W00504

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

DESCRIPTIVE REPORT

Type of Survey:	Navigable Area
Registry Number:	W00504

LOCALITY

State(s):	Massachusetts New Hampshire
General Locality:	Coastal Waters of MA and NH
Sub-locality:	Great Boars Head to Salisbury Beach

2016

CHIEF OF PARTY
Semme Dijkstra

LIBRARY & ARCHIVES

Date:

U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY NUMBER:
HYDROGRAPHIC TITLE SHEET	**W00504**

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):	**Massachusetts New Hampshire**
General Locality:	**Coastal Waters of MA and NH**
Sub-Locality:	**Great Boars Head to Salisbury Beach**
Scale:	**40000**
Dates of Survey:	**06/08/2016 to 06/24/2016**
Instructions Dated:	**N/A**
Project Number:	**ESD-PHB-20**
Field Unit:	**University of New Hampshire**
Chief of Party:	**Semme Dijkstra**
Soundings by:	**Kongsberg Maritime EM 2040 (MBES)**
Imagery by:	**Kongsberg Maritime EM 2040 (MBES Backscatter)**
Verification by:	**Pacific Hydrographic Branch**
Soundings Acquired in:	**meters at Mean Lower Low Water**

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 the datum in which the data was received. All references to other horizontal or vertical datums in this report are applicable to the processed hydrographic data provided by the field unit.

DESCRIPTIVE REPORT MEMO

June 30, 2020

MEMORANDUM FOR: Pacific Hydrographic Branch

FROM: Report prepared by PHB on behalf of field unit
Toshi Wozumi
Physical Scientist, Pacific Hydrographic Branch

SUBJECT: Submission of Survey W00504

The purpose of this survey was to provide instruction and experience to the students enrolled in the UNH CCOM/JHC Summer Hydrographic Field Course. Students gained experience with planning, acquisition and processing aspects of hydrographic survey operations. A secondary purpose of the Summer Hydrography 2016 survey was equipment and data comparison and experimentation between USACE Lidar and EM2040 MBES. This survey also serves the interest of Massachusetts Office of CZM to study and better understand the nearshore processes.

All soundings were reduced to Mean Lower Low Water using VDatum. The horizontal datum for this project is World Geodetic System (WGS) 1984. The projection used for this project is Universal Transverse Mercator (UTM) Zone 19.

All survey systems and methods utilized during this survey were as described in ESD-PHB-20_DAPR.

All data were reviewed for DTONs and none were identified in this survey.

University of New Hampshire CCOM/JHC acquired the data outlined in this report.

This survey does meet charting specifications and is adequate to supersede prior data. For further information regarding survey equipment, methods and results refer to the attached report submitted by University of New Hampshire.

University of New Hampshire
Center for Coastal and Ocean Mapping
Joint Hydrographic Center

DESCRIPTIVE REPORT

Type of Survey: Navigable Area

LOCALITY

State(s): Massachusetts and New Hampshire

General Locality: Coastal Waters of MA and NH

Sub-locality: Great Boars Head to Salisbury Beach

2016

Group Members:
Brandon Maingot
Evgenia Bazhenova
Elizabeth Weidner
Shannon Hoy
Erin Heffron
Wasim Muhamad
Azmi Rosedee
Chikara Tsuchiya
Renzo Menacho
Matt Birkebak
Tiziana Munene

CHIEF OF PARTY: Semme Dijkstra

SURVEY

Dates: June 8, 2016 – June 24, 2016

UNIVERSITY OF NEW HAMPSHIRE
CENTER FOR COASTAL AND OCEAN MAPPING
JOINT HYDROGRAPHIC CENTER

INSTRUCTIONS:

State(s):	Massachusetts and New Hampshire
General Locality:	Coastal Waters of MA and NH
Sub-locality:	Great Boars Head to Salisbury Beach
Scale:	1:40,000
Dates of Survey:	8 – 24 June 2016
Instructions Dated:	2 June 2016
Field Unit:	CCOM *R/V Gulf Surveyor*
Soundings by:	Kongsberg EM2040 Multibeam Echo Sounder
Imagery by:	Kongsberg EM2040 Backscatter
Soundings Acquired in:	meters at NAD83

Remarks:

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A. AREA SURVEYED

The area surveyed during Summery Hydrography 2016 extends from just south of the New Hampshire and Massachusetts border, offshore Salisbury beach. The survey extents were governed by the primary focus of surveying around the “Breaking Rocks” in the northern area of the survey extents *(*Figure 1*)*. The eastward extent was constrained by a previous bathymetry survey performed by the U.S. Geological Survey in 2007, and the westward (shoreward) extent was governed by time.

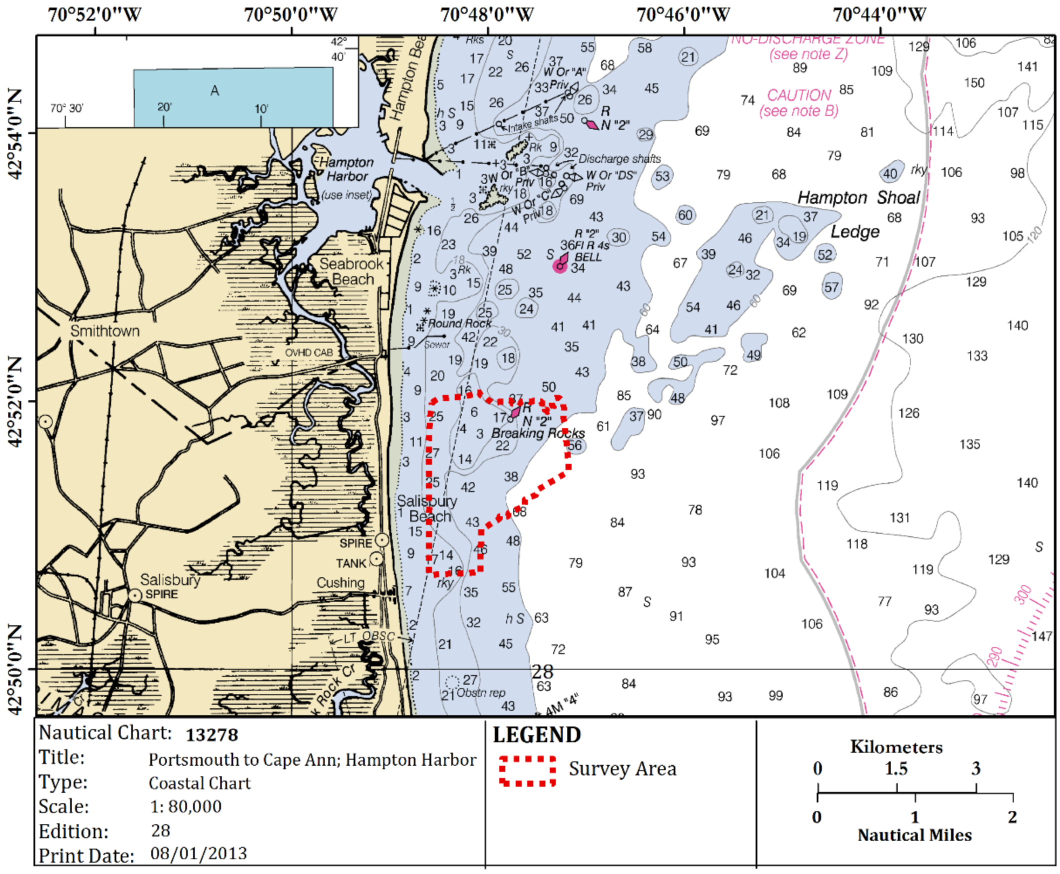


Figure 1. Survey Location

A.1 SURVEY LIMITS

Data was collected within a polygon that increases coverage northward. The most extreme limits are specified in Table 1.

Table 1. Survey Limits

Northern Limit	*Eastern Limit*	*Southern Limit*	*Western Limit*
42.536111 N	70.784722 W	42.513889 N	70.811111 W

A.2 SURVEY PURPOSE

The foremost purpose of this survey was to provide instruction and experience to the students enrolled in the UNH CCOM/JHC Summer Hydrographic Field Course. Students gained experience with planning, acquisition and processing aspects of hydrographic survey operations.

A secondary purpose of the Summer Hydrography 2016 survey is equipment and data comparison and experimentation. The purposed survey area overlaps with an existing lidar conducted by the USACE. There is interest internally in CCOM/JHC to verify the accuracy and viability of coastal lidar data collection with survey-grade equipment, such as the EM2040 multibeam echosounder.

Finally, the Massachusetts Office of CZM has requested CCOM/JHC conduct a hydrographic survey off the coast of the town of Salisbury. The Massachusetts Office of CZM is interested in this area for several reasons: 1) the survey area has little to no data coverage, 2) the beach inshore of the survey area is owned by the Commonwealth, 3) the federally endangered piping plover uses the beach inshore of the survey area as habitat, 4) the Salisbury beach is actively eroding, and 5) deposits of beach-compatible sand could be identified in the purposed survey area. The Summer Hydrography 2016 survey will enable the partnership between CCOM/JHC and Massachusetts Office of CZM to study and better understand nearshore processes.

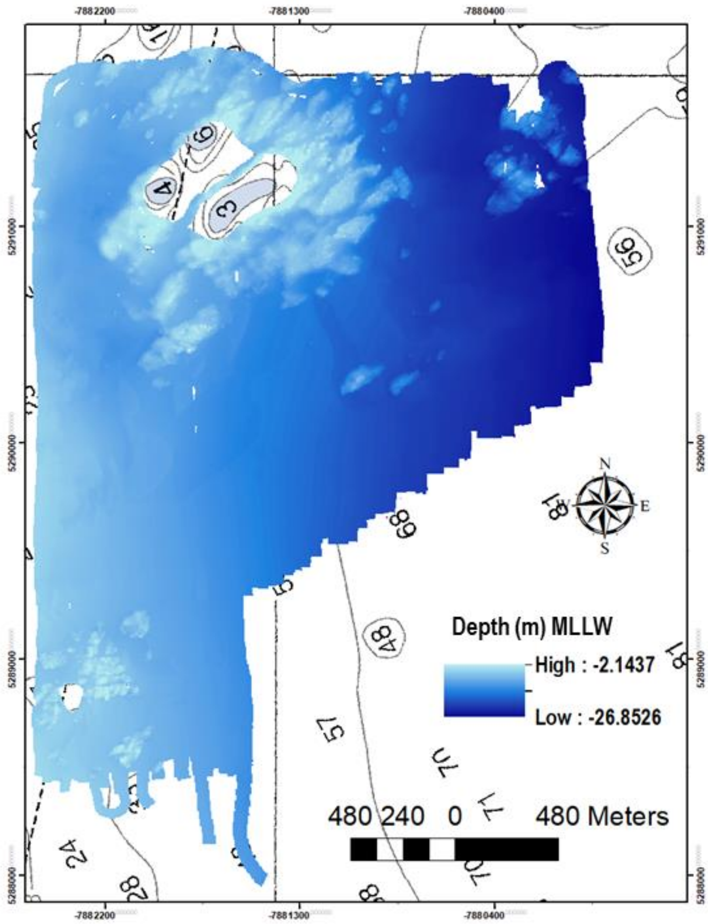


Figure 2: Final Coverage: SH2016 1 m Grid MLLW (m) UTM 19N with RNC 13274 (1:40,000) Edition 28 published 4/1/2011

A.3 SURVEY QUALITY

The entire survey is adequate to supersede previous data which is dating from 1949-1969 conducted by NOAA where bottom was partially covered. (Reference: Source diagram B3 from NOAA chart 13278-Portsmouth to Cape Ann). The entire survey contains data of adequate quality to supersede the areas previous data. This survey was conducted in accordance with best practices of the 2015 *NOAA Field Procedures Manual*. The data and deliverables that accompany this package have been prepared in order to meet the requirements of the *NOS Hydrographic Surveys and Specifications and Deliverables Manual (HSSD)*. Survey deliverables have been submitted to the NOAA Office of Coast Survey for the purpose of updating the nautical chart.

A.4 SURVEY COVERAGE

The survey limits were dictated by the requirements of Summer Hydrography 2016 course instructions and the NOS Hydrographic Survey Specifications and Deliverables. The final coverage of the Summer Hydrography 2016 survey is shown in Figure 2. The data holidays in the survey are discussed in section B.2.8 of this report.

A.5 SURVEY STATISTICS

Line plans are depicted below (Figure 4). Linear nautical miles acquired for mainscheme and crosslines (Table 2) and acquisition dates (Table 3) can also be found below.

Table 2. Survey statistics expressed in linear nautical miles (LNM).

Vessel	*R/V Gulf Surveyor (LNM)*	*Total (LNM)*
MBES Mainscheme	66.69	66.69
MBES Crosslines	3.74	3.74
Number of Bottom Samples	7	7
Total Number of SNM	0.988	0.988

Table 3. Survey data acquisition dates.

Survey Date	*Julian Day Number*	*Type of Data Acquisition*
6/16/2016	168	MBES
6/17/2016	169	MBES
6/20/2016	172	MBES
6/21/2016	173	MBES
6/22/2016	174	MBES
6/23/2016	175	MBES

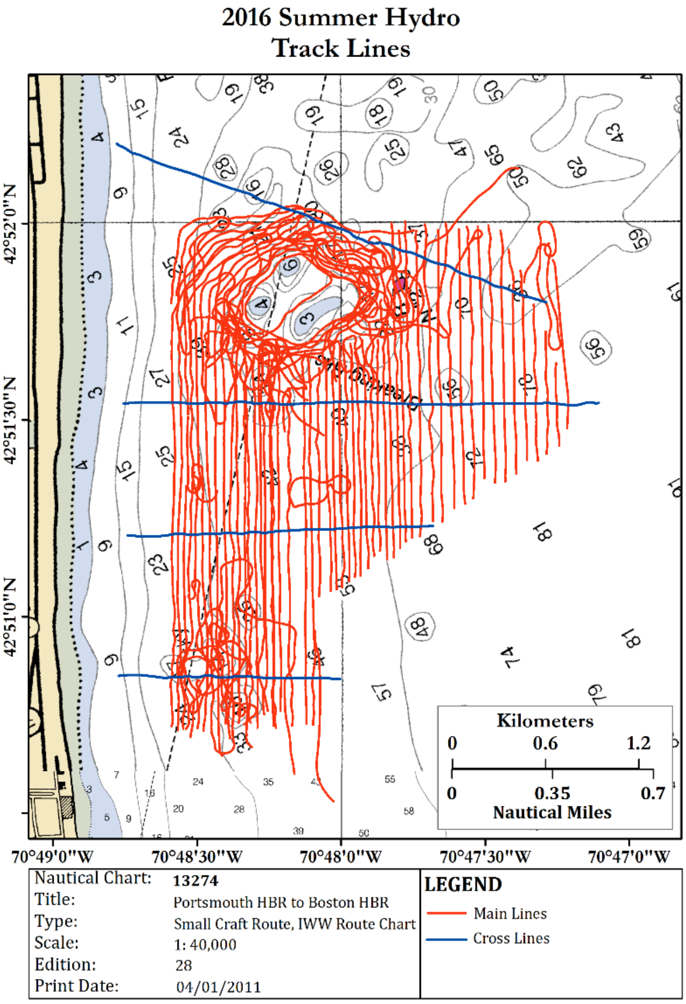


Figure 3. Final track lines of MBES data collected during Summer Hydrography 2016.

B. DATA ACQUISITION AND PROCESSING

B.1 EQUIPMENT AND VESSELS

Refer to the data acquisition and processing report (DAPR) for a description of survey vessel, data acquisition and processing equipment, quality control procedures, and data processing methodology.

B.1.1 Vessels

The following vessel was used as a survey platform during Summer Hydrography 2016:

Table 4. R/V Gulf Surveyor specifications.

Length	48 feet (14.6 m)
Beam	17 feet (5.18 m)
Maximum draft	5 feet 6 inches (1.68 m)
Flag	U.S.
Registry	U.S. Coastwise and Registry
Top speed	18 knots
GPS antennas	Trimble Zephyr Antennas (x2)
RTK GPS receiver	Trimble Trimark 3
Positioning and attitude	Applanix PosMV 320 with IMU 200
Data acquisition software	SIS and Hypack
Sound speed measurement	Digibar Pro
Primary Echosounder	Kongsberg EM2040

B.1.2 Equipment

The following systems were used for data acquisition during Summer Hydrography 2016:

Table 5. Major acquisition systems.

Manufacturer	*Model*	*Type*
Kongsberg	EM2040	MBES
Applanix	PosMV 320 V5	Positioning and attitude
Odom	Digibar Pro	Sound speed

B.2 QUALITY CONTROL

B.2.1 Crosslines

A total of 3.74 nautical miles of crosslines were collected during survey operations (Figure 4). This accounts for 5.61% of the total survey lines collected, which satisfies the >4% from NOS Specifications and Deliverables 2015.

Crossline agreement with main lines was tested by creating two surfaces: one surface from crossline soundings and one surface from main line soundings (Figure 5). A difference surface was calculated, where the average difference between the surfaces was 0.001 m, with a standard deviation of 0.14 m. The surface difference had a count of 274,123 and a range of -2.74 m to 4.50 m. There is no statistical significant difference in the surfaces.

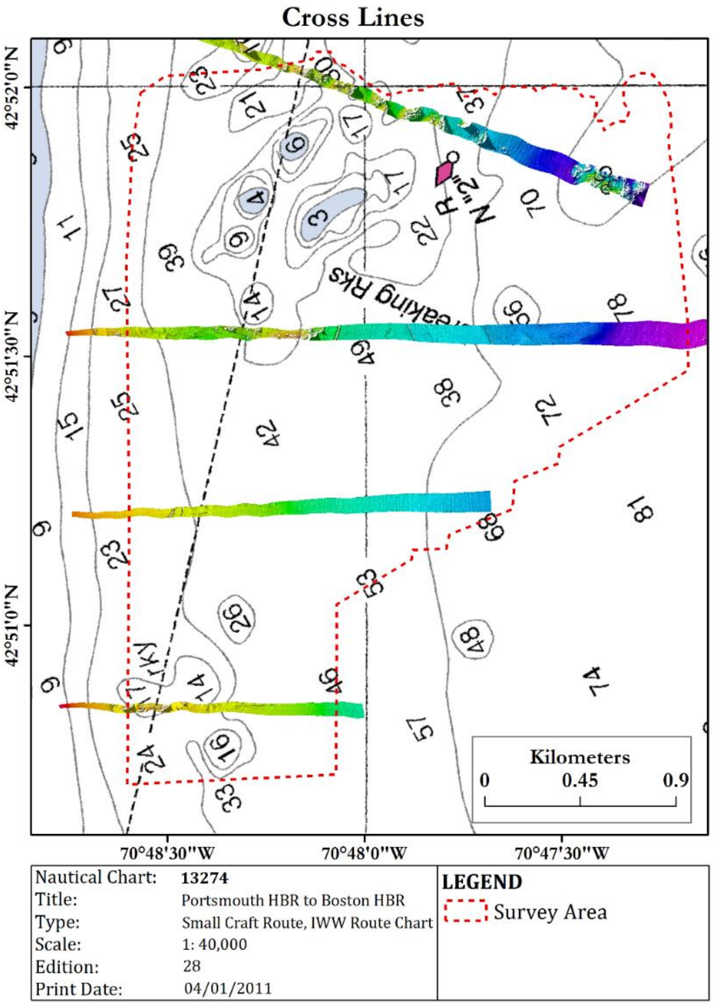


Figure 4. Crosslines surface generated at 0.5 meter resolution.

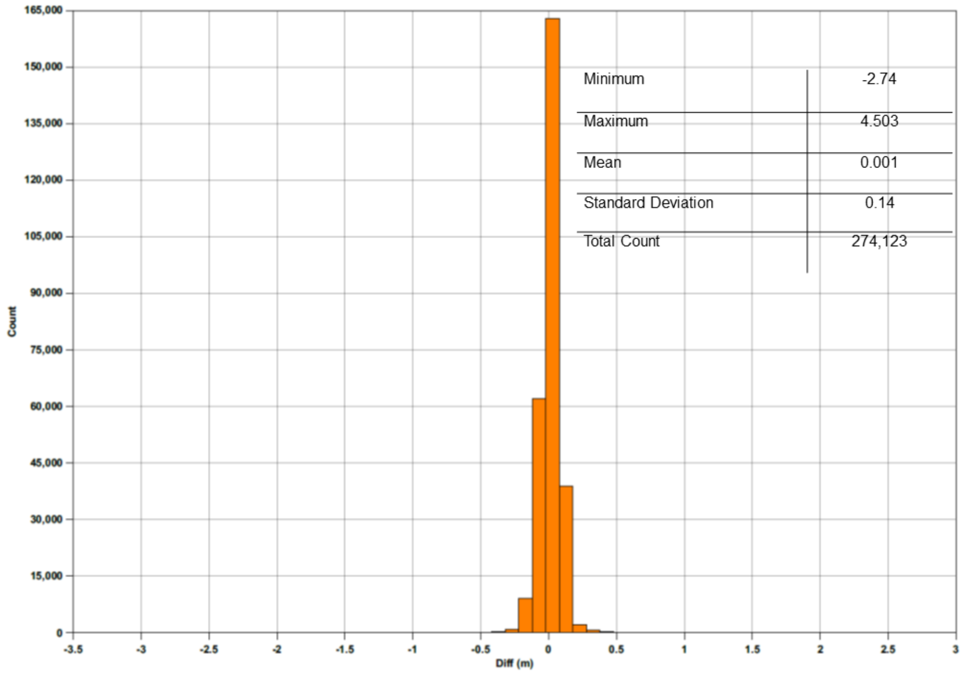


Figure 5. Histogram of Main Surface – Crosslines

B.2.2 Uncertainty

The follow uncertainty parameters were used for this survey specifically:

Table 6. Survey specific sound speed uncertainty values.

Hull ID	*Profile measurements*	*Surface sound speed*
R/V *Gulf Surveyor*	0.3 meters/second	0.3 meters/second

Table 7: Table of TPU components

<table>
<tr><td>Vessel</td><td colspan="4">R/V Gulf Surveyor</td></tr>
<tr><td>Echosounder</td><td colspan="4">Kongsberg EM2040</td></tr>
<tr><td rowspan="25">TPU Standard Deviation Values</td><td rowspan="9">EM2040</td><td rowspan="2">Echosounder</td><td>Pulse Length</td><td>0.200 ms</td></tr>
<tr><td>Sampling Length</td><td>0.050 m</td></tr>
<tr><td rowspan="3">Offsets</td><td>Roll</td><td>0.01 m</td></tr>
<tr><td>Pitch</td><td>0.01 m</td></tr>
<tr><td>Heading</td><td>0.01 m</td></tr>
<tr><td>Sound Velocity</td><td>Surface Sound Speed</td><td>0.03 m/s</td></tr>
<tr><td rowspan="3">Stabilization</td><td>Roll stabilization</td><td>0.00 m</td></tr>
<tr><td>Pitch stabilization</td><td>0.00 m</td></tr>
<tr><td>Heave compensation</td><td>0.00 m</td></tr>
<tr><td rowspan="6">POS/MV</td><td rowspan="5">Motion</td><td>Roll</td><td>0.02°</td></tr>
<tr><td>Pitch</td><td>0.02°</td></tr>
<tr><td>Motion Gyro</td><td>0.02°</td></tr>
<tr><td>Heave Fixed</td><td>0.05 m</td></tr>
<tr><td>Heave Variable</td><td>5%</td></tr>
<tr><td>Position</td><td>Navigation</td><td>0.1 m</td></tr>
<tr><td colspan="2"></td><td>Latency</td><td>0.0 s</td></tr>
<tr><td colspan="2" rowspan="4">Vessel</td><td>Vessel Speed</td><td>0.3 m/s</td></tr>
<tr><td>Loading</td><td>0.01 m</td></tr>
<tr><td>Draft</td><td>0.01 m</td></tr>
<tr><td>Delta Draft</td><td>0.01 m</td></tr>
<tr><td colspan="2" rowspan="5">Timing</td><td>Trans</td><td>0.005 s</td></tr>
<tr><td>Gyro</td><td>0.005 s</td></tr>
<tr><td>Heave</td><td>0.005 s</td></tr>
<tr><td>Pitch</td><td>0.005 s</td></tr>
<tr><td>Roll</td><td>0.005 s</td></tr>
<tr><td rowspan="3"></td><td colspan="2" rowspan="3">Offsets</td><td>x Offset</td><td>0.01</td></tr>
<tr><td>y Offset</td><td>0.01</td></tr>
<tr><td>z Offset</td><td>0.01</td></tr>
</table>

Using 1 m surface produced by the CUBE algorithm on the bathymetry soundings, the uncertainty of the soundings were analyzed. For vertical uncertainty the following equation is used at 95 % confidence:

$$TVU = +/- \sqrt{a2 + (b * d)^2}$$

Where 'a' represents the portion of the uncertainty that does not vary with depth, 'b' is a coefficient which represents that portion of the uncertainty that varies with depth and 'd' is the local water depth.

Per IHO Special Order the total allowable uncertainty for the depth in the area surveyed a= 0.25. Where d = 20 meters total allowable uncertainty was calculated as 0.3 meters. Figures 6 & 7 show that the majority of the surface meets this requirement. For IHO order 1a the maximum total allowable uncertainty is ~0.5 m in very shallow water (~0m).

However, there were was an issue with the vessel's RTK (GNSS) signal fidelity on some days that created a gap in the primary GNSS navigation data. A vertical offset of up to ~20cm is visible when there is signal loss. We created two subset bags to make it easier to distinguish uncertainty differences in these areas (Figure 8, Table 10). Overlap with other lines reduces the uncertainty in the final product (Figure 9). The uncertainty of the ellipsoid (NAD83) surface (Figure 9) and the MLLW surface (Figure 7) are both shown

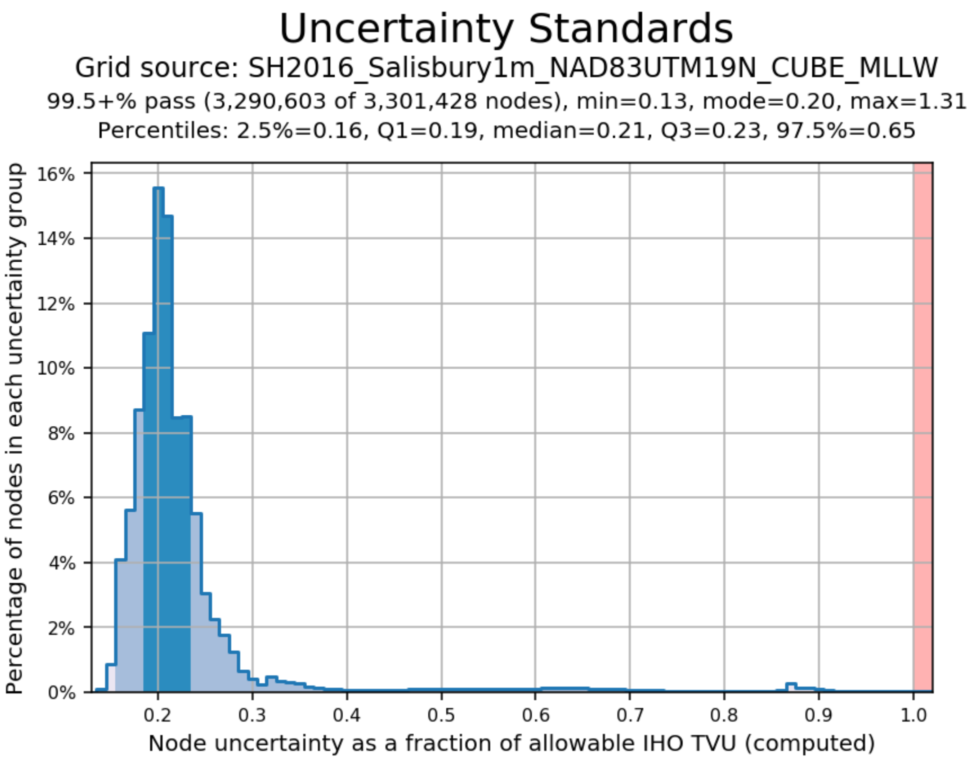


Figure 6: TPU % of Nodes as generated by QC Tools.

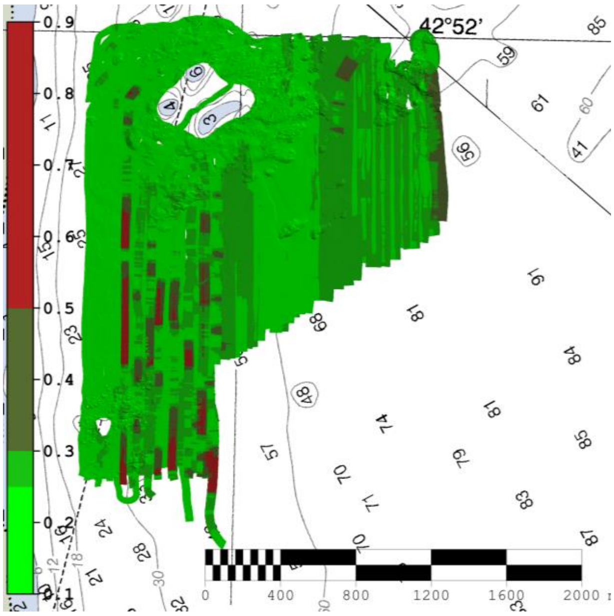


Figure 7: Uncertainty at 1 m: includes vertical datum transformation to MLLW uncertainty

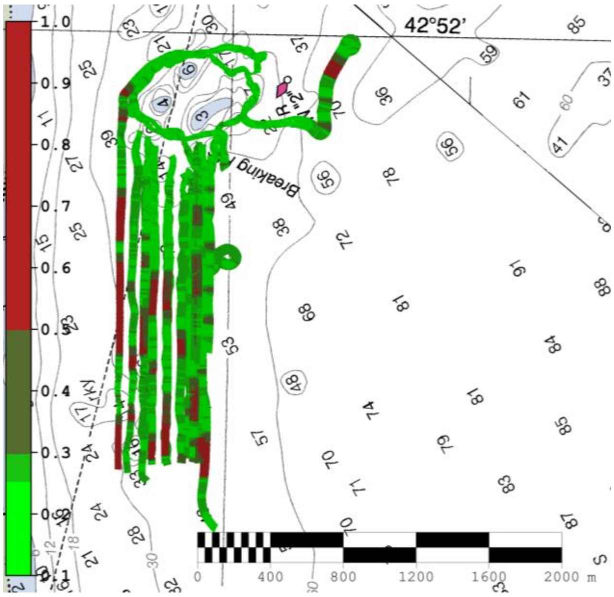


Figure 8: High Uncertainty lines with inconsistent GNSS signal strength leads to higher Vertical Uncertainty. (Includes VDatum Uncertainty for MLLW). 90% of cells are within the uncertainty threshold.

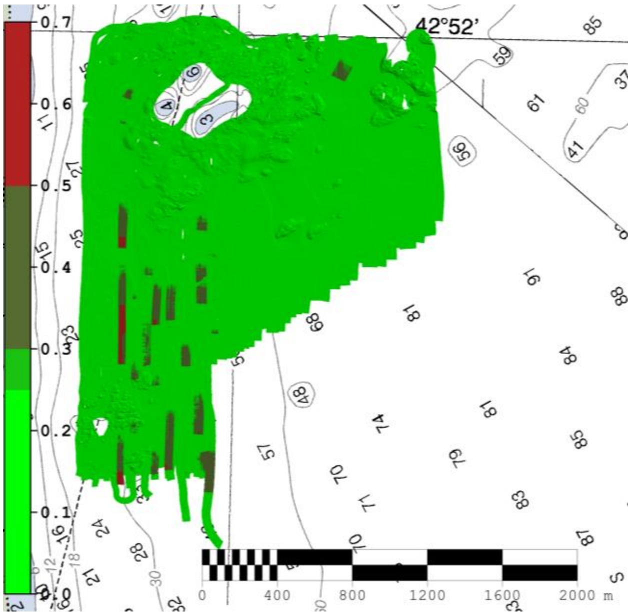


Figure 9: Uncertainty with respect to NAD83 surface (excludes VDatum uncertainty) puts most of the 1 m grids uncertainty at less than 0.25 m.

B.2.3 Junctions

The Summer Hydrography 2016 survey junctions with the Cape Ann Salisbury Beach survey conducted by USGS in 2007 as well as a USACE lidar survey performed in 2010 (Figure 10). Difference surfaces of the junction areas were created in ArcMAP 10.3.1.

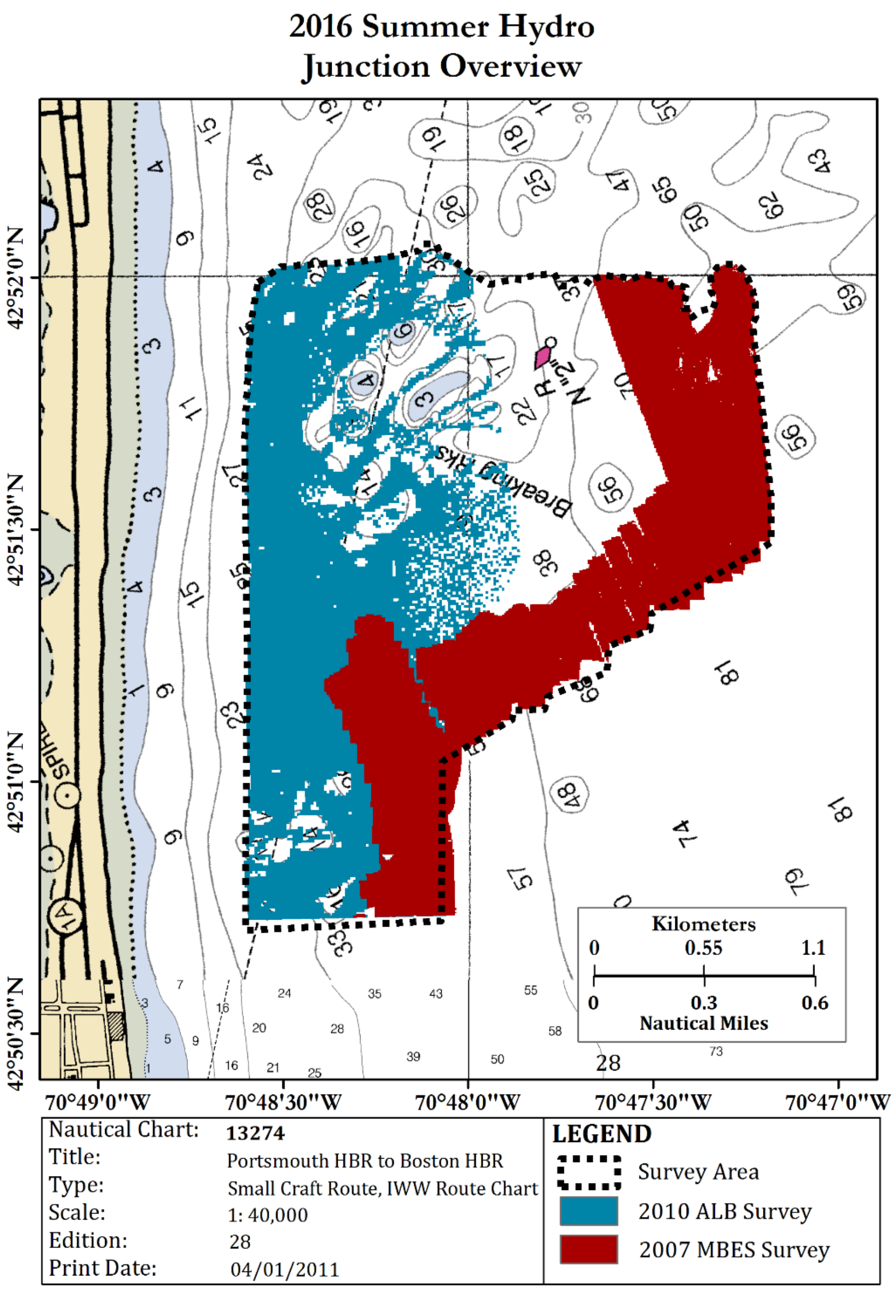


Figure 10. Overview of Summer Hydrography 2016 junctions with previous data.

B.2.3.1 Cape Ann Salisbury Beach

The Cape Ann Salisbury Beach USGS survey was conducted aboard the *R/V Ocean Explorer* with a Reson 8101 and SEA SwathPlus 2000. The Cape Ann Salisbury Beach survey was referenced to MLLW (Figure 11). A 5m surface for USGS was used. The mean difference between the Summer Hydrography 2016 survey and the 2007 Cape Ann Salisbury Beach USGS survey -0.01 m with a standard deviation of 0.28 m (Figures 12 & 13).

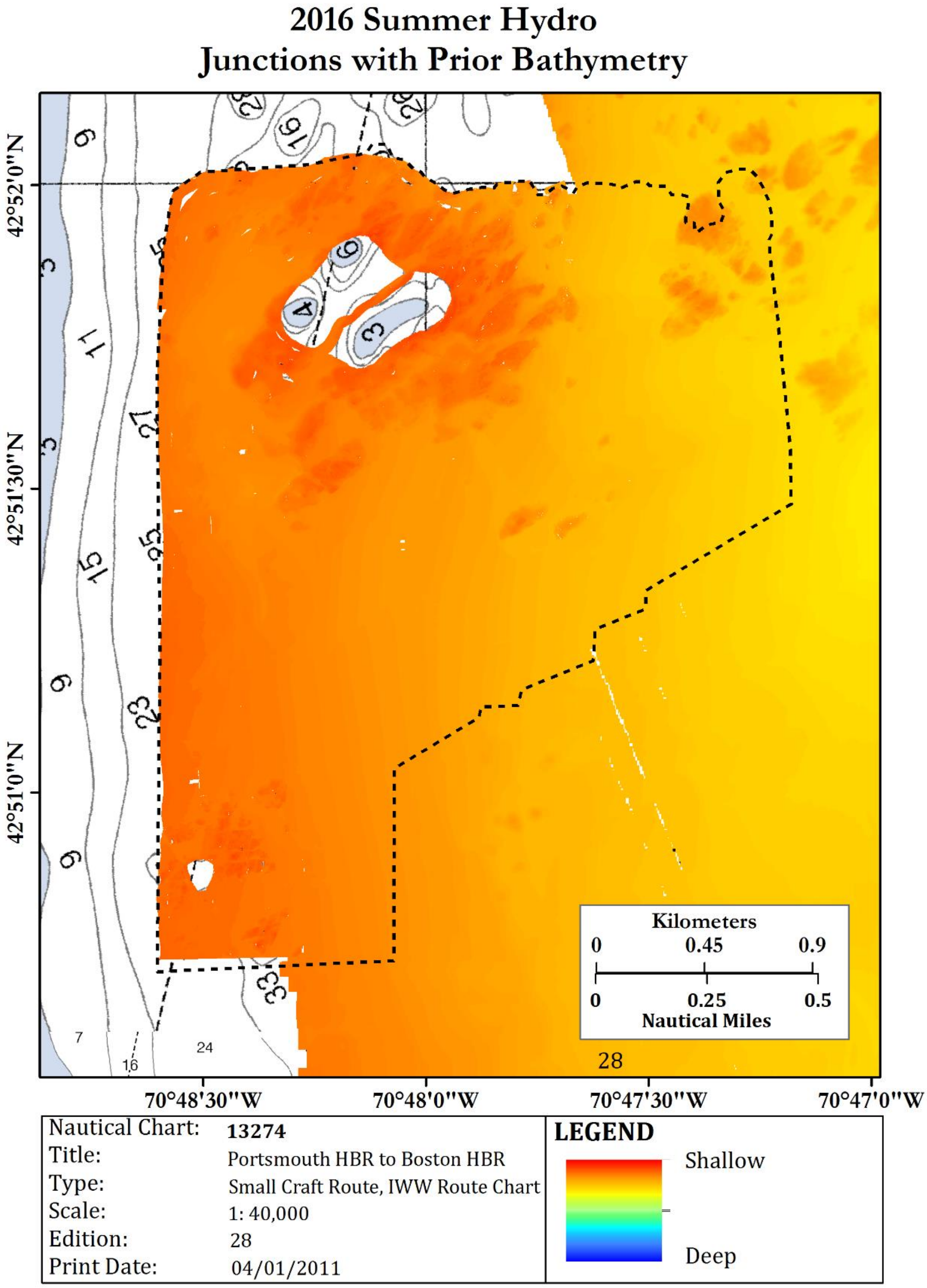


Figure 11. Summer Hydrography 2016 data (in black outline) and prior bathymetry from USGS.

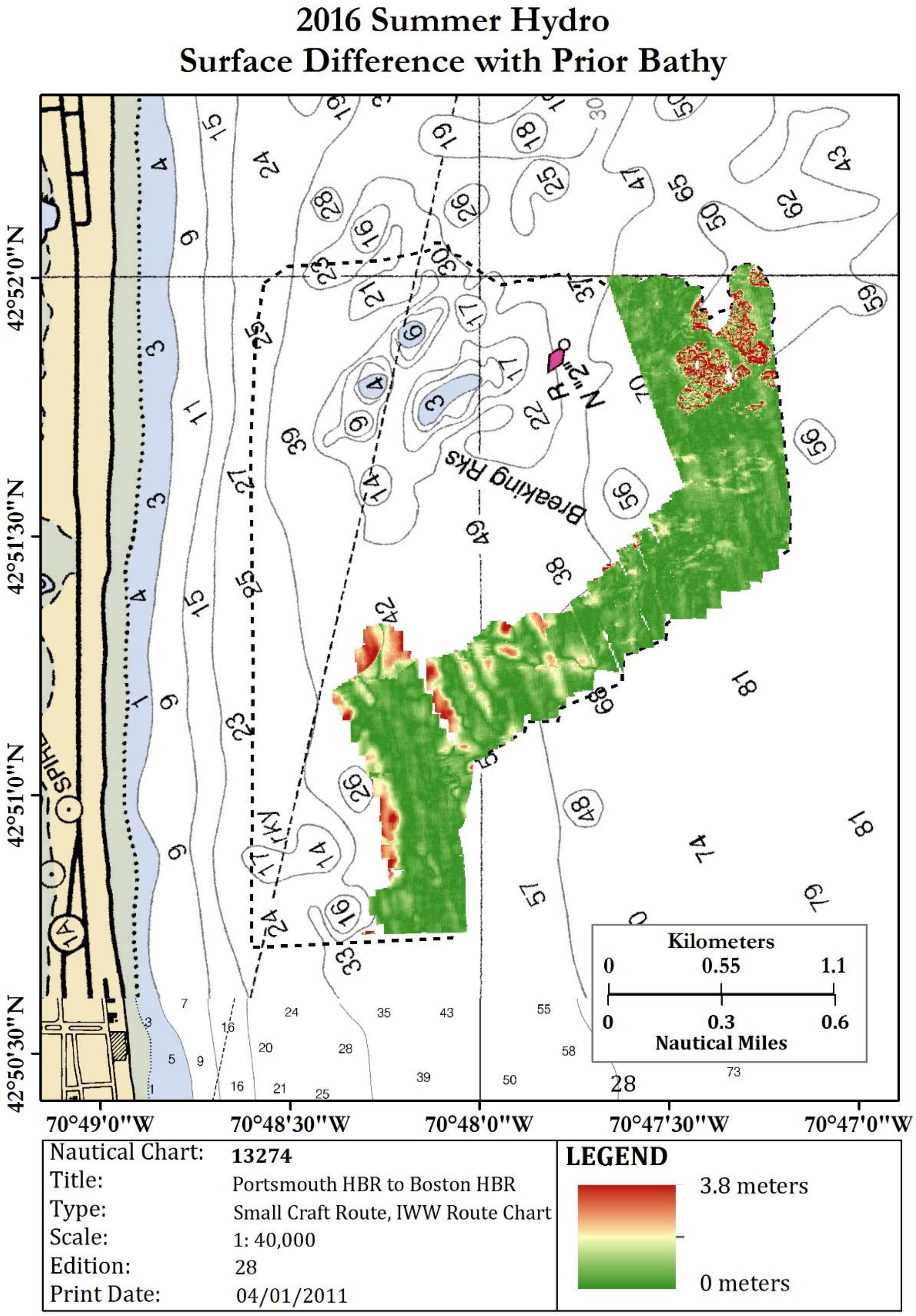


Figure 12. Difference surface of survey junction with 2007 USGS data.

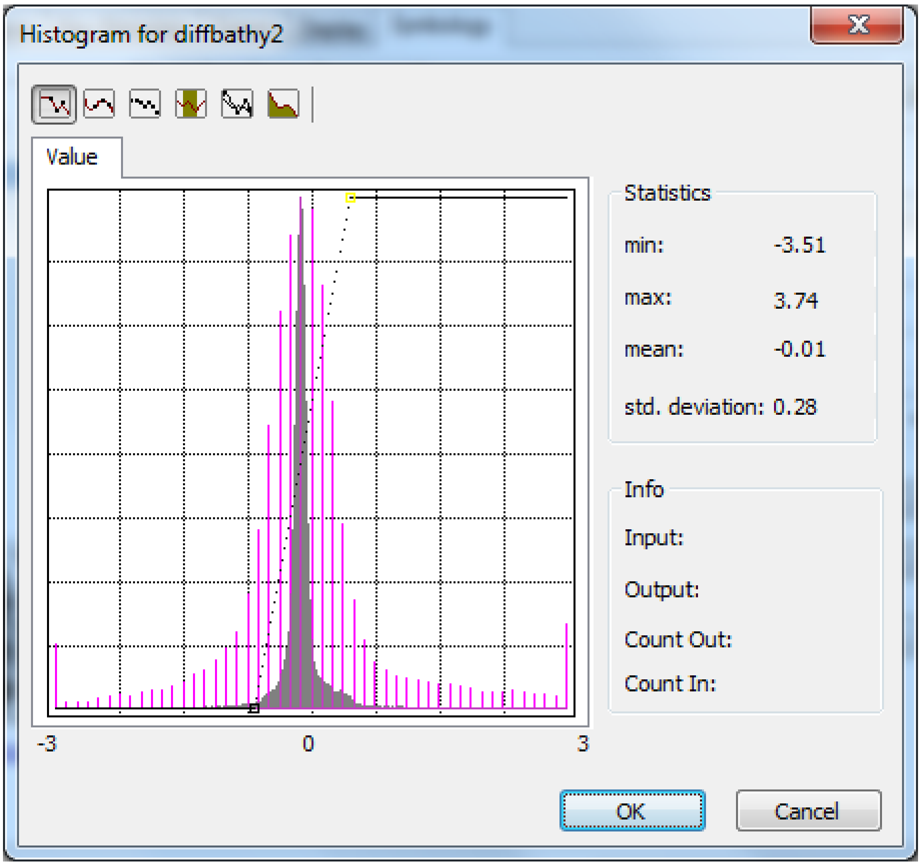


Figure 13. Statistics for the difference surface between Summer Hydrography 2016 and Cape Ann Salisbury Beach survey produced by ArcGIS.

B.2.3.2 USACE NCMP Topobathy Lidar: Northeast Atlantic Coast

The USACE NCMP Topobathy Lidar: Northeast Atlantic Coast survey was conducted in 2010. A 10 m resolution grid referenced to the NAD83 ellipsoid was used for comparison (Figure 14). The mean difference between the Summer Hydrography 2016 survey and the USACE NCMP topobathymetric lidar survey is -0.02 m (Figures 15 & 16).

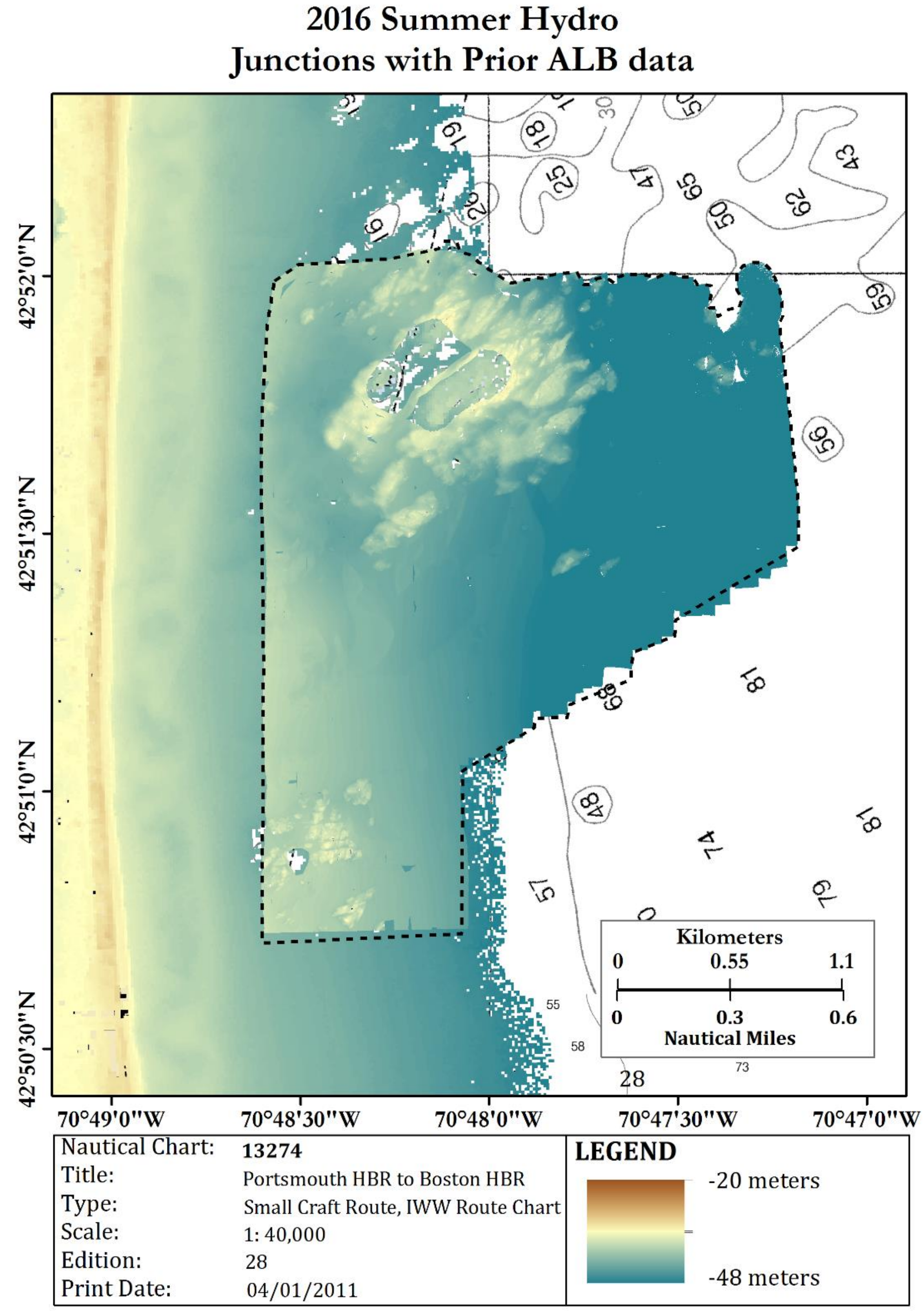


Figure 14. Summer Hydrography 2016 data (in black outline) and prior bathymetry from USACE.

2016 Summer Hydro
Surface Difference with Prior ALB data

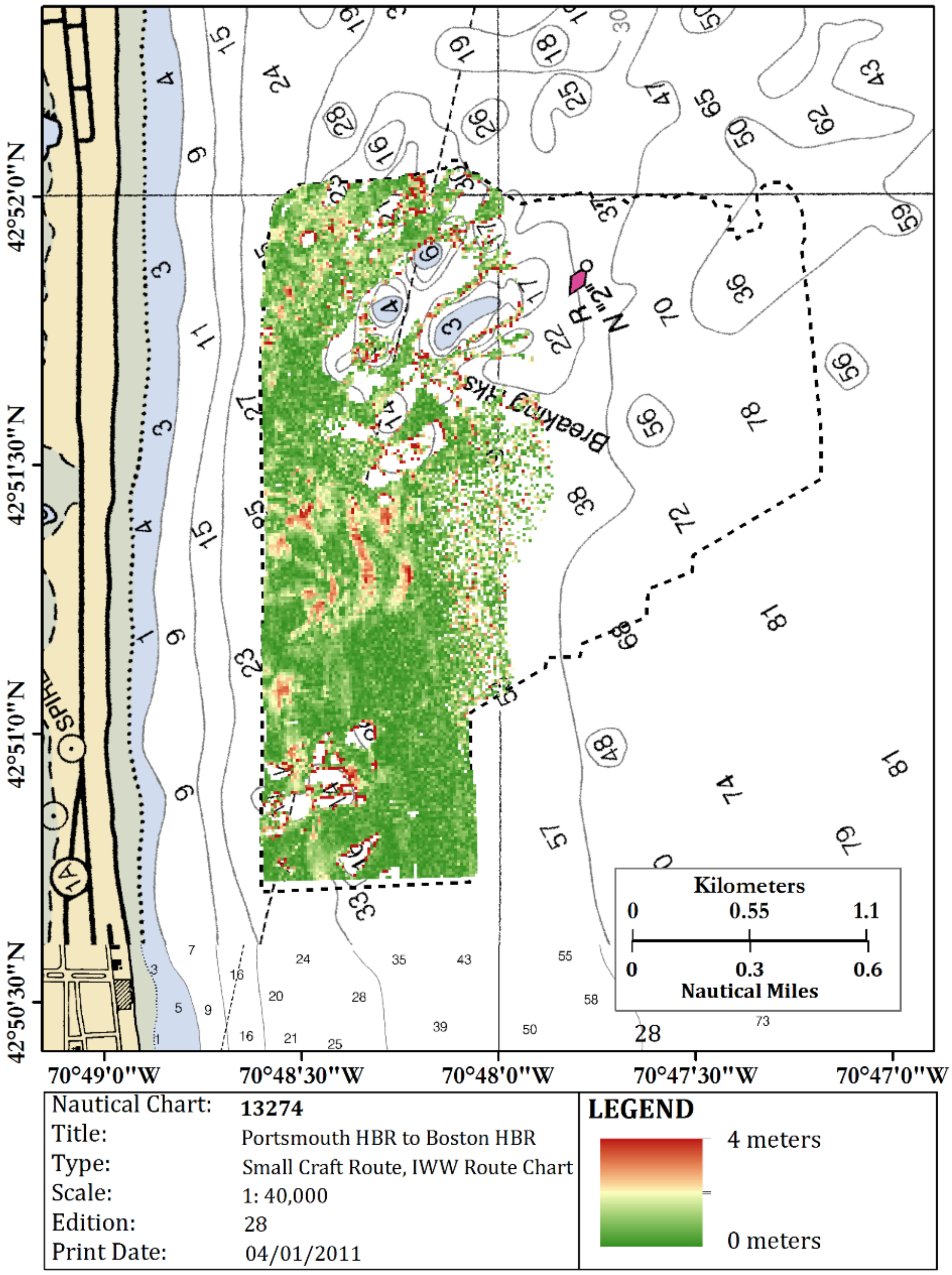
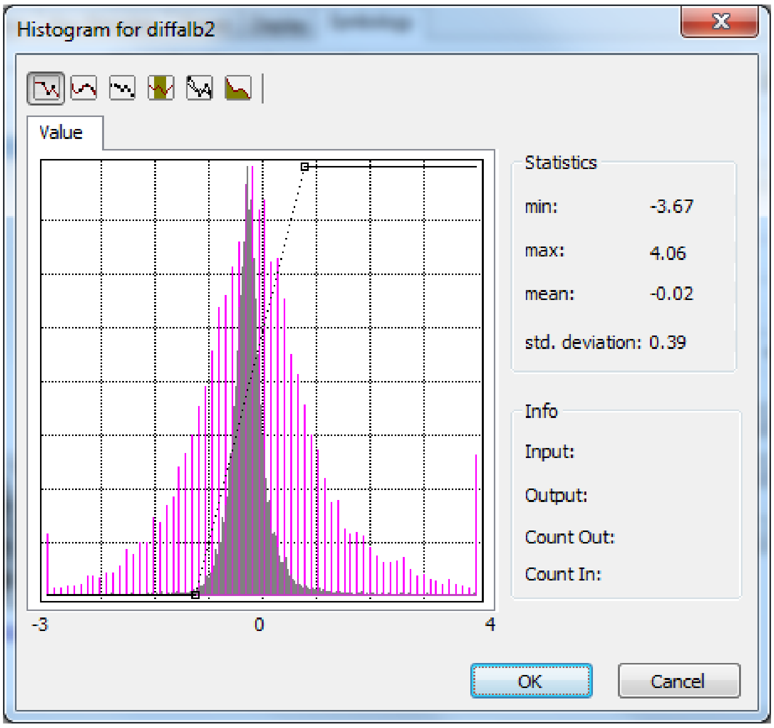


Figure 15. Difference surface of survey junction with USACE data.



Difference USACE 2010 and SH2016 Salisbury Statistics (NAD83)	
Minimum	-3.76
Maximum	4.06
Mean	-0.02
Standard Deviation	0.39

Figure 16. Statistics for the difference surface between Summer Hydrography 2016 and USACE survey.

B.2.4 Sonar QC Checks

Sonar system quality control checks were conducted and are detailed in the quality control section of the DARP. When issues with data collection occurred in the field, the affected lines were re-run. Affected lines (POS not logged) are excluded from the final project {DN172 lines 0295-310}.

B.2.5 Equipment Effectiveness

There were was an issue with the vessel's RTK (GNSS) signal fidelity on some days ('gap in primary GNSS navigation data'. The overall survey is still with expected uncertainty limits. A vertical offset of up to ~20cm is visible when there is signal loss. Two subset .csar sufaces are included to make it easier to distinguish uncertainty differences in these areas, as seen in discussion of areas of higher uncertainty causes (Table 10). Most of the DN 173 did not have a strong enough signal to get an accurate vertical offset. DN 172 also had a high percent of issues. Only a few lines were affected on DN 174 & 175.

Example errors: "*Gap in primary GNSS navigation data, IIN primary GNSS solution not in use, IIN primary GNSS observables not in use, IIN NL ambiguity failure cleared*."

The errors log documents periods of loss of signal strength, with fixed RTK mode returned when the GNSS signal improved.

B.2.6 Factors Affecting Soundings

Vertical differences in the CUBE surfaces on the order of 0.2 m exist from loss of GNSS/ fixed RTK signal during acquisition.

B.2.7 Sound Speed Methods

Real-time surface sound speed values and sound speed profiles were obtained using Odom DigibarPro instruments. SVP casts were taken every day prior to the survey start as surface sound speed at the sonar head became different from the last applied cast by a few m/s. The DAPR covers this topic more fully.

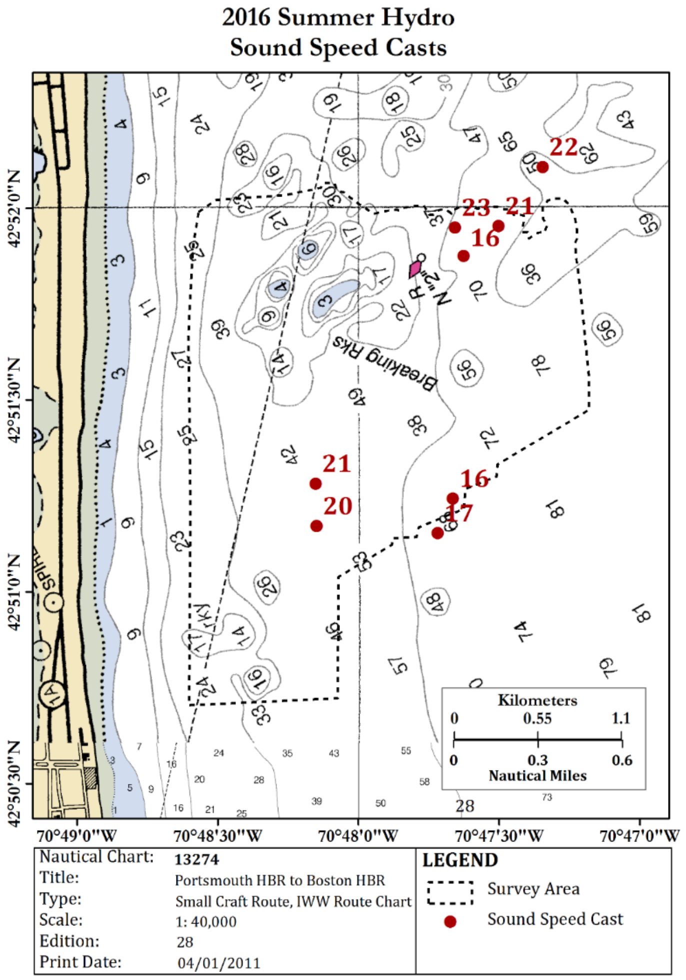


Figure 17. Location of sound speed cast (number designates day collected).

B.2.8 Coverage Equipment and Methods

Density analysis according to the NOS requirements for complete multibeam coverage was assessed: the compiled surfaces should have the grid resolution of 1 m in the depth range of 0-20 m. There are a few larger areas of charted shoals not covered by this survey.

A sounding density analysis was run on the final 1 m resolution surface using QC tools to calculate the number of data points per grid node. The NOS Hydrographic Specifications and Deliverables require a data density of 5 or more data points in at least 95% of total nodes. 99.5% of the nodes in the 1.0 m surface met the 5 sounding requirement, meeting the NOS requirement for data density (Figures 18 & 19). The survey did contain a number of data holidays due to inadequate overlap because of shoals, lobster trap avoidance, and acoustic shadowing in very rocky regions of seafloor.

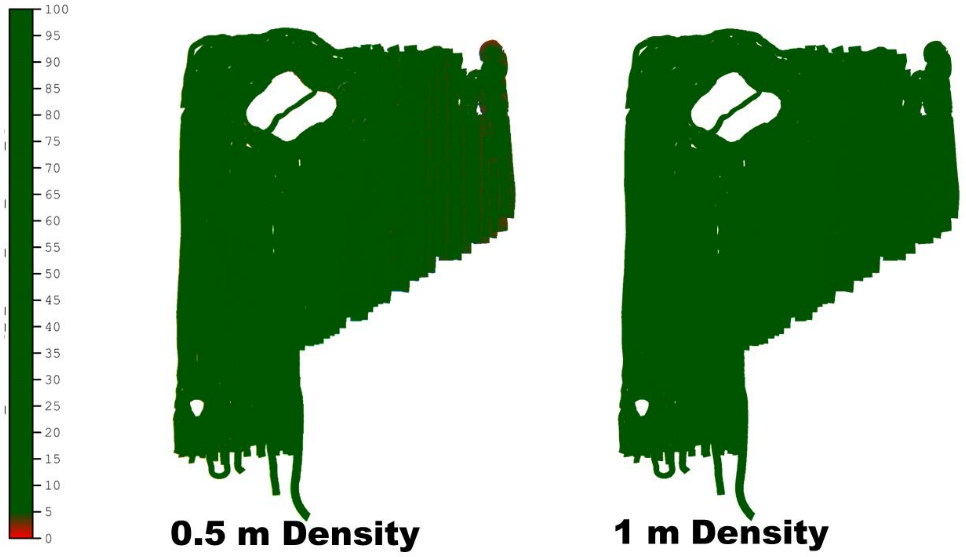


Figure 18. Sounding density of the Summer Hydrography 2016 surface Grid Density where green exceeds 5 nodes or greater per cell, and red is less than 5 nodes per cell. Left 0.5 m grid, Right 1 m grid.

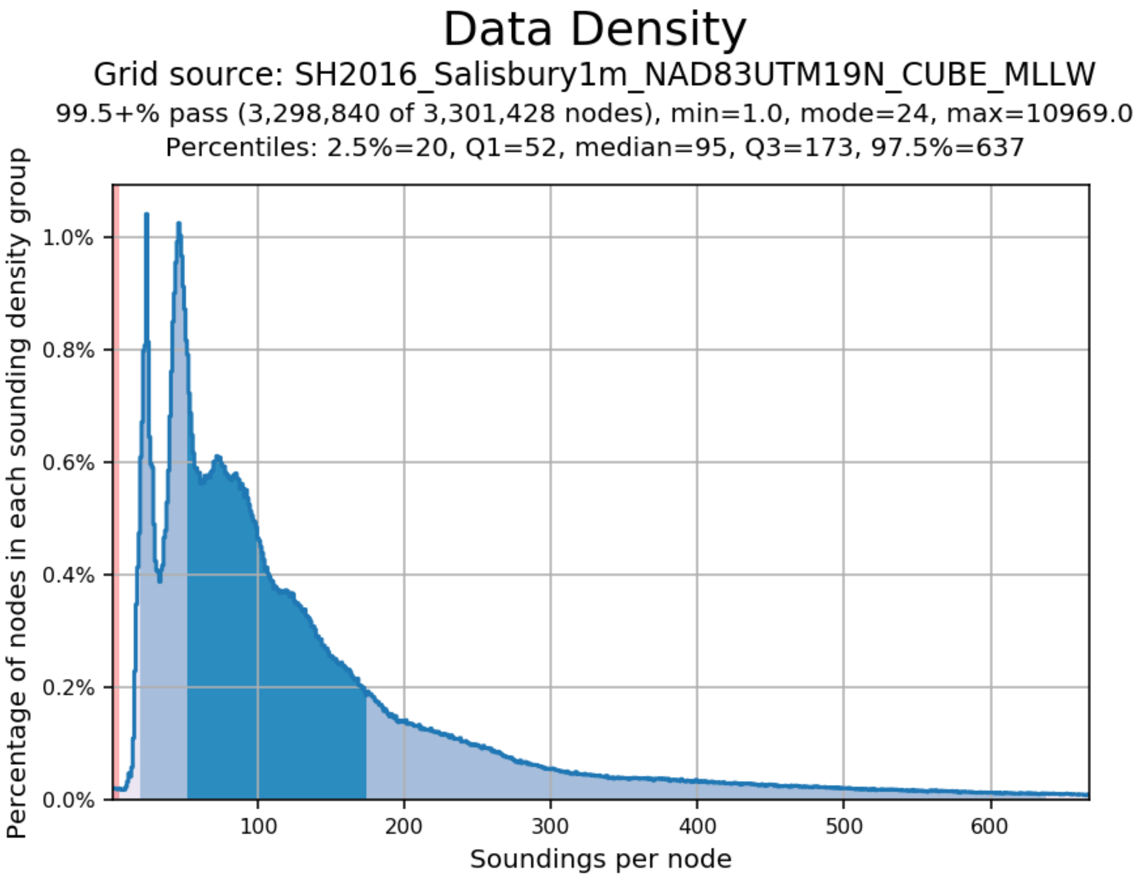


Figure 19: Graph of Sounding Density at 1 m.

A total of 27 holidays were found in the final surface, gridded at 1.0 m (Table 7). These holidays meet the NOAA specification for holiday: a holiday is defined as three or more collinear nodes sharing adjacent sides in the surface created at the required resolution.

Table 7. Locations of Holidays in the Summer Hydrography 2016 final surface 1 m.

FEATURE ID	LATITUDE	LONGITUDE
4U 0000000001 00001	42.859776N	070.803273W
4U 0000010002 00001	42.859986N	070.806487W
4U 0000020003 00001	42.844357N	070.806863W
4U 0000030004 00001	42.847284N	070.808527W
4U 0000040005 00001	42.847998N	070.806100W
4U 0000050006 00001	42.861383N	070.806442W
4U 0000060007 00001	42.848628N	070.809496W
4U 0000070008 00001	42.860388N	070.801590W
4U 0000080009 00001	42.856848N	070.803347W
4U 0000090010 00001	42.861641N	070.802606W
4U 0000100011 00001	42.861261N	070.804994W
4U 0000110012 00001	42.863714N	070.790449W
4U 0000120013 00001	42.863240N	070.789089W
4U 0000130014 00001	42.862210N	070.804226W
4U 0000140015 00001	42.865952N	070.794737W
4U 0000150016 00001	42.865188N	070.808964W
4U 0000160017 00001	42.866662N	070.800585W

4U 0000170018 00001	42.864592N	070.805103W
4U 0000180019 00001	42.855831N	070.803281W
4U 0000190020 00001	42.865247N	070.797814W
4U 0000200021 00001	42.862470N	070.805470W
4U 0000210022 00001	42.866026N	070.799244W
4U 0000220023 00001	42.865386N	070.806705W
4U 0000230024 00001	42.865979N	070.798753W
4U 0000240025 00001	42.866031N	070.809160W
4U 0000250026 00001	42.867079N	070.802690W
4U 0000260027 00001	42.865118N	070.789327W

B.3 CORRECTIONS TO ECHO SOUNDINGS

B.3.1 Corrections

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

B.3.2 Calibrations

B.3.2.1 Patch Test

The R/V Gulf Surveyor ran a patch test on June 7, 2016. The patch test was run over Cod Rock in Portsmouth Harbor. The location for the patch test is outside of the dock, and occurs in an area suitable for patch tests (discrete target and an area of gentle slope) as shown in Figure 20. Offsets were determined utilizing the CARIS HIPS calibration editor program. Offsets were applied in post processing to the data. The average of 3 tests was used (Table 8). For more detailed information see the DAPR C.3.

Table 8. Patch Test Information.

Calibration	Patch Test 1	Patch Test 2	Patch Test 3	Average
Latency (s)	0.00	0.00	0.00	0.00
Pitch (deg)	-1.2	-1.436	-0.89	-1.175
Roll (deg)	-0.13	0.072	-0.12	-0.059
Yaw (deg)	0	0.008	0.12	0.043

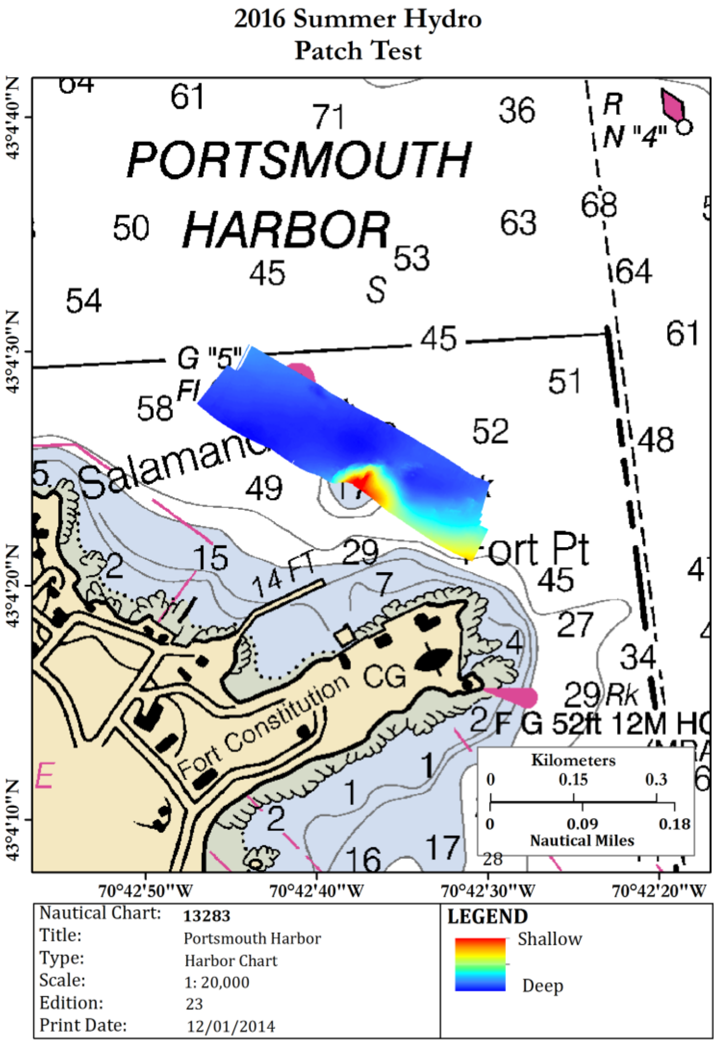


Figure 20. Summer Hydrography patch test location.

B.3.3 Waterline

Waterline (static draft) measurements were performed every day through the moon pool before leaving the pier in Newcastle (Table 9). Values were entered into SIS for real-time application. Waterline measurement were taken at the pier, not the Salisbury survey area, because taking a waterline measurement in the survey area would uncertainty given variable sea states.

Table 9. Waterline

Day	Year	Waterline, m
168	2016	1.02
169	2016	1.013
172	2016	1.000
173	2016	1.000
174	2016	0.997
175	2016	1.02

B.4 BACKSCATTER

Backscatter data was acquired by the EM2040 echosounder along with the bathymetric data. A 0.5 m backscatter mosaic was created in FMGT from the survey main lines (Figure 21).

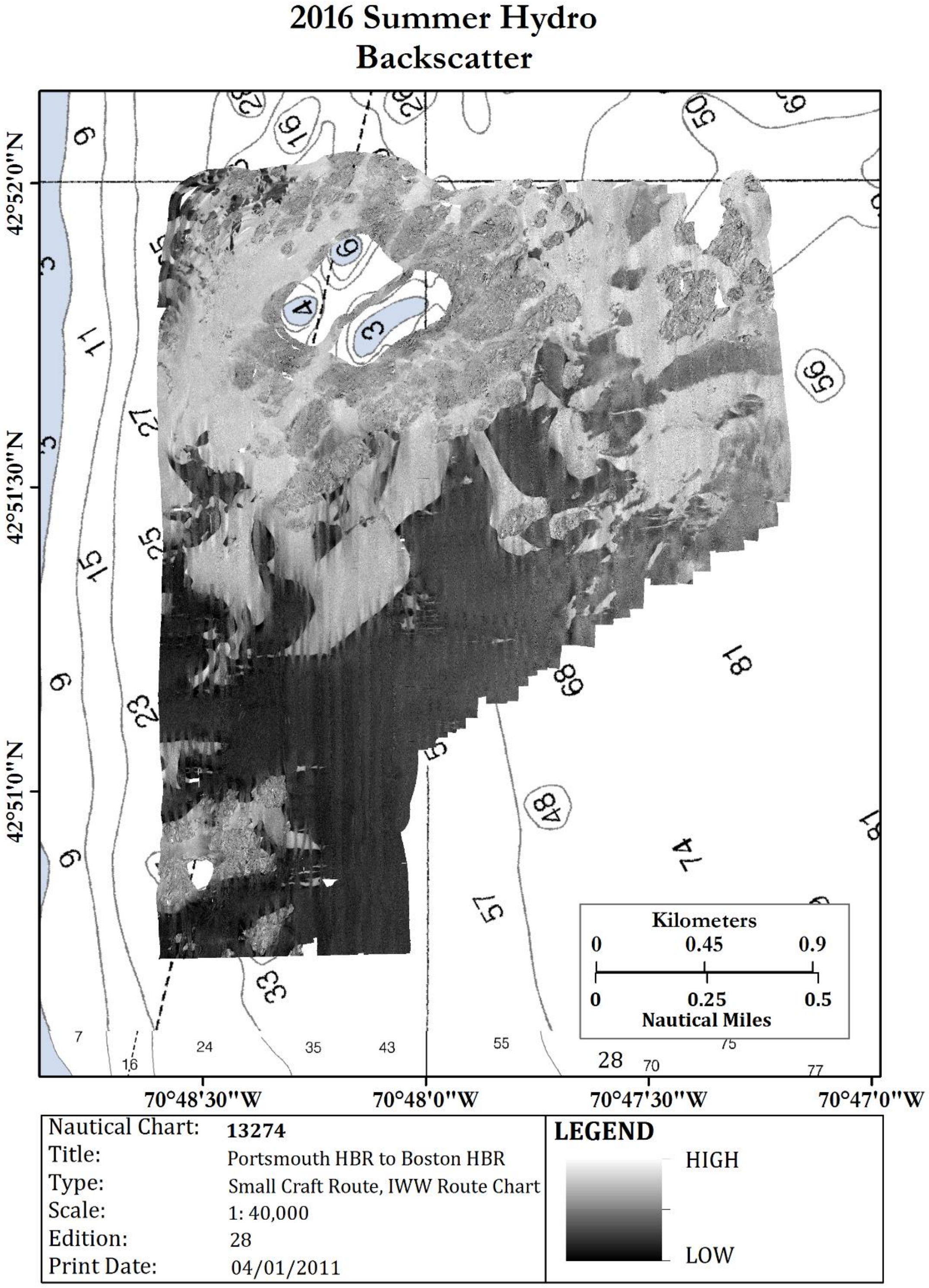


Figure 21: Backscatter mosaic gridded at 0.5 m resolution.

B.5 DATA PROCESSING

B.5.1 Software Updates

All the software updates were discussed in the DAPR.

B.5.2 Surfaces

Table 10. Surface Deliverables

Surface Type	Surface Name	Process Type	Data Format	Resolution	Surface Parameter	Purpose	Vertical Datum	Projection
Bathy Surface Salisbury	SH2016_Salisbury0_5m_NAD83UTM19N_CUBE_MLLW	CUBE	BAG, .csar	0.5 m	Bathy	MBES	MLLW	NAD83 UTM 19N
	SH2016_Salisbury1m_NAD83UTM19N_CUBE_MLLW	CUBE	BAG, .csar	1.0 m	Bathy	MBES	MLLW	NAD83 UTM 19N
	SH2016_Salisbury0_5m_NAD83UTM19N_CUBE_NAD83elev	CUBE	.csar	0.5 m	Bathy	MBES	NAD83	NAD83 UTM 19N
	SH2016_Salisbury1m_NAD83UTM19N_CUBE_NAD83elev	CUBE	.csar	1.0 m	Bathy	MBES	NAD83	NAD83 UTM 19N
Backscatter Surfaces Salisbury	SH2016_0_5_m_Backscatter	Mosaic	geoTIFF, xyz	0.5 m	Intensity	Backscatter mosaic	N/A	WGS84 UTM19N
	SH2016_0_5_m_Backscatter_ForARC	Mosaic	ArcGrid	0.5 m	Intensity	Backscatter mosaic	N/A	WGS84 UTM19N
Bathy High Uncertainty Lines	HigherUncertaintyLines_GNNSissuesNAD83_UTM19N	CUBE	.csar	0.5 m	Bathy	MBES	NAD83	NAD83 UTM 19N
Bathy Without High Uncertainty Lines	LowerUncertaintyLines_NAD83_UTM19N	CUBE	.csar	0.5 m	Bathy	MBES	NAD83	NAD83 UTM 19N

C. VERTICAL AND HORIZONTAL CONTROL

For complete review of horizontal and vertical controls for all survey operations see HVCR.

C.1 VERTICAL CONTROL

The survey was ellipsoidally referenced, mitigating the requirement for squat and settlement models for the newly mobilized R/V Gulf Surveyor. Vertical control was provided using RTK GNSS techniques, with corrections provided by a base station located atop the Seacoast Science Centre in Fort Point, New Hampshire. A MLLW referenced surface was creating using a NAD83 to MLLW transformation grid from VDATUM 4.0. The grid was brought into CARIS using Pydro and some layer math. The VDATUM offset was ~28.38 m with a vertical uncertainty of 0.1305450 m (Table 11).

Table 11. VDatum Components

To	From	meters	uncertainty
WGS84	NAD83 NAD83 (2011)	1.191	0.028
NAD83 (NAD83)	NAD83 NAVD88	26.800	0.073
NAD83 NAVD88	NAD83 MLLW	1.58	0.117
Sum			
WGS84 to NAD83 MLLW components		29.571	0.131
NAD83 to NAD83 MLLW		**28.38**	**0.131**

C.2 HORIZONTAL CONTROL

The horizontal datum for all surfaces of Summer Hydrography 2016 was NAD83 (2011), with coordinates for final products projected using UTM 19N. Positions are acquired using identical techniques as for Vertical Control. For further details, see the Horizontal and Vertical Control Report (HVCR).

D. RESULTS AND RECOMMENDATIONS

D.1 CHART COMPARISON

For the general chart comparison, the bathymetric surface was referenced to MLLW and converted from meters to feet using the raster calculator in ArcMap 10.3.1 (using 1 m = 3.28084 ft). Overlaying the largest scale chart (13274) over the surface showed good correlation between depths shown on the chart and depths collected during this survey (Figure 22).

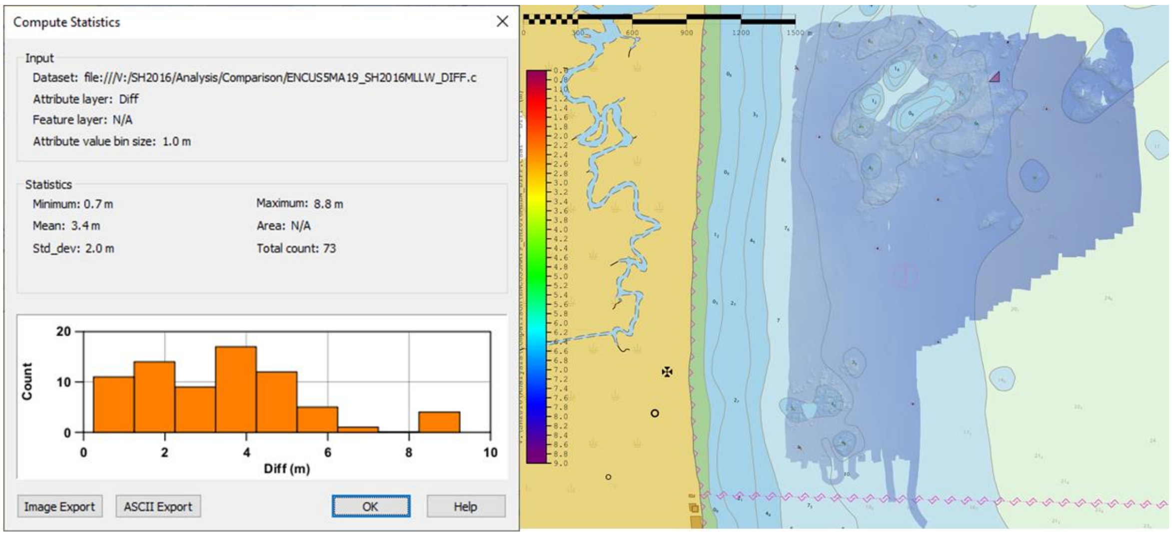


Figure 22: Difference between ENC and SH2016. R: 5 m Gridded Soundings Difference Statistics. L: 5 m Grid Difference for Salisbury is difficult due to sparse soundings at this chart scale.

For a more in-depth comparison, the original soundings used to create the nautical chart were brought into CARIS and a surface difference was performed. The predominant survey with soundings in this area is survey H08097 conducted in 1955 (Figure 23). A surface difference performed with this survey and the 5 m grid produced during Summer Hydro 2016 yielded a mean of (0.8 m) and standard deviation of 1.6 m (Figure 24). The Northeast side has a strip of soundings from the USGS data applied to the ENC (Figure 25). QC Tools ENC Comparison was done, but the settings used weren't optimal for the 1:40,000 scale with sparse soundings. It highlights differences in where soundings and contours should be to best depict the seafloor. The output is analyzed further in the DTON report.

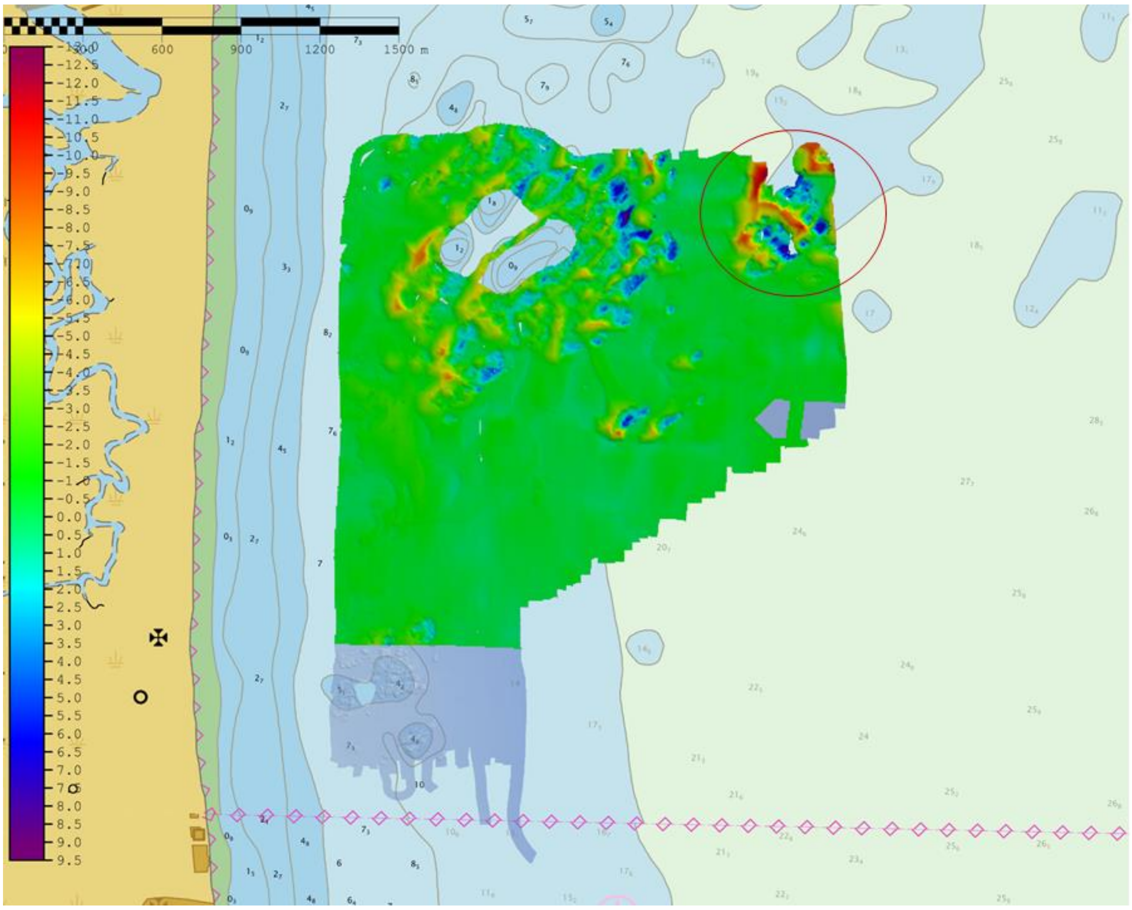


Figure 23: Chart comparison, surface difference between H08097 and SH2016.

Note one of the areas with the largest difference from the H08087 in Figure 24 (circled NE corner), is where the chart soundings are from the USGS 2007 survey (Figure 25). Thus the difference with the ENC and SH2016 are less there than between H08097 and SH2016.

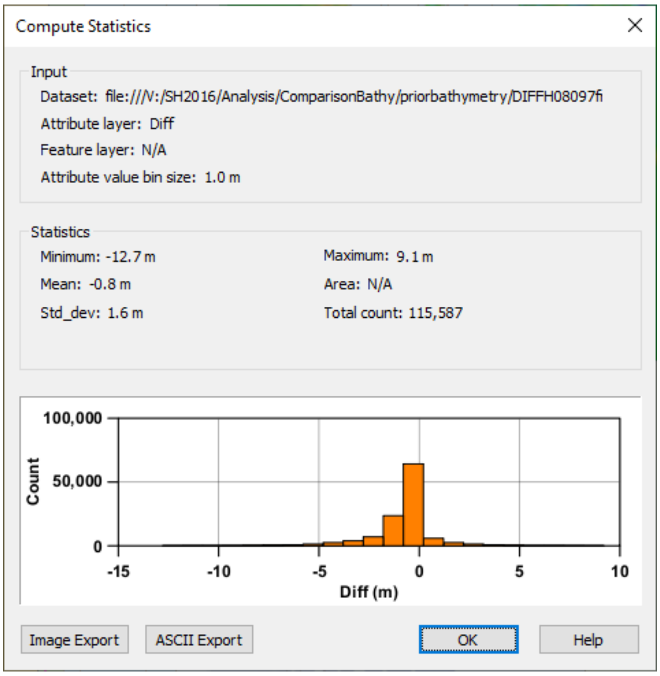


Figure 24: Histogram Difference between H08097 and SH2016.

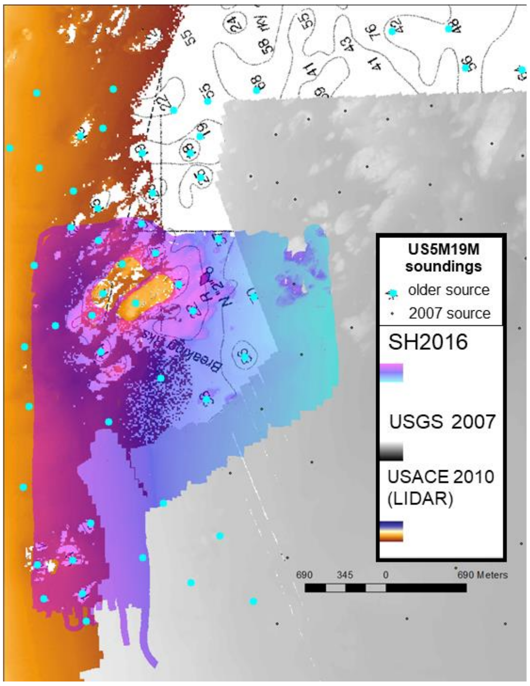


Figure 25. Source of ENC soundings. Blue dots= older soundings, ENC sourced from RNC, green dots ESD more recent ENC source, Greyscale = USGS overlapping coverage, magenta to blue = SH2016 Salisbury Coverage, Brown (left hand side) = USACE lidar Coverage

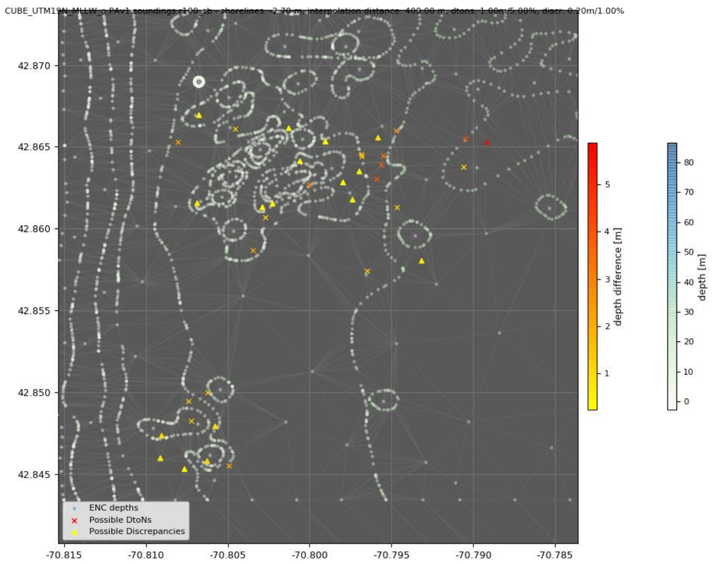


Figure 26: QC Tools Chart Comparison

D.1.1 Raster Charts

The following table summarizes the largest scale RNCs covering the survey area.

Table 12. Available RNCs in the Survey Area

RNC	*Title*	*Scale*	*Edition*	*Print Date*
13274	Portsmouth Harbor to Boston Harbor; Merrimack River Extension	1:40000	28	04/01/2011
13278	Portsmouth to Cape Ann; Hampton Harbor	1:80000	28	08/01/2013
13260	Bay of Fundy to Cape Cod	1:378838	41	08/01/2012
13006	West Quoddy Head to New York	1:675000	32	07/01/2012
13009	Gulf of Maine and Georges Bank	1:500000	36	05/01/2014

D.1.2 Electronic Navigational Charts

The following table summarizes the largest scale ENCs covering the survey area.

Table 13. Available ENCs in the area.

ENC	*Title*	*RNC*	*Scale*	*Edition*	*Update Application Date*	*Preliminary?*
US5MA19M	Merrimack River Extension	13274	1:40000	4.6	11/25/2014	No
US5MA04M	Portsmouth to Cape Ann	13278	1:80000	24.4	3/14/2016	No
US3EC10M	Bay of Fundy to Cape Cod	13260	1:378838	37.8	6/17/2016	No
US2EC04M	West Quoddy Head to New York	13006	1:675000	21.10	6/3/2016	No

D.1.3 AWOIS Items

There are not AWOIS items assigned for the survey area.

D.1.4 Charted Features

There are charted rocks and seabed characteristics in this area, but no features exist.

D.1.5 Uncharted Features

All features are included in the .hob file.

D.1.6 Dangers to Navigation

Dangers to navigation are reported in the DTON report. 6 Potential DTONS are described, with 4 definitely having greater than 10% water depth and 1 m height differences from the ENC. The other two are referred for further insight from the branch.

D.1.7 Shoal and Hazardous Features

The survey area contains several outcrop or shoals that are shoaler than charted, extend further than charted, are absent from the chart. The area is generally part of a rocky coastline offshore.

D.1.8 Channels

No channels exist in the survey area.

D.1.9 Bottom Samples

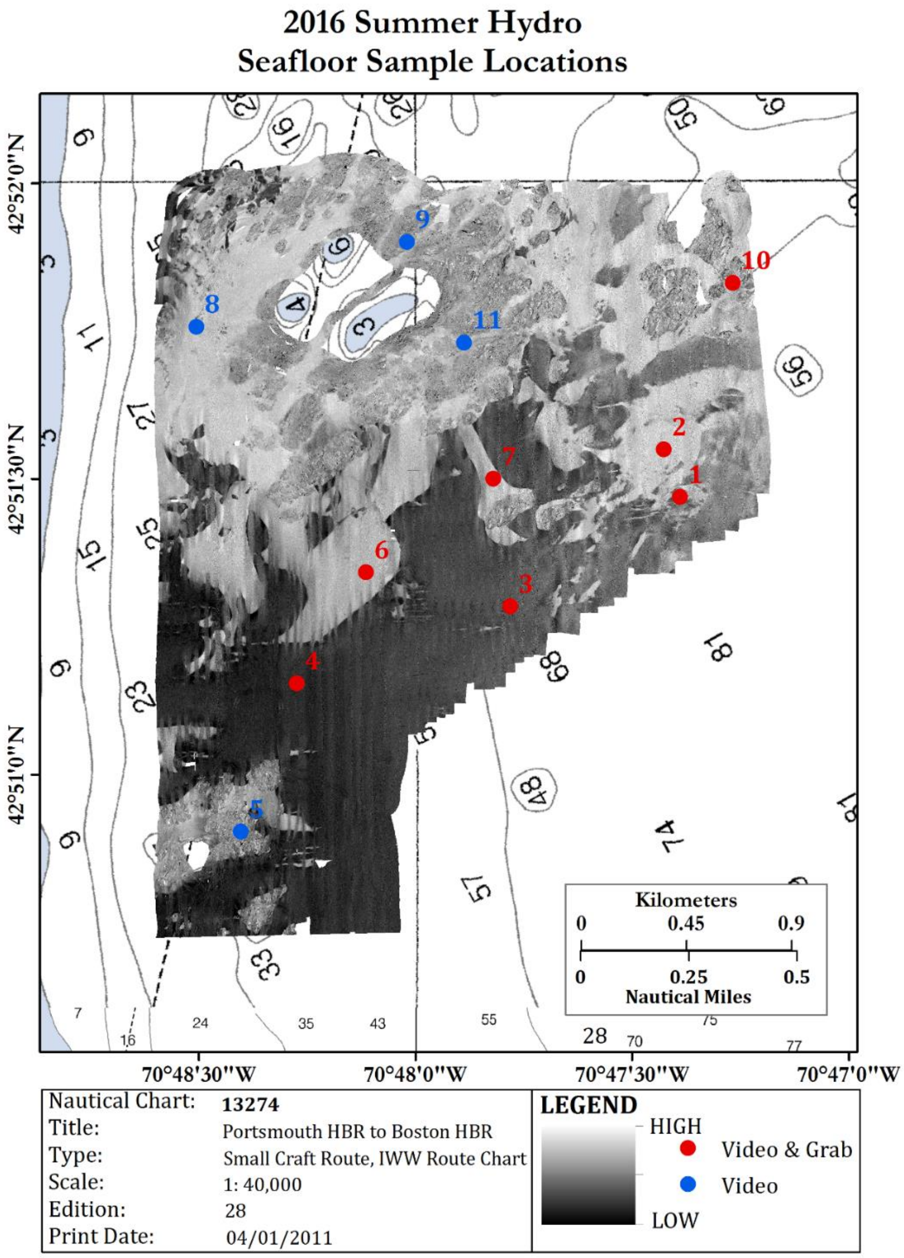


Figure 27. Grab and Video sample locations for Summer Hydrography 2016.

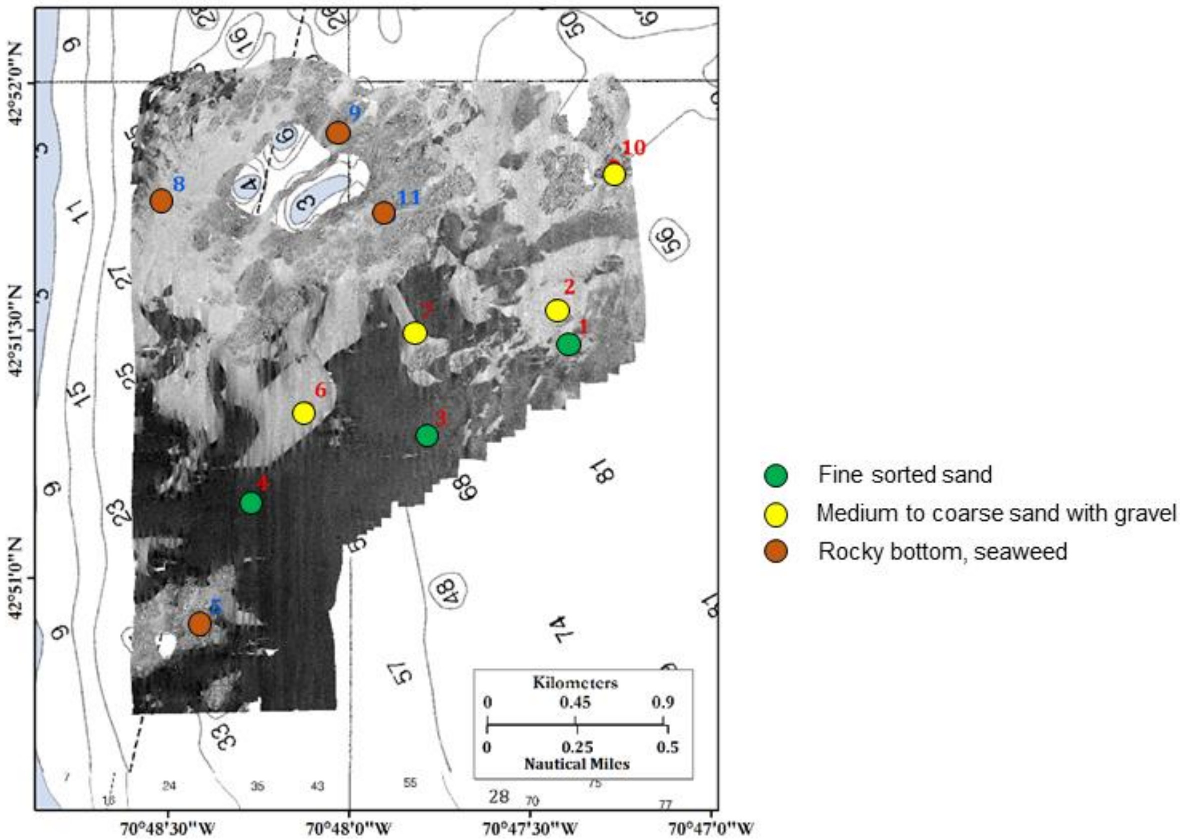


Figure 28: Map of sediment types overlain on the backscatter data from the MBES survey.

At the sites chosen based on the bathymetric and backscatter data from the multibeam survey, underwater video images were recorded, and where possible, bottom sediment samples were collected. Low intensity backscatter values correspond to the sites where fine sorted sands were recovered (sites 1,3,4). Transit zones at stations 2, 6, 7, 10 are characterized by coarser sediment types (medieum to coarse sand and gravel). Elevations of the sea floor (stations 5, 8, 9, 11) correspond to the rocky bottom type with seaweed observed in the video records(Figures 27-30).

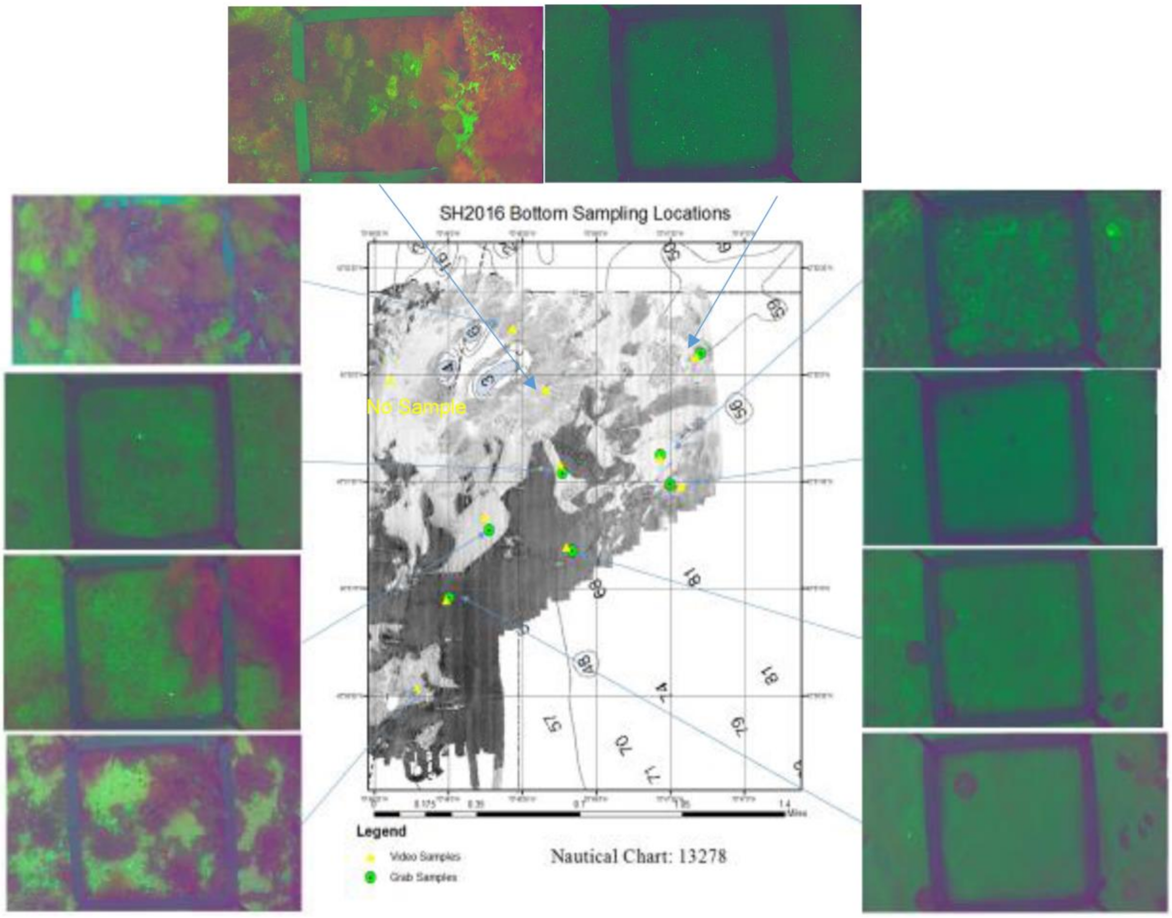


Figure 29: Video Imagery of the Breaking Rocks Area.

Figure 30: Sediment samples collected at the stations.

D.2 ADDITIONAL RESULTS

D.2.1 Shoreline and Nearshore Features

No investigation was conducted.

D.2.2 Prior Surveys

Discussed in B.2.3.

D.2.3 Aids to Navigation

No damaged or uncharted ATONS were observed.

D.2.4 Overhead Features

No overhead features exist in the survey area.

D.2.5 Submarine Features

No features exist in the category.

D.2.6 Ferry Routes and Terminals

No ferry routes or terminals exist in survey area.

D.2.7 Platforms

No structures exist in the category.

D.2.8 Significant Features

Breaking rocks occur in the survey area which cannot be navigable during low tide.

D.2.9 Construction and Dredging

No features exist in the category.

D.2.10 New Survey Recommendations

Further investigations are needed to report reliable bathymetry at the breaking rocks.

D.2.11 New Inset Recommendations

No new insets are recommended for the survey area.

E. APPROVAL SHEET

The approval sheet shall contain the following statements:

- Approval of the deliverable files, Descriptive Report, digital data, and all accompanying records. This approval constitutes the assumption of responsibility for the stated accuracy and completeness of the hydrographic survey.
- Indication of the completeness of the survey and adequacy for its intended purpose. Recommendation of additional work is required.
- The amount and degree of personal supervision of the work.
- Additional information or references helpful for verifying and evaluating the survey.

F. TABLE OF ACRONYMS

AWOIS	Automated Wreck and Obstruction Information System
BIST	Built-In Self-Test
CCOM/JHC	Center for Coastal and Ocean Mapping/Joint Hydrographic Center
CRM	Compact Measurement Records
CTD	Conductivity Temperature Depth
CUBE	Combined Uncertainty and Bathymetric Estimator
CW	Continuous Wave
DAPR	Data Acquisition and Processing Report
DGPS	Differential Global Positioning System
DP	Detached Position
DR	Descriptive Report
ENC	Electronic Navigational Chart
ERS	Ellipsoidal Referenced Survey
FM	Fledermaus
GAMS	GPS Azimuth Measurement Subsystem
GPS	Global Position System
HBR	Harbor
HVCR	Horizontal and Vertical Control Report
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
LNM	Linear Nautical Miles
LOA	Length Overall
MBES	Multibeam Echosounder
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OPS	Operations
OPUS	Online Positioning User Service
MBES	Multibeam Echosounder
POS/MV	Position and Orientation System for Marine Vessels
PPS	Pulse per second
PU	Processing Unit
QPS	Quality Positioning Systems

RNC	Raster Navigational Chart
RTK	Real Time Kinematic
RV	Research Vessel
RX	Receiver
SBES	Singlebeam Echosounder
SIS	Seafloor Information System
SNM	Square Nautical Miles
SSS	Side Scan Sonar
SVP	Sound Velocity Profiler
TPU	Total Propagated Error
TX	Transducer
UHF	Ultra High Frequency
USACE	United States Army Corps of Engineers
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

APPROVAL PAGE

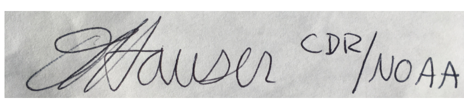
W00504

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

The following products will be sent to NCEI for archive

- Descriptive Report
- Collection of Bathymetric Attributed Grids (BAGs)
- Collection of backscatter mosaics
- Processed survey data and records
- Bottom samples
- GeoPDF of survey products

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



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Approved:____

Commander Olivia Hauser, NOAA
Chief, Pacific Hydrographic Branch