W00309

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

DESCRIPTIVE REPORT

Type of Survey:	External Source Data
Registry Number:	W00309

LOCALITY

State(s):	Massachusetts
General Locality:	Buzzards Bay
Sub-locality:	Offshore of Westport Point

2010

US Geological Survey

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Date:

U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY NUMBER:
HYDROGRAPHIC TITLE SHEET	**W00309**

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**
General Locality:	**Buzzards Bay**
Sub-Locality:	**Offshore of Westport Point**
Scale:	**1:10,000**
Dates of Survey:	**05/27/2009 to 05/14/2011**
Project Number:	**OSD-USGS-16**
Data Source:	**USGS**
Chief of Party:	**USGS and MCZM**
Soundings by:	**Interferometric**
Imagery by:	**Sidescan Sonar**
Verification by:	**Atlantic 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 NAD83 UTM 19N, MLLW. All references to other horizontal or vertical datums in this report are applicable to the processed hydrographic data provided by the field unit.

DR SUMMARY

Descriptive Report Summary to Accompany W00309	
Project	OSD-USGS-16
Survey	W00309
State	Massachusetts
Locality	Buzzards Bay
Sub Locality	South
Scale of Survey	1:10,000
Sonars Used	SEA SwathPlus (234kHz) Klein 3000 (132kHz) EdgeTech 512i (0.5-12kHz)
Horizontal Datum	World Geodetic System of 1984 (WGS 84)
Vertical Datum	Mean Lower Low Water (MLLW)
Vertical Datum Correction	TCARI Tidal Model
Projection	Latitude-Longitude (WGS84) - UTM Zone 19N
Field Unit	United States Geologic Survey at Woods Hole
Survey Dates	***06/07/2009*** - 06/18/2009 05/13/2011-05/14/2011
Chief of Party	USGS and MCZM

A. Area Surveyed

W00309 was surveyed by the US Geological Survey (USGS) with a SEA SwathPlus interferometric sonar with a towed Klein 3000 side scan onboard the 108 foot M/V Megan T. Miller. The survey area was covered over the course of one month (05/27/09 - 06/18/09) in 2009 and two days (05/13-14) in 2011. The data were not collected in accordance to NOS Hydrographic Surveys Specifications and Deliverables and the Field Procedures Manual requirements but were post-processed by the Joint Hydrographic Center (JHC) IOCM team in 2016 to meet those standards to the highest degree possible.

The W00309 survey is within the following limits:

NE Corner	41-30-18.59 N	70-55-20.54 W
SE Corner	41-22-09.71 N	70-55-06.11 W
SW Corner	41-21-57.01 N	71-07-10.02 W
NW Corner	41-30-05.82 N	71-07-25.94 W

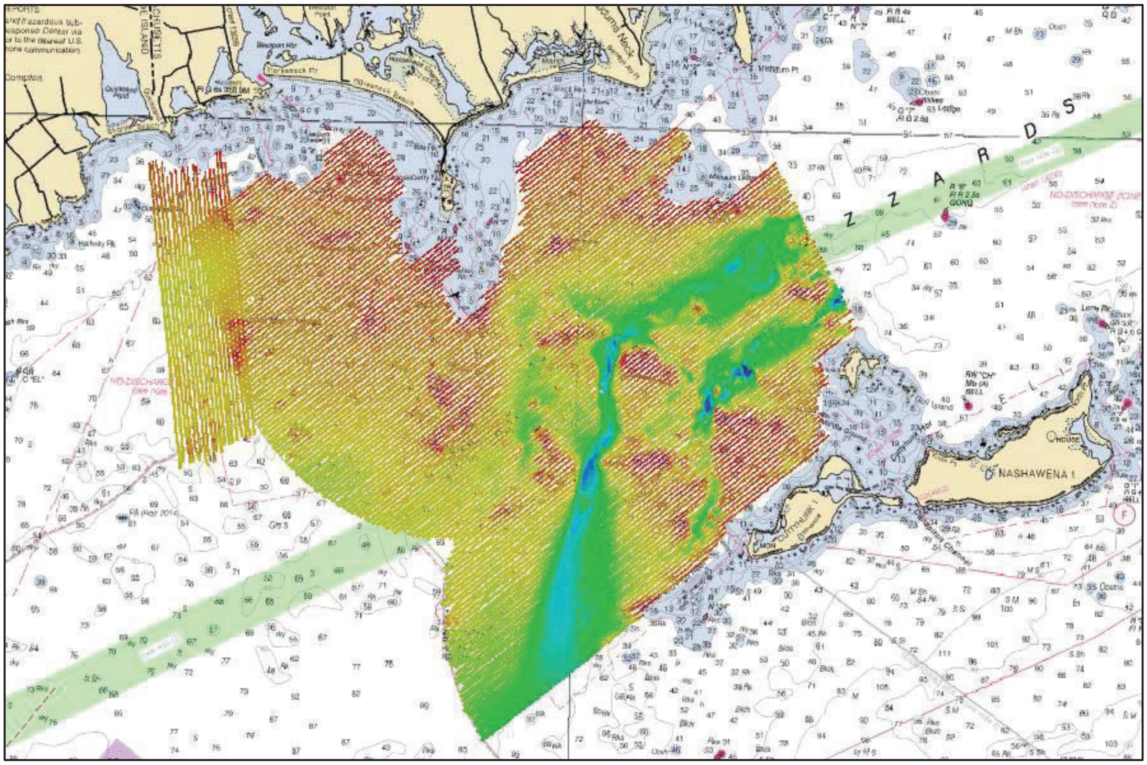

Figure 1: Survey W00309 1m CUBE surface overlaying Charts 13218.

B. Survey Purpose

Data were acquired by the United States Geologic Survey (USGS) in cooperation with the Massachusetts Office of Coastal Zone Management (MCZM). W00309 was part of a larger survey project for the USGS/MCZM to map the whole of Buzzards Bay, and surrounding coastal Massachusetts waters. The results of their efforts were published publicly under Open-File Report 2012-1002. NOAA learned of these data in early 2015 when NOAA Ship *Thomas Jefferson's* survey areas were being selected. Communication between NOAA and USGS lead to sharing of these data for charting evaluation. In response to the potential for charting, NOAA adjusted the *Thomas Jefferson* 2015 survey plans so as not to cover the same area twice (Figure 2).

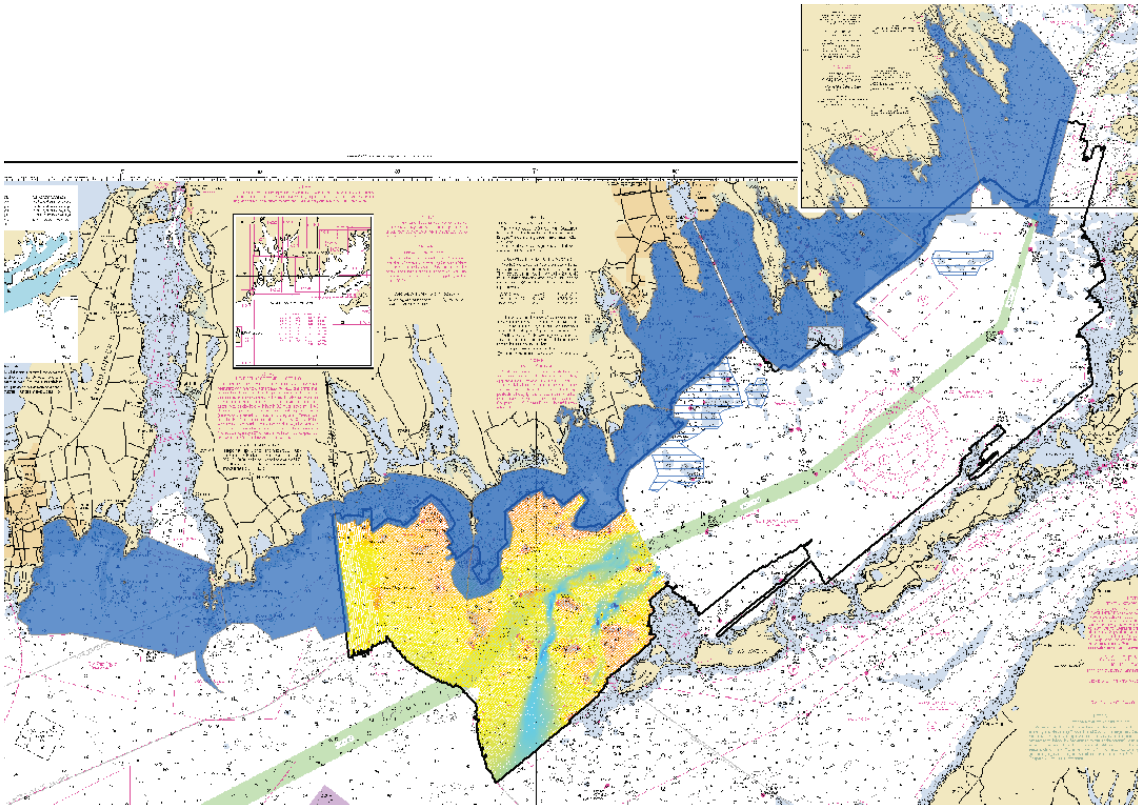

Figure 2: The USGS/MCZM survey area outlined in black with the NOAA Ship *Thomas Jefferson's* survey areas in blue. The boxed areas with blue lines are the areas assigned to the TJ for additional investigation. W00309 (North) 1m CUBE surface is shown.

Refer to the USGS Open-File Report 2012-1002 written by Ackerman et al submitted with this data for more information on the survey purpose and acquisition.

C. Intended Use of Survey

These re-processed data are adequate to supersede prior sounding data and are intended for chart compilation. The analysis of these data have determined that they meet the horizontal and vertical requirements for CATZOC A2 but coverage and feature measurements of CATZOC B. With additional coverage over sidescan identified targets and shoals, CATZOC A2 could be achieved.

D. Data Acquisition and Processing

D.1 USGS Acquisition

Survey data were collected by the USGS/MCZM in 2009-2010 with an EdgeTech Geo-Star FSSB and SB-0512i towfish for seismic profiling, a pole-mounted first-generation interferometric SEA SwathPlus sonar for bathymetry with concurrent side scan, and a towed Klein 3000 for supplementary side scan (Ackerman et al. 2012). These data were RTK navigated, referenced to Mean Lower Low Water (MLLW), and had an average tidal offset applied (Ackerman et al. 2012). The interferometric data were collected with the SEA SWATHPlus acquisition software and processed in CARIS 6.1-7.1 by the USGS.

Instrument	X	Y	Z
Transducer 1	-0.110	-0.019	0.158

Transducer 2	-0.110	-0.019	0.158

Table 1: Table represents the offset values in the received CARIS vessel files.

Bathymetric filters were applied to these data by the USGS in attempts to reduce the size of the data and remove inaccurate soundings. The filters applied to these data include: low amplitude (100%), range (0-4m), box (3-50m depth, 1.5-75m horizontal), median (window size 5), alongtrack 1 (depth difference of 5-m, window size 5-m, and learn rate of 0.7), alongtrack 2 (depth difference of 1.5-m, window size 1m, and learn rate of 0.9), and mean filters (0.25m) (Ackerman et al. 2012).

The data package received by the IOCM center included the raw interferometric files .sxr, CARIS projects using the processed interferometric files .sxp, raw Klein side scan .XTFs, and detailed daily survey logs with records of ship speed, navigation failures, and side scan feature identifications.

Refer to the USGS Open-File Report 2012-1002 (Ackerman et al) for more complete information on data acquisition, vessel configuration, processing hardware and software, data quality and offsets.

D.2 IOCM Processing

The W00309 supplied CARIS project was post processed by NOAA IOCM with CARIS Hips and Sips 9.1. The provided CARIS HVF (HIPS Vessel File) was altered to have the sonar system be “UNKNOWN” instead of the SEA SwathPlus option. This was done at the suggestion of JHC/CCOM Researched Val Schmidt who pointed out the CARIS sonar algorithm is not applicable for interferometric systems.

The NOAA TCARI 2015 tidal model for Buzzards Bay was applied to these data using Pydro to replace the tides applied by the USGS.

Also from the recommendation of Val Schmidt, these interferometric data were trimmed to limit the amount of noisy data included in surface creation by applying the CARIS across track distance filter. The across track distance CARIS filter of 1.73x water depth on either side of nadir was applied (Figure 3).

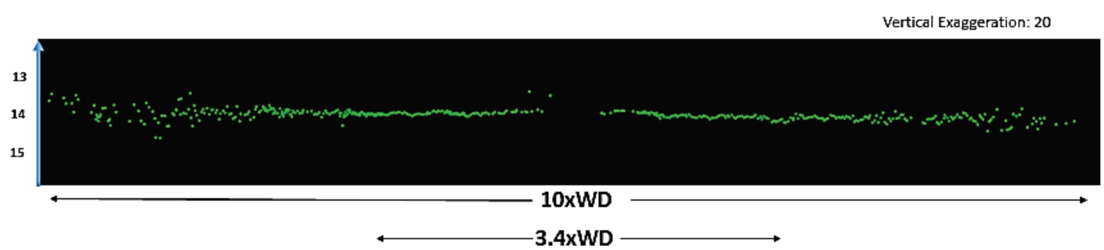

Figure 3: A single full swath of data at a depth of 14m. While there is data up to 10x water depth, only the data up to 3.4x water depth was kept after the CARIS filter was applied as it had less noise and less uncertainty.

This application limited the swath to ~50m at a depth of 14m and created ~50m data gaps in between each swath. The resulting surface is of a similar nature to that of a “skunk-stripe” multibeam survey.

E. Uncertainty

E.1 Total Propagated Uncertainty (TPU)

The USGS/MCZM CARIS projects included all imported .SXP files with their associated HIPS Vessel Files (HVF) and offsets already applied. In the CARIS HVF, the SEA SwathPlus sonar option was selected in the given project. However, this is not the best option. While a SEA SwathPlus interferometric sonar is what was used to collect these data, CARIS does not currently have a correct interferometric algorithm for the Total Propagated Uncertainty (TPU) calculation. By selecting the SEA SwathPlus option, the TPU will be calculated with a multibeam algorithm and will produce incorrect "Uncertainty" values upon surface creation. The solution to this problem is to choose "Unknown" as the sonar in the vessel file, and was done for this project.

NOAA TCARI tides were used to replace the USGS/MCZM tidal model. The TCARI tide errors were applied to each HDCS line file in CARIS. For the TPU calculation, the tidal uncertainty source was set to "Realtime" to accommodate the location of stored tidal error data. One sigma tidal uncertainty estimate of 0.15m from the TCARI tidal error surface generated in PYDRO (Figure 4).

Sound-speed profiles were collected approximately every four hours using a hand-casted Applied MicroSystems SV Plus sound velocimeter during the 2009 survey and with an ODIM MVP30 moving vessel profiler during the 2011 survey (Ackerman et al). These profiles were applied to the data in real time. Sound speed was not reapplied during post processing. Figure 5 shows the values that were used to calculate TPU based on the USGS/MCZM raw SVP documentation.

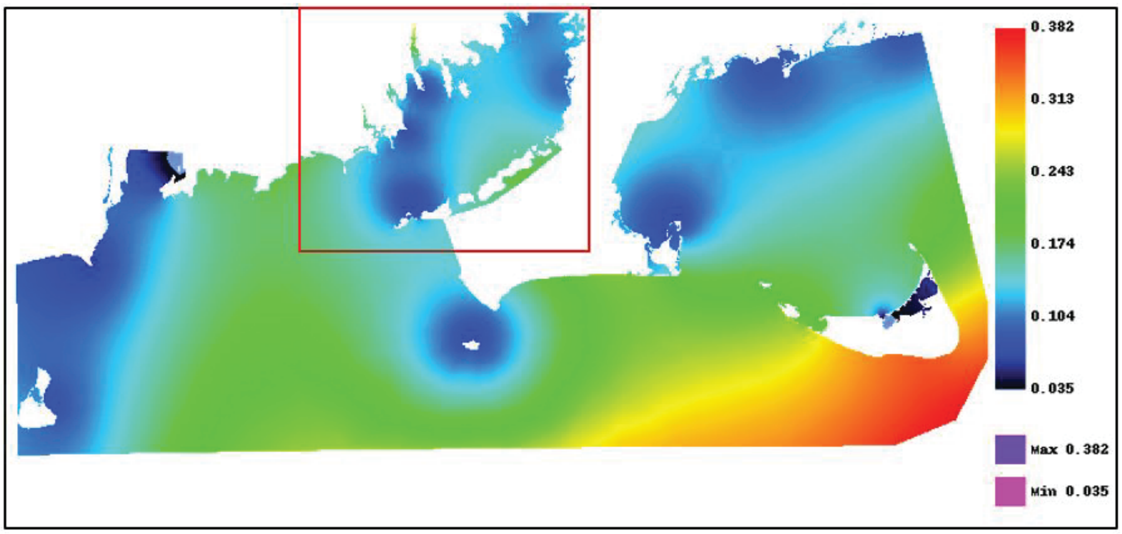

Figure 4: TCARI Tidal Error for the Buzzards Bay and surrounding area produced in PYDRO. The red box denotes where the survey area is located.

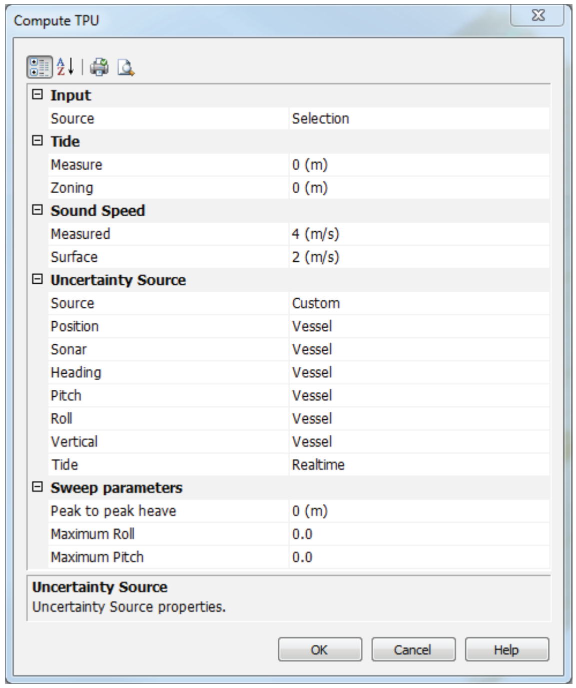

Figure 5: Shows the TPU values used to calculate W00307 CUBE surfaces

E.2. Cross-line Comparison

As part of a 2015 reconnaissance effort directed in the OPR-B367-TJ-15 project instructions, the NOAA ship *Thomas Jefferson* (TJ) ran cross-lines through the body of the survey area (Figure 5). The 1m W00309 surface was compared with a 0.5m surface from the *TJ* cross-lines. The surfaces had a mean difference of **0.54m** with a standard deviation of **0.46m**. The TJ data being consistently shoaler.

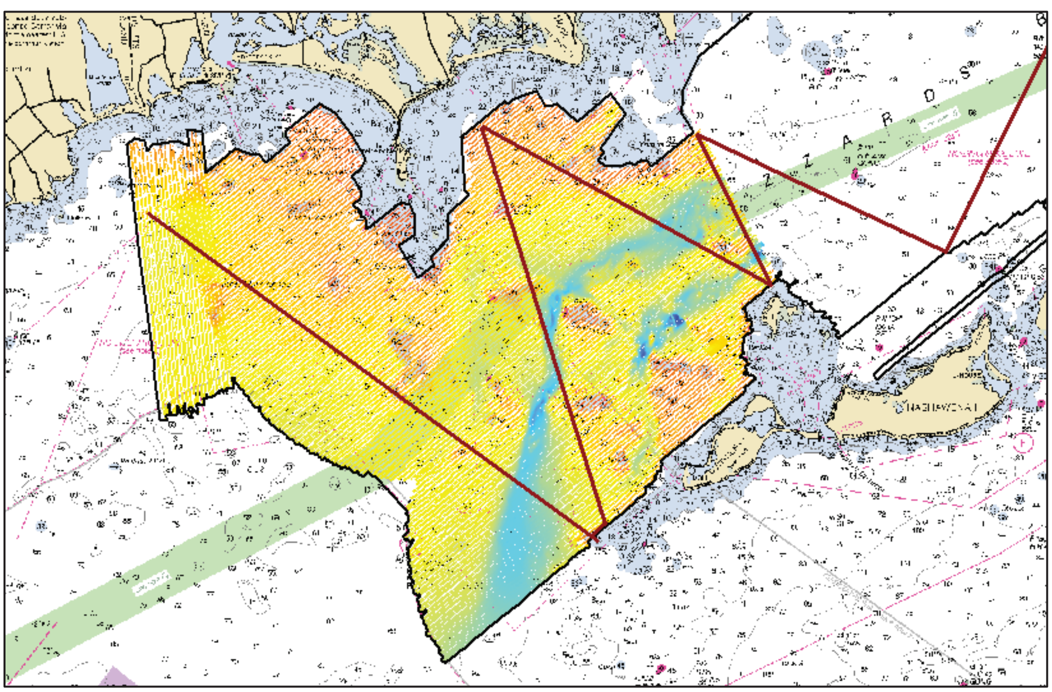

Figure 5: NOAA Ship *Thomas Jefferson* cross-lines on top of the W00309 survey and Chart 13218.

The TJ cross-line comparison identified a roll bias on the starboard side where the impact is more pronounced in deeper waters (+20m) (Figure 6).

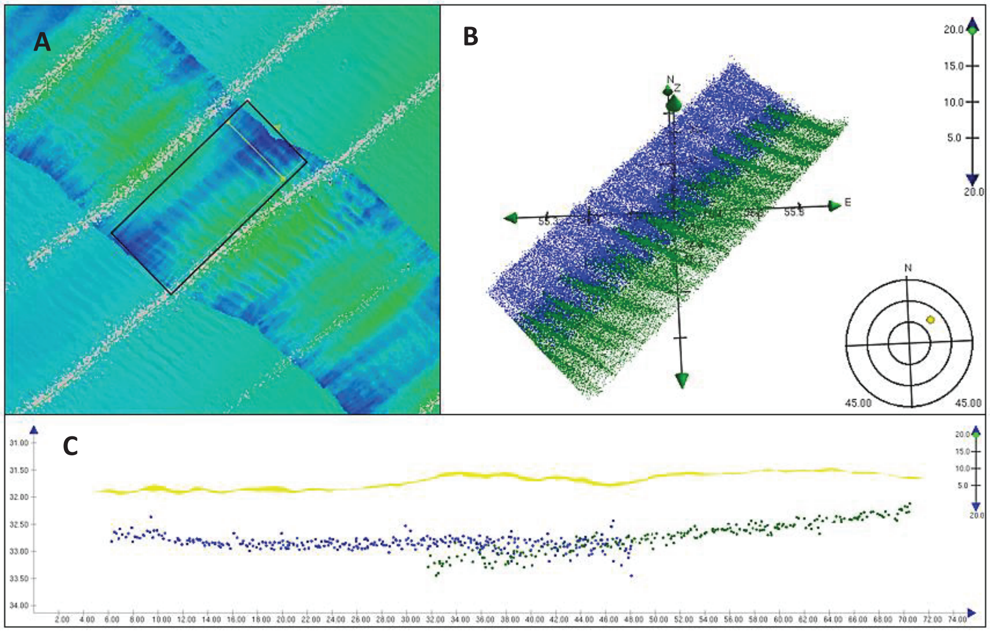

Figure 6: A. The crossline difference surface overtop of W00309 CUBE surface. The black box denotes the CARIS Subset Editor box. B. The 3D subset editor view of the black box in 6A. The blue and green represent soundings from two separate lines. C. the 2D subset editor view of the yellow line in the black box in 6A. The blue and green soundings are two separate lines and the yellow is the TJ crossline surface for reference.

The roll bias is also responsible for the higher standard deviation associated with this comparison. We attempted to simply correct the roll bias in CARIS, but the software could not apply the precise corrections due to the x,y,z nature of the ingested .SXP data format. To appropriately correct the .SXP data, one has to account for the raw receive angles. CARIS does not currently have that functionality and would require lengthy discussions with CARIS software engineers in order to fix. An alternative method to would be to re-run (at survey speed) the raw .SXR SEA SWATHPlus files through the acquisition software with the appropriate roll component included. This would result in a more accurate .SXP files which could later be ingested into CARIS. However, both of these options were deemed too time-consuming and were not performed. Instead, an additional variable was included in the uncertainty calculation (E.3) to conservatively capture the roll bias with respect to depth throughout the surface.
This component was conservatively added to the uncertainty calculations for both W00307 and W00308 even though no visual evidence of the roll bias was found.

E.3 Uncertainty

As discussed previously, specifying “unknown” as the sonar model in CARIS results in an incomplete computation of the uncertainty layer that is generated upon CUBE surface creation. Instead, the standard deviation layer of each surface was used to empirically estimate the uncertainty of these data. Once biases were identified (E.2), a more comprehensive “worst-case scenario” uncertainty calculation was created as a new layer in the CSAR file called the Estimated_Uncertainty.
The standard deviation of measurements in each 1 m grid cell was combined with tide, heave and draft as well as a separate component to accommodate the residual roll bias in a root-mean-square sum (Equation 1). A fixed value for the roll bias error at 60^{o} was used to simulate a worst-case scenario for these across-track filtered interferometric data. The roll bias itself was

estimated to be 0.7° due to the ~1m depth difference on the starboard side found during the TJ crossline comparison with W00309. The areas affected by the roll bias appeared deeper than the rest of the swath (Figure 6A). Equation 1 was used to calculate the uncertainty for each CUBE surface.

EQUATION 1:

$$\sigma_{estimated} = \sqrt{\sigma_{Sonar}{}^2 + \sigma_{Tide}{}^2 + \sigma_{Heave}{}^2 + \sigma_{Draft}{}^2 + \sigma_{Depth}{}^2}$$

$$\sigma_{Sonar} = Standard\ Deviation$$

$$\sigma_{Tide} = TCARI\ error\ estimate = 0.15$$ *Estimated average value based on Figure 4

$$\sigma_{Heave} = 0.05$$

$$\sigma_{Draft} = 0.05$$

$$\sigma_{Depth} = Depth^2 \times \tan(60^o) \times \sigma_{Roll}^2$$

$$\sigma_{Roll} = \frac{0.7}{180}\pi$$

The average depth of W00309 is 19.95m and was used as the depth component to estimate the IHO order 1a 2σ total vertical uncertainty (TVU) requirement. For areas shoaler than 100m, the IHO Order 1a parameters are the following: a = 0.5m and b = 0.013.

IHO Order 1a TVU Requirement:

$$\sqrt{(a)^2 + (b * d)^2} = \sqrt{(0.5)^2 + (0.013 * 19.95)^2}$$

Using the above equation, the total allowable vertical uncertainty is < 0.56m for W00309. The 2σ average uncertainty calculated for W00309 is **0.9068m** as seen in Figure 7. The USGS/MCZM Buzzards Bay data did not meet IHO order 1a based on these uncertainty calculations.

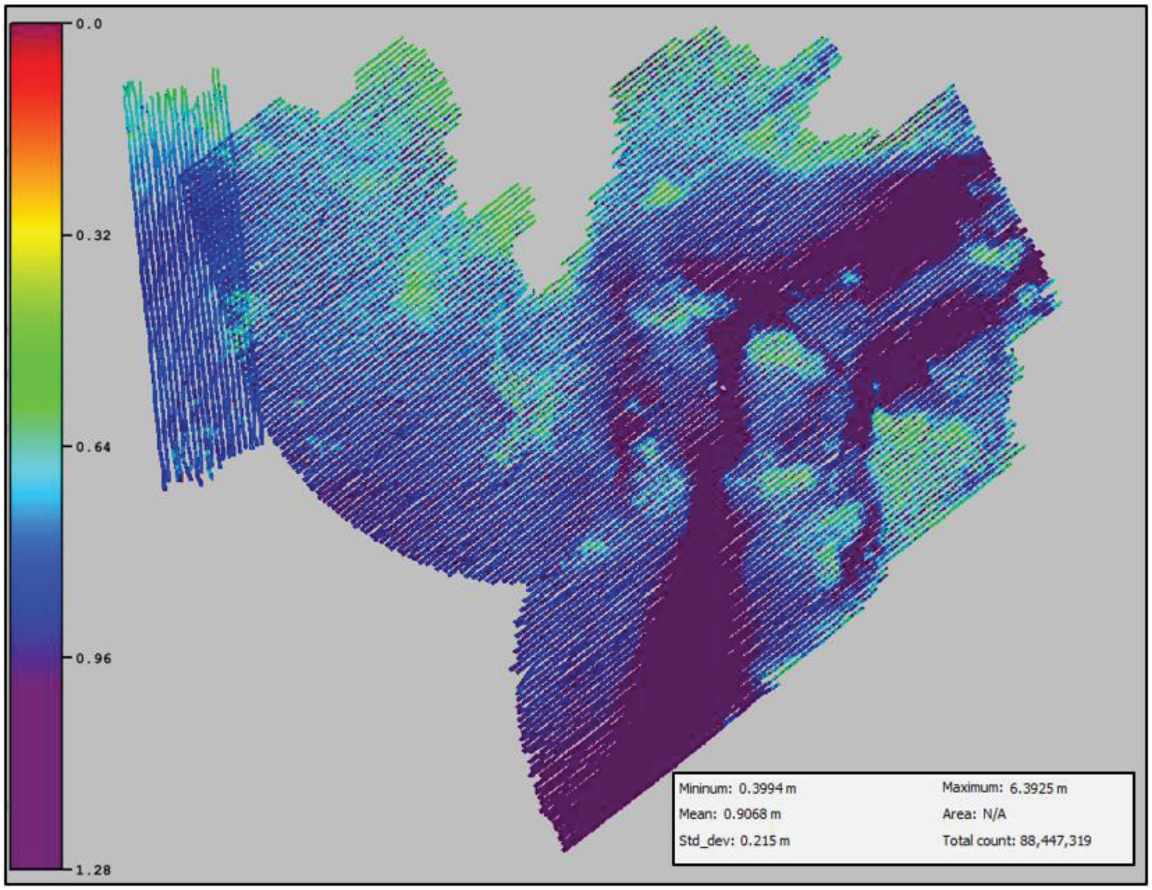

Figure 7: Uncertainty map of W00309 1m CUBE surface with the estimated uncertainty statistics. There is an average uncertainty of 0.9068m.

Without the roll bias contribution to the uncertainty calculation W00309 would meet IHO Order 1a requirements with an average vertical uncertainty of **0.3595m** (Figure 8). An additional layer was added to the W00309 CUBE surface with the same uncertainty calculation but without the roll bias component, and is named “Uncertainty_NoRollBias”.

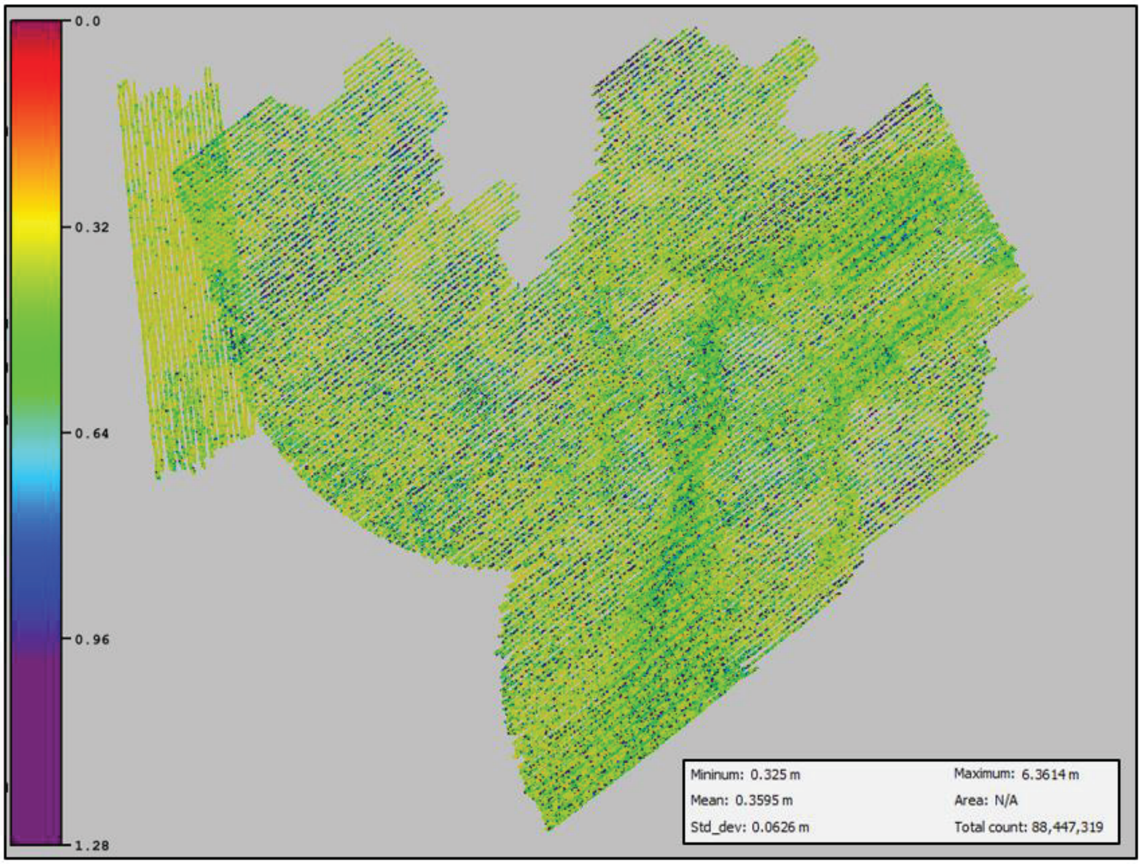

Figure 8: Uncertainty map of W00309 1m CUBE surface with the estimated uncertainty statistics without the roll bias contribution. There is an average uncertainty of 0.3595 m. 99.78% of these data would meet IHO Order 1a with this calculation.

These uncertainty layers were not put through PYDRO for analysis.

F. Results and Recommendations

The following surfaces were created from the processed data:

Surface Name	Surface Type	Resolution (m)	Depth Range (m)
W00309_south_1m_0to20	CUBE Base Surface	1	0-20
W00309_south_2m_18to40	CUBE Base Surface	2	18-40
W00309_south_4m_36to80	CUBE Base Surface	4	36-80
W00309_south_1m	CUBE Base Surface	1	0-47m
W00309_south_2m	CUBE Base Surface	2	0-47m
W00309_south_4m	CUBE Base Surface	4	0-47m

Table 2: List of surfaces and mosaics created for this project.

Table 2 does not include the 1m SSS mosaic created by the USGS which was used for analysis and feature identification. As backscatter was one of the USGS' main priorities during survey operations, recreation of the mosaic was not performed. SSS contact identification was made from the raw SSS files provided by USGS/MCZM (F.5).

F1. Chart Comparisons

A soundings layer of the USGS/MCZM Buzzards Bay data was made in order to directly compare with the soundings on the current charts (Table 3). Soundings from W00309 were selected by the depth layer in CARIS BASE Editor 4.0. Shoal biased soundings were selected using a single-defined radius of 15mm at a map scale of 1:10,000.

W00309 was compared with the following RNC and ENC, which cover the survey area:

Chart	Scale	Edition	Edition Date	NM Date
13228	1:20,000	12	11/1/2009	5/23/2015
13232	1:20,000	5	11/1/2009	5/23/2015
13236	1:20,000	31	4/1/2012	5/23/2015
13229	1:40,000	32	6/1/2013	5/19/2015
13230	1:40,000	51	4/1/2014	1/31/2015
13218	1:80,000	42	7/1/2013	6/27/2015
13246	1:80,000	40	10/1/2013	10/22/2015
12300	1:400,000	49	6/1/2012	6/13/2015
13200	1:400,000	38	9/1/2012	6/06/2015
13009	1:500,000	36	5/1/2014	6/13/2015
13006	1:675,000	36	7/1/2012	6/13/2015
5161	1:1,058,400	14	3/1/2016	5/30/2015
13003	1:1,200,000	52	10/1/2015	6/13/2015
US5MA27M	1:20,000	24.4	9/30/2014	5/11/2015
US5MA26M	1:20,000	15.4	7/23/2014	4/16/2015
US5MA24M	1:20,000	12.0	12/16/2014	12/16/2014
US5MA25M	1:40,000	20.0	9/24/2014	9/24/2014
US4MA14M	1:80,000	25.7	2/18/2014	5/11/2015
US4MA23M	1:80,000	27.17	11/7/2013	5/4/2015
US3EC09M	1:400,000	10.0	10/26/2015	10/26/2015
US3NY01M	1:400,000	32.21	1/24/2013	5/06/2015

Table 3: List of ENCs and RNCs that include W00309

In comparison to current NOAA RNCs and ENCs, it is clear that W00309 is fairly comparable to the charted soundings – generally within a meter (+/- 1-3ft) as shown in Figure 10A. However, there are a few areas where W00309 is considerably shoaler than currently charted soundings. An example of which is shown in Figure 10B.

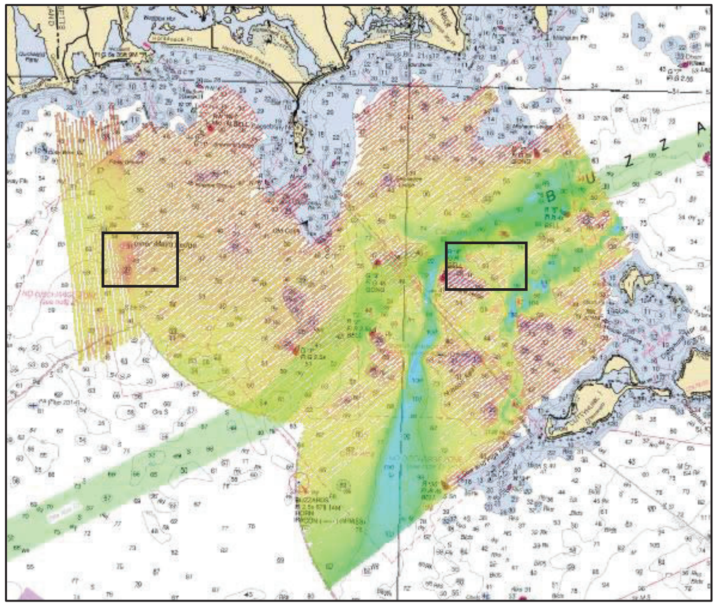

Figure 9: Top image is Chart 13218 over W00309 1m CUBE surface with two subsets identified in black boxes.

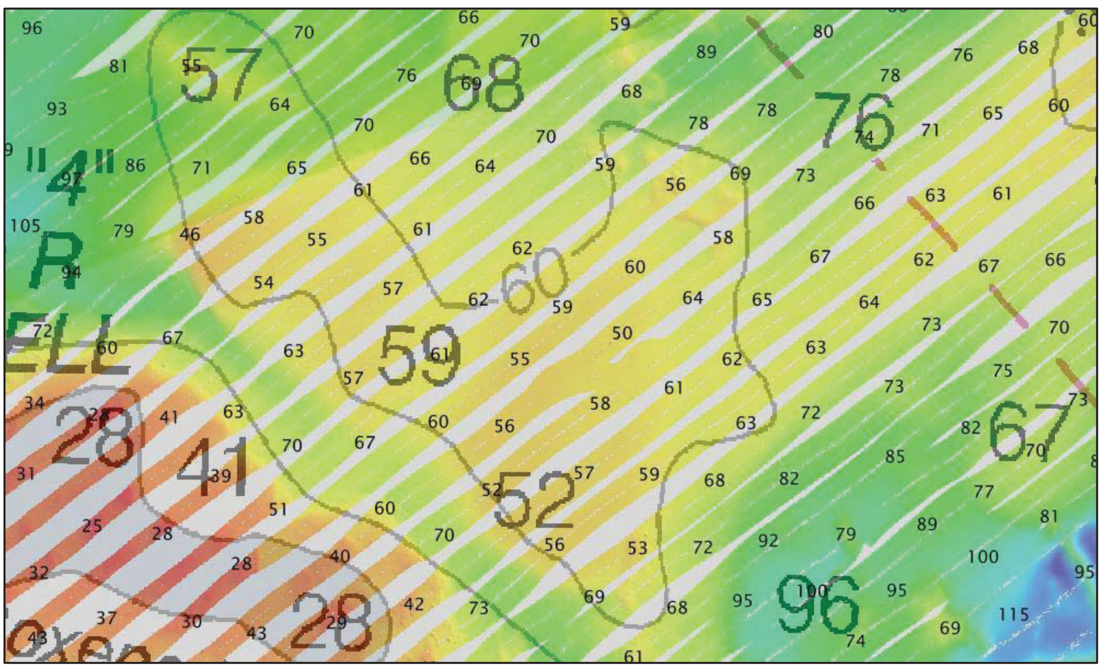

Figure 10A: The rightmost subset from Figure 9 is enlarged to show selected soundings from W00309 at 15mm spacing at map scale 1:10,000. The W00309 soundings are the smaller sized numbers and are clearly within +/- 1-3 feet (~1m) of each charted sounding (13218_1).

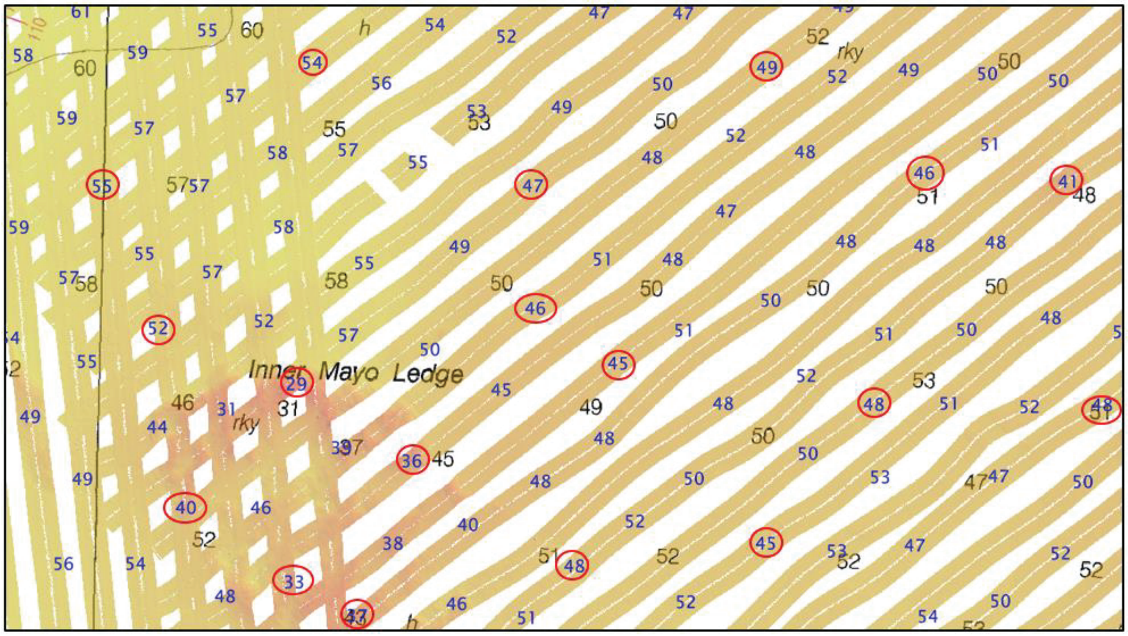

Figure 10B: The leftmost subset from Figure 9 is enlarged to show selected soundings (in blue) at 15mm spacing at map scale 1:10,000. The blue soundings in a red circle are shoaler soundings than those identified on the chart (13228_1).

An interpolated surface was created from the charted soundings covering W00309. The difference between these two surfaces was used to help identify areas of shoaling. Only a few shoals were identified, and of those one was in waters less than 35ft (Figure 11).

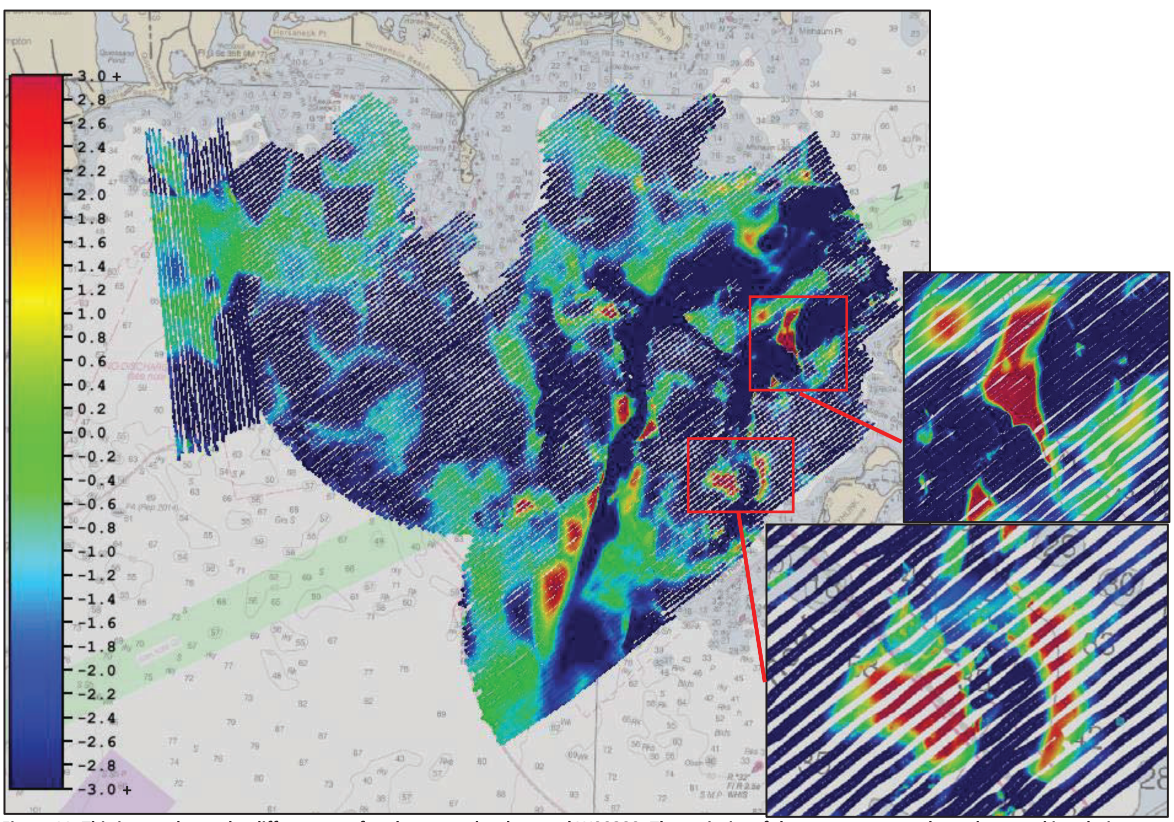

Figure 11: This image shows the difference surface between the chart and W00309. The majority of the area appears to have deepened in relation to the charted soundings and only a few areas of shoaling are indicated in warmer colors. The topmost subset of the top red box is shown in the middle right. This is the most drastic area of shoaling found in W00309. The differences here are upwards of 13m in charted depths of 41-147 ft. The bottommost subset of the bottom red box is shown in the bottom right. This is one of the more cartographically more significant areas of shoaling.

The differences in this area are upwards of 6m in charted depths of 35ft. * Note: color bar was shortened on either end (denoted with a +) to highlight areas of significant change

F2. Features

These data were not collected for charting purposes and feature investigations were not performed by USGS/MCZM. That said, a number of features were identified throughout the processing of W00309 that are not identified on the charts. Features were confirmed as wrecks by their appearances on CUBE surfaces and intensity differences in the 1m backscatter mosaic, and were confirmed in the SSS waterfall view (Figures 12). A total of 4 uncharted features have been identified in this survey (Table 4). A feature file has been created and submitted along with this project. None were identified as DTONs. Two of the four features were further investigated during NOAA Ship *Thomas Jefferson*'s time in Buzzards Bay as part of field sheet F00654.
For more information on the identified features, please see the TJ report and submission of F00654. For more information on the TJ investigations, please see the Visual Report Appendix included with these data.

Latitude	Longitude	Resurveyed?
41-26-51.7002N	070-57-10.8259W	YES
41-26-58.8152N	070-57-37.8943W	YES
41-28-59.8699N	071-06-44.8600W	NO
41-25-57.5299N	071-06-33.4598W	NO

Table 4: Table of wreck locations.

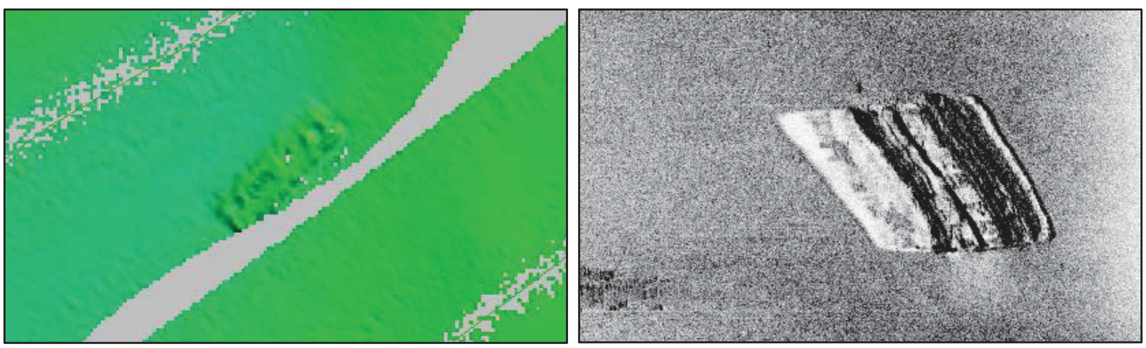

Figure 12: The left image represents the uncharted wreck in the 1m full-swath surface, and the right image is the same wreck in the CARIS side scan waterfall.

Latitude	Longitude
41-26-06.1991N	071-04-45.6031W
41-26-53.9934N	071-02-06.6379W
41-28-15.6511N	070-58-20.8603W
41-28-00.8875N	070-56-13.3944W

Table 5: Locations of charted features resurveyed by NOAA ship *Thomas Jefferson* as part of F00654

It is also recommended that presently charted features not listed in Table 5 be resurveyed for accurate and updated least depths. This is common practice for any NOAA survey and will be recommended to the USGS for future surveys.

Bottom samples were collected with these data and a surficial geology map released for the Buzzards Bay area. Both can be found in more detail in the USGS Open-File Report 2014-1220 submitted with this report.

F.3 Junction Surveys
No recent surveys performed in this area junction W00309.

F.4 Density
Within the trimmed surfaces, the W00309 survey meets the NOS density standard for complete coverage requiring 80% of all surface nodes having 5 soundings per node (Figure 13). 89.5% of all nodes in the survey have at least 5 soundings, with the majority having between 10-17 soundings.

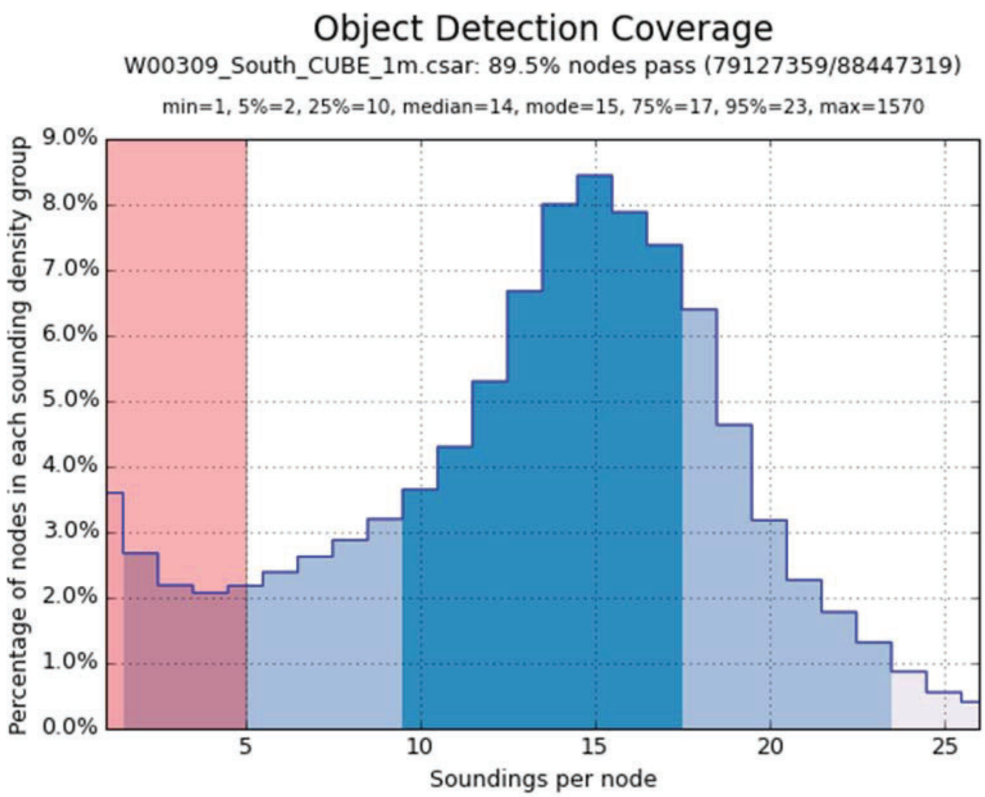

Figure 13: Graph created in PYDRO of W00309 1m CUBE surface statistics verifying 89.5% of the survey meets NOS specifications of 5 soundings per node.

Upon further inspection, it becomes clear that nodes with sounding densities that do not meet NOS standards are primarily found along the nadir gap of the trimmed swath (Figure 14). This area is expected as it is a known trouble spot for this type of sonar.

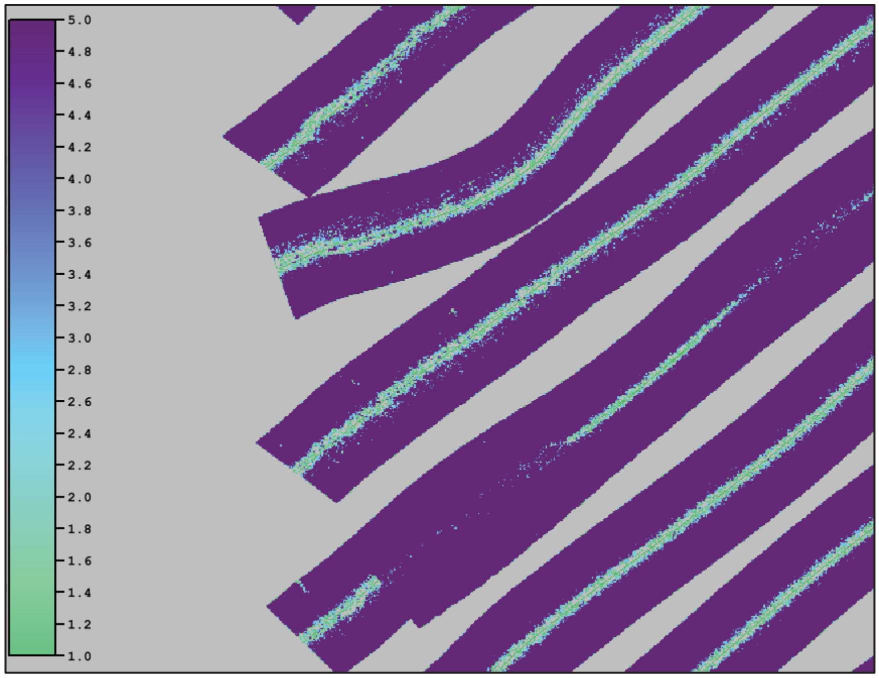

Figure 14: A closer look shows that the areas with a sounding density of less than 5 sounding per node are primarily found near the nadir gap.

F.5 KLEIN Sidescan

The KLEIN 3000 sidescan data were processed by the USGS using Xsonar and ShowImage software. The USGS created a 1m mosaic of the entire Buzzards Bay area using PCI Geomatica (Figure 15). For more information on USGS sidescan acquisition and processing, refer to the USGS Open-File Report 2012-1002 (Ackerman et al).

Initial IOCM post-processing efforts were focused on contact identification primarily north of the main channel throughout the USGS survey areas. Contacts with an estimated 1m or greater shadow height were selected for a general understanding of the area through the CARIS SIPS 9.0 sidescan waterfall. A number of significant contacts were identified from these and resurveyed during the TJ reconnaissance effort (see section F.2) for more accurate least depths.

After the TJ reconnaissance effort was completed, a more thorough analysis of the sidescan was achieved only for the W00307 survey area where contacts with 1m or greater shadow height were identified and recorded in accordance to NOS standards (see the W00307 DR Summary for more information). After the total number of contacts recorded climbed into the thousands for just the W00307 survey area, contact identification ceased and a different approach was taken for this survey. Using the 1m backscatter mosaic (published by the USGS) as a guide, areas that included significant numbers of boulders were identified and designated using the S-57 “Caution Area” feature class. These identified areas were confirmed in the SSS waterfall view. A textual description was also included in the S-57 feature attributes for each area to say something close to: “This area represents a seriously rocky area made up of a significant number of SSS contacts all with heights 1m or greater.” In W00309, 15 Caution Areas were identified.
Additionally, a significant number of sand waves and sand ripples were also identified in this survey area. A final feature file has been submitted with these data and includes all the caution areas identified through this process.

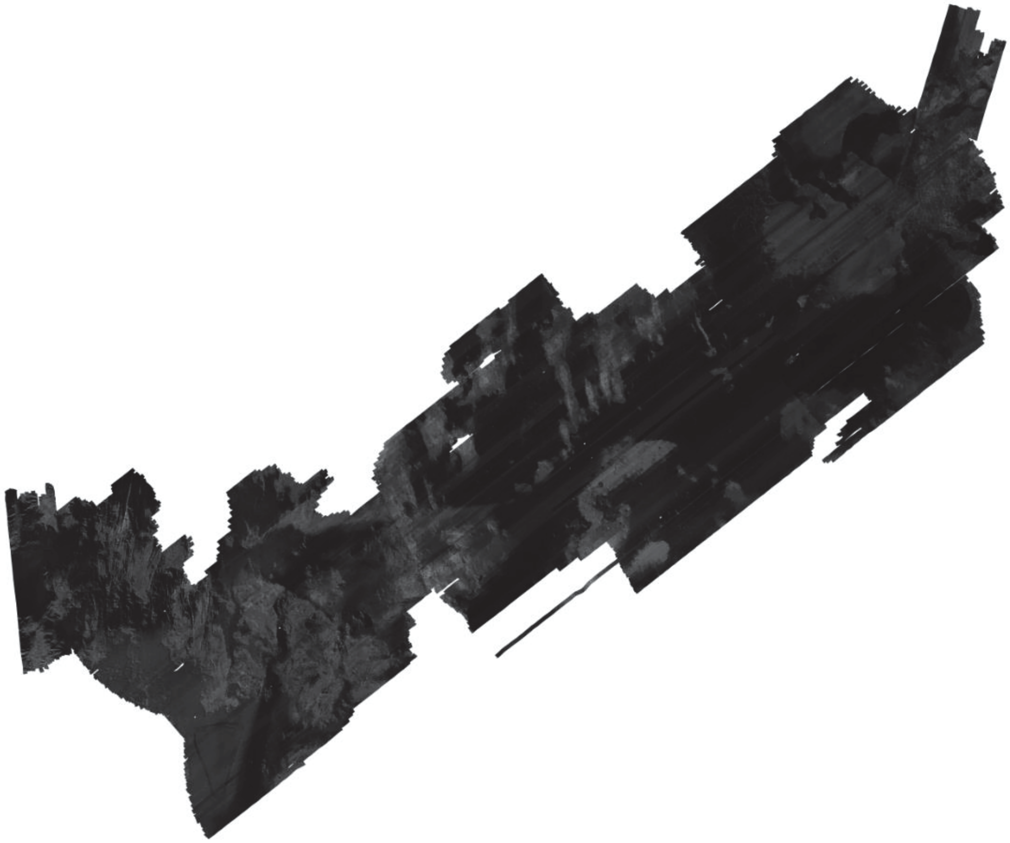

Figure 15: 1m combined sidescan mosaic of W00307, W00308, and W00309.

It is recommended that the sidescan accompanied with these data be used as much as possible to update the chart – even simply updating the amount of areas designated "rky" (Figure 16). It is also important to note that these areas are boulder fields, and that is not necessarily conveyed in the traditional use of the charted term "rky." This particular body of water has had problems in the past with tugs with tows slacking their tow lines and getting caught on these boulders. For this reason, it is suggested that a new chart designation of "rky, bldrs" be used to differentiate between rock outcrops and boulder fields.

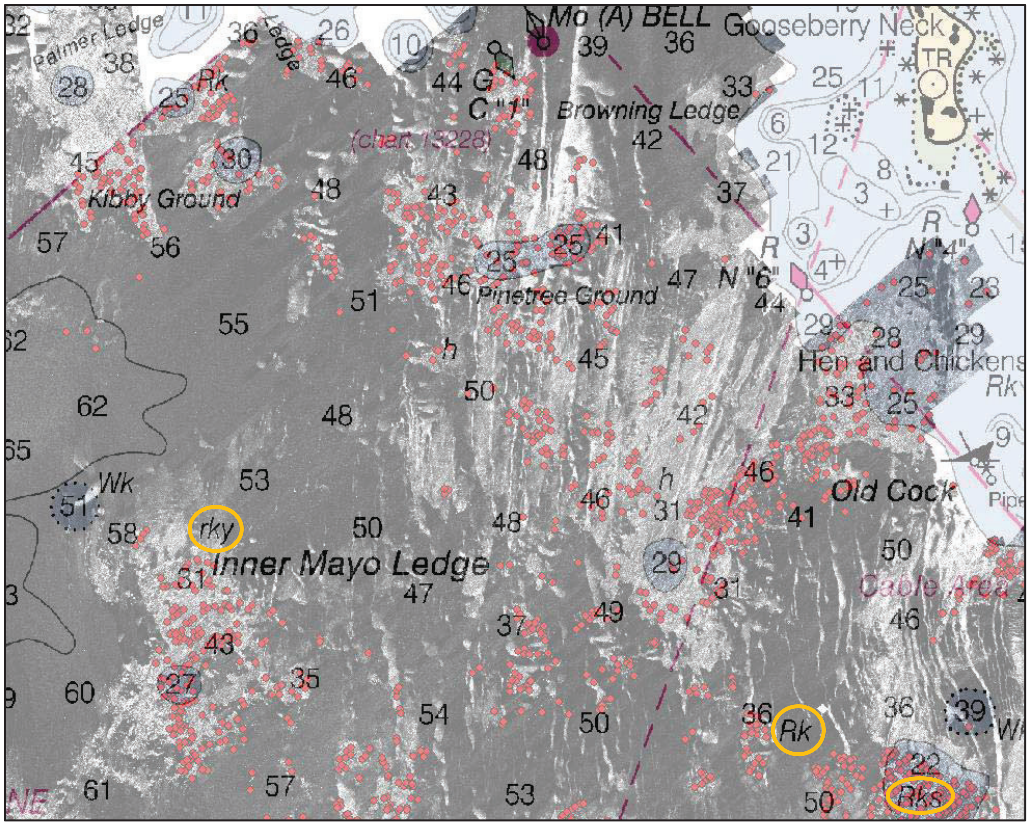

Figure 16: Close up of the Northeast corner of W00309 sidescan mosaic with contacts (>1m) in RED and the 13218 chart overlain. The YELLOW circles represent areas of the chart that are currently designated "rocky." Clearly more rocks surround this area than are designated.

G. Vertical and Horizontal Control

The vertical datum for this project is Mean Lower Low Water. Heights for these data were obtained by Real Time Kinematic Global Positioning System (RTK-GPS) and were referenced to the USGS Marine Operations Facility (MOF) in Falmouth, Mass. Revisions were communicated over a cellular modem and high frequency radio between the ship and base station. The USGS applied their own tidal model and referenced the following tidal benchmarks:

Station Name	Station ID
Chappaquoit	8447685
Monument Beach	8447355
Piney Point Wings Cove	8447416
Round Hill	8447842

To maintain consistency between the USGS interferometric and NOAA surveys, the USGS tidal model was removed upon arrival at the IOCM center. The NOAA 2015 TCARI model was applied to the CARIS HDCS data through PYDRO (E.1).

The horizontal datum for this project is World Geodetic System 1984 (WGS84) and is projected to Universal Transverse Mercator (UTM) Zone 19N. USGS horizontal positioning was acquired using a differential GPS.

For more information, please reference the USGS Open-File Report 2012-1002 (Ackerman et al).

H. Approval/Recommendations

Following IOCM processing, the survey data do not fully meet the requirements as set forth in the NOS Hydrographic Surveys and Specifications Deliverables Manual, Field Procedures Manual, Standing and Letter Instructions, and all HSD Technical Directives. However, these data are adequate to supersede charted general sounding data in their common areas. This survey requires additional least-depth investigations over identified features, shoals, and rocky areas from both this survey and prior charted surveys.

Approver Name	Approver Title	Approval Date	Signature
Andrew A. Armstrong, III	Co-Director, Joint Hydrographic Center	08/16/2016	 Digitally signed by Andrew A. Armstrong, III DN: cn=Andrew A. Armstrong, III, o=NOAA/NOS/OCS, ou=Joint Hydrographic Center, email=andy.armstrong@noaa.gov, c=US Date: 2016.08.16 16:30:59 -04'00'

Note: Because there was an observed vertical offset between the depths in this survey with the depths of F00659 (2015 survey from a verified source, the NOAA Ship Thomas Jefferson), the W00309 depths were shifted vertically by -0.675 meters, which is the mean difference in the gridded depths between the two sources. Note that depths are positive down, so the vertical shift applied to W00309 was a shoal bias. This correction was performed in accordance with the External Source Data Vertical Alignment Policy in the NOAA Office of Coast Survey.

APPROVAL PAGE

W00309

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)
- Processed survey data and records
- Geospatial PDF of survey products

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

Approved: MCGOVERN.MEGHAN.ELIZABETH.1284020495 Digitally signed by MCGOVERN.MEGHAN.ELIZABETH.1284020495 Date: 2020.02.06 09:23:58 -05'00'

Commander Meghan McGovern, NOAA
Chief, Atlantic Hydrographic Branch