

<b>Descriptive Report Summary</b> <b>W00463</b>	
Project	NCCOS #418 Proposed Wisconsin-Lake Michigan NMS
Survey	W00463
State	Wisconsin
Locality	Lake Michigan
Sub Locality	Sheboygan
Scale of Survey	1:40000
Sonars Used	Kongsberg Maritime EM 2040C (MBES) Klein Marine Systems System 3000 (SSS) AML Oceanographic MicroX SVS (Sound Speed Probe)
Horizontal Datum	World Geodetic System (WGS) 1984
Vertical Datum	Ellipsoidally Referenced Survey
Vertical Datum Correction	VDatum
Projection	Projected UTM 16 N
Field Unit	R/V Storm
Survey Dates	06/02/2018 - 06/11/2018
Chief of Party	Will Sautter

## A. Area Surveyed

The hydrographic survey W00463 was conducted for the benthic habitat mapping of NCCOS Project #418 titled "Environmental and Socioeconomic Assessments of the Proposed Wisconsin-Lake Michigan National Marine Sanctuary". The Area of Interest (AOI) was chosen in consultation with the Office of National Marine Sanctuaries and Wisconsin Historical Society to improve information regarding underwater geology, habitats, and cultural resources. The 2018 AOI was planned to cover a region with several potential shipwreck and mussel bed locations off the shores of Sheboygan, Wisconsin (Figure 1). Sidescan Sonar (SSS), Multibeam Echo Sounder (MBES) bathymetry, water column, and backscatter data were collected simultaneously in transects to cover approximately 24 square miles of the AOI.

Data were acquired within the following survey limits:

<b>Northwest Limit</b>	<b>Southeast Limit</b>
43° 48' 37.36" N 87° 43' 40.16" W	43° 37' 47.42" N 87° 31' 17.16" W

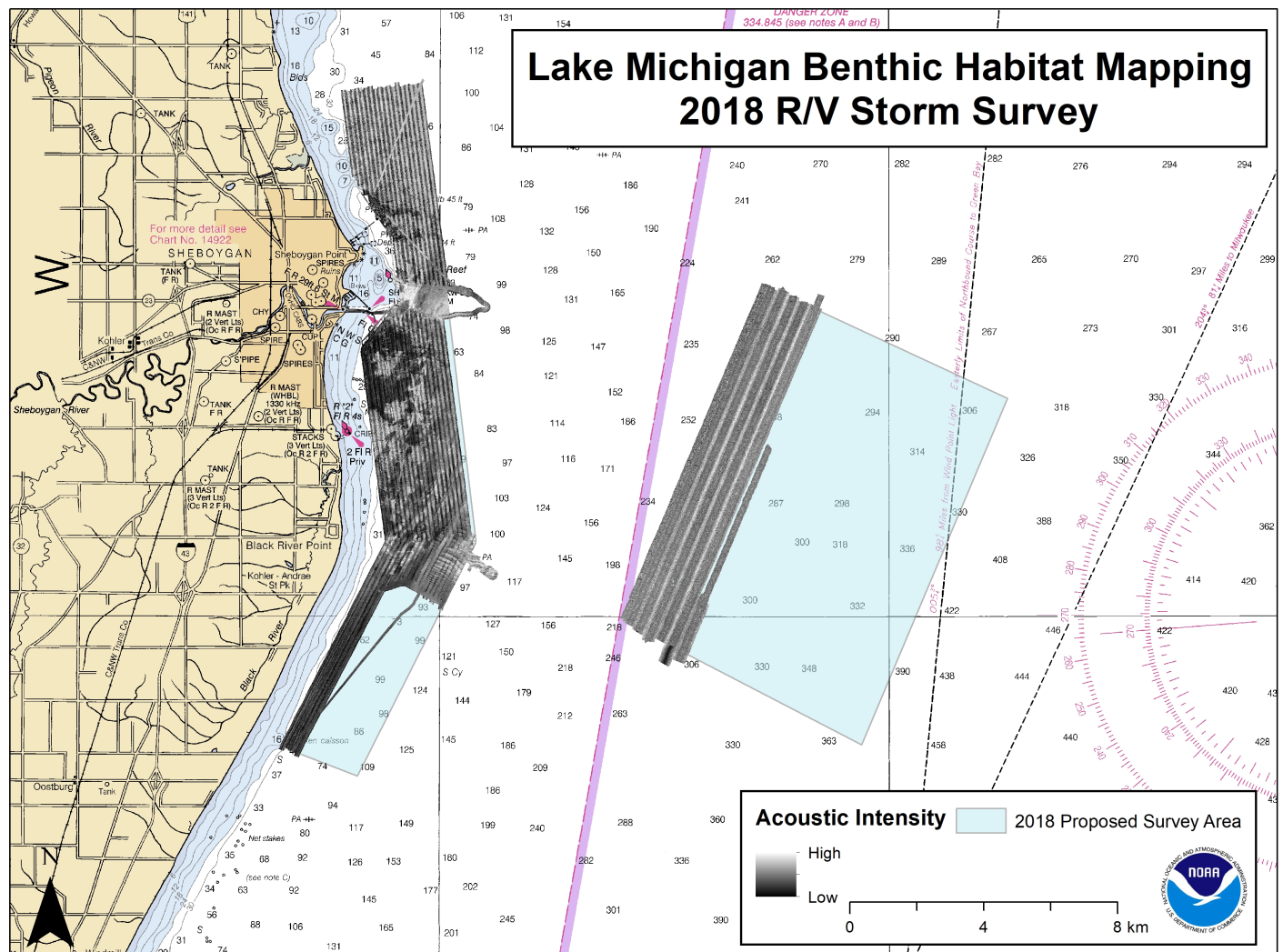


Figure 1. The proposed survey AOI and mapping coverage of W00463.

### B. Survey Purpose

The 2018 survey off of Sheboygan, WI was conducted for two purposes:

- 1) create a benthic habitat map to classify and understand the changes in substrate, geoforms, and biotic components
- 2) locate lost shipwrecks described in historical documents

The National Centers for Coastal Ocean Science (NCCOS) and Great Lakes Environmental Research Laboratory (GLERL) collaborated to conduct the hydrographic survey to collect new lake bed data using acoustic mapping technologies. The 2018 proposed AOI was guided by a mapping prioritization report which determined areas with a high probability of historical resources, sediment movement, and important natural habitat. This data will be used to inform coastal management objectives, fill in data gaps, replace existing data, and identify priorities for future mapping and monitoring.

## C. Intended Use of Survey

The entire survey is adequate to supersede previous data.

The intent of this survey was to collect bathymetry, backscatter, and sidescan imagery of submerged natural and cultural resources in Lake Michigan, WI. Previous hydrographic mapping within the planned AOI were conducted up to the 1950's using lead line and single beam echo sounders (SBES). Survey data were acquired within survey limits in accordance with the requirements in the NCCOS Project Instructions and meet the guidelines of the Hydrographic Survey Specifications and Deliverables (HSSD). The SSS and MBES data were not required to meet IHO specifications, object detection standards, or 100% coverage of the AOI. However, this hydrographic survey does provide high quality imagery for natural resource managers, environmental scientists, and historians on the benthic habitats, invasive aquatic species, and maritime heritage along the Wisconsin shores of Lake Michigan.

The survey has been submitted to the External Survey Data division of the Office of Coast Survey and is recommended to update nautical charting of Lake Michigan in the Sheboygan, WI area.

## D. Data Acquisition and Processing

Chief Scientist Charles Menza (NCCOS/NOAA) directed mission planning and objectives for the benthic habitat mapping research. The hydrographic survey party was led by CSS Inc. contractor Will Sautter (NCCOS/NOAA) along with NOAA Corps Officer LTJG Jen Kraus (NCCOS/NOAA). Sensor installation and calibration were conducted by Brent Johnson (SolMAR Hydro) under subcontract by CSS Inc. Kongsberg LLC loaned the EM2040C and Thunder Bay National Marine Sanctuary loaned the Klein 3000 sidescan sonar at no cost to support the mapping of the Great Lakes. The survey was carried out on the 50 foot GLERL research vessel (R/V) Storm with Captain Travis Smith from June 2nd to June 11th, 2018 (Figure 2). This survey did not require a DAPR. Details on vessel and systems used to acquire bathymetry, SSS, and SVP are contained within the discussion of this Descriptive Report Summary.

### -Sensor Installation and Calibrations

The Kongsberg EM2040C was installed through the moon pool mount on the R/V Storm while it was alongside the GLERL pier in Muskegon, MI on May 31st, 2018. Preliminary leadline, waterline, and draft measurements were collected after the sonar was mounted. Lever arm offsets were recalculated by using a 3D Computer Aided-Design model from the NOAA Boat R5002 (STORM) IMU and MULTI-BEAM Component Spatial Relationship Survey Field Report (2010). Artificially induced heave and roll tests were also performed by rocking the vessel while tied to the pier. A new vessel configuration file was created with a POS MV as the 0, 0, 0, reference point with the measurements. A patch test was conducted on June 2, 2018 over the Schooner Helvetia, a known shipwreck approximately 5.3 miles northeast of Sheboygan Point, WI (Figure 3). The entire system's integration was tested, timing was synced, and all of the offsets were calibrated using CARIS 10.4.

### -Survey Coverage

The 2018 AOI was divided into three parts. About 12 square miles were covered in Part A, 1 mile east of Sheboygan, WI. Three square miles of Part B were surveyed, 0.6 miles southeast of Black River Point and directly south of Part A. These two sections overlap with Survey 2644 of the US Army Corps of Engineers 2012 topobathymetric LiDAR of the Lake Michigan shoreline. About 9 square miles of data were collected in Part C, located 8 miles southeast from Sheboygan Harbor specifically to locate submerged cultural resources.

Due to time constraints from poor weather conditions, mechanical issues, and commercial fishing activities, 100% coverage was not obtained in all three sections of the AOI. During the first week of survey, there was an area outside of the Sheboygan Harbor in Part A where commercial and recreational fishing activities were taking place. Vessel traffic and submerged fishing nets prevented the use of the towed sidescan in that area until the following week. The team subsequently went to southern section of the AOI, until the Chief Scientist decided to leave the lower eastern extent of Part B unsurveyed (1 x 4 miles) due to the relatively flat and featureless lake bottom. Therefore, MBES and Sidescan coverage was prioritized to collect data on more diverse benthic habitats and locate submerged cultural resources in Part C. However due to equipment failure, 4 x 8 miles of the eastern portion of Part C remained unsurveyed (see Sidescan Acquisition section).

#### -Multibeam Acquisition

The bathymetry and backscatter were acquired by the EM2040C using the Seafloor Imaging System (SIS). Raw multibeam files were logged in the Kongsberg .ALL format. The multibeam bathymetry was processed by using the CARIS 10 HIPS and SIPS work flow. PPK positioning were applied to the soundings for vertical reference and motion compensation, and signal noise were manually cleaned using CARIS subset editor. Offsets of the installed EM2040C and surface sound velocity were collected and applied to the vessel configuration file.

#### -Delayed Heave

Delayed heave was applied in post-processing with SBETS using the HIPS and SIPS work flow from the POS (.000) files processed with PosPac software. These files logged positioning information from the pair of GPS antennae linked to an Applanix IMU unit. Several calibration tests were conducted to ensure there was no latency or delayed heave artifacts.

#### -Sound Speed Methods

Surface sound speed was collected from an AML Micro-X sound speed probe mounted to the starboard railing of the R/V Storm and applied to the MBES in real time through SIS. Sound speed profiles were acquired using a Sonar Pro PC Castaway device at discrete locations within the survey area at least once every four hours, when significant changes in surface sound speed were observed, or when surveying in a new area. A total of 33 casts were applied to all survey lines (Figure 4) using the "Nearest in distance within time" profile selection method at four hour intervals in CARIS HIPS.

#### -Backscatter Data

The .ALL files contain raw backscatter time-series data for each beam footprint and each ping from the EM2040C. The .ALL files were merged with the final processed CARIS HDCS data files using the Fledermaus Geocoder Toolbox. Decibel offsets across track were measured and corrected by applying a beam pattern. Other decibel offsets along track due to increasing depth were fixed by applying Time Varying Gain corrections. The final corrected mosaic were exported as a 1m 8-bit geotiff and included in the final deliverables. The decibel values were rendered as 0-255 (low to high) pixel values because the raw intensity of the backscatter is uncalibrated to bottom type.

#### -Sidescan Acquisition

The Sidescan Sonar (SSS) data was collected simultaneously with the MBES data on the R/V Storm using a towed Klein 3000 system provided by Thunder Bay National Marine Sanctuary. Data was logged in the Trident .XTF and Sonar Pro .SDF formats. The Klein 3000 collected dual frequency sidescan imagery at 100kHz (Low Frequency Mode) and 500 kHz (High Frequency Mode). The sidescan altitude and cable-out was manually controlled with a winch and cable counter. Data acquisition was collected and monitored using Sonar Pro software. After comparing

image resolution and survey coverage, the range of the sidescan was set to 75m to optimize image quality and to avoid refraction from the thermocline in the nearshore areas. The range was extended to 150m for greater coverage in Part C to search for cultural resources in deeper waters. The raw sidescan files were processed using Sonar Wiz13 software into a mosaic. Beam angle corrections were applied first to normalize the intensity signals and correct across track gain offsets. Bottom tracking corrections were applied manually to fix with altitude changes in the towfish. Slant range corrections to eliminate water column artifacts were not applied to the mosaic due to the positional distortion of features closest to nadir and thus affecting the spatial accuracy of the habitat map. The decibel values were rendered as 0-255 (low to high) pixel values because the raw intensity of the sidescan are uncalibrated to bottom type, and are relative to the physical properties of the water column and attitude of the SSS. The mosaics of the near shore Part A and Part B were rendered to a 25cm resolution, while the offshore Part C was rendered to 1m. The final mosaics were exported from SonarWiz as 8-bit geotiffs and included in the final deliverables.

On June 10th, the sidescan system completely shut down from a power failure in the topside hardware during the data collection in Part C. The issue could not be resolved during the survey which resulted in NCCOS returning the entire system back to Thunder Bay National Marine Sanctuary for repairs. Thus Part C remained incomplete and the focus of the final day of survey switched to filling in gaps where there was commercial fishing activity the previous week in Part A with the EM2040C multibeam system.



Hull Number	R5002
Builder	Munson Boats
Year Built	1992
Weight	52,000 lbs
Length Overall	50'6"
Beam	13'5"
Draft, Maximum	3'6"
Cruising Speed	22 knots
Max Survey Speed	8 knots
Range	300 nautical miles

*Figure 2. Vessel details for the NOAA R/V Storm at the Thunder Bay National Marine Sanctuary, MI.*

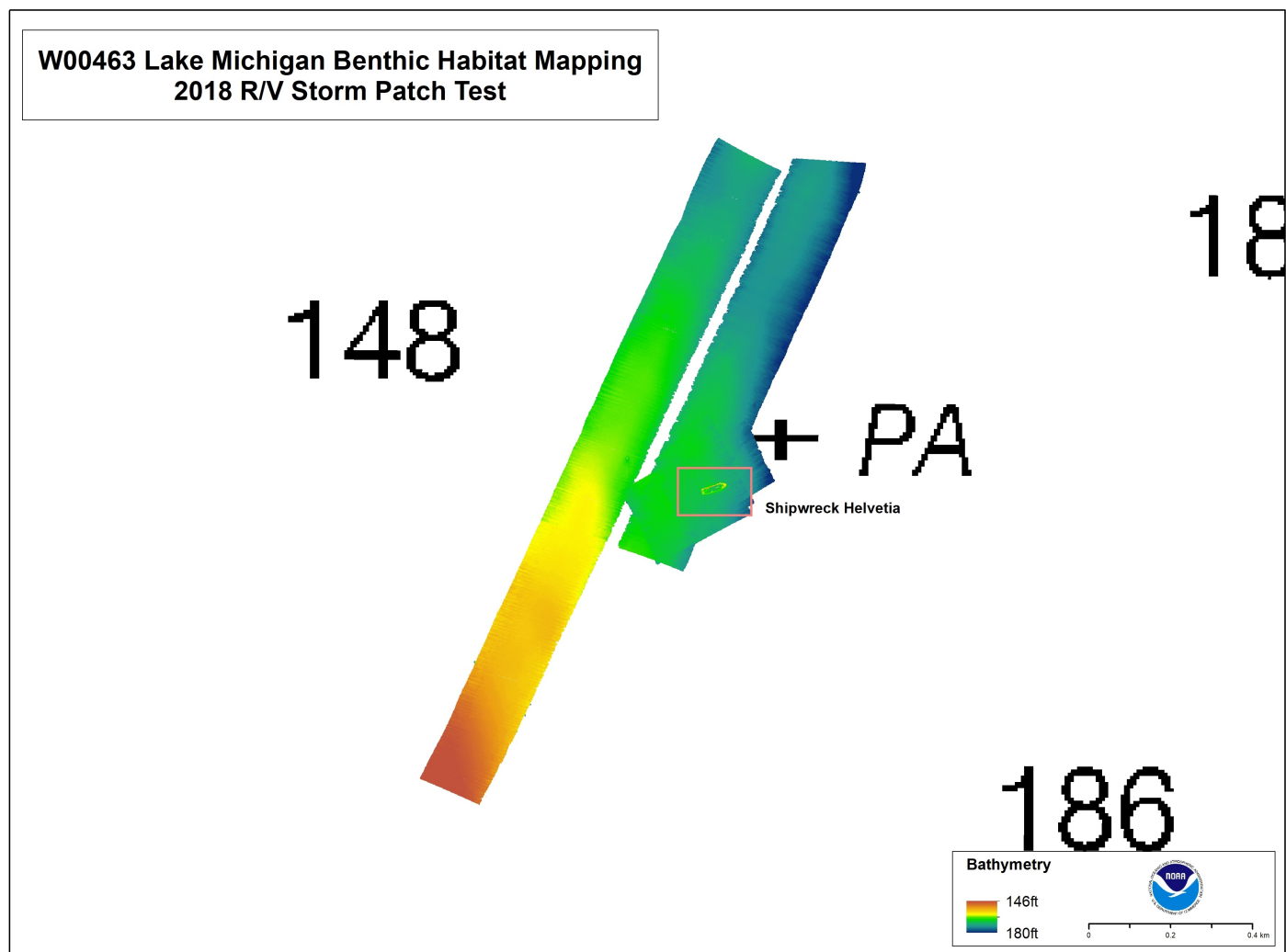
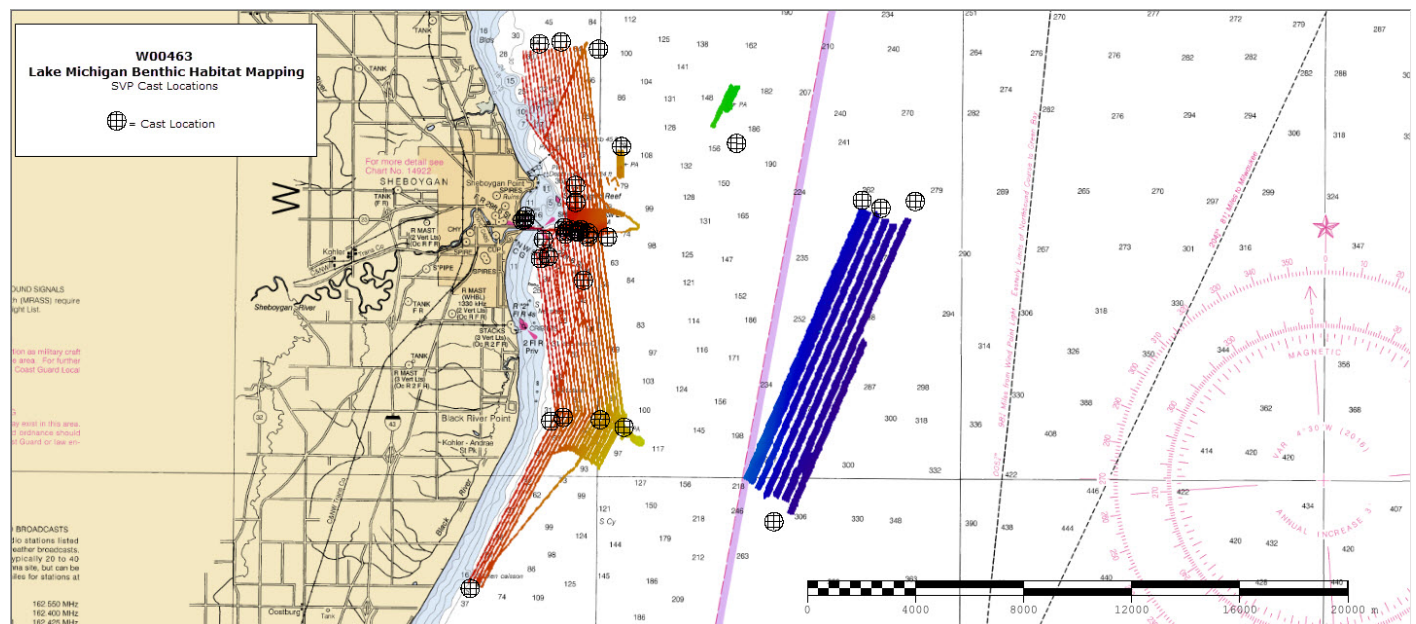


Figure 3. Patch test conducted over the Schooner Helvetia, a known shipwreck off the coast of Sheboygan, WI.







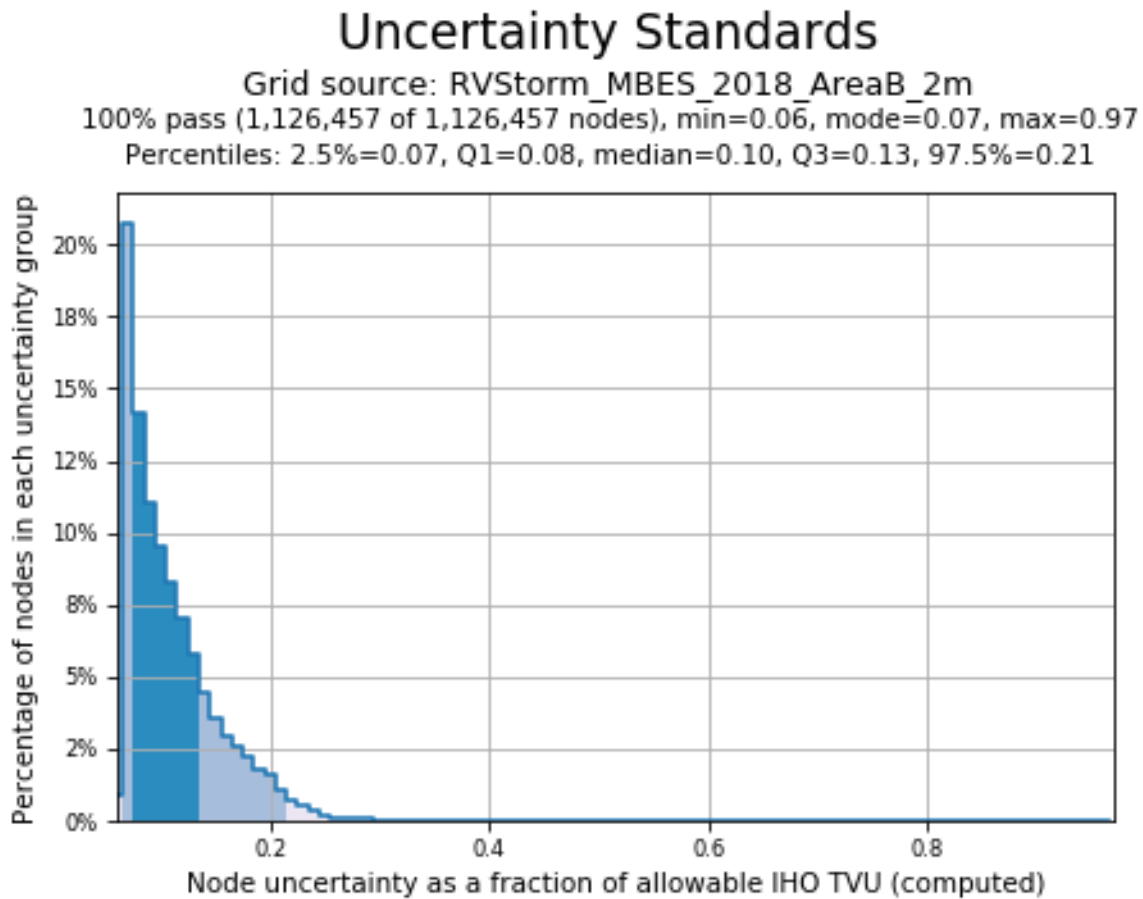


Figure 5. TVU Compliance to NOAA uncertainty standards as calculated using Pydro QC Tools 2.

## F. Results and Recommendations

The following are the largest scale ENC that cover the survey area:

ENC	Scale	Edition	Update Application Date	Issue Date	Preliminary?
US5WI32M	1:10000	2	03/08/2017	03/08/2017	NO
US4WI34M	1:120000	12		03/08/2017	NO

Raster Nautical Chart (RNC) 14903 covered the entire W00463 survey area was compared to W00463 survey data using a 2 meter resolution CUBE surface. In general, charted soundings and contours agree with surveyed depths, but some areas show horizontal divergence in contour position up to 0.3 nautical miles (556 meters). Overall, contours from surveyed areas were generally deeper than charted contours. Figure 6 and 7 show some discrepancies between

charted and surveyed contours, however the depths in this area are very dynamic and would therefore need further surveying to determine true contours.

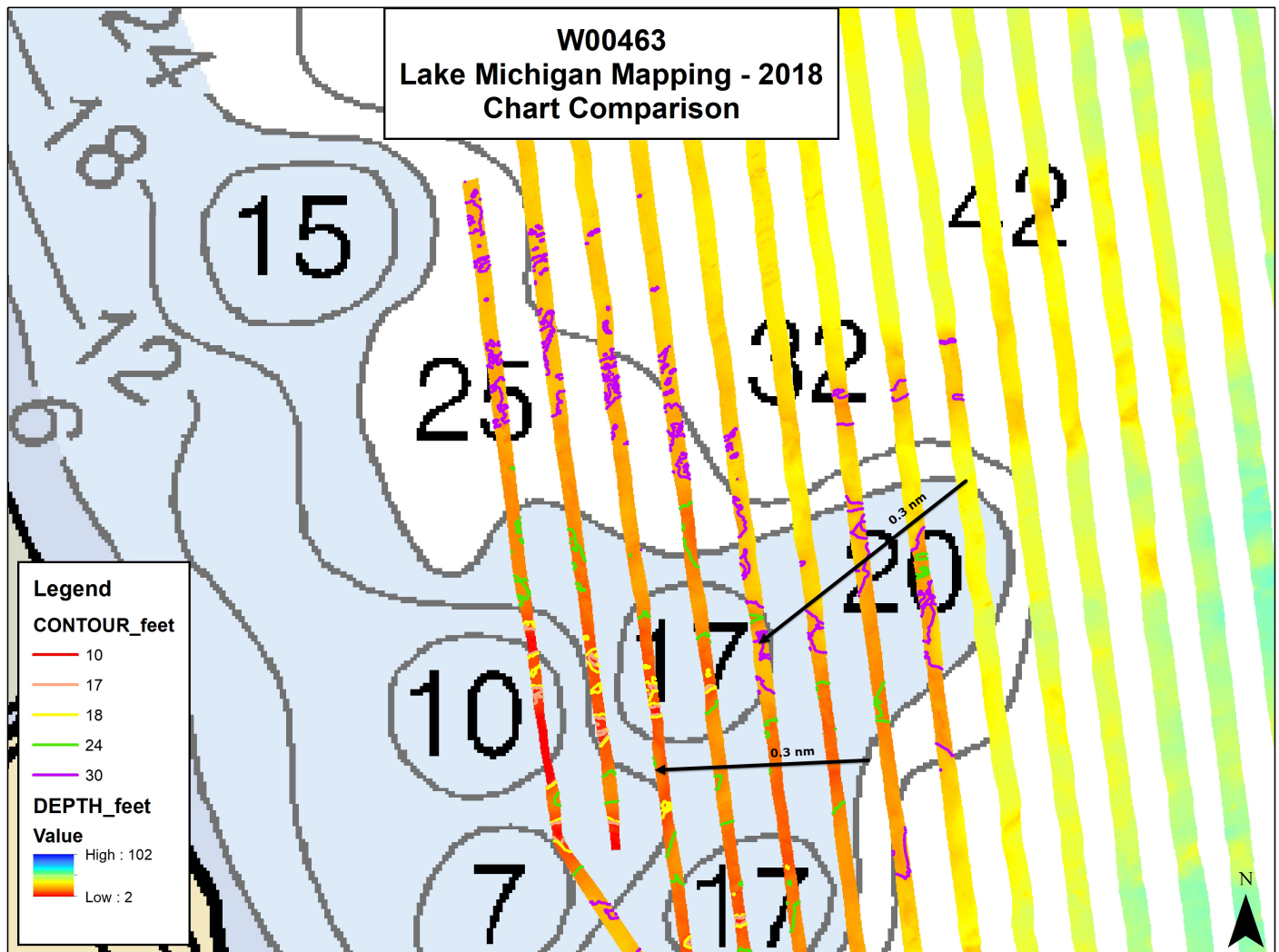


Figure 6. Surveyed contours compared to charted contours (RNC 14903).

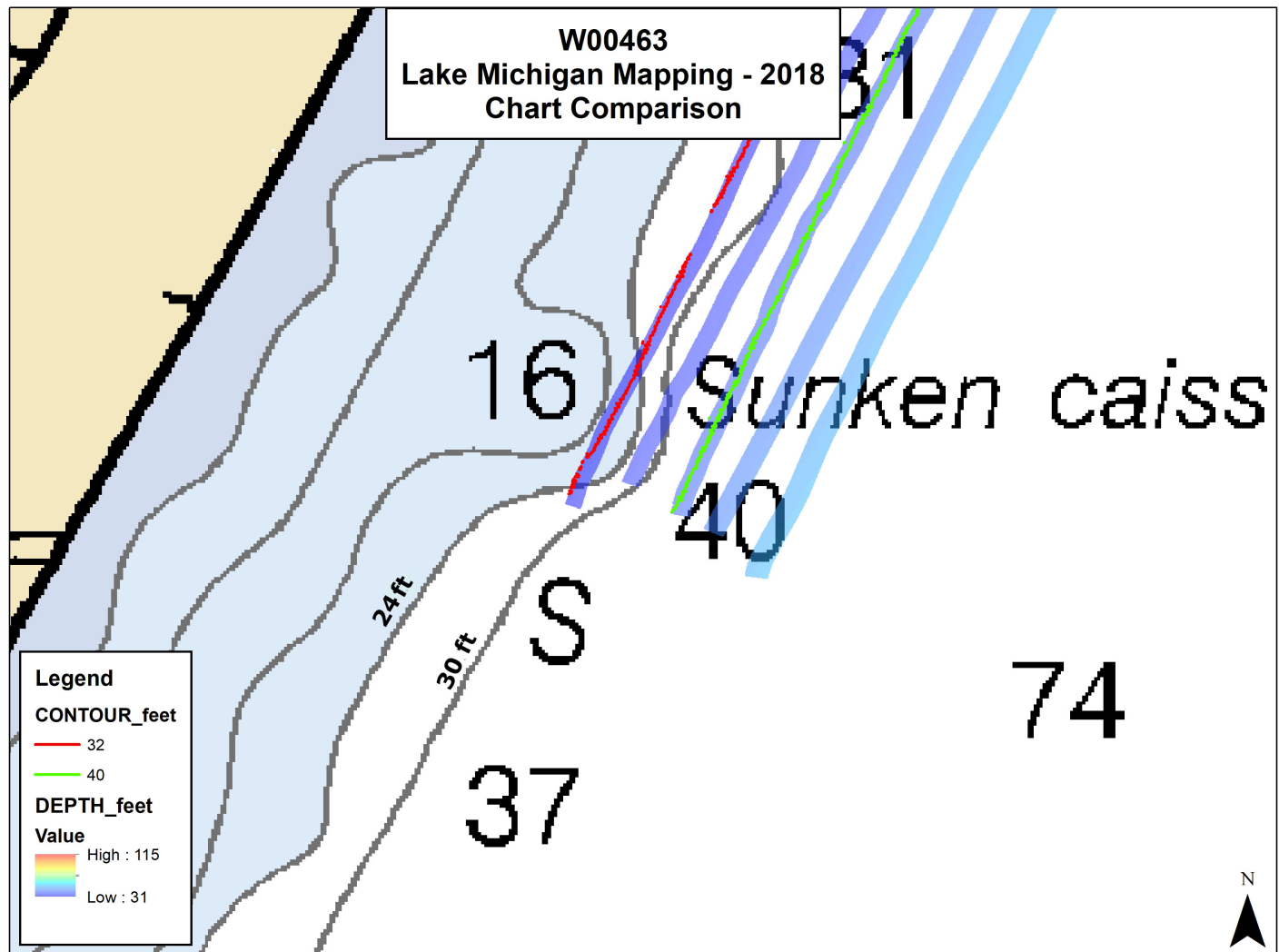


Figure 7. Surveyed contours are in general deeper than charted contours (RNC 14903).

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

Surface Name	Surface Type	Resolution	Depth Range	Surface Parameter	Purpose
LakeMichigan_RVStorm_2018_EM2040c_Bathy_PartA_CUBE	CUBE	2 m	144.9 m - 175.4 m	Elevation	Depth
LakeMichigan_RVStorm_2018_EM2040c_Bathy_PartB_CUBE	CUBE	2 m	140.9 m - 166.5 m	Elevation	Depth
LakeMichigan_RVStorm_2018_EM2040c_Bathy_PartC_CUBE	CUBE	4 m	87.6 m - 105.2 m	Elevation	Depth
LakeMichigan_RVStorm_2018_EM2040c_Backscatter_Backscatter	Backscatter	1 m	-	Decibels Relative (0-255)	Intensity
LakeMichigan_RVStorm_2018_EM2040c_Backscatter_Backscatter	Backscatter	1 m	-	Decibels Relative (0-255)	Intensity

	Surface Name	Surface Type	Resolution	Depth Range	Surface Parameter	Purpose
keMichigan_RVStorm_2018_EM2040c_Backscatter	Backscatter	Backscatter	2 m	-	Decibels Relative (0-255)	Intensity
Michigan_RVStorm_2018_Klein3000_SidescanHF_Part1	Sidescan	Sidescan	25 cm	-	Decibels Relative (0-255)	Intensity
Michigan_RVStorm_2018_Klein3000_SidescanHF_Part2	Sidescan	Sidescan	25 cm	-	Decibels Relative (0-255)	Intensity
LakeMichigan_RVStorm_Klein3000_SidescanHF_Part3	Sidescan	Sidescan	1 m	-	Decibels Relative (0-255)	Intensity

## G. Vertical and Horizontal Control

The vertical datum for this project is Ellipsoidally Referenced Survey.

The vertical control method used for this survey was VDatum.

No tidal datum was used to process this data.

The horizontal datum for this project is World Geodetic System (WGS) 1984. The projection used for this survey is Projected UTM 16 N.

The survey was referenced to the ellipsoid using the Wisconsin Continuously Operating Reference Stations (WISCORS) from the Post Processed Kinematic data collected by the PosMV, then was projected to the International Great Lakes Datum (IGLD 1985) using Vdatum.

## H. Additional Results

## I. Approval

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.

This Descriptive Report Summary and all accompanying records and data are approved. All records are forwarded for final review and processing to the External Survey Division of the Pacific Hydrographic Branch.

The survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys Specifications and Deliverables, Field Procedures Manual, Standing and 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 Survey Summary Report.

Approver Name	Title	Date	Signature
Charles Menza	Chief Scientist	04/09/2019	
Will Sautter	Chief of Party	04/09/2019	
Jennifer Kraus	Hydrographer	04/09/2019	