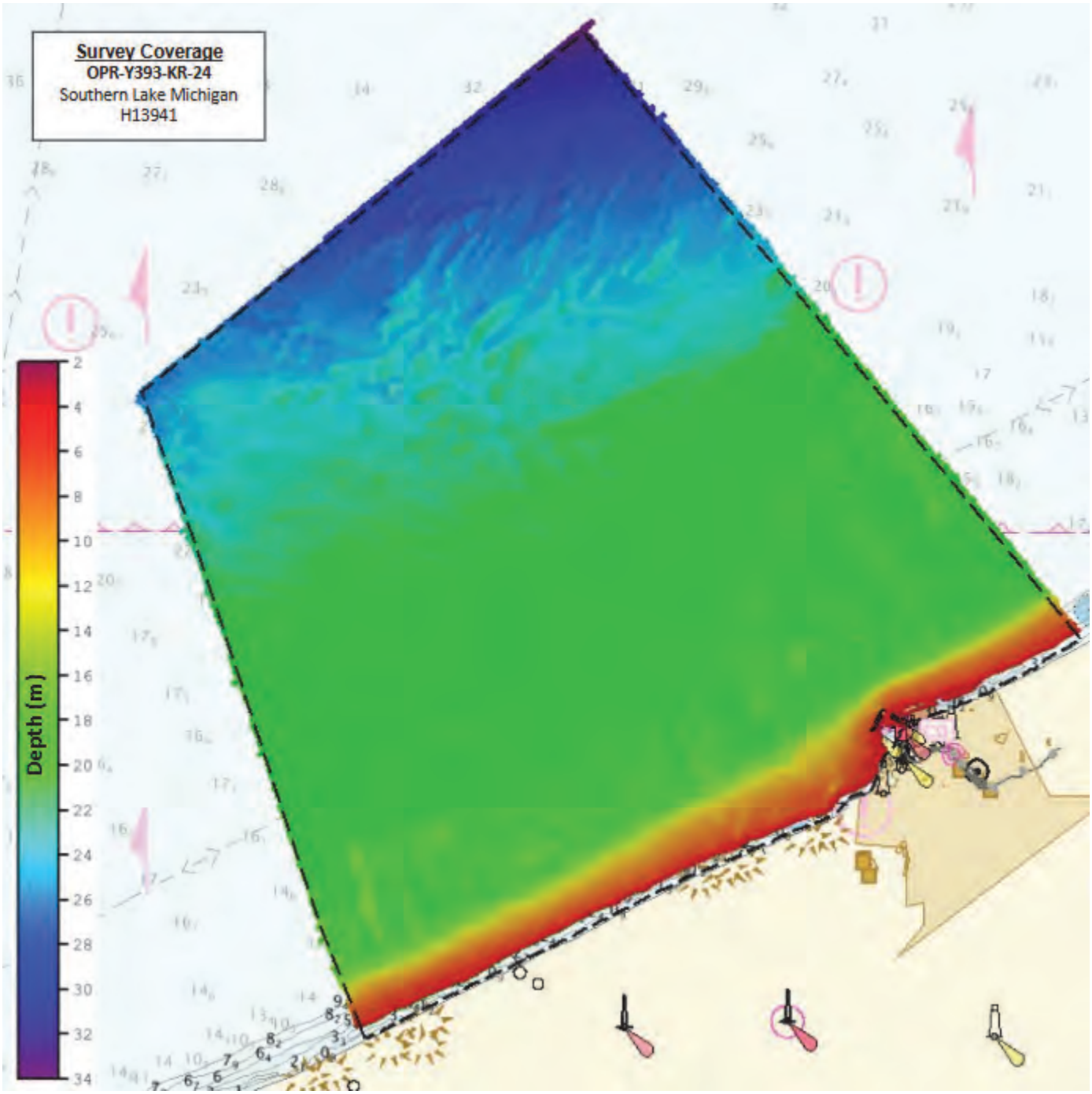


Figure 3: H13941 survey coverage overlaid onto Charts US4MI2AM, US4IN1DD, and US4IN1CD, and US4IN1CE

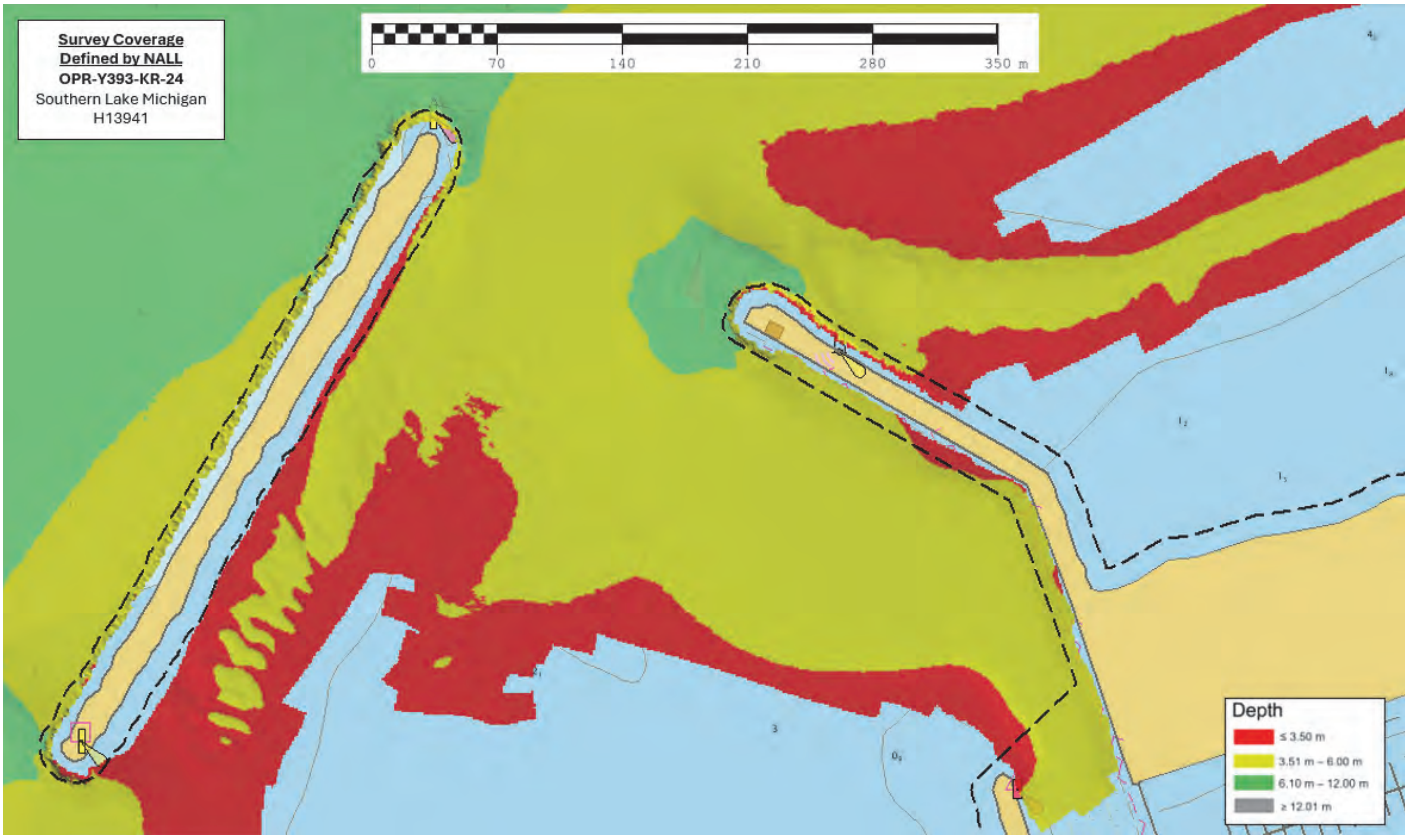


Figure 4: H13941 example of an area where survey coverage was defined by NALL (3.5 m), overlaid onto Chart US5CHIHV

A.6 Survey Statistics

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

	HULL ID	*R/V Benthos*	*R/V Substantial*	*Total*
LNM	**SBES Mainscheme**	0.0	0.0	0.0
	MBES Mainscheme	597.41	1137.5	1734.91
	Lidar Mainscheme	0.0	0.0	0.0
	SSS Mainscheme	0.0	0.0	0.0
	SBES/SSS Mainscheme	0.0	0.0	0.0
	MBES/SSS Mainscheme	0.0	0.0	0.0
	SBES/MBES Crosslines	87.28	0.0	87.28
	Lidar Crosslines	0.0	0.0	0.0
Number of Bottom Samples				10
Number Maritime Boundary Points Investigated				0
Number of DPs				0
Number of Items Investigated by Dive Ops				0
Total SNM				52.4

Table 3: Hydrographic Survey Statistics

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

Survey Dates	Day of the Year
07/20/2024	202

Survey Dates	Day of the Year
07/21/2024	203
07/22/2024	204
07/23/2024	205
07/27/2024	209
07/28/2024	210
07/31/2024	213
08/01/2024	214
08/02/2024	215
08/04/2024	217
08/05/2024	218
08/06/2024	219
08/07/2024	220
08/08/2024	221
08/09/2024	222
08/16/2024	229
08/17/2024	230
08/21/2024	234
08/22/2024	235
08/23/2024	236
08/24/2024	237
08/25/2024	238
08/26/2024	239
09/04/2024	248
09/05/2024	249
09/08/2024	252
09/10/2024	254
09/11/2024	255
09/12/2024	256
09/14/2024	258
09/17/2024	261
09/18/2024	262
09/20/2024	264

Table 4: Dates of Hydrography

Bottom Sample were collected on 09/17/2024, 09/18/2024 and 09/20/2024. It should be noted that several bottom samples were collected after the last day of MBES collection. Therefore, the last day of survey and SORDAT reflects a bottom sample acquisition day and does not have accompanying MBES data for that specific date. See Project Correspondence for more information.

B. Data Acquisition and Processing

B.1 Equipment and Vessels

Refer to the OPR-Y393-KR-24 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	*R/V Benthos*	*R/V Substantial*
LOA	9.14 meters	18.0 meters
Draft	0.61 meters	2.22 meters

Table 5: Vessels Used

B.1.2 Equipment

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

Manufacturer	Model	Type
Kongsberg Maritime	EM 2040C	MBES
Applanix	POS MV OceanMaster	Positioning and Attitude System
AML Oceanographic	1-RT Velocity Probe	Sound Speed System
AML Oceanographic	AML-3 LGR	Sound Speed System
AML Oceanographic	MVP30-350	Sound Speed System

Table 6: Major Systems Used

R/V Benthos and the R/V Substantial utilized a dual-head Kongsberg EM 2040C multibeam system, a POS M/V OceanMaster positioning and attitude system, and AML Oceanographic AML-1 RT surface sound speed units. The R/V Benthos utilized an AML-3 LGR sound speed system for sound speed profiles. The R/V Substantial utilized an AML MVP30-350 sound speed profiling system. Further details on equipment and software used can be found in the DAPR.

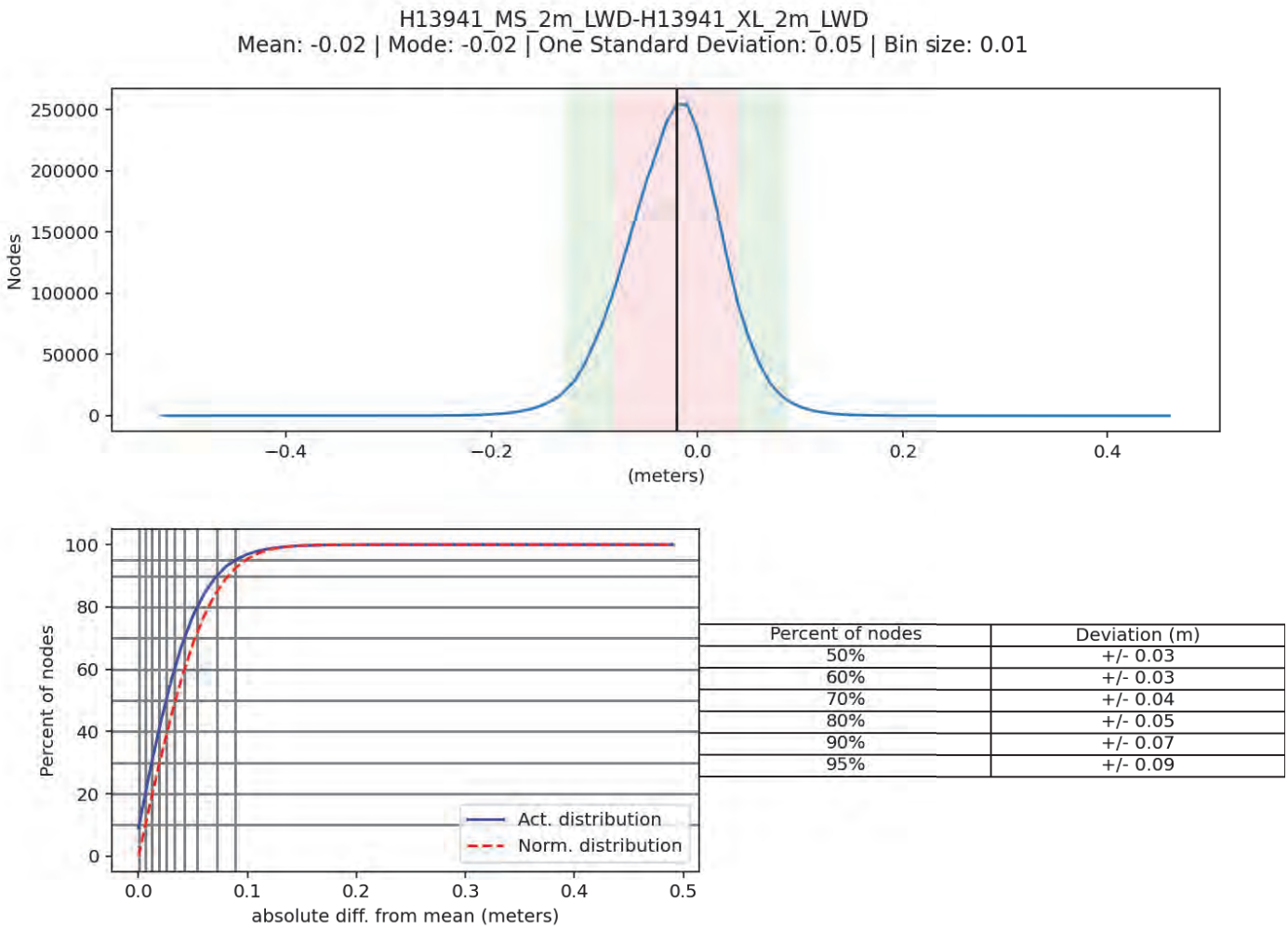
B.2 Quality Control

B.2.1 Crosslines

Multibeam crosslines acquired for H13941 totaled 5.03% of mainscheme acquisition. It should be noted that additional crosslines were acquired, as needed, to verify data accuracy in areas where temporal change was evident. Refer to Section D.2.8 of this report for further information.

H13941 crosslines were collected and analyzed in accordance with Section 5.2.4.2 of the HSSD. Crosslines were evaluated in CARIS HIPS with a detailed visual inspection followed by a thorough statistical analysis. To conduct the statistical analysis, a 2 m CUBE surface was generated with strictly mainscheme data and another, separate 2 m CUBE surface was generated with only crossline data. The mainscheme and crossline surfaces were analyzed using the Compare Grids tool in Pydro Explorer, which generated a difference surface and associated statistics. In addition to the direct statistics from the surface differencing, the tool assessed the difference surface statistics and computed the proportion of NOS total allowable vertical uncertainty (TVU) consumed by the mainscheme to crossline differences per surface node.

The statistical results of the difference comparison show 95% of nodes falling within +/- 0.09 m, with a mean difference of -0.02 m (Figure 5). Additionally, greater than 95% of the difference surface nodes meet or exceed TVU specifications, as described in Section 5.1.3 of the HSSD.



Percent of nodes	Deviation (m)
50%	+/- 0.03
60%	+/- 0.03
70%	+/- 0.04
80%	+/- 0.05
90%	+/- 0.07
95%	+/- 0.09

Figure 5: H13941 crossline to mainscheme difference statistics

B.2.2 Uncertainty

The following survey specific parameters were used for this survey:

Method	Measured	Zoning
ERS via VDATUM	0.0 meters	0.045 meters

Table 7: Survey Specific Tide TPU Values.

Hull ID	Measured - CTD	Measured - MVP	Measured - XBT	Surface
R/V Benthos	2.00 meters/second	N/A meters/second	N/A meters/second	0.05 meters/second
R/V Substantial	N/A meters/second	2.00 meters/second	N/A meters/second	0.05 meters/second

Table 8: Survey Specific Sound Speed TPU Values.

The finalized CUBE surfaces were analyzed using the HydrOffice QC Tools Grid QA tool to assure at least 95% of the surface nodes met TVU specifications. The results of the Grid QA tool determined that all finalized CUBE surfaces meet or exceed the TVU specifications, as shown in Figures 6 - 7.

The multibeam surfaces were finalized with the computed uncertainty, derived from a mix of a priori and real-time uncertainty estimates, assigned as the uncertainty value. It should be noted that the uncertainty associated with the SEP model was applied in CARIS as the GPS Sounding Datum uncertainty, and not as Tide Zoning uncertainty. Additional details related to uncertainty methods may be found in the DAPR.

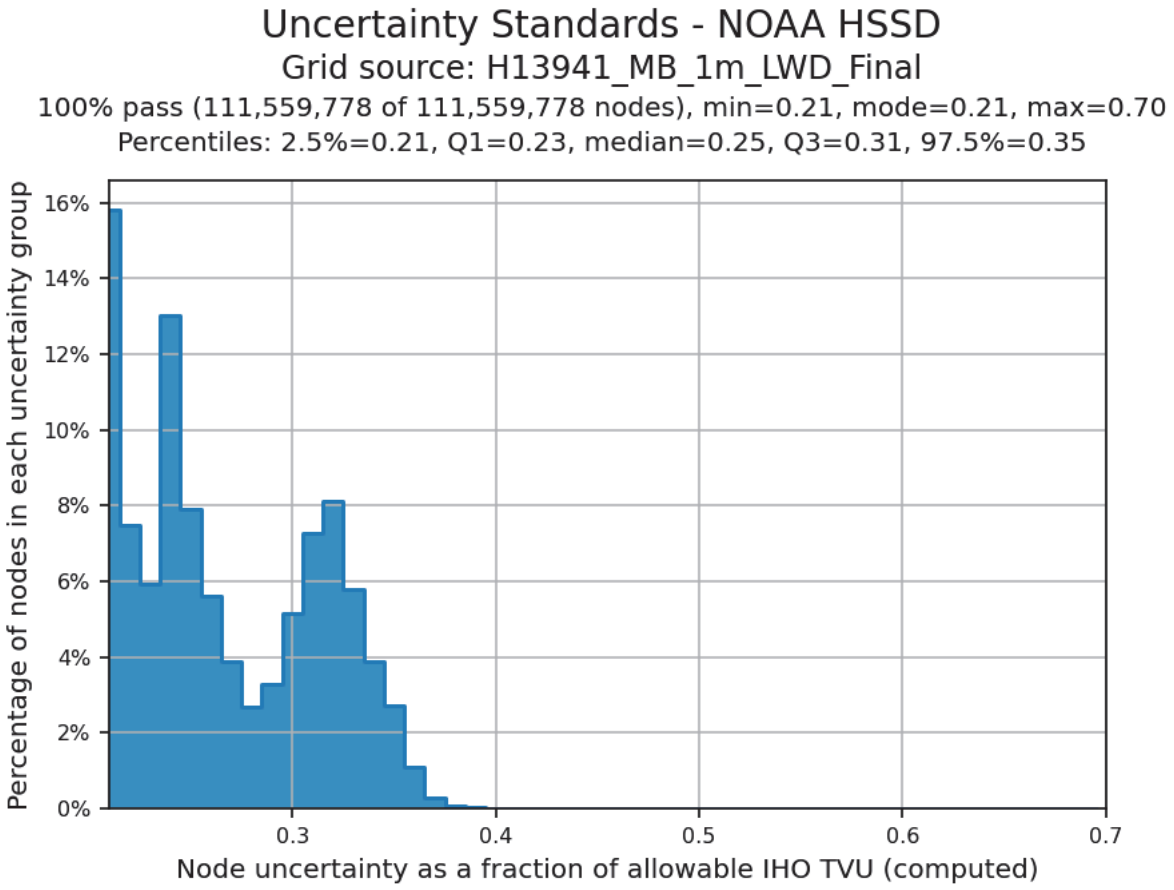


Figure 6: Finalized 1 m CUBE surface TVU statistics for H13941

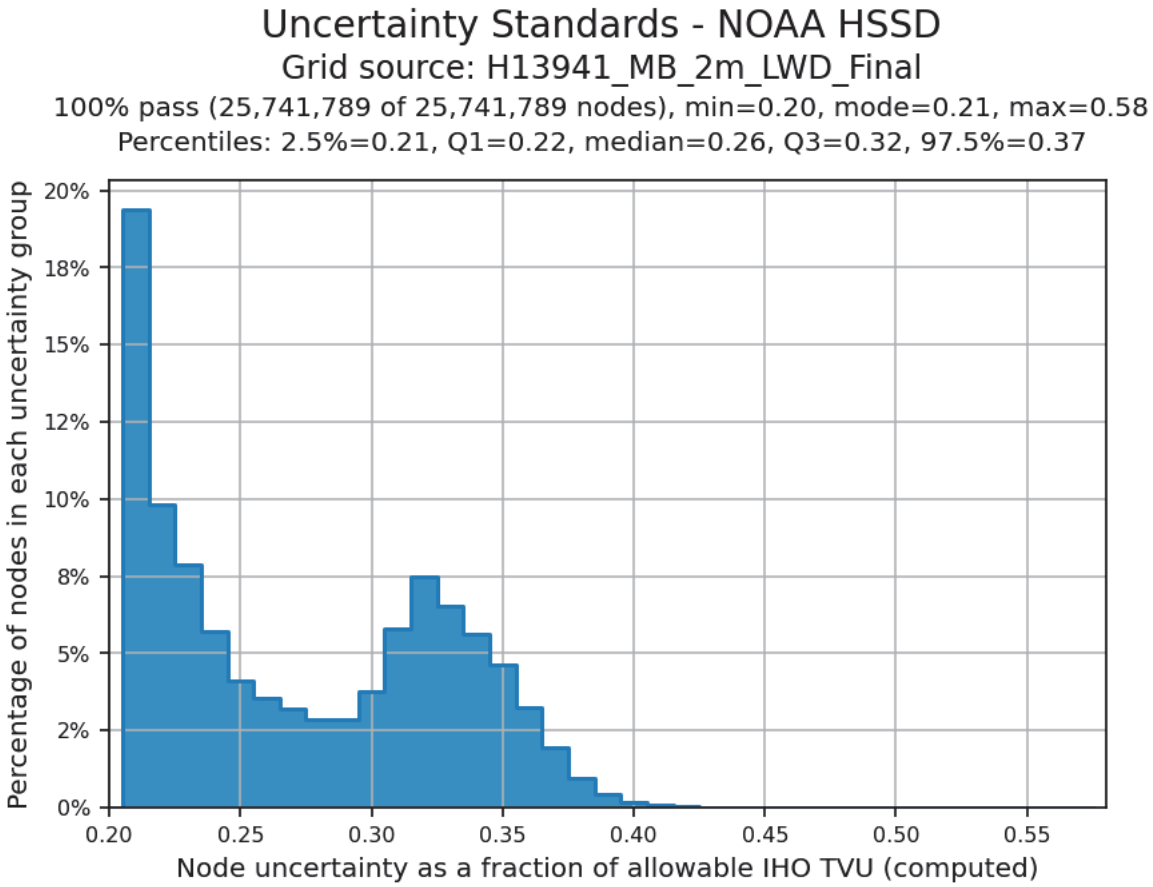


Figure 7: Finalized 2 m CUBE surface TVU statistics for H13941

B.2.3 Junctions

H13941 junctions with H13948 and H13949, as well as with previously existing 2020 Geodynamics MBES data, registry number H13367 (Figure 8).

Data overlap between H13941 and the adjacent surveys were attained. To conduct junction analyses, similar to Section B.2.1 of this report, the Pydro Compare Grids tool was utilized. The inputs for this tool were the surfaces for each individual survey at matching resolutions. In addition to the statistical results of the junction analyses, the resultant difference surfaces were visually inspected and CARIS HIPS Subset Editor was used to examine overlapping data for consistency, agreement between surveys, and confirming data met TVU specifications.

Details regarding the results of the comparisons can be found below.

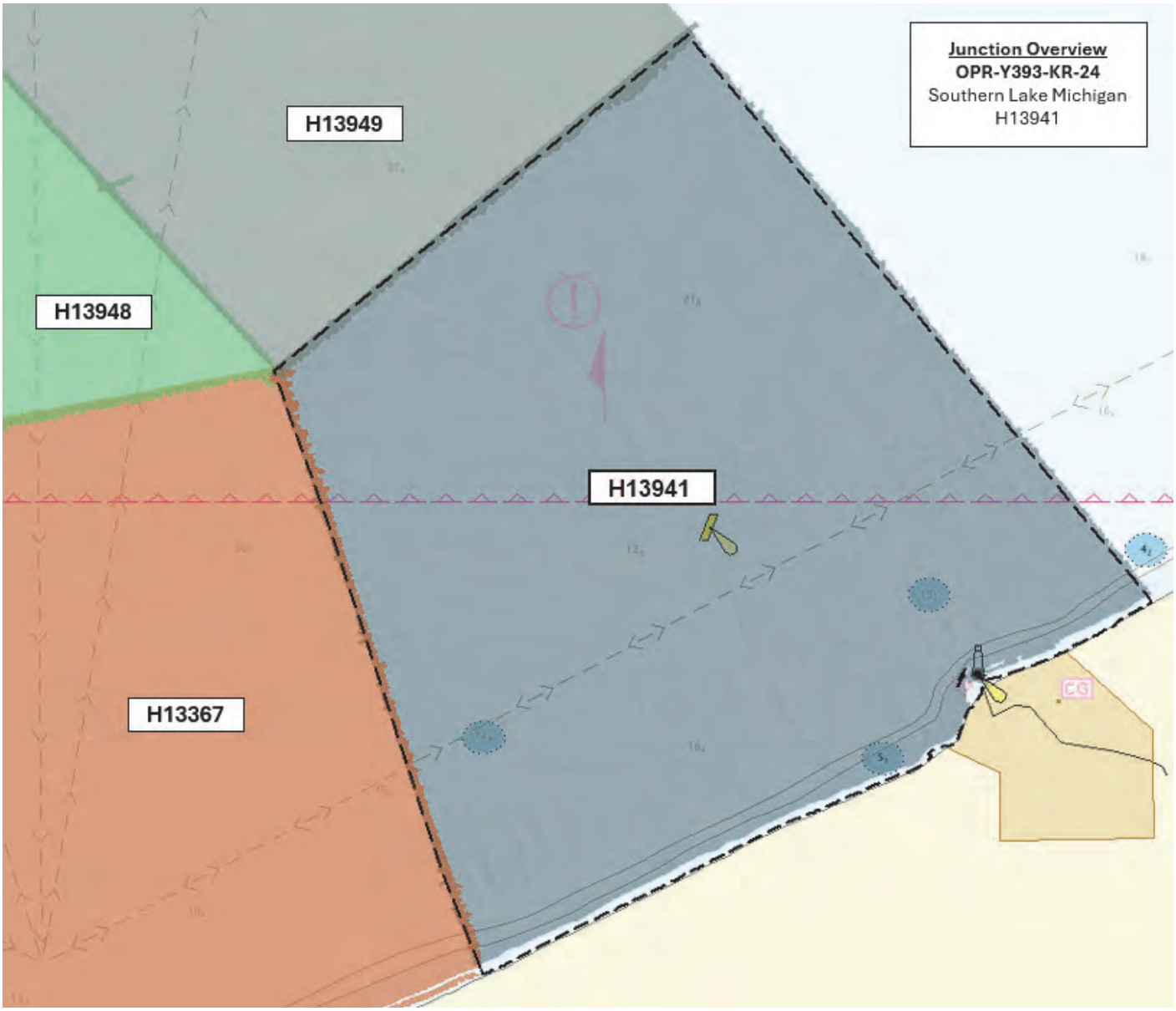


Figure 8: Overview of H13941 junction surveys

The following junctions were made with this survey:

Registry Number	Scale	Year	Field Unit	Relative Location
H13948	1:10000	2024	Geodynamics	NW
H13949	1:5000	2024	Geodynamics	N
H13367	1:5000	2020	Geodynamics	W

Table 9: Junctioning Surveys

H13948

Please refer to the H13948 Descriptive Report for the junction analysis between H13941 and H13948.

H13949

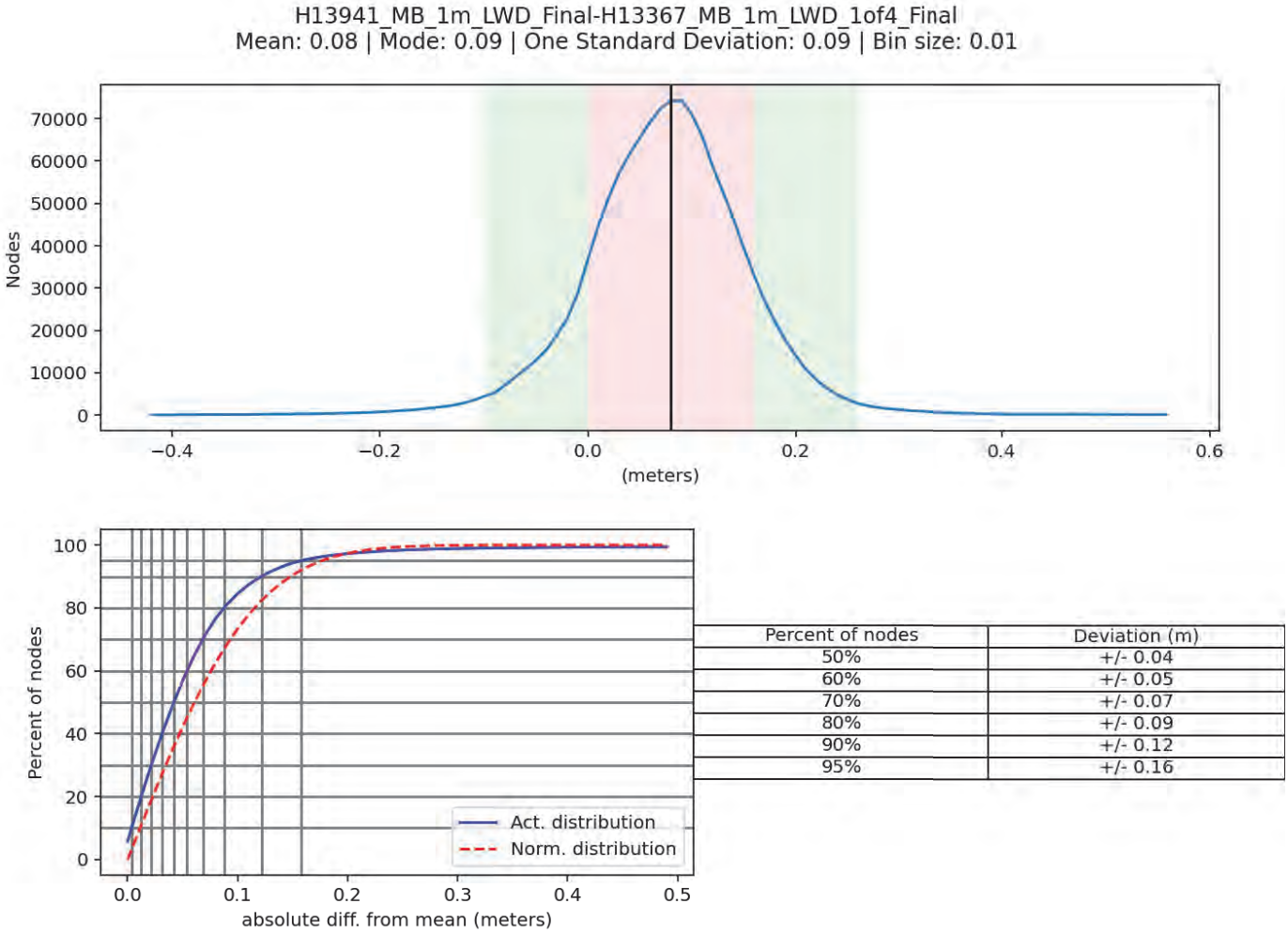
Please refer to the H13949 Descriptive Report for the junction analysis between H13941 and H13949.

H13367

The statistical results of the difference comparison with the H13367 Finalized 1 m MBES CUBE surface show 95% of nodes falling within +/- 0.16 m, with a mean difference of 0.08 m (Figure 9). Additionally, greater than 95% of the difference surface nodes meet or exceed TVU specifications, as described in Section 5.1.3 of the HSSD.

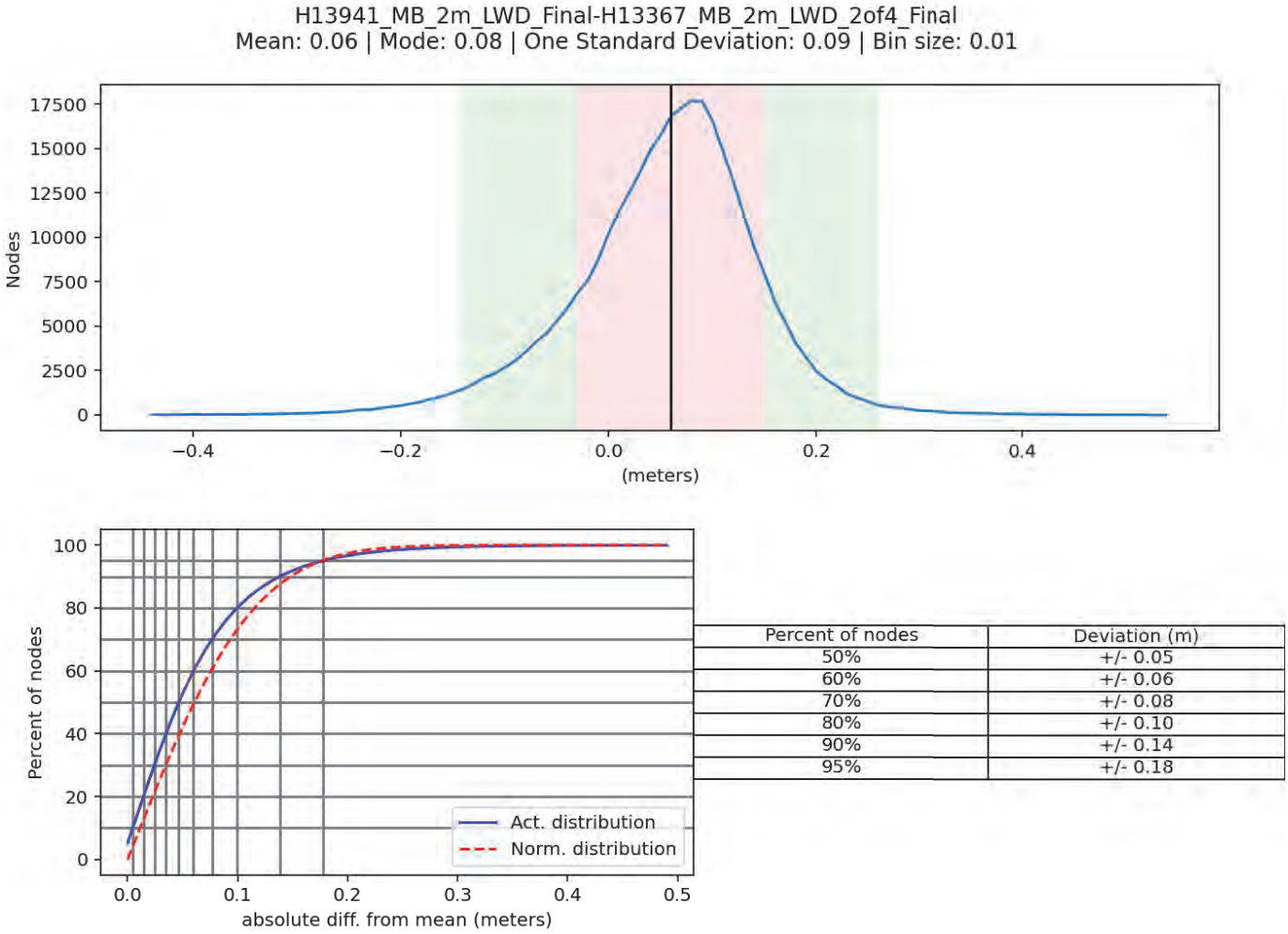
The statistical results of the difference comparison with the H13367 Finalized 2 m MBES CUBE surface show 95% of nodes falling within +/- 0.18 m, with a mean difference of 0.06 m (Figure 10). Additionally, greater than 95% of the difference surface nodes meet or exceed TVU specifications, as described in Section 5.1.3 of the HSSD.

During analysis, failed nodes were noticed in the southwest corner of the junctioning portions of H13941 and H13367. This change was signified by multiple nodes having depth differences greater than allowable TVU between the Finalized 1 m MBES CUBE surfaces of H13941 and H13367. To verify that this change was not related to quality or accuracy of the current data, an additional QA/QC line was run over this area (Figure 11). The additional QA/QC line showed good agreement between survey days on this survey. Therefore, the cause of failed nodes between H13941 and H13367 is not due to the quality of current data and could likely be natural temporal change given the very shallow depths in that area. Lastly, it should be noted that although there were several failed nodes, the junctioning surveys still show greater than 95% of the nodes of the difference surfaces meet or exceed TVU specifications.



Percent of nodes	Deviation (m)
50%	+/- 0.04
60%	+/- 0.05
70%	+/- 0.07
80%	+/- 0.09
90%	+/- 0.12
95%	+/- 0.16

Figure 9: Junction analysis between H13941 and H13367 Finalized 1 m MBES CUBE surface



Percent of nodes	Deviation (m)
50%	+/- 0.05
60%	+/- 0.06
70%	+/- 0.08
80%	+/- 0.10
90%	+/- 0.14
95%	+/- 0.18

Figure 10: Junction analysis between H13941 and H13367 Finalized 2 m MBES CUBE surface

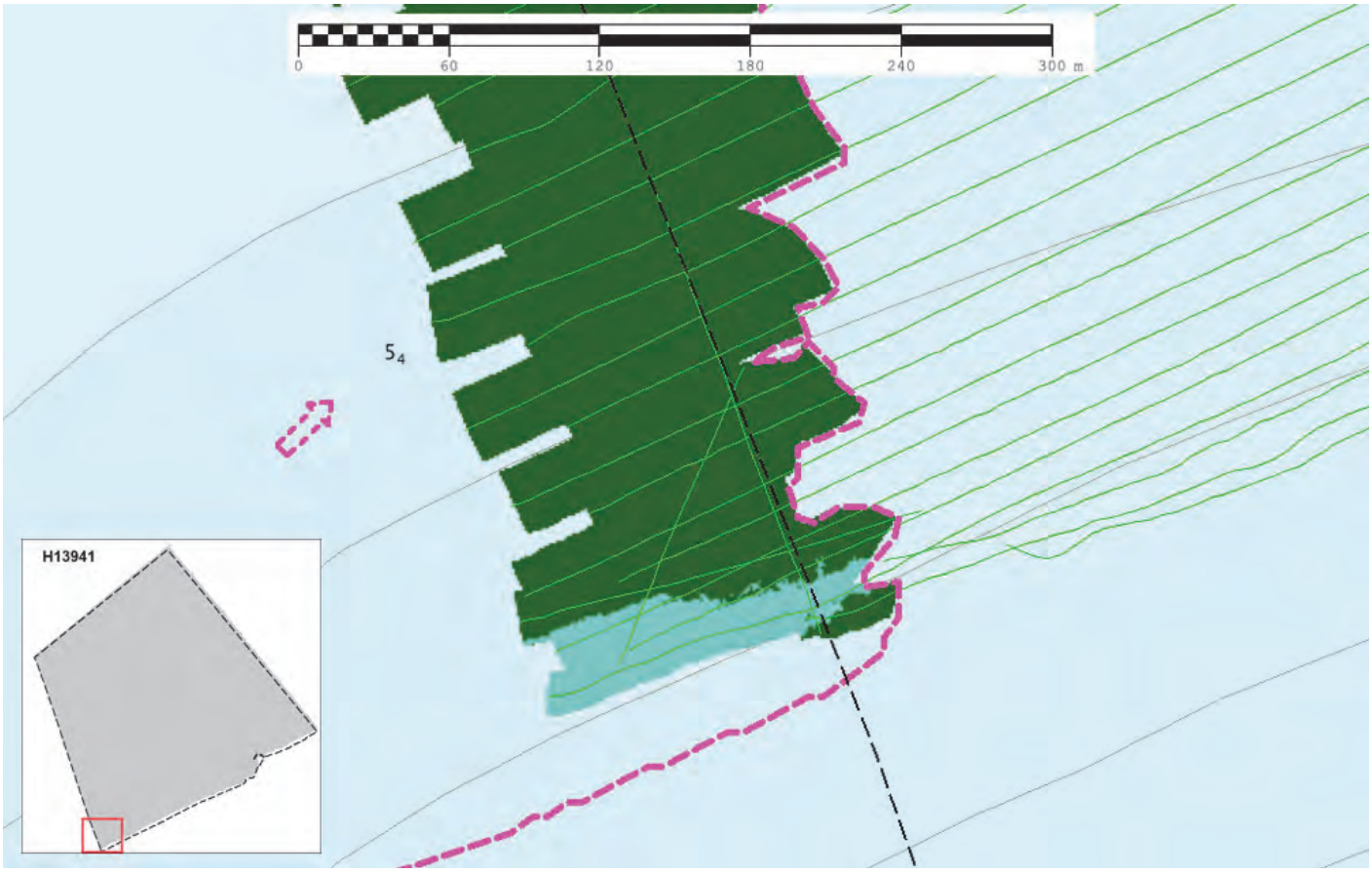


Figure 11: Area in H13941 where Junction Analysis shows failed nodes (in blue) where an additional QA/QC line was run to verify quality or accuracy of the current data. The additional QA/QC line showed good agreement between survey days. The failed nodes could likely be caused by natural temporal change due to the shallow depths.

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

Multibeam Echosounder Ping Drops

On rare occasions, it was observed that the R/V Benthos and R/V Substantial's multibeam echosounder would experience a "ping drop" issue which resulted in unexpectedly missing ping records, which were not observed by survey personnel at the time of acquisition. These ping drops were observed in the multibeam

data from R/V Benthos on 08/17/2024 and in the multibeam data from R/V Substantial on 08/23/2024 and 08/24/2024. An example of these ping drops is shown below in Figure 12.

Ping drops resulting in data gaps were recovered and no holidays resulting from these intermittent issues remain in the final delivered surfaces. Additionally, in the final delivered surfaces, density requirements were achieved for the finalized CUBE surfaces (see Section B.2.10 below). For further information on echo sounding equipment, please reference the DAPR.

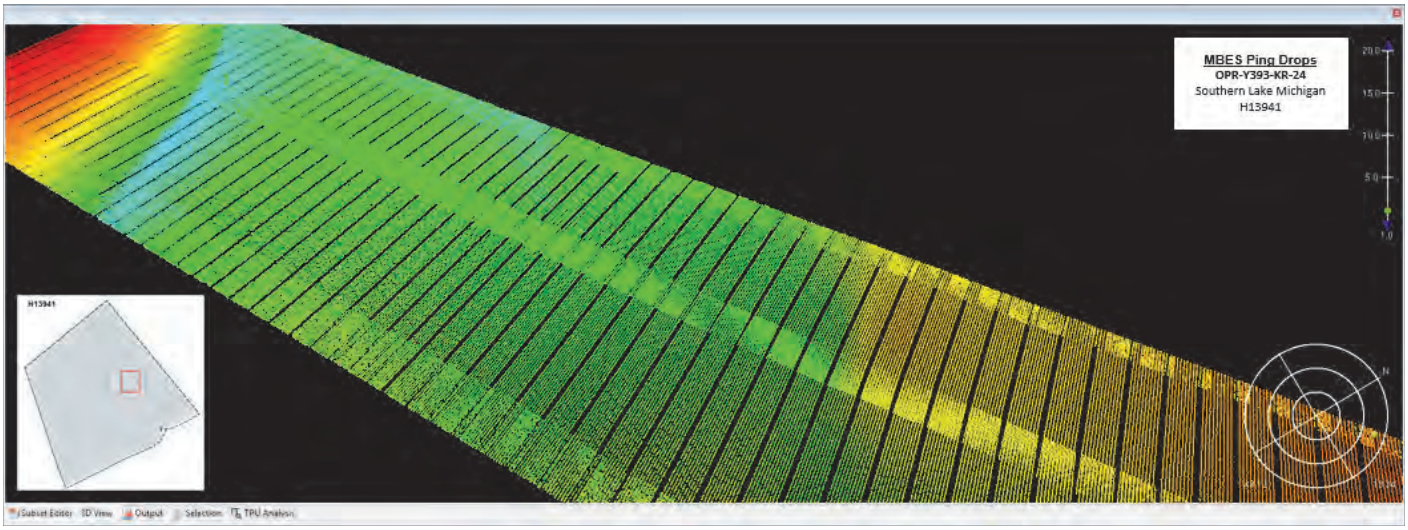


Figure 12: Example of MBES ping drops observed from R/V Substantial on 08/24/2024

B.2.6 Factors Affecting Soundings

Sound Speed

The spatio-temporal variability in temperature of the water column created complex sound speed conditions throughout the survey. These complexities often created challenges for the field team and resulted in occasional refraction artifacts in the survey data and resultant surfaces, as shown in Figures 13 and 14.

The hydrographer made considerable efforts to reduce the impact of sound speed issues during acquisition. These efforts included increasing frequency of casts, closely monitoring real-time swath "smiling" or "frowning", utilizing alerts for surface-to-profile sound speed deviation, observing the real-time standard deviation map display, and increasing the percentage of swath overlap. Additional efforts in post-processing to minimize refraction artifacts included outer beam filtering, manual outer beam editing, and assessing the application of sound speed profiles. When deemed appropriate, split lines were acquired to get additional coverage over outer swath refraction. An example of split coverage is shown in Figure 15.

In addition to the outer beam noise associated with refraction, the convex or concave trend in the across-track sonar data is most prevalent in the outer beams and is noticeable in the surface as a striped line to line artifact. Remaining artifacts in the final delivered surfaces are all within the allowable TVU limit.

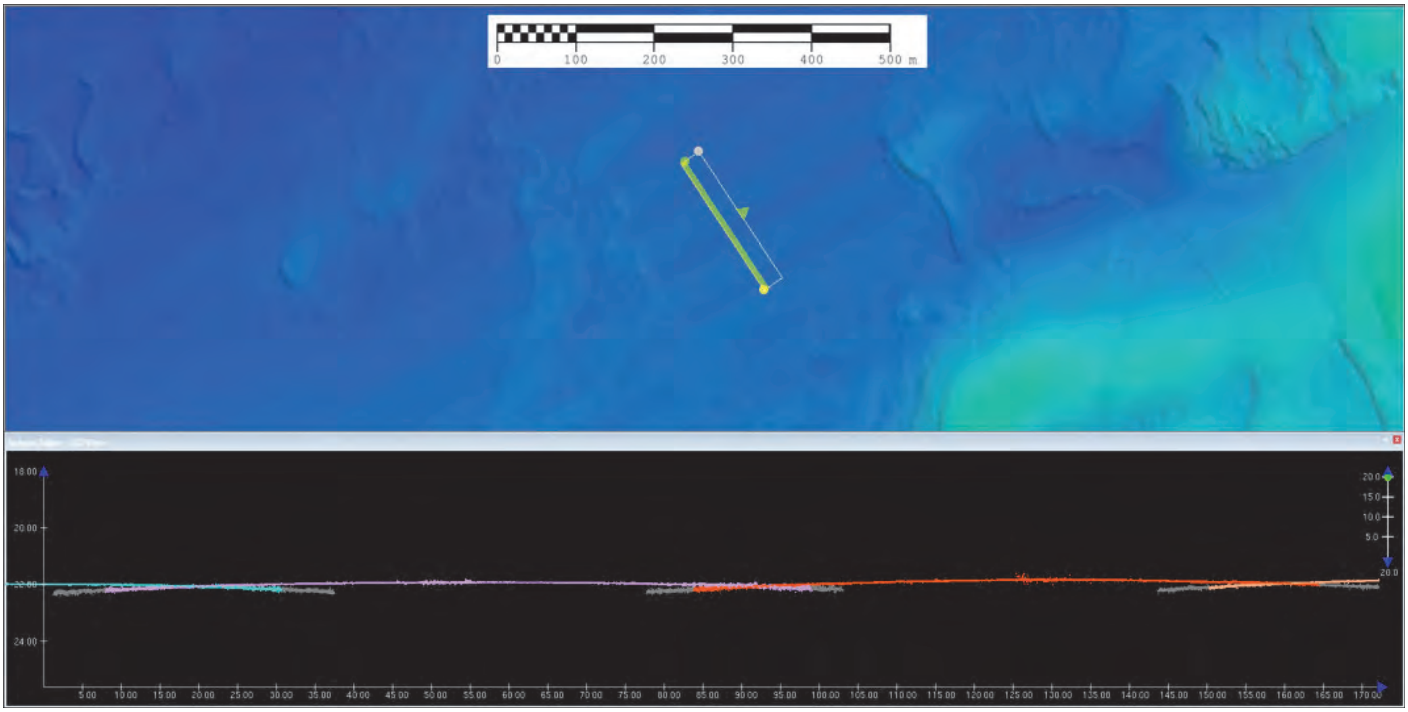


Figure 13: H13941 surface artifacts as a result of refraction causing the soundings to trend concave / convex

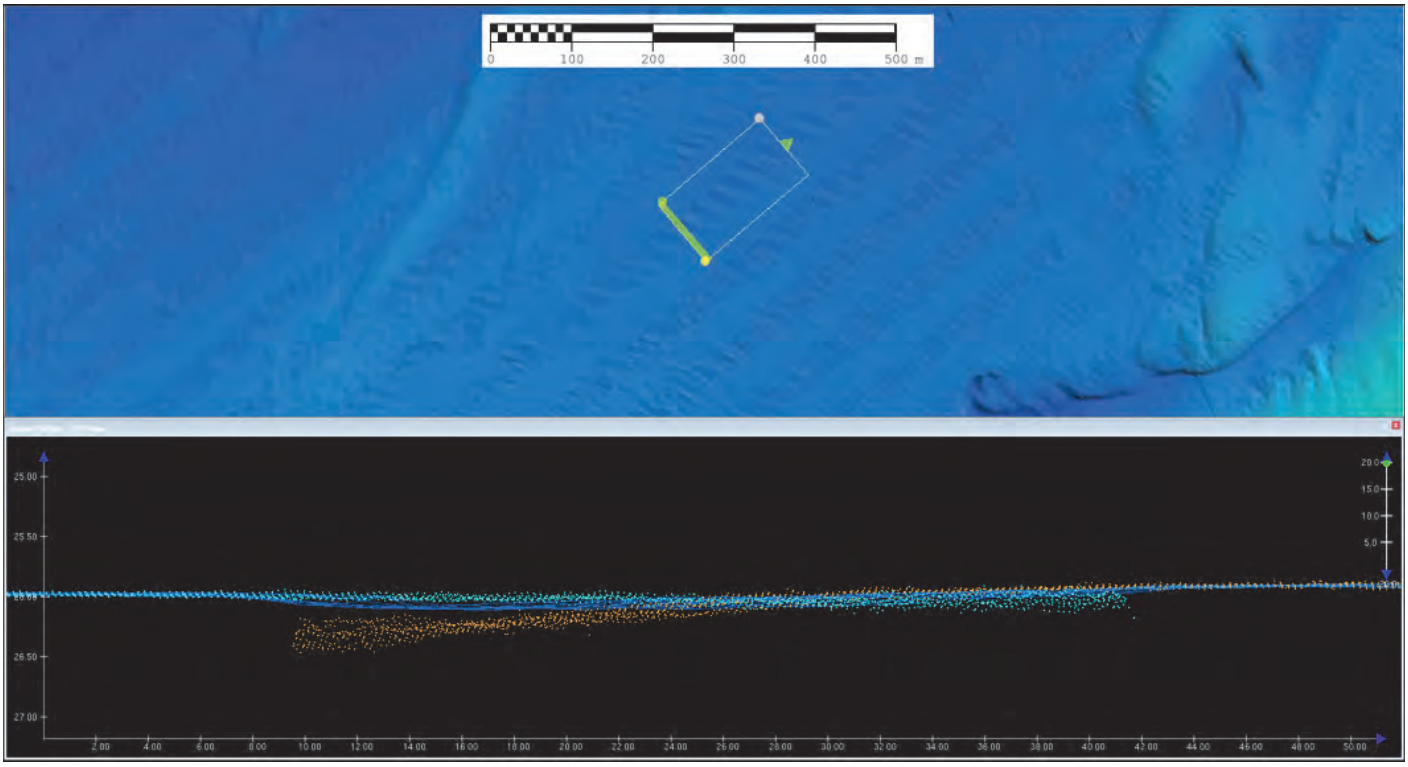


Figure 14: H13941 surface artifacts as a result of refraction causing outer beam noise

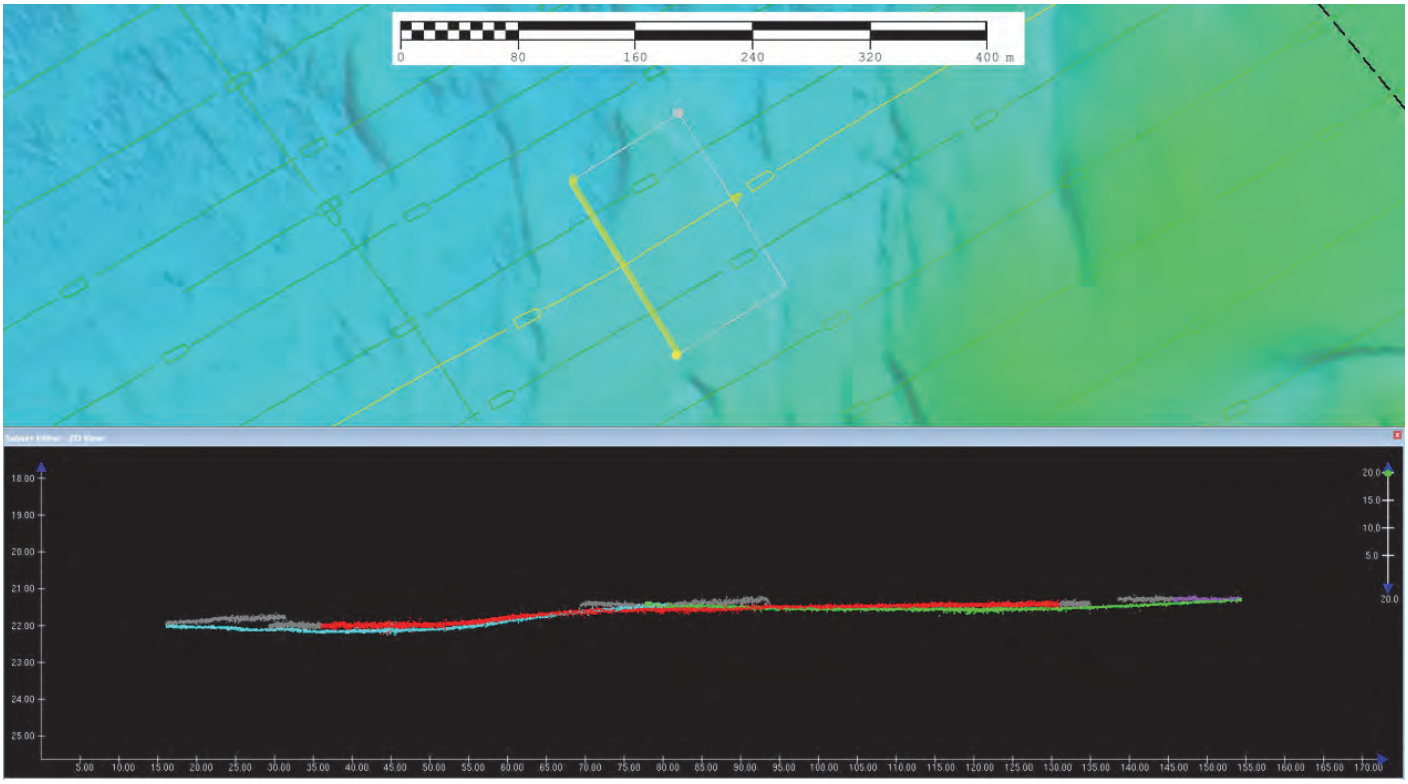


Figure 15: H13941 example of where a split was acquired for additional coverage over refracted outer swaths

B.2.7 Sound Speed Methods

Sound Speed Cast Frequency: Sound speed casts were acquired at least once every four hours. Casts were often conducted more frequently than this time interval because of the dynamic water properties in the survey area. Additionally, the R/V Substantial utilized an MVP onboard which allowed for a higher frequency of casts.

Surface sound speed was compared in real-time to the sound speed profile. When the comparison differed by more than 2 m/s, a new sound speed profile was acquired. Additionally, QPS Qinsy and Kongsberg SIS provided a real-time visual assessment of data quality (standard deviation grids, bathymetric grids, swath views) aiding the hydrographer in determining when a new cast was required.

For more detailed information on sound speed methods, please refer to the DAPR.

B.2.8 Coverage Equipment and Methods

On rare occasion, the desired 20-30% overlap was unable to be achieved due to conditions within the shallow waters near Michigan City Harbor around NALL. In these areas, splits were acquired in areas

with minimal overlap, however, small data gaps may be observed in CARIS Subset Editor due to risks associated with maneuvering the vessel in shallow and/or hazardous areas. An example of a resulting data gap in CARIS Subset Editor due to minimal overlap can be seen in the figure below. It should be noted that these areas of minimal overlap do not create complete coverage holidays in the finalized CUBE surfaces and density requirements were achieved (see Section B.2.10 below).

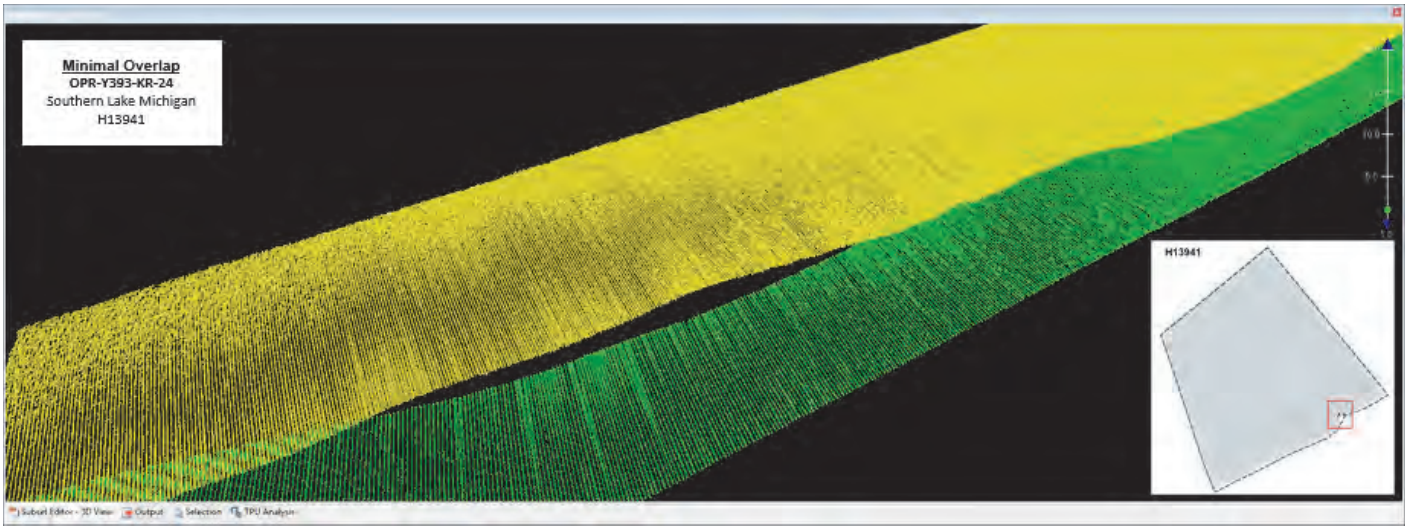


Figure 16: Example of minimal overlap near Michigan City Harbor on 07/31/2024, resulting in a data gap that can be observed in CARIS Subset Editor. This data gap did not result in a complete coverage holiday in the finalized CUBE surfaces.

B.2.9 Holidays

All CUBE surfaces were analyzed using HydrOffice QC Tools Holiday Finder to determine if the surfaces contained holidays, as described in Section 5.2.2.3 of the HSSD. The tool scanned the CUBE surfaces, identifying any holidays, and generated an S-57 file to illustrate the locations of holidays.

Another method of holiday evaluation was to visually pan the CUBE surfaces to identify holidays. The hydrographer would often alter the surface display (color ranges, symbology, shading) to help aid the hydrographer in identifying coverage gaps. Any data gaps remaining in the finalized surfaces are the result of coverage defined by NALL. It should be noted that NALL (safety limitations) created a "donut hole" in the finalized grid for the shoal associated with DTON 01. Refer to Section A.4 and Section D.1.2 of this report for further information.

B.2.10 Density

All finalized CUBE surfaces were analyzed using HydrOffice QC Tools Grid QA tool to assure data met the required density specifications. Density requirements were achieved for the finalized surfaces in H13941

with greater than 95% of the surface nodes containing at least five or more soundings, exceeding the specifications required by Section 5.2.2.3 of the HSSD (Figures 17 - 18).

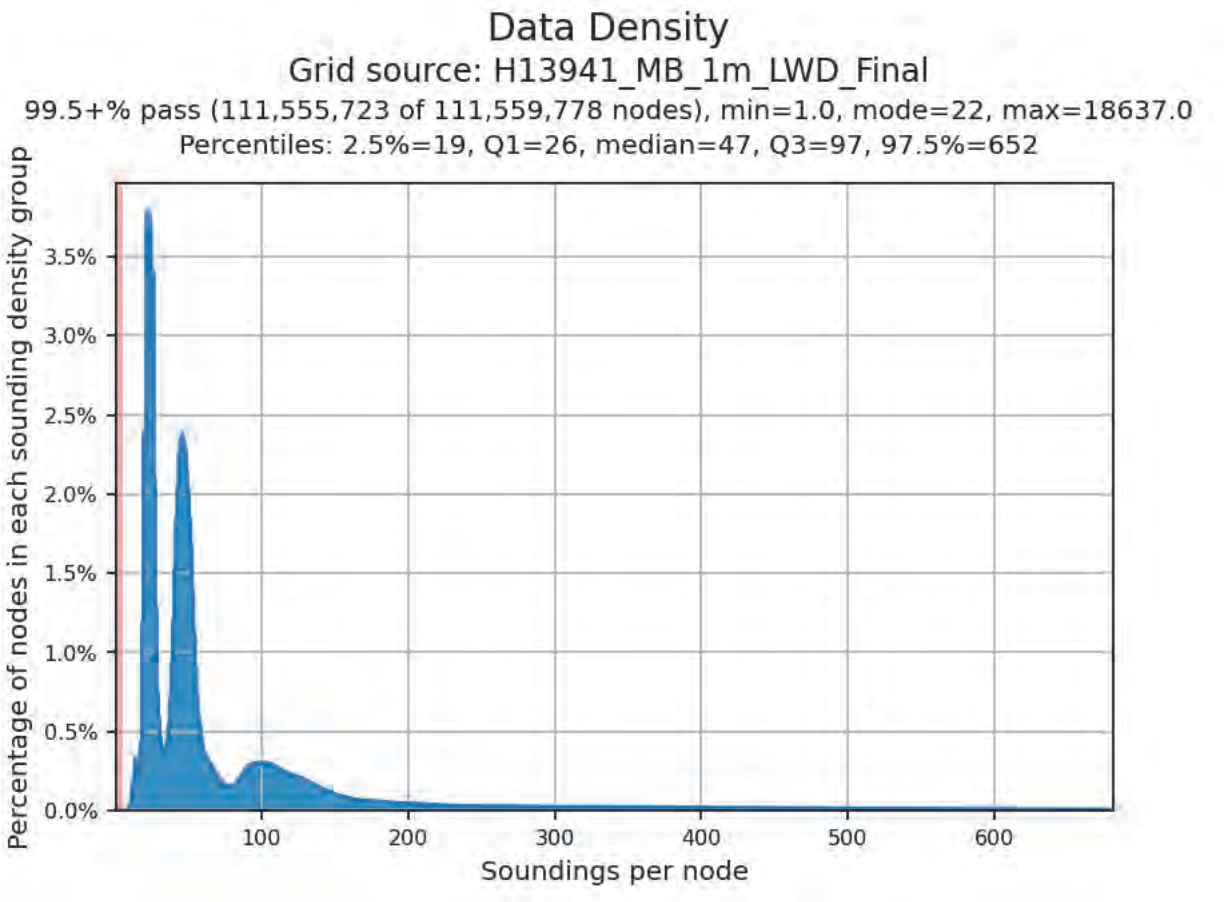


Figure 17: Finalized 1 m CUBE surface density statistics for H13941

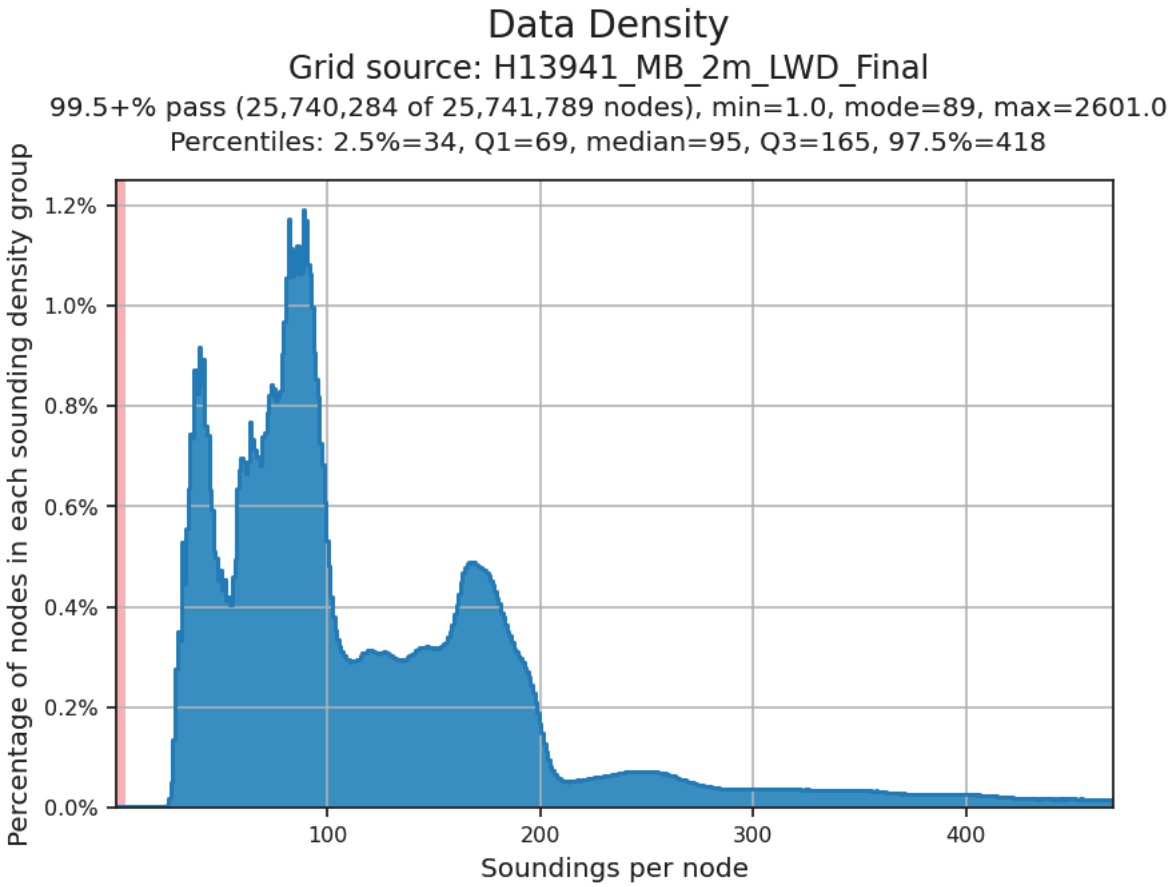


Figure 18: Finalized 2 m CUBE surface density statistics for H13941

B.2.11 Flier Finder

In addition to a visual inspection, all CUBE surfaces were analyzed using HydrOffice QC Tools Flier Finder tool to assure data does not contain fliers. While the Flier Finder tool flags surface fliers meeting a set criteria, it will also flag real surface features that meet the same criteria. Spurious soundings flagged by Flier Finder were cleaned until either no fliers remained or the remaining flagged fliers were deemed valid aspects of the surface. It should be noted that flagged fliers were especially prevalent on the riprap associated with breakwaters. Extreme detail was given to cleaning soundings near the breakwaters to ensure the baring feature associated with the charted shoreline construction was rejected and the submerged riprap leading up to the breakwater remained. See DR Appendix II Supplemental Records for more information regarding cleaning methods for submerged riprap around the charted shoreline construction.

B.3 Echo Sounding Corrections

B.3.1 Corrections to Echo Soundings

All data reduction procedures conform to those detailed in the DAPR.

B.3.2 Calibrations

All sounding systems were calibrated as detailed in the DAPR.

B.4 Backscatter

Raw backscatter data were collected and stored within the .ALL files. Backscatter data were processed and reviewed for quality assurance in QPS FMGT. In accordance with the HSSD, GSFs and backscatter mosaics were exported from FMGT. Hydrographers in the field monitored backscatter intensities in real-time and made efforts to collect quality backscatter without hindering bathymetric data quality. Refer to the DAPR for more information on backscatter data acquisition and processing procedures.

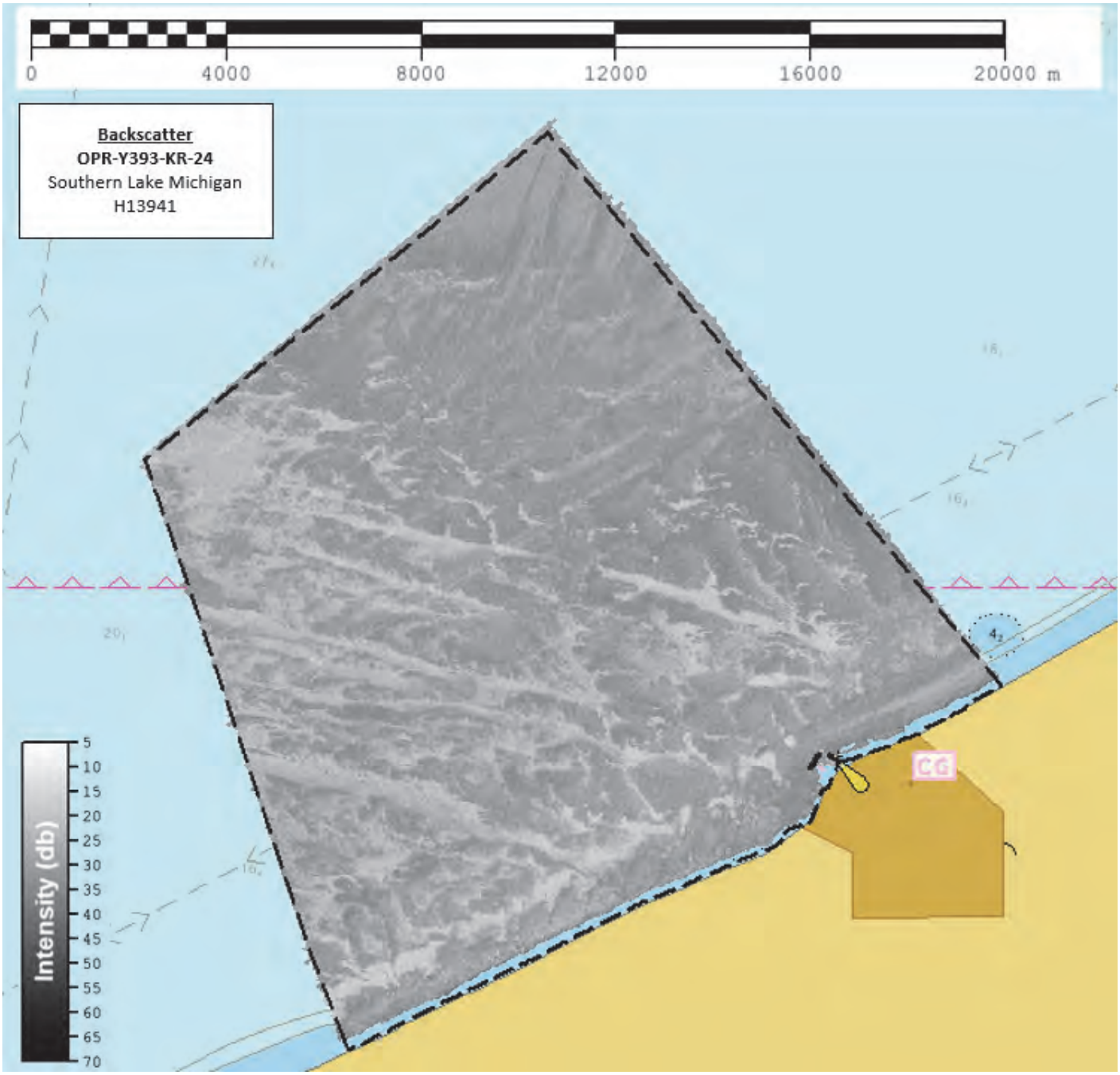


Figure 19: H13941 combined backscatter coverage

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
CARIS	HIPS and SIPS	11.4.20
CARIS	HIPS and SIPS	11.4.26

Table 10: Primary bathymetric data processing software

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

Manufacturer	Name	Version
QPS	FMGT	7.10.1

Table 11: Primary imagery data processing software

The following Feature Object Catalog was used: NOAA Profile Version 2023.

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
H13941_MB_1m_LWD_Final	CARIS Raster Surface (CUBE)	1 meters	1.22 meters - 20.0 meters	NOAA_1m	Complete MBES
H13941_MB_2m_LWD_Final	CARIS Raster Surface (CUBE)	2 meters	18.0 meters - 33.04 meters	NOAA_2m	Complete MBES
H13941_MB_1m_LWD	CARIS Raster Surface (CUBE)	1 meters	1.22 meters - 33.9 meters	NOAA_1m	Complete MBES
H13941_MB_2m_LWD	CARIS Raster Surface (CUBE)	2 meters	1.23 meters - 33.04 meters	NOAA_2m	Complete MBES
H13941_MBAB_2m_Substantial_300kHz_1of2	MB Backscatter Mosaic	2 meters	-	N/A	Complete MBES

Surface Name	Surface Type	Resolution	Depth Range	Surface Parameter	Purpose
H13941_MBAB_2m_Benthos_300kHz_2of2	MB Backscatter Mosaic	2 meters	-	N/A	Complete MBES

Table 12: Submitted Surfaces

All surfaces submitted are in compliance with the complete coverage MBES requirements per Section 5.2.2.3 of the HSSD. See Figure 20 below for an overview of the submitted finalized surface resolutions.

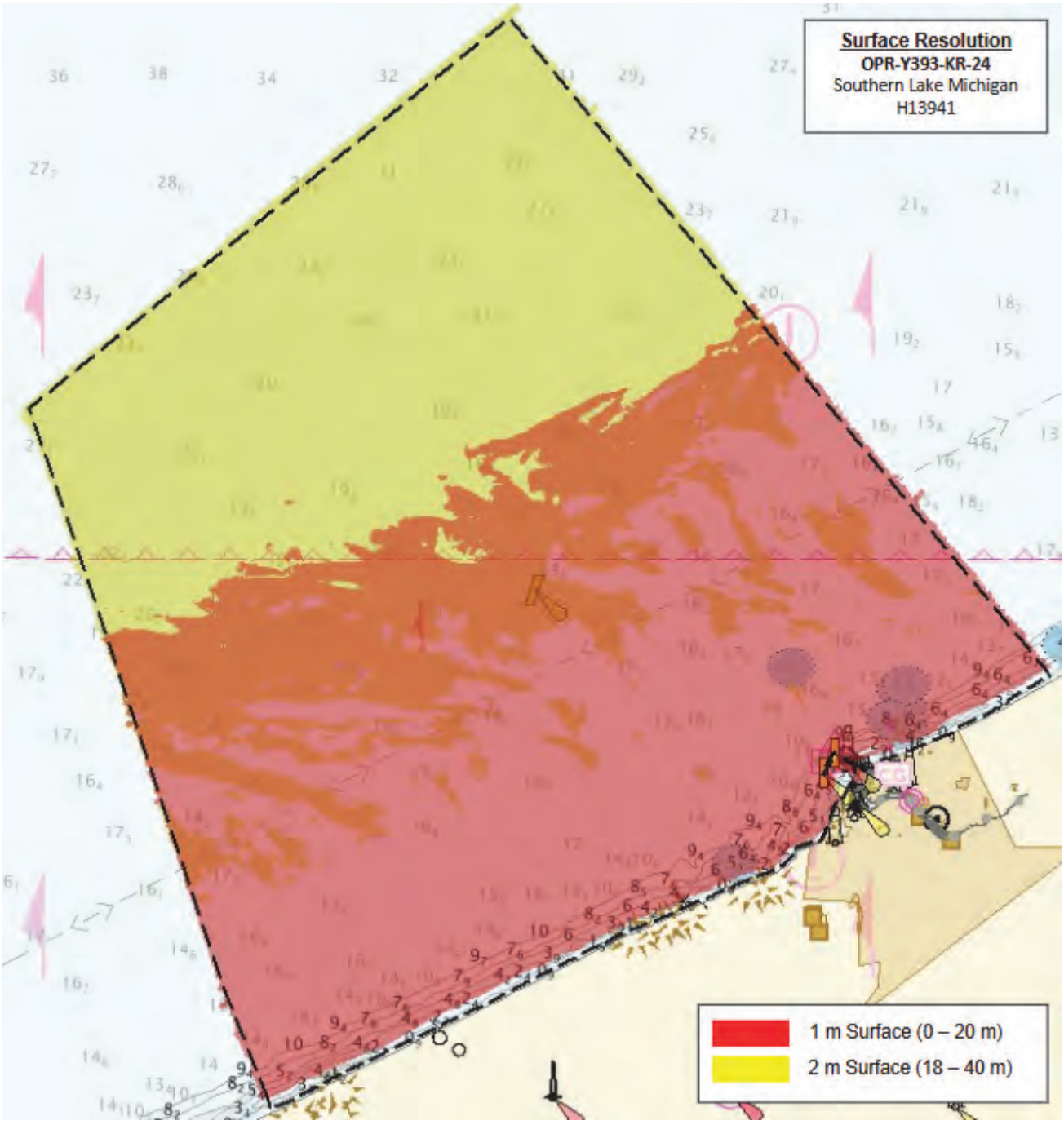


Figure 20: Image representing 1 m and 2 m finalized CUBE surface resolutions in H13941

B.5.3 Designated Soundings

H13941 contains 29 designated soundings in accordance with Section 5.2.1.2.3 and 7.4 of the HSSD. These designated soundings were created to facilitate feature management and best represent the least depths over

features in the Final Feature File (FFF). In the finalized CUBE surfaces, the CARIS HIPS Apply Designated Soundings function ensured designated soundings depths are retained in the finalized surfaces.

C. Vertical and Horizontal Control

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

C.1 Vertical Control

The vertical datum for this project is Low Water Datum IGLD-1985.

ERS Datum Transformation

The following ellipsoid-to-chart vertical datum transformation was used:

Method	Ellipsoid to Chart Datum Separation File
ERS via VDATUM	OPR-Y393-KR-24_100m_NAD83_2011-LWD_IGLD85_geoid18.csar

Table 13: ERS method and SEP file

Real-time positional and GPS Height data were corrected with G2+ Global Navigation Satellite System (GNSS) satellite corrections provided by the Fugro Marinestar Satellite-Based Augmentation System (SBAS). To improve the accuracy of the real-time data, real-time position and GPS Height data were post-processed using Applanix POSPac Mobile Mapping Solution (MMS) software. Trimble CenterPoint RTX correction methods were used to create Smoothed Best Estimate of Trajectory (SBET) files, which were applied to the survey data in CARIS HIPS. The provided separation model was then utilized to bring the data from ellipsoid heights to chart datum. For further information regarding processing and application of SBET and SEP files, please reference the DAPR.

C.2 Horizontal Control

The horizontal datum for this project is North American Datum 1983 (2011).

The projection used for this project is Universal Transverse Mercator (UTM) Zone 16.

RTK

Real-time positional and GPS Height data were corrected with G2+ GNSS satellite corrections provided by the Fugro Marinestar SBAS.

D. Results and Recommendations

D.1 Chart Comparison

A comparison was performed in CARIS HIPS between H13941 and the ENCs listed in Table 14 of Section D.1.1. Sounding layers were generated from the CUBE surfaces and overlaid onto the ENCs to visually assess differences between the surveyed and charted depths.

In addition to a detailed visual inspection in CARIS HIPS, all soundings from the chart were downloaded as a shapefile from NOAA's ENC Direct to GIS application and differenced with the nearest surveyed depth from the 2 m surface in ESRI ArcPro. A statistical analysis of the difference comparison is shown in Figure 21. The surveyed depths from H13941 generally agree with the charted soundings from the largest scale ENCs within the survey area, with a mean difference of 0.58 m. Areas with large discrepancies between the charted soundings and surveyed depths were assessed and multiple shoal soundings, as well as two obstructions, were determined to pose an imminent danger to navigation and were subsequently reported as Dangers to Navigation (DTONs). Refer to Section D.1.2 of this report for further information.

It should be noted that an ENC re-scheme occurred mid-project. ENCs US4IN01M, US4IN11M, and US5IN11M no longer exist and were subsequently removed and replaced with the ENCs listed below in Table 14.

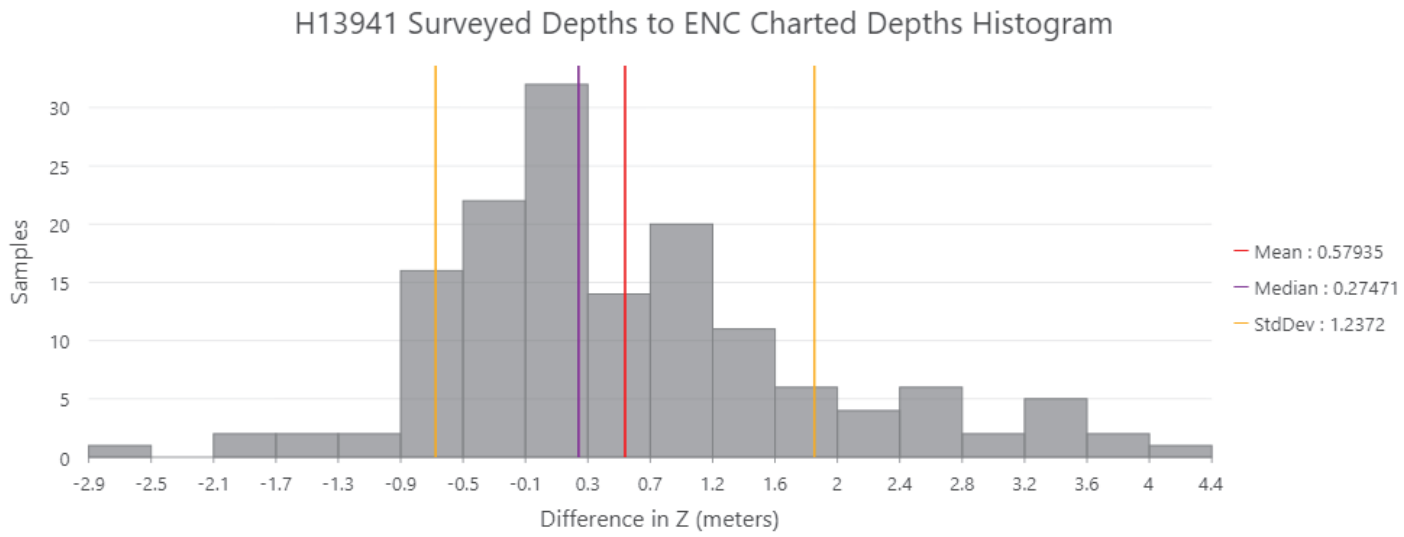


Figure 21: H13941 statistical analysis of surveyed depths to charted soundings

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
US4IN1CD	1:90000	1	08/27/2024	10/09/2024
US4IN1CE	1:90000	1	12/13/2024	12/13/2024
US4IN1DD	1:90000	2	10/04/2024	10/04/2024
US4MI2AM	1:90000	1	12/13/2024	12/13/2024
US5CHIHV	1:12000	2	10/04/2024	10/04/2024

Table 14: Largest Scale ENCs

D.1.2 Shoal and Hazardous Features

Two shoals were identified as hazardous in H13941 and were reported and forwarded to MCD as Dangers to Navigation (DTONs) and are included in the FFF with Special Feature Type as "DTON". These sounding features are adequately represented in the final delivered surface and therefore do not have accompanying designated soundings. It should be noted that additional guidance was provided by NOAA HSD OPS in order to best represent H13941 DTON 01 for DTON submission given the unique aspects of this DTON. This DTON represented a large shoal, and the vessel was unable to fully develop the shoal due to safety limitations. The provided guidance was to submit a selection of soundings outlining the shoal for DTON submission (see DR Appendix II Supplemental Records). In addition to the DTONs submitted for the two

shoals, two additional DTONs were submitted for dangerous obstructions and were accepted by AHB and forwarded to MCD as DTONs. All DTONs are included in the FFF with Special Feature Type as "DTON". It should be noted that the least depth, position, or feature geometry may have changed slightly during post-processing for reported DTONs. Refer to the FFF for the remarks and recommendations for each feature. See DR Appendix II Supplemental Records for submitted DTON reports and related correspondence.

D.1.3 Charted Features

All assigned charted features within H13941 are detailed in the FFF in accordance with Section 7.3 of the HSSD and the investigation requirements within the provided Composite Source File (CSF).

It should be noted that all assigned features in the FFF were imported from the provided CSF. As mentioned in Section D.1, an ENC re-scheme occurred mid-project. Refer to Section D.1 of this report for further information.

D.1.4 Uncharted Features

One new obstruction (Unique ID: 2_033_1) was identified that did not meet the vertical minimum size requirements for new features at the surveyed depth as defined by Sections 7.3.2 and 5.2.2.3 of the HSSD. Due to the potential anthropogenic significance of this feature, the uncharted obstruction was included in the FFF to be left up to cartographic discretion.

With respect to the aforementioned deviation, all new features found within H13941 are detailed in the FFF in accordance with Section 7.3 of the HSSD.

D.1.5 Channels

A comparison of the surveyed depths to the Depth Range Value 1 (DRVAL1) attribute listed in the most up to date ENCs was conducted for USACE maintained Michigan City Harbor channel in H13941. The findings were submitted to NOAA HSD OPS on 09/12/2024 per HSSD specifications. The comparison showed that within the Michigan City Harbor channel there was an exceedance of the DRAVL1 value in the Outer Harbor ROQ, which had a DRVAL1 of 2.4 m and a shoal surveyed depth of approximately 1.29 m. It should be noted USACE eHydro was also assessed and the same shoaling is represented in the most recent USACE survey of the channel with similar shoal values (USACE survey 20240501). Given that the shoaling of the Outer Harbor ROQ has been documented in the most recent USACE surveys and is limited to the outer edge of the channel, this shoaling was not considered to pose an imminent danger to navigation. See DR Appendix II Supplemental Records for all related correspondence with NOAA HSD OPS. A detailed analysis of the surveyed depths in this channel was provided to NOAA HSD OPS and forwarded to the Navigation Manager in accordance with Section 1.6.2.1 of the HSSD.

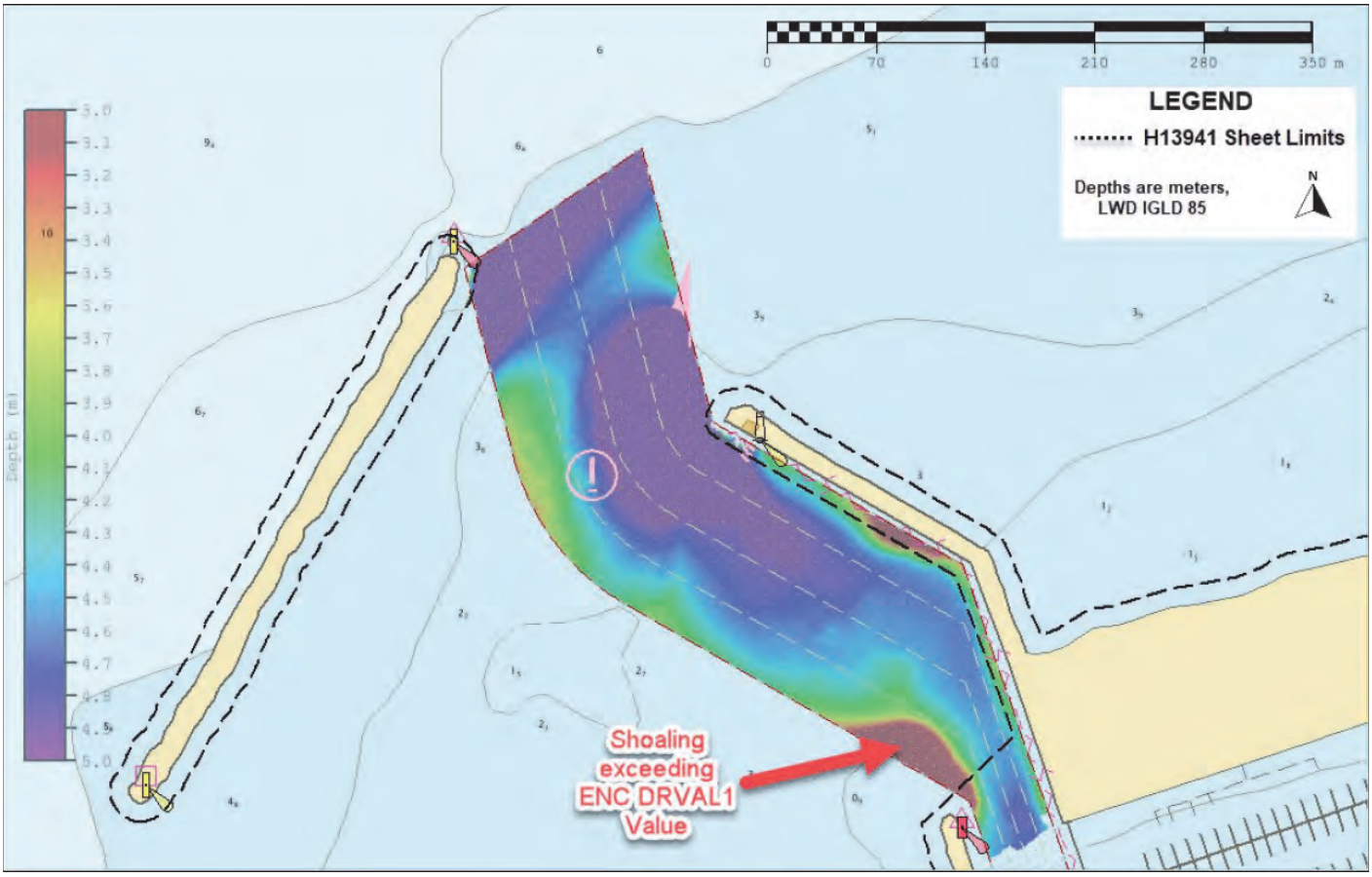


Figure 22: H13941 Michigan City Harbor channel coverage showing the intruding shoal that exceeds the DRVAL1 in the Outer Harbor ROQ

D.2 Additional Results

D.2.1 Aids to Navigation

Charted ATON, Purdue Research Lighted Buoy A (LLNR: 19544), was investigated and observed to be off-station. This charted ATON (Unique IDs: 2_012_1 and 2_013_1) was imported into the FFF from ENC US4MI2AM and is addressed as a Delete/New (Unique IDs: 2_012_2 and 2_013_2). This ATON discrepancy was reported to USCG via the Navigation Center's online ATON Discrepancy Report Form in accordance with HSSD 2022 Section 1.6.2.2. See DR Appendix II Supplemental Records for related correspondence.

Two uncharted, Type 3 buoys were observed in the field that were not represented on the ENC or included in the USCG Light List. ASSIST Reports were submitted for these buoys in accordance with Section 1.6.2.2 of the HSSD. Considering the ASSIST report responses, these buoys are not included in the FFF. See DR Appendix II Supplemental Records for related correspondence.

D.2.2 Maritime Boundary Points

No Maritime Boundary Points were assigned for this survey.

D.2.3 Bottom Samples

Ten bottom samples were acquired in accordance with Section 7.2.3 of the HSSD and are described in the FFF. Predetermined bottom sample locations were not provided for this project. Instead, ten bottom sample locations within each sheet were identified by the team of hydrographers based off of multiple factors including but not limited to, backscatter data, bathymetric data, geologic and/or navigation areas of interest. See Project Instructions for more information.

Bottom samples were collected on 09/17/2024, 09/18/2024, and 09/20/2024. It should be noted that one bottom sample was collected after the last day of MBES collection. Therefore, the last day of survey and SORDAT reflects a bottom sample acquisition day and does not have accompanying MBES data for that specific date. See Project Correspondence for more information.

D.2.4 Overhead Features

No overhead features exist for this survey.

D.2.5 Submarine Features

There were three assigned submerged pipelines within H13941. None of the three assigned pipelines were visible within the multibeam data, therefore, these features are included in the FFF with description 'Retain' in accordance with the Investigation Requirements listed in the CSF.

There were three uncharted, submerged pipelines that were visible as exposed or unburied within the multibeam data. The three pipelines are detailed in the FFF and were reported in accordance with Section 1.7.3 of the HSSD. See DR Appendix II Supplemental Records for related correspondence.

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.

D.2.8 Abnormal Seafloor or Environmental Conditions

Significant temporal depth and bottom changes were observed in multiple nearshore, shallow areas around Michigan City between dates of survey. The soundings are time stamped and variations are not related to quality or accuracy but believed to likely be related to sediment transport and movement around the breakwaters and the nearshore environment. When deemed necessary, additional crosslines were ran to verify the accuracy of our data. These areas were reviewed in detail to verify that the final grids best represent the most recent depths while adhering to the allowable TVU limits. Below, Figures 23 - 24 are examples of temporal depth differences and the grid's representation of those changes.

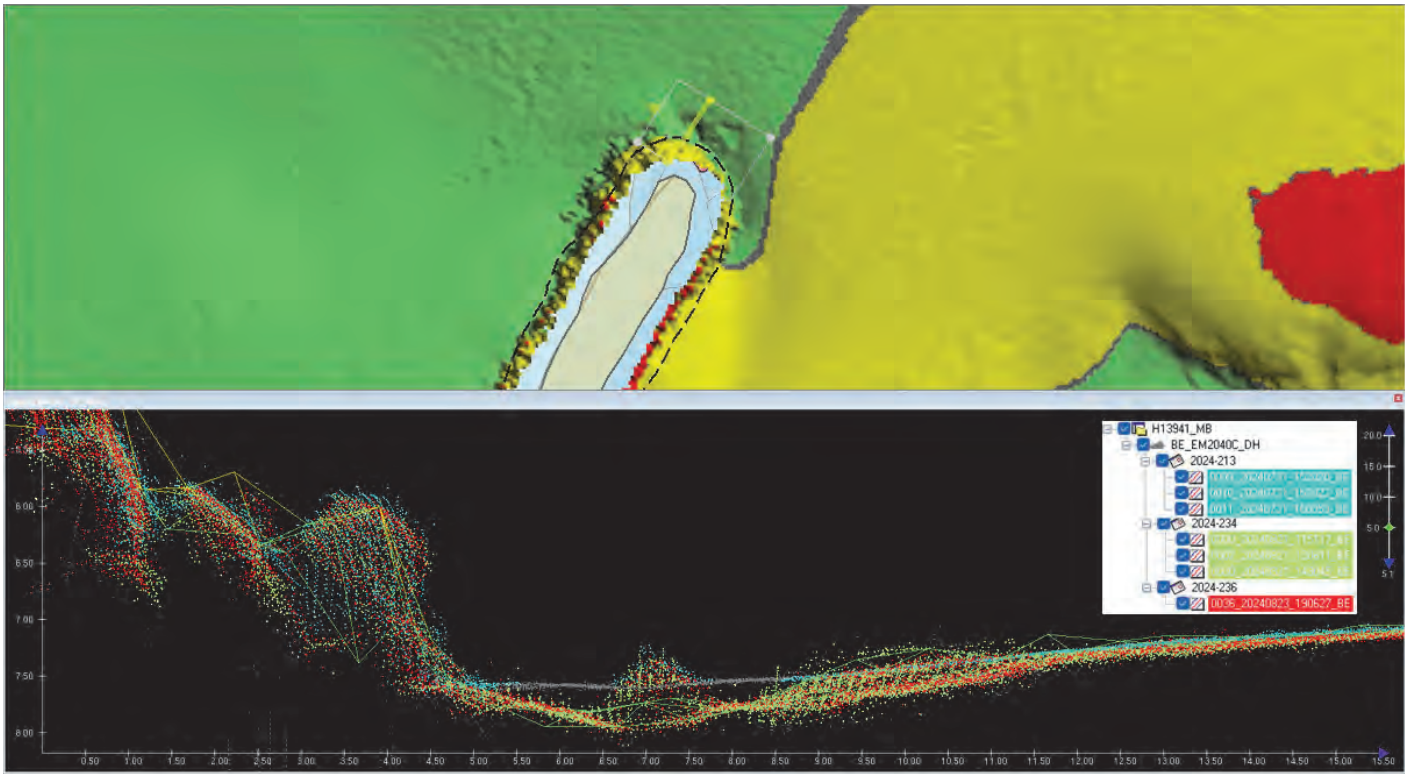


Figure 23: Example of bottom feature alignment between survey days demonstrating temporal change around Michigan City breakwater. Soundings colored by survey day.

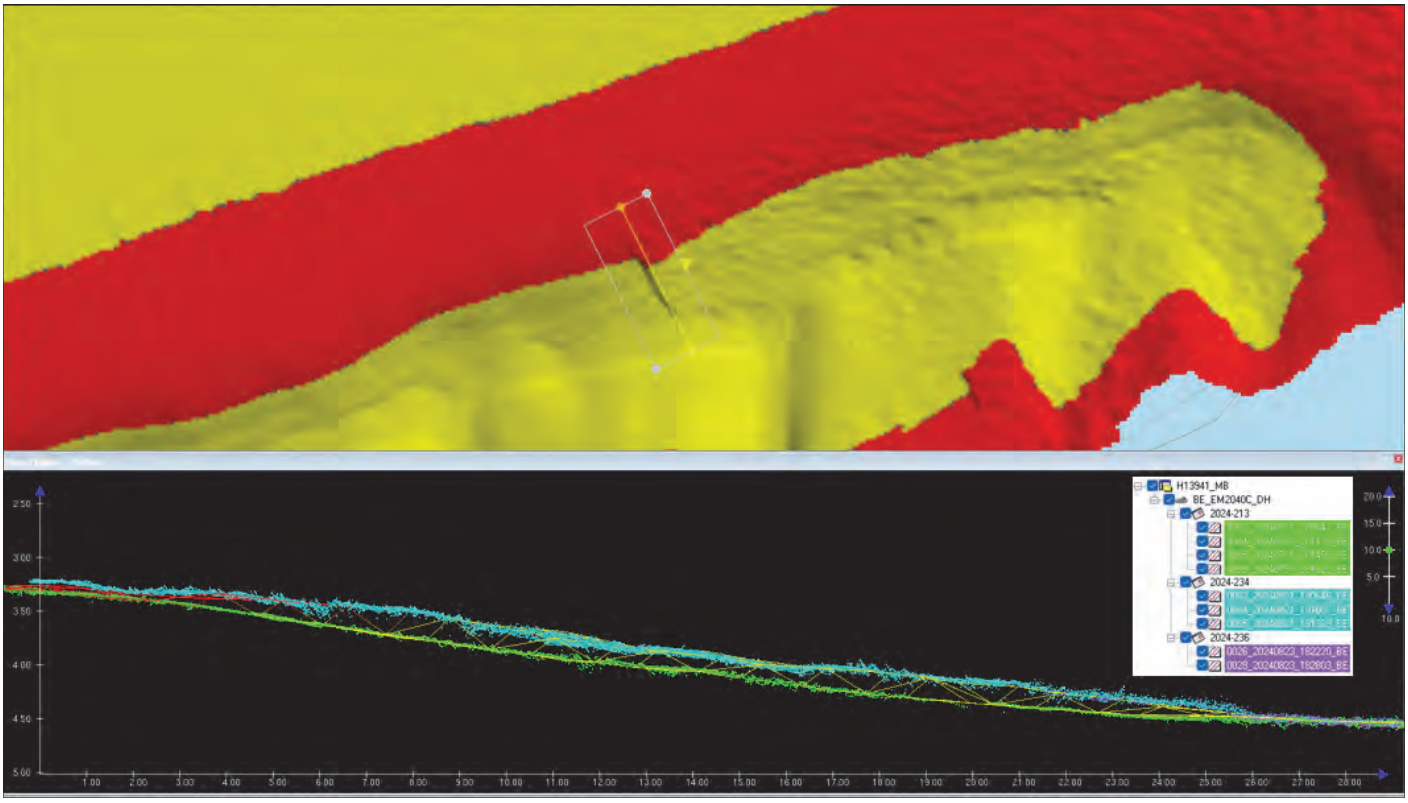


Figure 24: Example of temporal change likely due to shoal migration. Soundings colored by survey day.

D.2.9 Construction and Dredging

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

D.2.10 New Survey Recommendations

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

D.2.11 ENC Scale Recommendations

No new ENC scales 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 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.

Report Name	Report Date Sent
Data Acquisition and Processing Report	2025-01-20
Coast Pilot Report	2024-11-27

Approver Name	Approver Title	Approval Date	Signature
Nicholas Damm, CH	Chief of Party	04/11/2025	Nicholas Damm Digitally signed by Nicholas Damm Date: 2025.04.11 18:05:36 -04'00'

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	Continuously Operating Reference Station
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
ERTDM	Ellipsoidally Referenced Tidal Datum Model
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

Acronym	Definition
HSSD	Hydrographic Survey Specifications and Deliverables
HSTB	Hydrographic Systems Technology Branch
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
MBAB	Multibeam Echosounder Acoustic Backscatter
MCD	Marine Chart Division
MHW	Mean High Water
MLLW	Mean Lower Low Water
NAD 83	North American Datum of 1983
NALL	Navigable Area Limit Line
NTM	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

Acronym	Definition
PRF	Project Reference File
PS	Physical Scientist
RNC	Raster Navigational Chart
RTK	Real Time Kinematic
RTX	Real Time Extended
SBES	Singlebeam Echosounder
SBET	Smooth Best Estimate and Trajectory
SNM	Square Nautical Miles
SSS	Side Scan Sonar
SSSAB	Side Scan Sonar Acoustic Backscatter
ST	Survey Technician
SVP	Sound Velocity Profiler
TCARI	Tidal Constituent And Residual Interpolation
TPU	Total Propagated Uncertainty
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
UTM	Universal Transverse Mercator
XO	Executive Officer
ZDF	Zone Definition File