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

Data Acquisition & Processing 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

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CCOM/JHC

Party Chief: Semme Dijkstra and Andrew Armstrong

Year: 2016

Version: 1

Publish Date: July 1, 2016

A. Equipment

A.1 Survey Vessels

A.1.1 R/V Gulf Surveyor

Table 1. R/V Gulf Surveyor specifications.

Name	R/V Gulf Surveyor	
Hull Number	R/V Gulf Surveyor	
Description	R/V Gulf Surveyor was designed to collect high resolution multibeam bathymetry data.	
Utilization	Survey operations	
Dimensions	*LOA*	48 feet
	Beam	17 feet
	Max Draft	55 inches
Most Recent Full Static Survey	April 26, 2016 By Doucet Survey Inc.	
Most Recent Partial Static Survey	Partial static survey was not preformed	
Most Recent Full Offset Verification	Full offset verification was not preformed	
Most Recent Partial Offset Verification	*Date*	June 6, 2016
	Method Used	Measuring tape
	Discussion	Vertical and horizontal offsets of the EM2040 location on the ram system were measured
Most Recent Static Draft Determination	*Date*	Daily
	Methods Used	Measuring tape
	Discussion	Daily draft measurements are taken before and after survey operations through the moon pool
Most Recent Dynamic Draft Determination	Dynamic draft determination was not preformed	

Length	48 feet
Beam	17 feet
Maximum draft	55 inches
Flag	U.S.
Registry	U.S. Coastwise and Registry
Top speed	10 knots
GPS antennas	Trimble Zephyr Antennas (x2)
RTK GPS receiver	Trimble 5700
Positioning and attitude	Applanix PosMV 320 with IMU 200
Data acquisition software	SIS and Hypack
Sound speed measurement	Digibar Pro
Primary Echosounder	Kongsberg EM2040

Figure 1. R/V Gulf Surveyor

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

No side scan sonars were utilized for data acquisition.

A.2.2 Multibeam Sonars

A.2.2.1 Kongsberg EM2040

Table 2. Kongsberg EM2040 MBES specifications.

Manufacturer	Kongsberg		
Model	EM 2040-07		
Description	The EM2040 pod is mounted to the R/V Gulf Surveyor's moon pool MBES ram. The TX/RX are collected to the topside PU on board. The PU is connected via Ethernet to an acquisition machine running SIS.		
Serial Numbers	*Vessel Installed On*	R/V Gulf Surveyor	
	Processor s/n	1368	
	Transceiver s/n	263	
	Transducer s/n	N/A	
	Receiver s/n	165	
	Projector 1 s/n	140	
	Projector 2 s/n	N/A	
Specifications	*Frequency*	200, 300, 400 kHz	
	Beamwidth	*Along Track*	0.5 degree
		Across Track	0.5 degree
	Max Ping Rate	50 Hz	
	Beam Spacing	*Beam Spacing Mode*	N/A
		Number of Beams	400
	Max Swath Width	140 degrees	
	Depth Resolution	26 mm	
	Depth Rating	*Manufacturer Specified*	6000 meters

		Ship Usage	1.5 meters
Manufacturer Calibrations	Manufacturer calibrations were not preformed		
System Accuracy Tests	*Vessel Installed on*	R/V Gulf Surveyor	
	Methods	BIST	
	Results	Internal self-test was performed before survey operations each day. Results were saved to text file.	
Snippets	Sonar does not have snippets logging capability		

Figure 2. Kongsberg EM2040 multibeam echo sounder.

A.2.3 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

Table 3. Lead line (boat hook) specifications.

Manufacturer	N/A
Model	N/A
Description	A boat hook was used as a makeshift lead line measurement.
Serial Numbers	N/A
Calibrations	No calibrations were performed.
Accuracy Checks	Lead line measurements were checked against MBES nadir depth measures at dock.
Correctors	Correctors were not determined.

Non-Standard Procedures	Non-standard procedures were not utilized.

Figure 3. Boat hook measurement of water level at dock.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No addition manual sounding equipment was utilized for data acquisition.

A.4 Positioning and Attitude Equipment

A.4.1 Applanix POS/MV

Table 4. Applanix POS/MV specifications.

Manufacture	Applanix	
Model	POS/MV	
Description	The Applanix POS/MV 320 v4 provides the R/V Gulf Surveyor with attitude, heading, heave, position, and velocity data. These data are utilized by the EM2040 for sonar beam steering corrections and minimization of vessel motion artifacts.	
PCS	*Manufacturer*	Applanix
	Model	320 version 5

	Description	The POS/MV computer system consists of a processor, GPS receiver, and interface cards. These elements allow the computer to process data from both the IMU and antennas.			
	Firmware Version	8.46			
	Software Version	8.46			
	Serial Numbers	Vessel Installed On		R/V Gulf Surveyor	
		PCS s/n		6921	
IMU	*Manufacturer*	Applanix			
	Model	IMU-200			
	Description	The IMU provides roll, pitch, and yaw vessel motion data to the POS computer.			
	Serial Numbers	Vessel Installed On		R/V Gulf Surveyor	
		IMU s/n		2886	
	Certification	IMU certification was not produced.			
Antennas	*Manufacturer*	Trimble			
	Model	Zephyr			
	Description	There are two GPS antennas mounted to the top of the R/V Gulf Surveyor. The port antenna is the primary antenna; the starboard antenna was utilized to improve accuracy of heading measurements.			
	Serial Numbers	Vessel Installed On	Antenna s/n	Port or Starboard	Port or Starboard
		R/V Gulf Surveyor	7756	Port	Primary
		R/V Gulf Surveyor	7766	Starboard	Secondary
GAMS Calibration	A GAMS test was run on 6/3 for verification of antenna lever arm. GAMS results were within 1 cm (GAMS: 3.67 Surveyed value :3.66)				
Configuration Report	POS/MV configuration reports were not produced.				

Figure 4. Applanix POS/MV antenna configuration.

A.4.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.4.3 Trimble Backpacks

Trimble backpack equipment was not utilized for data acquisition.

A.4.4 Laser Rangefinders

No laser rangefinders were utilized for data acquisition.

A.4.5 Other Positioning and Attitude Equipment

No addition positioning and attitude equipment was utilized for data acquisition.

A.5 Sound Speed Equipment

A.5.1 Sound Speed Profilers

A.5.1.1 CTD Profilers

No CTD profilers were utilized for data acquisition.

A.5.1.2 Sound Speed Profilers

A.5.1.2.1 Odom Digibar Pro

Table 5. Odom Digibar Pro specifications.

Manufacturer	Odom	
Model	Digibar Pro DB1200	
Description	The Digibar Pro was used to collect sound speed profiles of the water column during survey operations. The profiles were loaded into SIS.	
Serial Numbers	*Vessel Installed On*	R/V Gulf Surveyor
	Sound Speed Profiler s/n	DB98536
Calibrations	No sound speed profiler calibrations were performed.	

Figure 5. Odom Digibar Pro sound speed profiler.

A.5.2 Surface Sound Speed

A.5.2.1 Odom Digibar Pro

Table 6. Odom Digibar Pro specifications.

Manufacturer	Odom	
Model	Digibar Pro DB1200	
Description	The Digibar Pro was used to collect sound speed values at the multibeam transducer face location on the MBES ram. The Digibar Pro was connected to the SIS computer via serial port. A 60 second filter was applied to the data to remove any high frequency noise.	
Serial Numbers	*Vessel Installed On*	R/V Gulf Surveyor
	Sound Speed Profiler s/n	98139
Calibrations	No sound speed profiler calibrations were performed.	

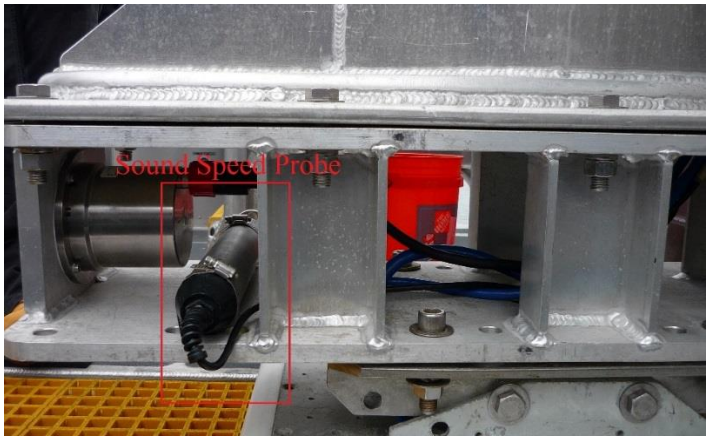

Figure 6. Odom Digibar Pro probe setup on MBES ram.

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

A.6.1.1 Base Station Equipment

Table 7. RTK Base Station specifications.

Description	An RTK base station broadcasted RTK corrections to the R/V Gulf Surveyor. The base station is permanently attached to the roof of the Seacoast Science Center at Odiorne State Park, NH.

GPS Antennas	*Manufacturer*	Trimble
	Model	Zephyr Geodetic
	Description	Base station antenna at Odiorne
	Serial Numbers	Unknown
GPS Receivers	*Manufacturer*	Trimble
	Model	5700
	Description	Odiorne Point Station is powered by A/C supply from the Science Center building. It continuously broadcasts RTK corrections via UHF radio at a frequency of 461.075 MHz. Corrections are in CMR+ format.
	Firmware Version	2.24
	Serial Number	220311827
UHF Antennas	*Manufacturer*	Trimble
	Model	24253-46
	Description	The CMR+ formatted correctors were broadcasted on UHF antennas. The antennas are able to transmit and receive at frequencies 450-470 MHz.
	Serial Number	unknown
UHF Radios	*Manufacturer*	Trimble
	Model	TrimMark 3
	Description	The modern for broadcasting corrections from the RTK base stations.
	Firmware Version	unknown
	Serial Number	unknown
Solar Panels	No solar panels were installed.	
Solar Chargers	No solar chargers were installed.	
DQA Tests	No DQA tests were performed.	

Figure 7. RTK base station at Odiorne Point.

A.6.1.2 Rover Equipment

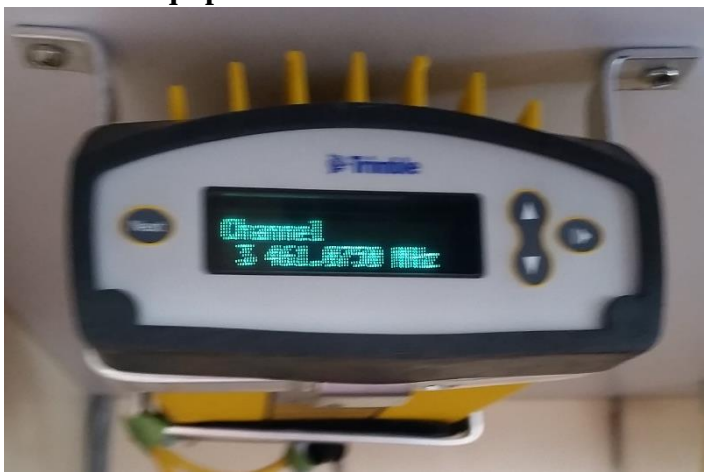

Figure 8. RTK modem aboard R/V Gulf Surveyor.

Table 8. RTK rover specifications.

UHF Radios	*Manufacturer*	Trimble	
	Model	TrimMark 3	
	Description	UHF radio transmits RTK corrections to the POS/MV system.	
	Serial Numbers	*Vessel Installed On*	R/V Gulf Surveyor
		UHF Radio s/n	JUP-9414-450
UHF Antennas	*Manufacturer*	Trimble	
	Model	24253-46	
	Description	UHF antennas receive the CMR+ correctors from the RTK base station. The antennas transmit and receive at frequencies of 450-470 MHz.	
	Serial Numbers	*Vessel Installed On*	R/V Gulf Surveyor
		UHF Radio s/n	Unknown

A.6.2 Vertical Control Equipment

A.6.2.1 Water Level Gauges

Table 9. WaterLog tide gauge specifications.

Manufacturer	WaterLog
Model	H-3611
Description	A radar water height sensor measured real-time tides in Rye Harbor, NH
Serial Numbers	CVJ1816HWPL2
Calibrations	No calibrations were preformed

Figure 9. Tide gauge box with radar unit and computer.

A.6.2.2 Leveling Equipment

Table 10. Carl Zeiss automatic leveling system specifications.

Manufacturer	Carl Zeiss
Model	NI2 Automatic Level
Description	The NI2 automatic level was used to measure offsets from the installed tide gauge and two benchmarks in the Rye Harbor vicinity.
Serial Numbers	JHC 0016S

Calibrations	No calibrations were performed.	
Kukkamaki	*Level s/n*	N/A
	Date	6/14/16
	Procedure	A Kukkamaki test was conducted using standard practices outlined in the NOAA form 75-29: Kukkamaki. A 0.011 mm/m value was found. This meets the NOAA manual NOS NGS-3 Geodetic Leveling specifications of within +/-0.05 mm/m.

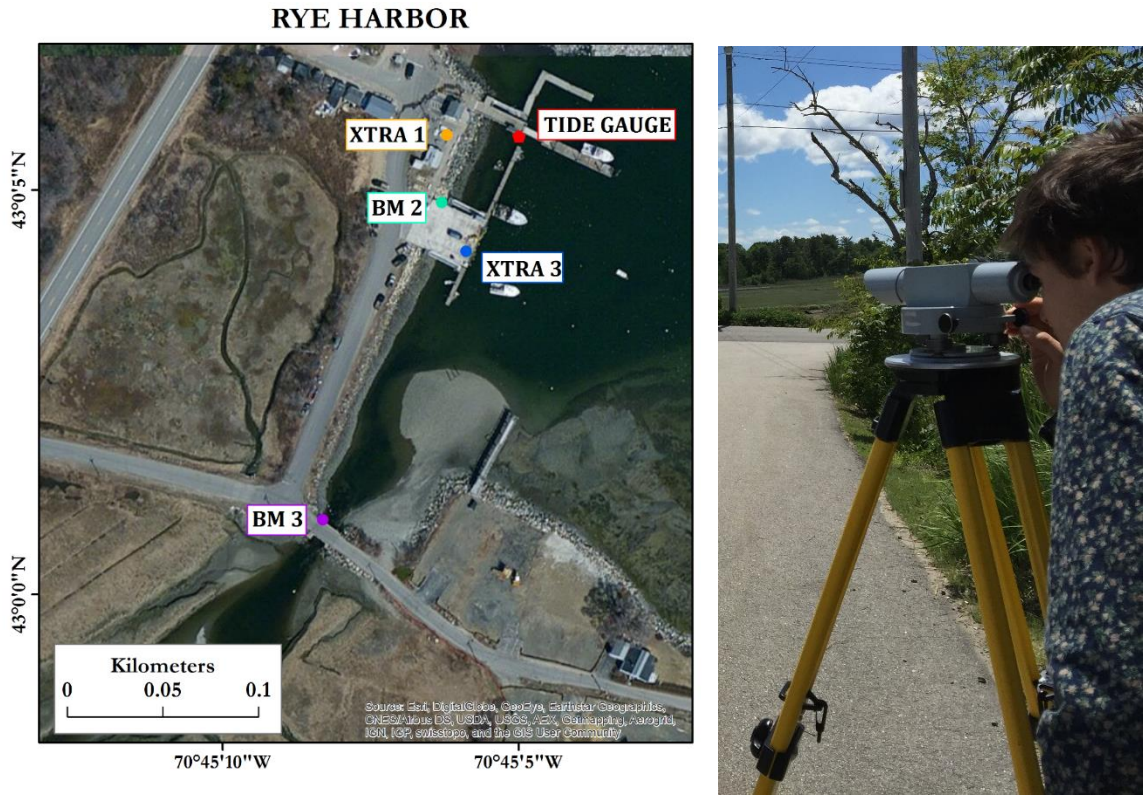

Figure 10. Location of gauge and benchmarks at Rye Harbor. NI2 automatic level (right).

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

No computer hardware was utilized for data acquisition.

A.7.2 Computer Software

Table 11. SIS multibeam collection software specifications.

Manufacturer	Kongsberg
Software Name	SIS
Version	4.3.2, build 31
Service Pack	N/A
Hotfix	N/A
Installation Date	June 4, 2016
Use	MBES acquisition and processing

Description	SIS was utilized for real-time acquisition of multibeam data during survey operations. Water line, vessel offsets, and sound speed values were processed and applied in real time to MBES data in SIS.

Table 12. Hypack navigational software specifications.

Manufacturer	Hypack Inc
Software Name	Hypack 2016
Version	16.0.1.0
Service Pack	N/A
Hotfix	N/A
Installation Date	March 25, 2016
Use	Navigation
Description	Hypack was utilized for line planning and visualization during survey operations (both for survey team and captain). No data was collected via Hypack.

Table 13. Applanix positioning and motion software specifications.

Manufacturer	Applanix
Software Name	POSView
Version	8.15
Service Pack	N/A
Hotfix	N/A
Installation Date	June 2, 2016
Use	Acquisition
Description	POSView was utilized to monitor and collect position and attitude data during survey operations.

Table 14. QPS data processing software specifications.

Manufacturer	QPS
Software Name	Qimera
Version	1.2.4.429
Service Pack	N/A
Hotfix	N/A
Installation Date	June 7, 2016
Use	Processing
Description	Qimera was utilized to process, clean, and analyze data collected during survey operations.

Table 14. QPS data processing software specifications.

Manufacturer	CARIS
Software Name	CARIS HIPS and SIPS
Version	9.1.2
Service Pack	N/A
Hotfix	N/A
Installation Date	April 22, 2016

Use	Processing
Description	CARIS HIPS and SIPS was utilized to process, clean, and analyze data collected during survey operations.

A.8 Bottom Sampling Equipment

A.8.1 Bottom Sampling Equipment

A.8.1.1 Wildco Shipek grab sampler

Table 15. Ponar Dredge specifications.

Manufacturer	WILDCO®
Model	SHIPEK® grab sampler (P/N 860-A10, S/N 3710)
Description	The Shipek sampler is designed for sampling unconsolidated sediments from soft ooze to hard packed sand. The sole driving force is the Shipek's® weight, which totals over 130 pounds with the trip weight. The body itself weights about 40 kg (85 pounds) which is augmented by the trip weight 22 kg (48 lbs), which is securely fastened by two (2) side pins.

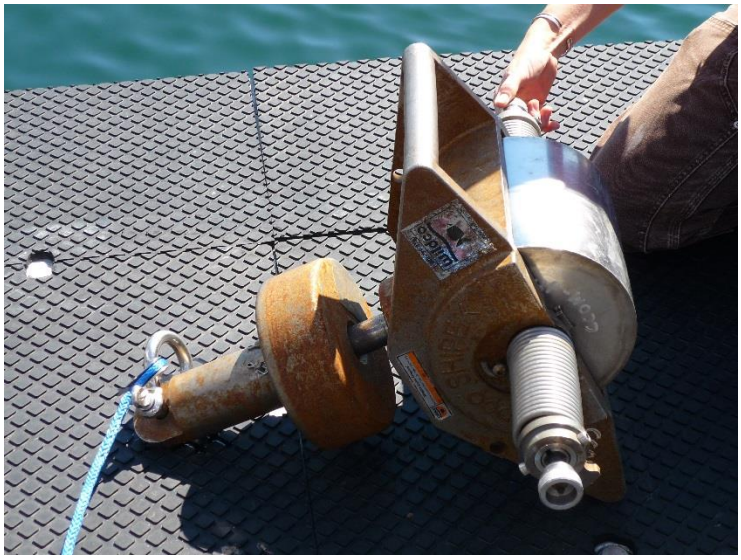

Figure 11. Wildco Shipek grab sampler.

A.8.1.2 Drop Camera System

Table 16. Drop camera specifications.

Manufacturer	Paul Lavoie (designed and constructed cage), Ocean Systems (camera)
Model	Delta Vision Industrial HD Underwater Video Camera
Description	The drop camera system provides *in situ* information of the benthic environment being mapping. This facilitates the linking of bathymetric surface characteristics (rugosity, slope, etc.), backscatter measurements, and physical characteristics (vegetation, sediment type, etc.) of the sample site.

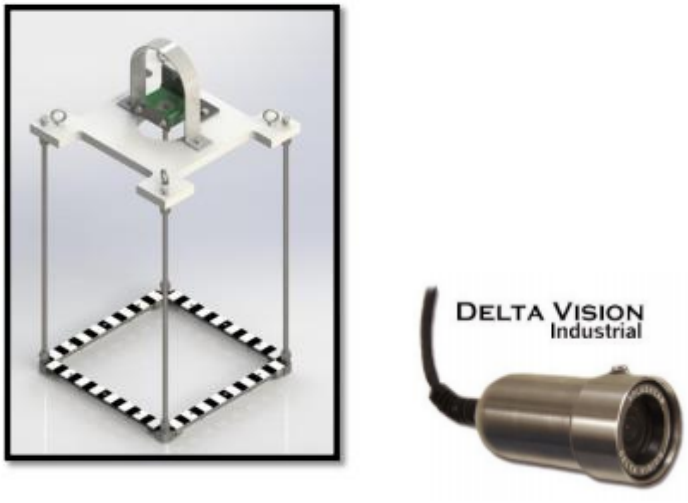

Figure 12. Drop camera cage (left) and camera (right)

B. Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

The Kongsberg EM2040-07 multibeam echosounder was run during all survey operations. It was run in normal operations mode with a frequency of 400 kHz. The pulse type was a short CW (70 microseconds) pulse.

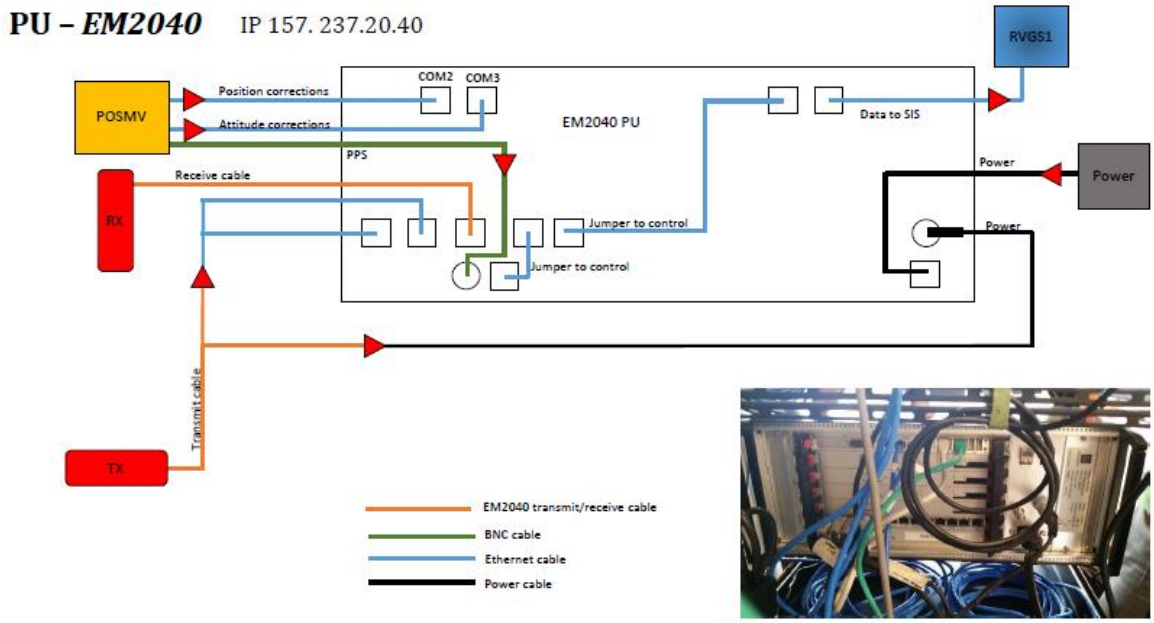

Figure 13. EM2040 MBES wiring diagram from R/V Gulf Surveyor.

B.1.1.2 Single Beam Echosounder

Single beam echosounder data was not acquired.

B.1.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar data was not acquired.

B.1.2 Imagery

B.1.2.1 Single Beam Echosounder

Side scan sonar imagery was not acquired.

B.1.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

B.1.3 Sound Speed

B.1.3.1 Sound Speed Profiles

Sound speed profiles were collected with the Digibar Pro during survey operations. A sound speed probe connected to the data measurement unit was lowered over the side of the R/V Gulf Surveyor. The probe is lowered to a calibration mark, which indicates the depth of the transducer, then data recording is started. The probe is lowered to the seafloor at approximately 1 m/s. The probe is brought back to the surface, data recording is stopped, and the measurement unit is connected to the SIS computer via serial cable to download and apply collected data.

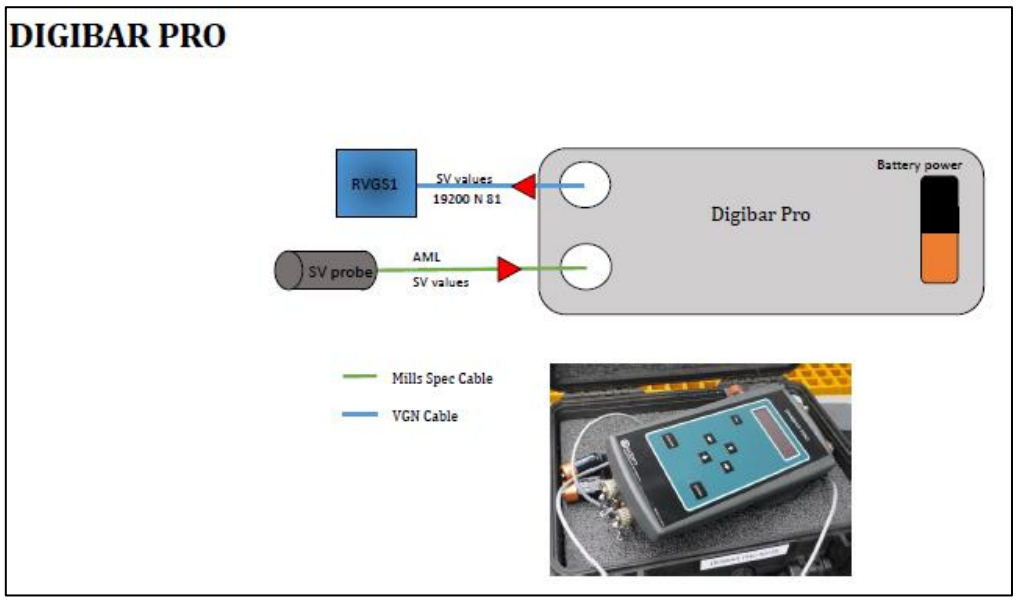

Figure 14. Odom Digibar Pro wiring diagram from R/V Gulf Surveyor.

B.1.3.1 Surface Sound Speed

Surface sound speed at the transducer head was collected by a Digibar Pro probe during survey operations. The probe was connected to the data measurement unit on-board, which was connect to the SIS computer via serial cable. The device measured sound speed at a rate of 1 Hz.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

Horizontal control data was not acquired.

B.1.4.2 Vertical Control

Vertical control data was not acquired.

B.1.5 Feature Verification

Feature verification data were not acquired.

B.1.6 Bottom Sampling

Bottom samples were collected on the *R/V Gulf Surveyor* on June 30, 2016. Station locations (Fig. 15) were preliminary chosen based on the bathymetric and backscatter data from the multibeam survey. At the chosen sites, underwater video images were recorded, and where possible, bottom sediment samples were collected. Video imaging was performed using the Delta Vision Industrial HD Underwater Video Camera (A.8.1.2) mounted in the cage. The cage system was put overboard using an isolated wire. Sediment sampling was performed at chosen locations (avoiding rocky sea floor) using a WILDCO® SHIPEK® grab sampler (A.8.1.1). Collected samples were visually described and photographed. Results are described in the Geological sampling_report.pdf (Field reports).

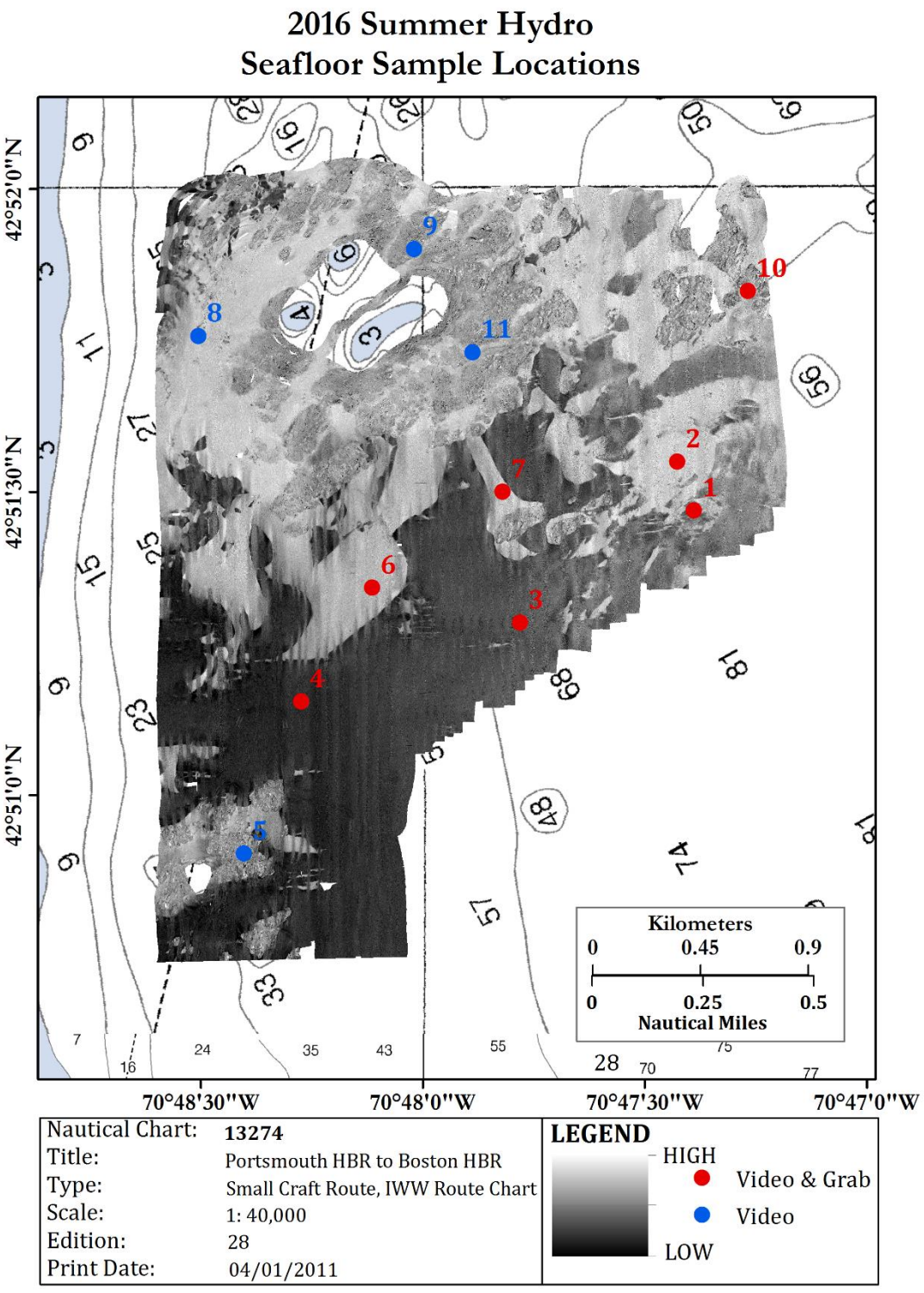

Figure 15. Grab and video sample locations.

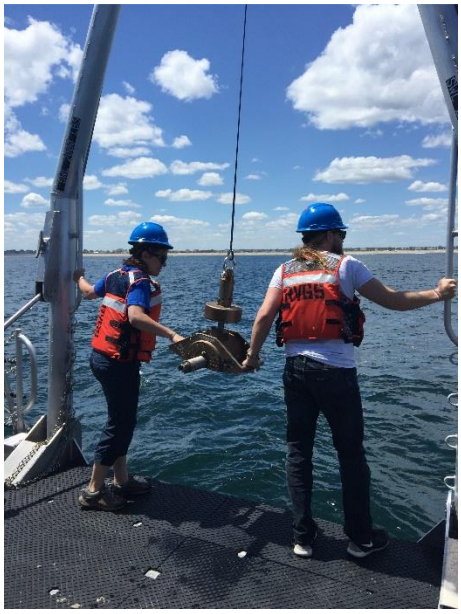

Figure 16. BELS group deploying the grab sampler from the R/V Gulf Surveyor.

B.1.7 Backscatter

Backscatter was collected utilizing the EM2040 echo sounder concurrently with the multibeam data. Backscatter data was recorded in the .all file format. Backscatter data was recorded continuously during survey operations but turn and transit data was not utilized in the final mosaic.

B.1.8 Other

Lead lines were collected at the dock for quality control purposes. Lead lines were taken in line with the MBES ram for direct comparison between MBES depth reading and lead line value.

B.2 Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

During acquisition the multibeam .all files were logged on the SIS multibeam acquisition computer. The .all files include both multibeam and backscatter data, as well as attitude, navigation and position data from the POS/MV. POS/MV binary navigation files (.000 format) were also logged during all survey operations. In the survey area the multibeam was run in normal mode, at 400 kHz, with a short CW pulse. The swath angle was set to 140º for all survey operations. Multibeam coverage was monitored in Hypack in real-time and during survey operations collected data was loaded into CARIS HIPS and SIPS to check for data holidays and any systematic errors.

Multibeam .all files and POS/MV binary navigation files were copied to an external hard drive at the end of each survey, brought back to the office, and copied onto a network location.

CARIS HIPS and SIPS was utilized to process all multibeam data. Multibeam .all files were imported into CARIS HIPS and SIPS and referenced to the NAD83(2011) ellipsoid with gps heights. Lever arm offset of the POS/MV and EM2040 were checked in the vessel editor menu. Patch test angular offsets and TPU values were entered for each day of survey data.

Due to navigational data drop outs, the binary navigation file (.000 format) recorded in PosView and edited (.sbets) were imported into CARIS. In the data processing settings menu the binary navigation data was set as the main position file and the sound velocity strategy was set to the "Nearest in Time" methodology.

The data was gridded at 0.5 and 1.0 meter resolution, with Shallow Water CUBE settings to increases the likelihood separate hypothesis creation for outer beams. Once the data was gridded a CUBE filter, based on IHO Order 1 Depth Uncertainty was applied. The resulting surface was exported.

B.2.1.2 Single Beam Echosounder

Single beam echosounder data was not processed.

B.2.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not processed.

B.2.1.4 Specific Data Processing Methods

B.2.1.4.1 Methods Used to Maintain Data Integrity

Acquisition and processing logs were reviewed for each day of data to ensure the correct lever arms, angular offsets, and other correctors were applied during collection or in post processing. Vessel configuration files for each day were updated upon data import. Dynamic line spacing was run in order to ensure complete coverage of the survey area. In instances of data holidays, fill lines were run.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

Methods follow the specifications laid out in the NOS Hydrographic Surveys Specifications and Deliverables (May 2015) from NOAA.

B.2.1.4.3 Methods Used to Derive Final Depths

Final depths were derived via CUBE gridding parameters in CARIS

Table 17. Gridding specifications.

Methods Used	Gridding parameters
	Surface computation algorithms
Description	NOS Hydrographic Surveys Specifications and Deliverables, May 2015

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

Side scan sonar imagery was not processed.

B.2.2.2 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar was not processed.

B.2.2.3 Specific Data Processing Methods

B.2.2.3.1 Methods Used to Maintain Data Integrity

Acquisition and processing logs were maintained on a daily basis. Any problems with specific data sets were communicated through these logs from the survey vessel to the post-processing in the office.

B.2.2.3.2 Methods Used to Achieve Object Detection and Accuracy Requirements

There were no specific object detection or accuracy requirements for imagery.

B.2.2.3.3 Methods Used to Verify Swath Coverage

Real time swath coverage was monitored in SIS during data acquisition. Outer beams were also monitored in the SIS across track window for any refraction artifacts.

B.2.2.3.4 Criteria Used for Contact Selection

No contacts were selected for the survey area.

B.2.2.3.5 Compression Methods Used for Reviewing Imagery

No compression methods were used to review imagery.

B.2.3 Sound Speed

B.2.3.1 Sound Speed Profiles

Sound speed at the MBES head was collected in real-time by the Digibar Pro probe and applied in SIS for beam steering corrections. Sound speed profiles were collected at least twice a day with the Digibar Pro (Figure 14), converted to an .asvp file format, and loaded into SIS for sound speed corrections.

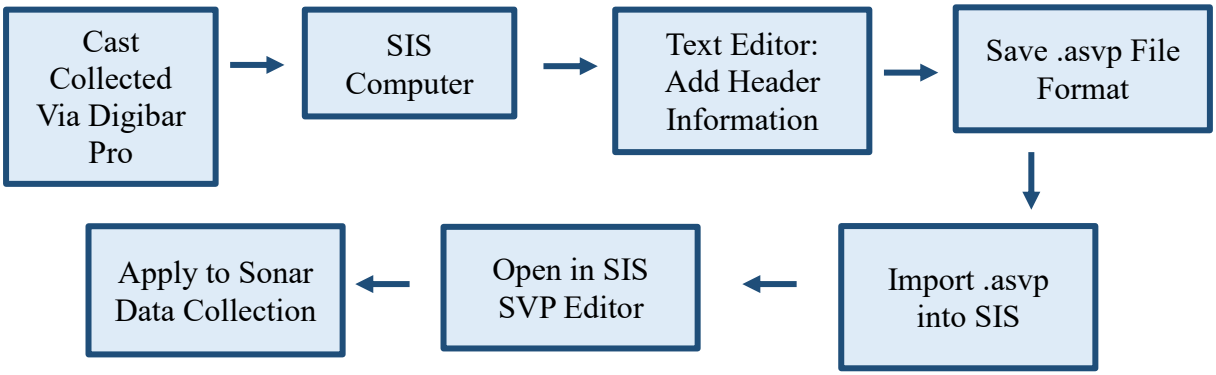

Figure 17. Sound speed profile application methodology.

B.2.3.2 Surface Sound Speed

Surface sound speed data was smoothed with a 60 second average filter to remove data spikes.

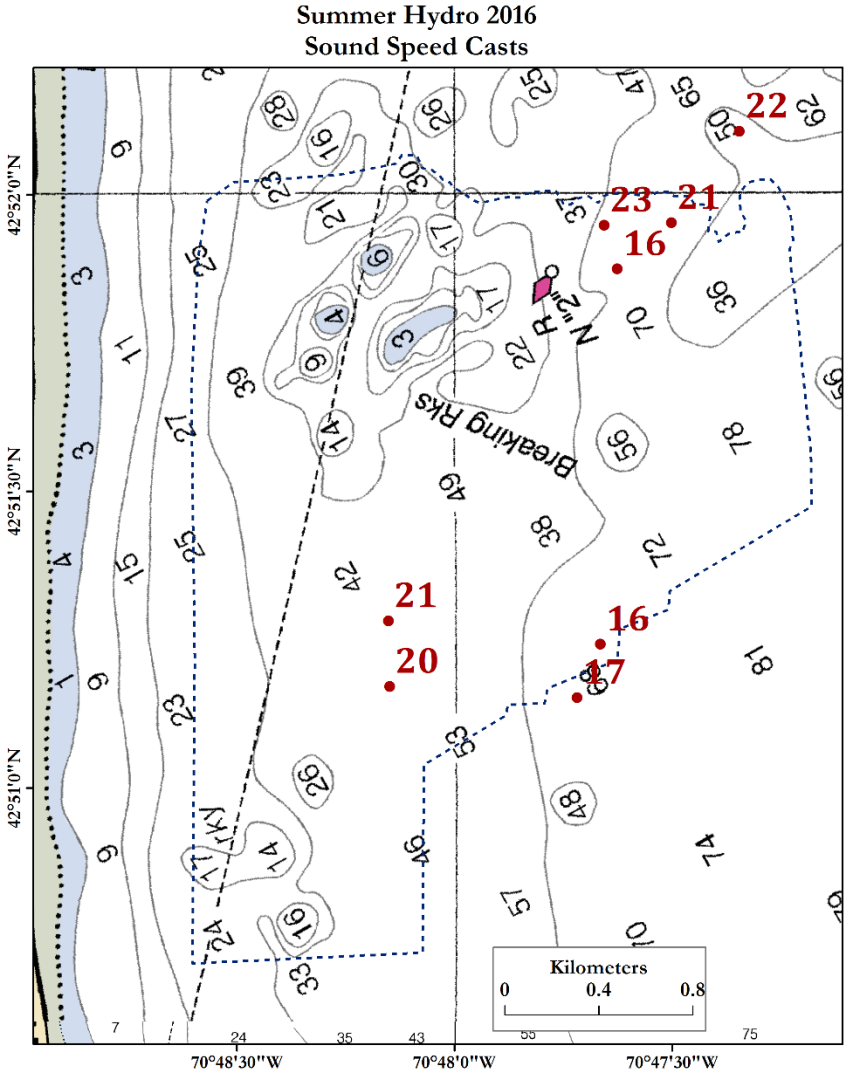

Figure 18. Sound speed cast locations for Summer Hydrography 2016, number labels refer to collection day.

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal and Vertical Control

Horizontal control data were not processed.

B.2.4.2 Horizontal and Vertical Control

Vertical control data were not processed.

B.2.5 Feature Verification

Feature verification data were not processed.

B.2.6 Backscatter

Backscatter data was logged with the multibeam data on the SIS acquisition machine (.all format). The .all files are then imported into QPS FM Geocoder version 7.5.2. The backscatter mosaic was gridded at 0.5 meter resolution and was exported as a geotiff file.

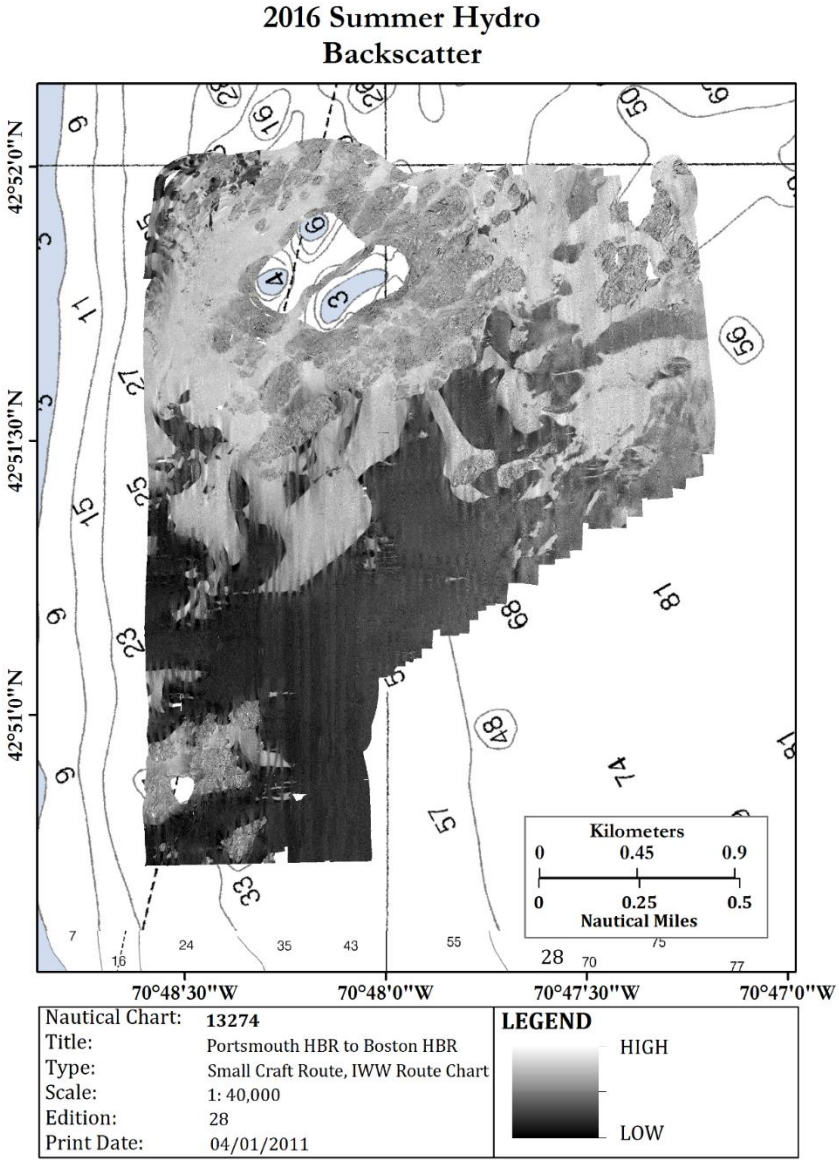

Figure 19. Final backscatter mosaic gridded at 0.5 meters.

B.2.7 Other

No additional data were processed.

B.3 Quality Management

During survey operations multibeam data quality control was executed in real-time. Collected .all files were transferred immediately to a processing laptop and loaded into a CARIS HIPS field processing project. The lines were converted to HCDS files, and a surface was generated to compare pre-existing data (crosslines) for any systematic errors.

At the end of survey each day in the office the collected .all files were transferred to a network location. On processing data the files were converted to an ellipsoidally referenced surface (NAD83) with the binary navigation data, filtered, cleaned and added to the final surface.

Data acquisition and data processing logs were also kept up-to-date on board and in the office.

B.4 Uncertainty and Error Management

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU calculation method

TPU values were calculated in Qimera.

B.4.1.2 Source of TPU values

TPU values were provided by Qimera (based on equipment specifications sheets), field data, and expert advice.

B.4.1.2 TPU values

Table 18. TPU values from Qimera.

Vessel	R/V Gulf Surveyor			
Echosounder	Kongsberg EM2040			
TPU Standard Deviation Values	*EM2040*	*Echosounder*	*Pulse Length*	0.200 ms
			Sampling Length	0.050 m
		Offsets	*Roll*	0.05
			Pitch	0.05
			Heading	0.05
		Sound Velocity	*Surface Sound Speed*	0.03 m/s
		Stabilization	*Roll stabilization*	0.00 m
			Pitch stabilization	0.00 m
			Heave compensation	0.00 m
			Pitch offset	0.05
			Heading offset	0.05
	POS/MV	*Motion*	*Roll*	0.01º
			Pitch	0.01º
			Heading	0.01º
			Heave Fixed	0.05 m
			Heave Variable	5%
			Roll Offset	0.05º
			Pitch Offset	0.05º
			Heading Offset	0.05º
		Position	*Horizontal*	0.01 m
			Vertical	0.017 m
	Patch Test		*Roll*	0.0274º
			Pitch	0.031º
			Heading	0.067º
			Latency	0.0 seconds

B.4.2 Deviations

There were no deviations from the requirement to compute total propagated uncertainty.

C. Corrections to Echosoundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

The R/V Gulf Surveyor was survey at dry dock by Doucet Survey Inc. on April 26, 2016. Final coordinates were delivered to CCOM on June 3, 2016. A reference point in the main cabin was established. Lever arm measurements (x, y, and z) for the MBES TX and RX, IMU, and Antennas were established in reference to this point.

C.1.1.2 Methods and Procedures

Doucet Survey Inc. survey in 13 total benchmarks on the R/V Gulf Surveyor on April 26, 2016. Precision survey equipment such as theodolites, laser range finders, total stations and optical levels were utilized to determine the location of vessel benchmarks.

C.1.1.3 Vessel Offset Correctors

Table 19. Vessel offsets entered into SIS and PosView.

Vessel	R/V Gulf Surveyor		
Echosounder	EM2040		
Date	April 26, 2016 (initial survey)		
	June 3, 2016 (final coordinates		
	June 6, 2016 (MBES ram offsets)		
Offset	Reference Point to IMU (m)	X	-1.673
		Y	+0.018
		Z	+1.944
	Reference Point to MBES TX (m)	X	-1.376
		Y	+0.218
		Z	+2.289
	Reference Point to MBES RX (m)	X	-1.274
		Y	-0.080
		Z	+2.289
	Reference Point to Primary Antenna	X	3.320
		Y	-1.845
		Z	-4.319
	Primary Antenna to Secondary Antenna	Y	+3.665

C.1.2 Layback

Layback corrections were not applied.

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Daily water level measurement at dock.

C.2.1.2 Methods and Procedures

Static draft was measured at the beginning of each survey day at the dock. The height of the waterline relative to the MBES ram grating was measured. This was added to the known distance to the ship reference point for a static draft measurement.

C.2.2 Dynamic Draft

No dynamic draft corrections were applied to the data.

C.3 System Alignment

C.3.1 Description of Corrector

Patch test

C.3.2 Methods and Procedures

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). The patch test lines are described in the figure below. Offsets were determined utilizing the CARIS patch test processing program. Offsets were applied in post processing to the data.

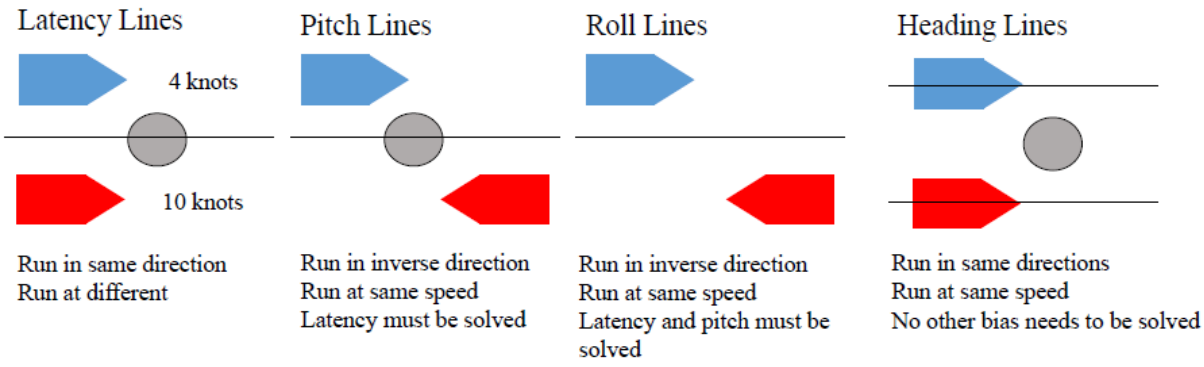

Figure 20. Patch test set up for single head MBES system.

C.3.3 System Alignment Correctors

Table 20. EM2040 alignment correctors from patch test used in post processing.

Vessel	R/V Coast Surveyor	
Echosounder	EM2040	
Date	June 7, 2016	
Patch Test Values	*Latency*	0 seconds
	Pitch	-1.175 degrees
	Roll	0.107 degrees
	Yaw	0.043 degrees

C.4 Positioning and Attitude

C.4.1 Description of Correctors

RTK corrections are transmitted via UHF radio at 4800 bps using TT450S Trimtalk protocol. They are provided in CMR+ format as 8 bit, 1 stop bit, None Parity corrections with a 35W signal.

C.4.2 Methods and Procedures

RTK correction data was collected from the GNSS base station established at Odiorne State Park. RTK corrections in CMR+ format were broadcast from the roof of the Seacoast Science Center from a Trimble Trimmark 3 radio Modem.

C.5 Tides and Water Levels

No tide or water level correctors were applied.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

Sound speed profiles were applied to the data during survey operations in SIS and reapplied in post processing in Qimera using closest in time methodology.

C.6.1.2 Methods and Procedures

Sound speed profiles were collected by deploying the Digibar Pro probe over the side of the vessel. The collect cast was loaded into SIS for real-time ray tracing calculations. In Qimera post-processing sound speed profiles were applied to the multibeam data based on “Nearest in Time” methodology.

C.6. Surface Sound Speed

C.6.2.1 Description of Correctors

Surface sound speed correctors were applied to data in SIS.

C.6.2.2 Methods and Procedures

Surface sound speed measurements were made by the Digibar Pro probe located at the MBES head. Measurements were logged in SIS in real-time at a rate of 1 Hz. A 60 second smoothing filter was applied to the data in SIS to get rid of data spikes.