University of New Hampshire

DATA ACQUISITION AND PROCESSING REPORT

Summer Hydro 2017

Gulf of Maine Survey

CCOM/JHC, UNH

Party Chief: Semme Dijkstra and Andy Armstrong

Group Members:

Masanao Sumiyoshi	Sattiabaruth Seeboruth
Jose M. Cordero Ros	Mohamed Eisaied
Tinah Martin	Daniel Tauriello
Pichet Puahengsup	Cassandra Bongiovanni
Michael Smith	Kevin Rychert
Coral Moreno	Ivan Ryzhov

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A. Equipment

A.1 Vessels

A.1.1 R/V Gulf Surveyor

Figure 1: The R/V Gulf Surveyor from bow and stern

The R/V Gulf Surveyor (Figure 1) is UNH CCOM's 48-foot hydrographic research vessel built in 2015. This vessel is a propeller powered catamaran outfitted with a strut-mounted Kongsberg EM2040 and a stern-mounted Rolls-Royce MVP30. The vessel reference frame is: +x bow forward, +y to starboard, and +z down. All points in the vessel reference frame are referenced to the reference point (0, 0, 0) which is located at the top of the bolt on the plate that the IMU is mounted on.

A.1.2 Vessel Data Flow

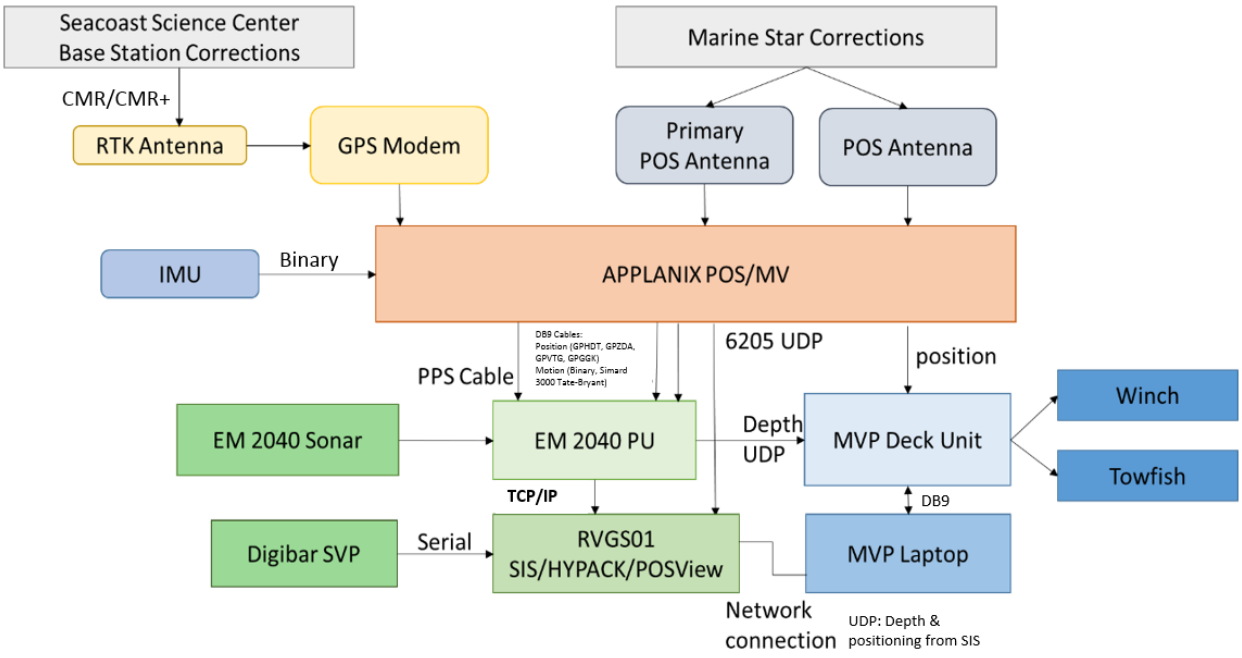


Figure 2: R/V Gulf Surveyor data flow and connections

The Applanix PosMV was utilized for primary positon and motion compensation. Real-time RTK GPS corrections from the Seacoast Science Center base station were streamed via RS232 communication with the Trimble Trimark modem. Secondary positioning corrections were streamed via the PosMV antennas from Fugro's MarineStar Positioning Service.

The POSM/V transmits tightly coupled positioning and motion solutions via RS232 to the EM 2040 processing unit, along with a one pulse per second timing signal. From the EM 2040 PU the full sonar solution is sent to the RVGS-01 workstation via a TCP/IP connection.

Sound speed corrections come from two profiling instruments; a Digibar Pro, and the AML MVP30. Cast data is uploaded to the workstation computers via RS232. The MVP30 compiles cast data on the system's winch and fish for transmission via RS232 from the deck box to the laptop running MVP Controller software. In turn, the RVGS-01 workstation sends depth and navigation data to the MVP Controller software via UDP.

A.2 Depth Measurement Equipment

A.2.1 Kongsberg Simrad EM2040 Multibeam Echosounder

Figure 3: EM2040 installation on strut

The EM2040 was installed on the stern strut aboard the R/V Gulf Surveyor. Fully extended, EM2040 sits ~2m below the vessel reference point. The EM2040 is a high resolution multibeam echosounder with dual swath, frequency-modulated (FM) or continuous wave (CW), and three-sector angular coverage capabilities. The system is of modular design which allows for customization of beam widths and coverage for specific

surveys. The sonar has a ping rate of at least 50Hz and relies on the processing unit (PU) for beam forming and bottom detection. An AML sound speed probe (see Section A.5.2) is used for real-time sound speed at the transducer head. Kongsberg Seafloor Information Systems (SIS) is used to monitor data quality and incorporate complete sound speed profiles during acquisition (see section A.6.3).

This system was mounted backwards and the vessel files will note a receiver heading offset of 180 degrees. Additional details will be provided in later sections.

Instrument	Kongsberg EM 2040			
Manufacturer	Kongsberg			
Serial Number	Transmitter	143	Receiver	165
Runtime Specs	Bathymetric Sonar			
	Mounted	RVGS Strut		
	Frequency	300 kHz		
	Ping Rate	50 Hz		
	Swath Width	140^{o}		
	Yaw Stabilized	OFF		
	Pitch Stabilized	ON		
	Pulse Type	CW		
	Sector Mode	Normal		
	Beam Spacing	Equidistance		
	Max Coverage	1000m		

Table 1: EM2040 Specifications

A.3.1 Applanix POS/MV

Figure 4: Applanix POS/MV in RVGS systems rack in main cabin.

The R/V Gulf Surveyor is configured with an Applanix POS/MV 320 to determine the positioning and orientation of the Kongsberg EM2040 during acquisition. The Applanix POS/MV PU is located in the main cabin of the RVGS about ~1m above the vessel RP in the systems rack. The Inertial Motion Unit (IMU) is located just above the EM2040 on its

side in the strut. All configuration settings for the Applanix and Kongsberg systems are included in the MBES Report submitted with this document.

Instrument	POS/MV 320		
Manufacturer	Applanix		
Serial Number	6921		
Description	The Applanix POS/MV 320 records attitude, heading, heave and position data. These data are utilized by the EM 2040 for sonar beam steering corrections.		
PCS	Manufacturer	Applanix	
	Model	320	
	Description	The POS/MV system is the combination of a processing unit, IMU and GPS receiver antennas. The processing unit process the IMU and GPS data.	
	Firmware	9.12	
	Software version	9.12	
	Serial Number	6921	
IMU	Manufacturer	Applanix	
	Model	IMU - 200	
	Description	The IMU provides roll, pitch and yaw vessel motion data to the POS computer	
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 and the starboard antenna was utilized to improve accuracy of the heading measurements	
	Serial Numbers	Port side	7756
		Starboard side	7756

Table 2: Applanix Pos M/V specifications

A.3.3 Trimble Trimmark 3

Figure 5: (top) GPS antennas (red circles) on RVGS top platform. (bottom) Trimble Receiver Modem inside main cabin above system rack.

The GPS antennas are secured atop the RVGS approximately 3.74m apart. The port side antenna is the primary antenna. These antennas receive RTK corrections from the base station at the Seacoast Science Center at Odiorne Point State Park, NH. These corrections are then applied to the Trimble Trimmark 3 Radio Modem GPS locations. The Trimmark 3 is outfitted to the RVGS inside the main cabin above the main systems rack and ~2 m above the vessel RP. The Trimmark 3 provides these corrections to the POS/MV.

Instrument	Trimble Trimmark 3		
Manufacturer	Trimble		
Serial Number	JUP-94141-450		
Description	Used to establish a wireless data broadcast network for real-time GPS survey and telemetry applications. A single unit is able to be used as a base station and can support up to two rovers.		
Radio Modem Settings	Line of Sight	15km	
	Channel	3	
	Transmit Power	2W, 10W, 25W	
	Frequency	461 MHz	
	Data Output	9600 baud rate	
	Range	10-12 km (for 25W), 5-8 km (for 2W)	
Antenna	Manufacturer	Trimble	
	Model	24253-46	
	Serial Number	UHF Radio	Unknown

Table 3: Trimble Trimmark 3 Specifications

A.5 Sound Speed Equipment

A.5.1 Rolls-Royce MVP30

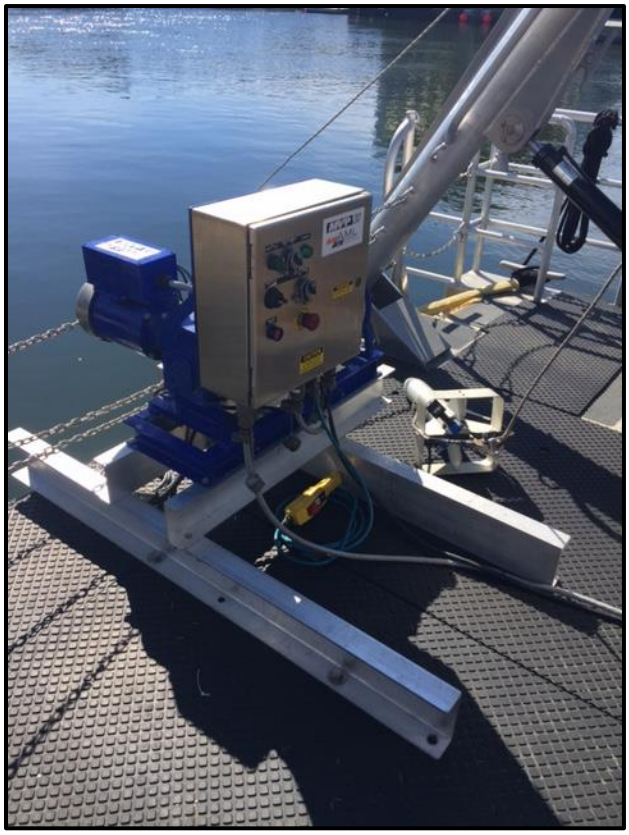


Figure 6: MVP-30 stern-mounted on RVGS

The Rolls-Royce Moving Vessel Profiler (MVP) is stern deck mounted (Figure 7). The MVP30 is designed to collected a sound speed profile while the vessel is moving, thus eliminating the need to stop surveying. Profiles collected from this system will be integrated into acquisition software (SIS and Discover) upon collection.

Instrument	Rolls-Royce MVP30	
Manufacturer	Rolls-Royce	
Serial Number	10285	
Description	MVP stands for Moving Vessel Profiler and is used to collect sound speed data while underway, thus eliminating the need to stop and take a profile. Determines conductivity, temperature, and pressure (depth) during each profile.	
Specifications	Speeds	0-12 knots
	Depths	125-30m (respective to speeds)
	Cycle Time	2.6-1.6 minutes (respective to speeds)

	Conductivity Range	0-70 mS/cm
	Conductivity Accuracy	+/- 0.01 mS/cm
	Temperature Range	-2 to 32°C
	Temperature Accuracy	+/- 0.005°C
	Depth Range	Various to 6000m
	Depth Accuracy	+/- 0.05% of full scale

Table 4: MVP specifications

A.5.2 AML Oceanographic Smart SV&P

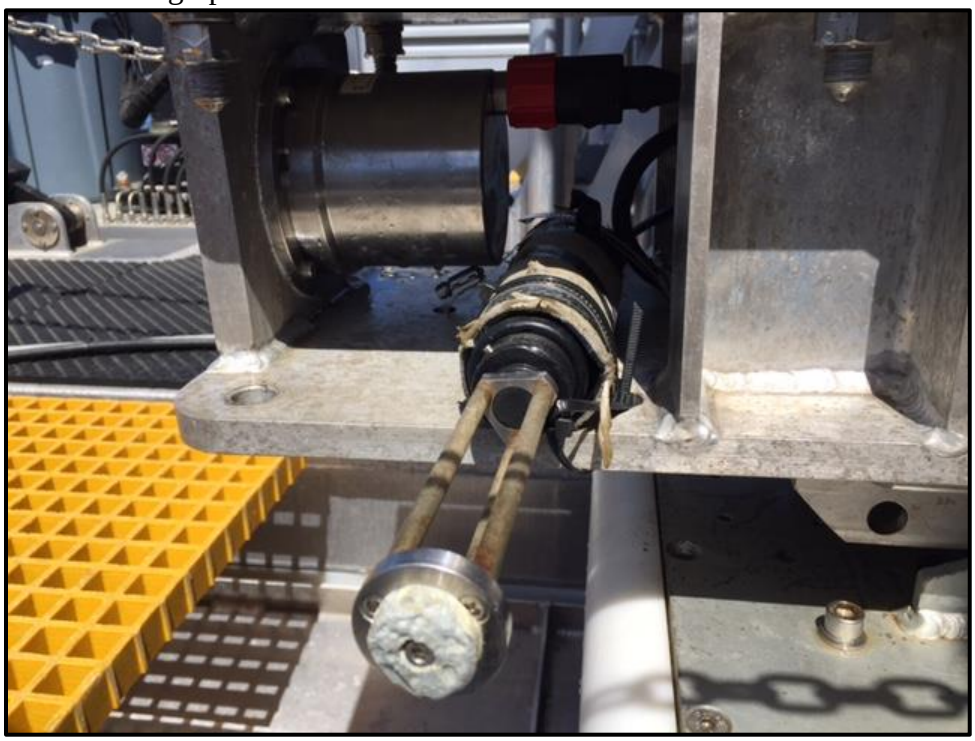


Figure 7: AML Sound speed probe attached to the strut

The AML Oceanographic Smart SV&P sound speed profiler was secured atop the EM2040 (see Figure 8) to ensure accurate sound speed measurements at the transducer head. These measurements are used by the EM2040 PU for beam corrections.

Instrument	AML Smart SV&P	
Manufacturer	AML Oceanographic	
Serial Number	98139	
Description	Designed for accurate sound velocity and CTD measurements in shallow water environments to support multibeam systems.	
Specifications	Power	7.5-26 VDC

	Sample Speed	25Hz
	Sound Velocity Range	1400-1600 m/s
	Sound Velocity Accuracy	+/- 0.05 m/s
	Sound Velocity Resolution	0.015 m/s
	Depth Range	Up to 6000m
	Depth Accuracy	+/- 0.05% of full scale
	Depth Resolution	0.005% of full scale

Table 5: AML SVP specifications

A.5.3 Teledyne Odom Digibar Pro- Profile Sound Speed

The Odom Digibar Pro sound speed profiler was used during the patch test collection (06/13/2017, 06/19-06/20/2017) and at the beginning of most survey days during data acquisition.

Figure 8: Odom Digibar spound speed probe

Instrument	Digibar Pro
Manufacturer	Teledyne Odom Hydrographic
Serial Number	91839

Description	Hand-held unit designed for accurate sound velocity measurements in shallow water environments to support multibeam systems.	
Specifications	Sample Rate	10Hz
	Sound Velocity Range	1400-1600 m/s
	Sound Velocity Accuracy	+/- 0.03 m/s
	Sound Velocity Resolution	0.03 m/s
	Depth Accuracy	31cm (1ft)
	Cable Length	100m
	Temperature Range	4-40^{o}C

Table 6: Digibar Pro specifications

A.6 Data Acquisition Software

The following software systems were used for data collection during the survey:

Name	Manufacturer	Version	Installation Date
Acquisition			
Hypack	Hypack Inc.	17.00	5/9/2017
Hypack Survey	Hypack Inc.	17.00	5/9/2017
Hysweep	Hypack Inc.	17.00	5/9/2017
PosView	Applanix		5/9/2017
SIS-Seafloor Information System	Kongsberg		5/9/2017

Table 7: Acquisition software

A.6.1 Hypack Hysweep

Hypack, Hypack Survey, and Hysweep were used for line planning, and real-time data display, and navigation.

A.6.2 Applanix PosView

Applanix POSView was used to configure and monitor the POSM/V motion data. These data were logged as POSPac files to be used during post-processing to apply lever arm corrections (see the MBES Report Appendix submitted with this document).

A.6.3 Kongsberg SIS- Seafloor Information System

SIS was used to collect EM 2040 MBES data, apply lever-arms and water lines, patch test offsets, motion corrections, and real-time sound speed corrections.

A.7 Data Processing Software

The following processing software was used during post-processing:

Name	Manufacturer	Version	Installation Date
Processing			
Qimera	QPS	1.5.1	5/9/2017
SonarWiz	Chesapeake Technologies	V6005.0016	5/9/2017
VDatum/PYDRO	NOAA	13.8	5/9/2017
POSPac	Applanix		
ArcGIS for Desktop	ESRI	10.5	5/9/2017
Base Editor	CARIS	4.1	
Other			
Microsoft Office Suite	Microsoft	2013	5/9/2017

Table 8: Processing software

A.7.1 QPS Qimera

Qimera was used for all MBES data processing including identifying patch test biases, tidal corrections, line cleaning, and CUBE surface creation.

A.7.3 VDatum & PYDRO

VDatum and PYDRO are open-source free softwares developed by NOAA and were used to translate these bathymetric data into MLLW and QC the final products respectively.

A.7.4 POSPAC

POSPAC was used to correct for an incorrectly entered lever-arm (more information is included in the MBES Report Appendix included with this document). This software was also used to QA/QC the positioning and motion data from the survey and ultimately create SBETs.

A.7.5 ESRI ArcGIS for Desktop

ESRI (Environmental Systems Research Institute) ArcGIS was used to visualize final products and create final report images.

A.7.6 CARIS Base Editor

CARIS Base Editor was used for junctioning survey and chart sounding comparisons.

A.8 Survey Methodology

A.8.1 Mobilization

A.8.1.1 Vessel Mobilization

Mobilization, including sensor installation, and calibration of the R/V Gulf Surveyor occurred at the UNH Coastal Marine Lab pier in New Castle, NH from 6/7/2017-6/13/2017. Vessel offsets and associated measurement uncertainties were calculated from monument marks derived from a laser scan survey by Doucet Survey completed in May, 2015. Offsets to phase centers of each transducer were measured using tapes and levels from the nearest monument mark. Resulting offsets and uncertainties were used in the QPS Qimera Vessel Configuration File. The vessel underwent system calibration and patch tests on 6/13/2017 in the vicinity of Cod Rock near Fort Point, New Castle, NH.

A.8.2 Survey Coverage

All survey lines are oriented parallel to charted contours (NE-SW) and all crosslines are oriented perpendicular to survey lines (NW-SE). The combination of an assumed angular coverage of 120 degrees, and the average charted depth in each area allowed derivation of the total swath width. Lines were spaced to allow for 15% overlap between adjacent swaths. These specifications were used to create complete coverage over the survey area and meet the requirements for an IHO Special Order survey. In areas with charted features, captain discretion was used with respect to coverage and safety.

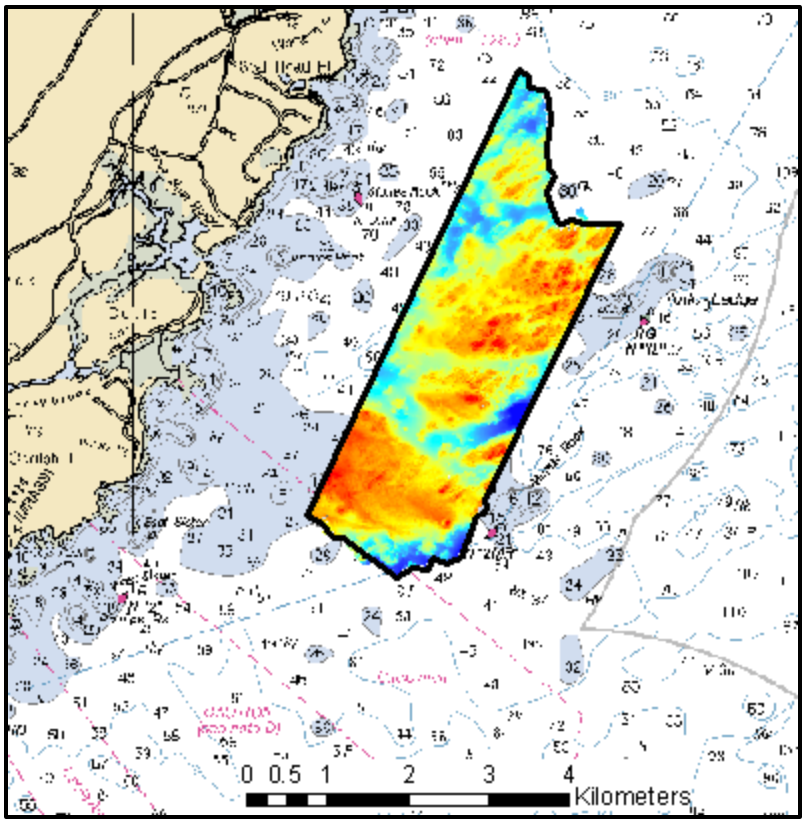


Figure 9: Survey Area (black line) and final bathymetry.

Both sonars were strut-mounted in fixed positions for the entirety of the survey (see C.1.1.1 for lever-arm offsets). Complete multibeam coverage was collected within the bounds of the survey area. Supplemental side scan data were acquired in concert with the EM2040 multibeam data.

A.8.3 Depth Measurement Operations

See MBES Report Appendix submitted with this document for more information.

A.8.5 Bottom Sampling

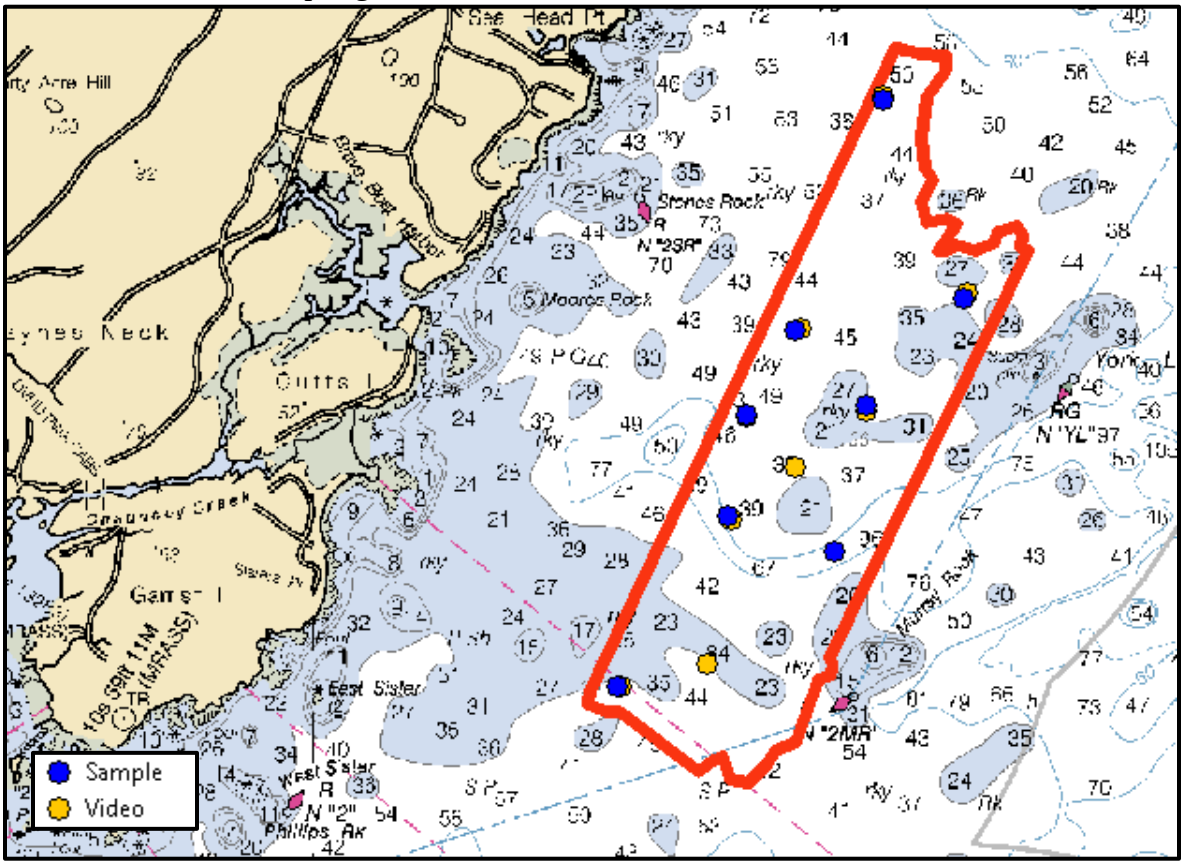


Figure 10: Bottom and Video sample locations.

Bottom ground truth was collected on 07/05/2017 at 10 locations. At each of the 10 stations bottom video was acquired. Only 6 bottom samples were recovered at the 8 locations attempted. All data were acquired in accordance to Zach McAvoy's (CCOM/UNH) SOPs.

More information can be found in the Bottom Sample Report included with this submission.

B. Quality Control

B.1 Multibeam Echosounder Data

B.1.1 Acquisition Operations

See the MBES Report Appendix submitted with this document for more information.

B.1.2 MBES Processing Workflow

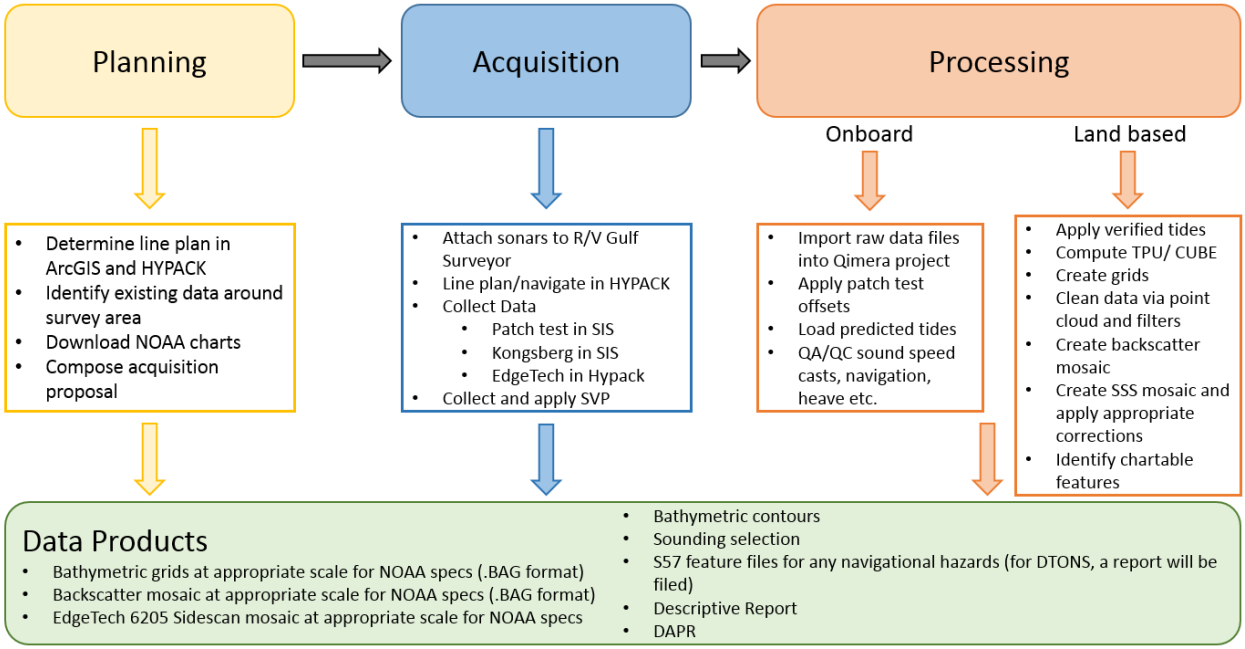


Figure 11: MBES processing workflow

B.3 Feature Data

B.3.1 Hydrography Features

No hydrographic features were identified in these data.

B.3.2 Shoreline Features

No shoreline features were identified in these data.

C. Corrections to Echo Soundings

C.1 Vessel 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 Static Offsets

C.1.1.1 Vessel Lever-Arms

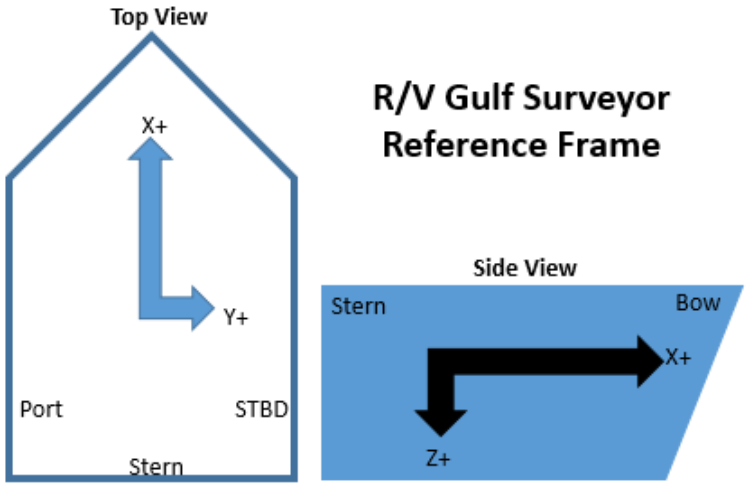


Figure 12: RVGS Reference Frame Diagram.

The RVGS vessel reference frame is: +x bow forward, +y to starboard, and +z down.

	Foreward (X) m	Starboard (Y) m	Downward (Z) m
EM2040 Tx	-1.101	0.228	2.284
EM2040 Rx	-0.963	-0.084	2.276
IMU	-1.615	0.019	1.943
Port Antenna (Primary)	3.320	-1.845	-4.319
STBD Antenna	3.320	1.895	-4.319

Table 9: Offsets entered into SIS and PosView

More information on the entered lever arms can be found in the MBES Report and Vessel Offset Report Appendices included with the submission of this document.

C.1.1.2 Static Draft

Static draft was measured daily. Before getting underway, the distance from the top of the inner lip that holds the moon pool grating to the water's surface is measured. This value is added to the known vertical distance to ship's reference point, in order to find the total static draft of the MBES. The measurement is applied in SIS>Installation Parameters> Sensor Depth.

C.1.2 Dynamic Offsets

Dynamic draft was compensated for by referencing GPS elevations to the ellipsoid. Therefore, a dynamic draft model was unnecessary.

C.1.3 Patch Test Biases

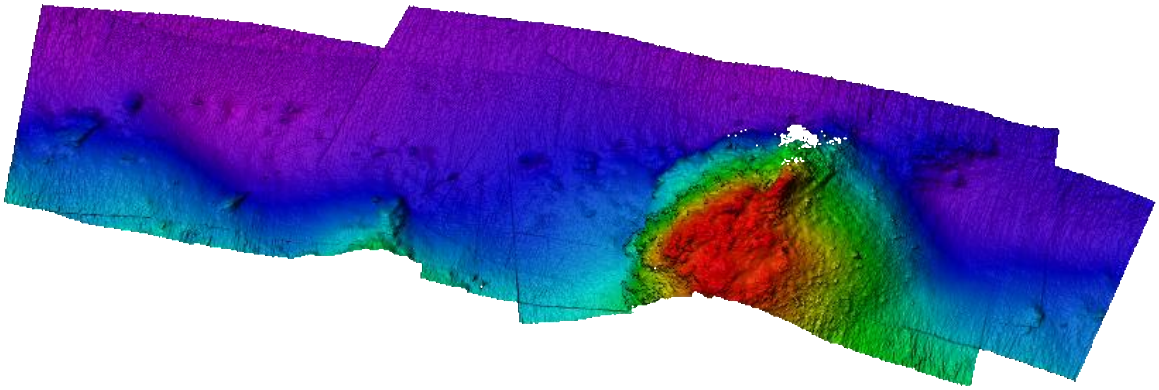
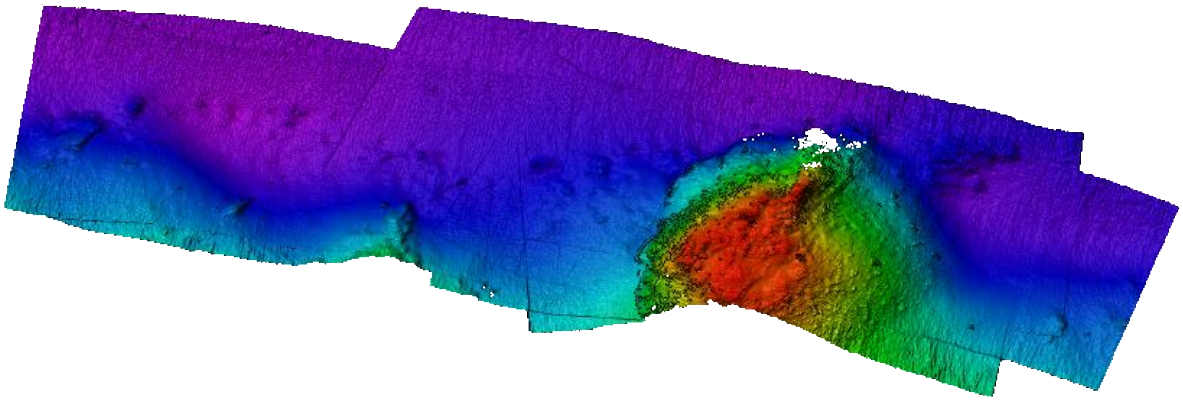


Figure 13: Patch test raw data over Cod Rock (charted depth 17ft) in Portsmouth Harbor, NH

The EM2040 data used for a patch test were acquired onboard the RVGS on June, 13, 2017 (JD 165) over Cod Rock (charted depth 17ft) located ~200m North of the Coast Guard Station off New Castle in Portsmouth Harbor, New Hampshire. The data were processed using QPS Qimera's patch test module. Qimera's automatic picking was not used. Instead, a manual iterative approach was utilized. The following are the patch test values from Qimera upon completion of the Latency (Time), Yaw (Heading), Pitch, and Roll bias tests on June 23, 2017 (JD 174). More information on the patch test are included in the Patch Test Report appendix submitted with this document.



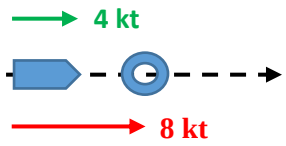
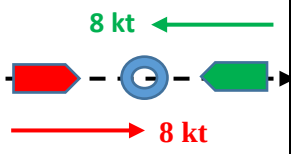
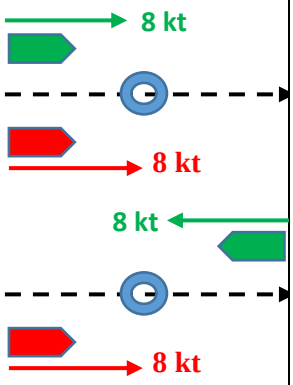
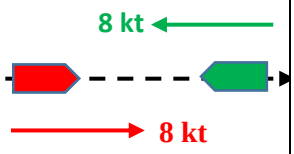
Time Bias	Pitch Bias	Yaw Bias	Roll Bias
			
• Boat pass above a feature, e.g. a rock. • Same direction. • Same line • 2 different vessel speeds: 4 and 8 knots.	• Boat pass above a feature, e.g. a rock. • Opposite directions. • Same line • Same vessel speed: 8 knots.	• Boat pass next to a feature, e.g. a rock. • Same or opposite directions. • 2 different lines • Same vessel speed: 8 knots.	• Boat pass above a flat featureless area. • Opposite directions. • Same line • Same vessel speed: 8 knots.

Figure 14: Patch test data with offsets applied and diagram of setup for the single head MBES (EM2040) over Cod Rock in Portsmouth Harbor, NH.

System	Parameter	Original Value	New Value	Delta
EM2040	Tx Pitch	0.00	-1.88	-1.88
EM2040	Rx Roll	0.00	0.29	0.29
EM2040	Tx Heading	0.00	-0.05	-0.05

Table 10: Patch test result summary of applied offsets

C.2 Sound Speed

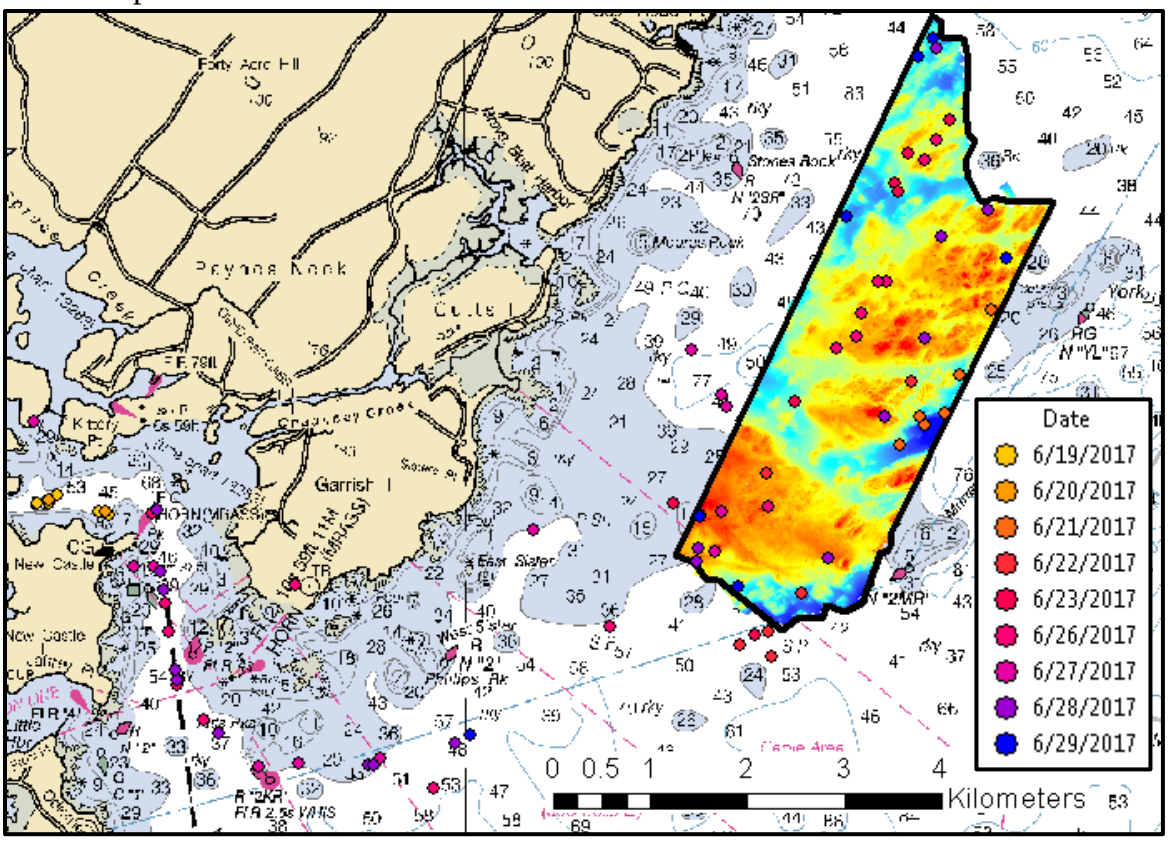


Figure 15: MVP cast locations.

Real-time sound speed corrections were applied to the EM2040 data through SIS. Casts were taken about every hour using the MVP30. More information can be found in the SVP Report Appendix submitted with this document.

C.3 Corrections

Horizontal and Vertical corrections are outlined in the HVCR Appendix submitted with this document. Additionally, VDatum was used to translate the survey data to MLLW.

D. Approval Sheet

As Chief of Party, field operations for this hydrographic survey were conducted under my direct supervision, with frequent personal checks of progress and adequacy. I have reviewed the attached survey data and reports. All field sheets, this Survey Summary Report, and all accompanying records and data are approved. All records are forwarded for final review and processing to the Processing Branch.