U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

# Data Acquisition & Processing Report

*Type of Survey* Hydrographic

*Project No.* Summer Hydro 2018

*Time frame* May – July 2018

## LOCALITY

*State* New Hampshire & Maine

*General Locality* Western Gulf of Maine

**2018**

## CHIEF OF PARTY

Semme Dijkstra, PhD & CAPT Andy Armstrong, NOAA (ret)

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**DATE**

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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 R2Sonic 2024, and a stern-mounted AML MVP-30. 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 in the aft of the cabin.

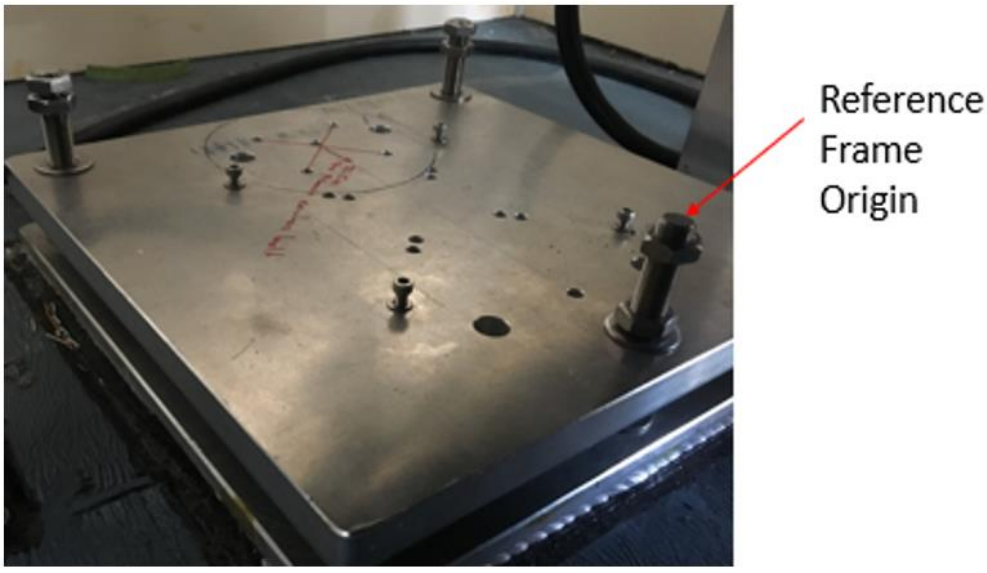


*Figure 2: Reference Frame Origin*

| | | |
|---|---|---|
| *Name* | R/V Gulf Surveyor | |
| *Hull Number* | TD14-45AA | |
| *Utilization* | Survey operations | |
| *Dimensions* | *LOA* | 14.6m (48 feet) |
| | *Beam* | 5.2m (17 feet) |
| | *Max Draft* | 1.68m (5ft 6 inches) |
| *Most Recent Full Static Survey* | April 26, 2016 By Doucet Survey Inc. | |
| *Flag* | U.S. | |
| *Top speed* | 18 knots (8 knots survey speed) | |

*Table 1: R/V Gulf Surveyor specifications.*

### A.1.2. Vessel Data Flow

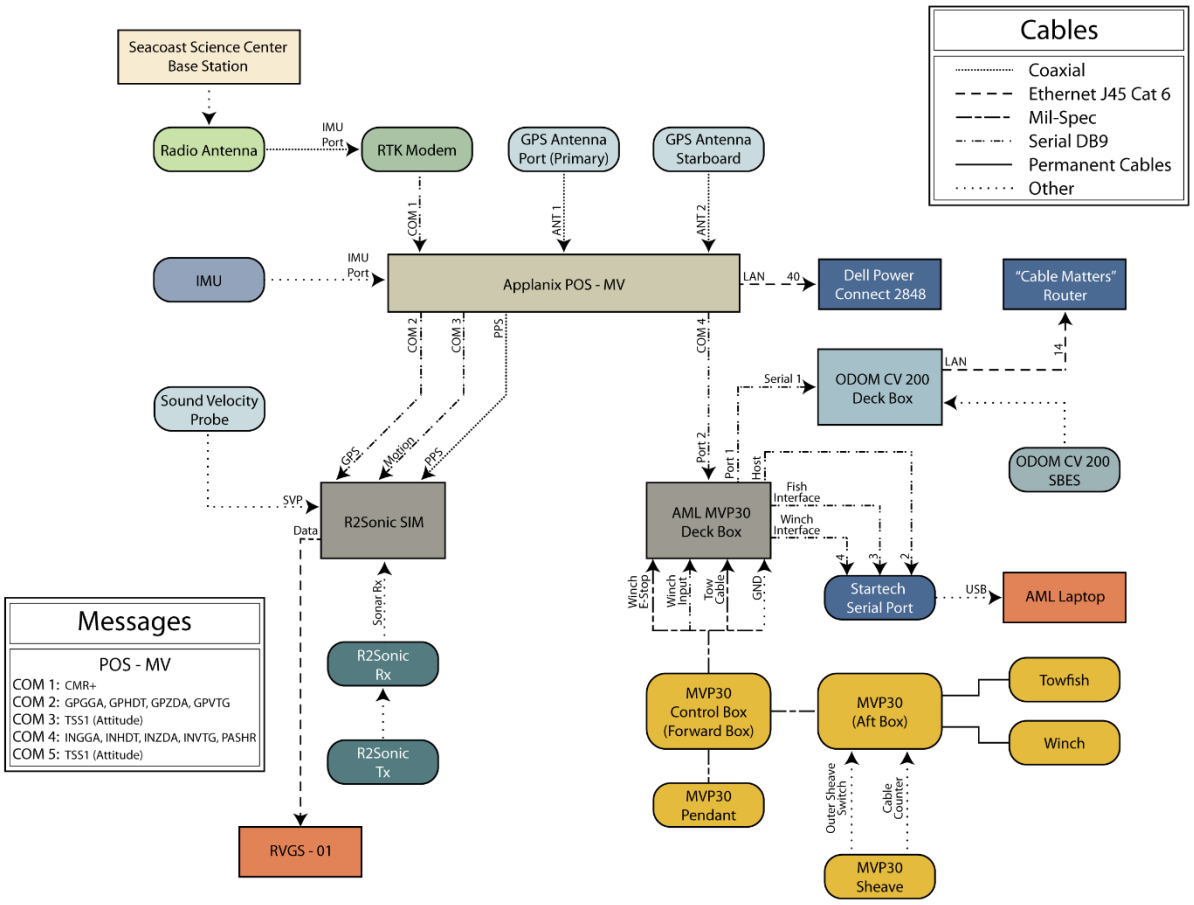


*Figure 3: R/V Gulf Surveyor data flow and connections*

The Applanix POS MV was utilized for primary positon and motion compensation. Real-time RTK GPS corrections from the Seacoast Science Center base station were streamed via RS-232 communication with the Trimble Trimmark modem.

The POS MV transmits tightly coupled positioning and motion solutions via RS-232 to the R2Sonic 2024 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. R2Sonic 2024 Multibeam Echosounder

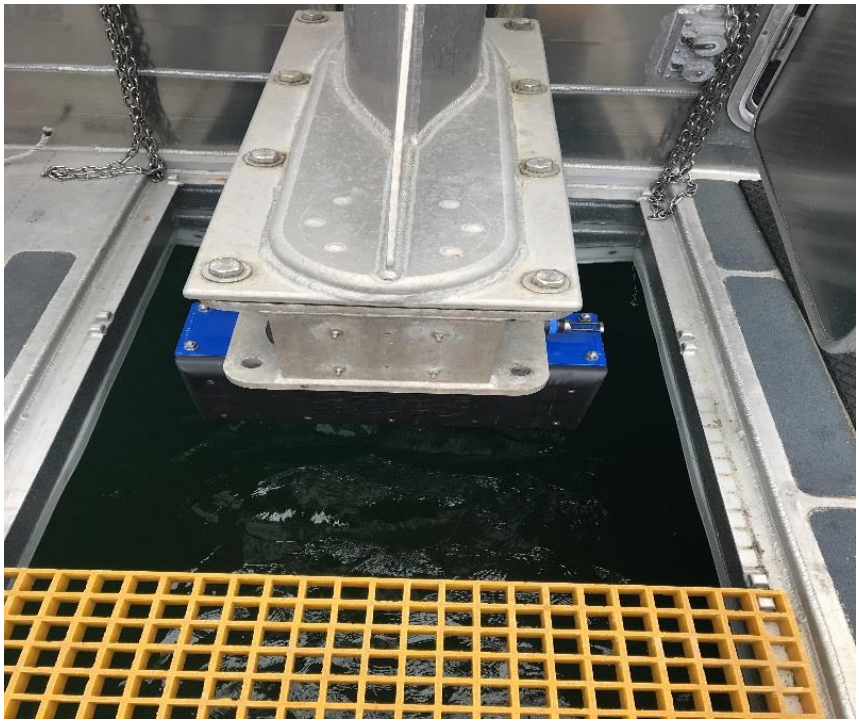

*Figure 4: R2Sonic 2024 installation on strut*

The R2Sonic 2024 was installed on the (stern) moonpool strut aboard the R/V Gulf Surveyor. Fully extended, R2Sonic 2024 sits ~2m below the vessel reference point. The R2Sonic 2024 wideband high resolution shallow water multibeam echo sounder with a 60 kHz signal bandwidth. With over 20 selectable operating frequencies to choose from 200 to 400 kHz. In addition to selectable operating frequencies, the Sonic 2024 provides variable swath coverage selections from 10° to 160° as well as ability to rotate the swath sector. Both the frequency and swath coverage have to be selected in Real-time during survey operations.

The Sonar consists of the three major components: a compact and lightweight projector, a receiver and a small dry-side Sonar Interface Module (SIM). Third party auxiliary sensors are connected to the SIM. Sonar data is tagged with GPS time.

| | | | | |
|---|---|---|---|---|
| **Instrument** | SONIC 2024 | | | |
| **Manufacturer** | R2 SONIC | | | |
| **Description** | The Sonic2024 is a wideband high resolution shallow water MBES. The 60kHz of signal bandwidth offers higher resolution of data acquisition than any other commercial sonar. The R2Sonic has over 20 operating frequencies to choose, between 200 to 400kHz, allowing the user much flexibility in controlling resolution, range and interference from other active acoustic system. This instrument also provides variable swath coverage selections from 10° to 160°. | | | |
| **Serial Numbers** | Transmitter | S/N 806286 | Receiver | S/N 101568 |
| **Systems Specifications** | Bathymetric Sonar | | | |
| | Mounted | RVGS Strut | | |
| | Frequency | 200kHz-400kHz | | |
| | Beamwidth, across track | 0.5° | | |
| | Beamwidth, along track | 1.0° | | |
| | Number of beams | 256 | | |
| | Swath sector | Up to 160° | | |
| | Max Range | 500m | | |
| | Pulse Length | 10µs-500µs | | |
| | Pulse Type | Shaped CW | | |
| | Ping Rate | Up to 60 Hz | | |
| | Depth rating | 100m | | |

*Table 2: SONIC 2024 MBES Specifications*

## A.3. Positioning and Attitude

*Figure 5: 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 R2Sonic 2024 systemduring 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 R2Sonic 2024 on its side in the strut. All configuration settings for the Applanix and acquisition 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 R2Sonic 2024 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 | |
| | Serial Number | 2886 | |
| **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 3: Applanix POS M/V specifications*

## A.4. Sound Speed Equipment

### A.4.1. AML Oceanographic MVP30

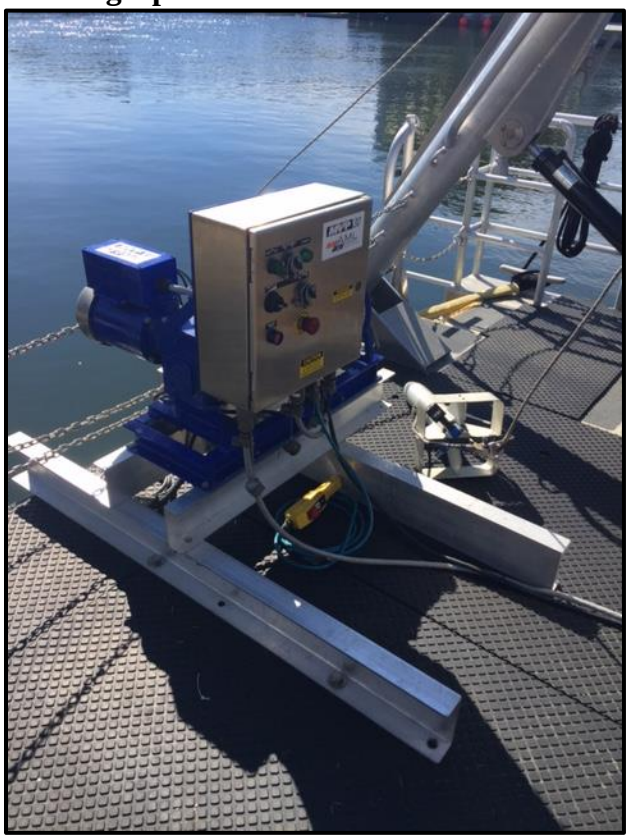

*Figure 6: MVP-30 stern-mounted on RVGS*

The AML Oceanographic 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** | AML Oceanographic MVP30 |
| **Manufacturer** | AML Oceanographic Ltd. |
| **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 32ºC |
| | Temperature Accuracy | +/- 0.005ºC |
| | Depth Range | Various to 6000m |
| | Depth Accuracy | +/- 0.05% of full scale |
| *Serial Numbers* | CTD sensor s/n | 10737 |

*Table 4: MVP specifications*

### A.4.2. AML Oceanographic Smart SVP

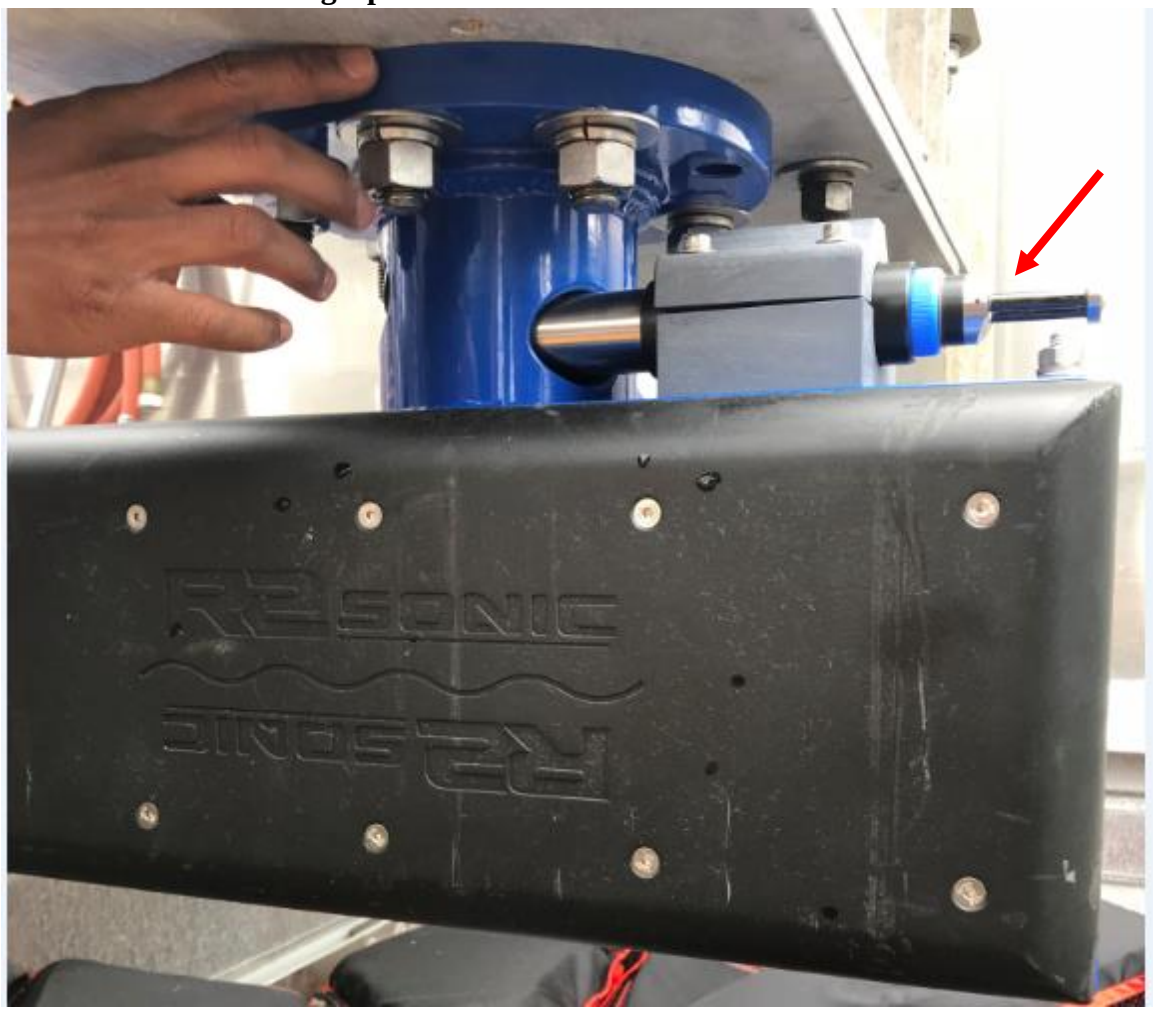


*Figure 7: AML Sound speed probe attached to the strut*

*Figure 8: AML Oceanographic Smart SV&P Sensor*

The AML Oceanographic Smart SV&P sound speed profiler was secured atop the R2 SONIC (see Figure 8) to ensure accurate sound speed measurements at the transducer head. These measurements are used by the R2 SONIC for beam corrections.

| INSTRUMENT | AML Smart SV&P | | | |
|---|---|---|---|---|
| Manufacturer | AML Oceanographic | | | |
| Serial Number | 10082 | | | |
| RECOMMENDED APPLICATIONS | Transducer Mount / Surface SV | | | |
| SENSOR PORTS | 1 | | | |
| DEPTH RATING | 500 m | | 6000 m | |
| HOUSING MATERIAL | 500 m: Acetal | | 6000 m: Titanium | |
| ACCURACY (+/-) | 0.025 m/s [g] | | | |
| TEMPERATURE ACCURACY | +/- 0.005ºC | | | |
| CONDUCTIVITY RANGE | 0-70 mS/cm | | | |
| TEMPERATURE RANGE | -2 to 32ºC | | | |
| CONDUCTIVITY ACCURACY | +/- 0.01 mS/cm | | | |
| OTHER APPLICATIONS | AUV / Glider Integration | Buoy / In-Situ | Deployments | ROV Integration |
| RESOLUTION | 0.001 m/s | | | |
| COMMUNICATIONS | RS-232 | | RS-485 | |
| BAUD RATE | 19200 | 9600 | | 38400 |
| POWER SOURCE | External | | | |
| DATA/POWER CONNECTOR | SubConn MCBH6F | | | |
| DATA OUTPUT | Real-time Output | | | |
| INPUT VOLTAGE | 8-26 V | | | |
| LENGTH | 214 mm (8.4″) | | | |
| DIAMETER | 33 mm (1.3″) | | | |
| WEIGHT IN AIR | 500 m: 0.24 kg (052 lbs) | | 6000 m: 0.39 kg (0.86 lbs) | |
| WEIGHT IN WATER | 500 m: 0.09 kg (0.2 lbs) | | 6000 m: 0.25 kg (0.55 lbs) | |

*Table 5: AML SVP specifications*

### A.4.3. Teledyne Odom Digibar Pro- Profile Sound Speed

The Odom Digibar Pro sound speed profiler was used during data acquisition (02/09/2018, 03/09/2018) replacing the MVP 30.

*Figure 9: 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.5. Horizontal and Vertical Control Equipment

### A.5.1. RTK Base Station Equipment

A RTK base station broadcast RTK corrections, to be received via the Trimble TRIMMARK 3 VHF modem on board the R/V gulf surveyor. The base station permanently located on the roof of the Seacoast Science Center at Odiorne State Park, NH.

*Figure 10: RTK base station at Odiorne Point.*

| | | |
|---|---|---|
| *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 base 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, in CMR+ format. |
| | Firmware Version | Unknown |
| | 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 modem for broadcasting corrections from the RTK base stations. |

*Table 7: RTK Base Station specifications.*

### A.5.2. Trimble Trimmark 3


*Figure 11: (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. | | |
| **UHF 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) | |
| **UHF Antenna** | Manufacturer | Trimble | |
| | Model | 24253-46 | |
| | Serial Number | UHF Radio | Unknown |

*Table 8: Trimble Trimmark 3 Specifications*

## A.6. Data Acquisition Software

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

| Name | Manufacturer |
|---|---|
| Hypack | Hypack Inc. |
| Hypack Survey | Hypack Inc. |
| QINSy | QPS |
| PosView | Applanix |

*Table 9: Acquisition software*

### A.6.1. Hypack

Hypack and Hypack Survey 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 .000 files.

## A.7. Data Processing Software

The following processing software was used during post-processing:

| Name | Manufacturer |
|---|---|
| Qimera | QPS |
| POSPac | Applanix |
| ArcGIS | ESRI |
| FMGT | |

*Table 10: 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.7.2. VDatum

VDatum is an open-source free software developed by NOAA and was used for datum transformations.

### A.7.3. POSPAC

This software was also used to QA/QC the positioning and motion data from the survey and ultimately create SBETs.

### A.7.4. ESRI ArcGIS for Desktop

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

### A.7.5. FMGT

QPS's Fledermaus Geocoder Toolbox was used to process backscatter using the Qimera cleaned data outputs.

## A.8. Bottom Sampling Equipment

### A.8.1. Wildco Shipek grab sampler

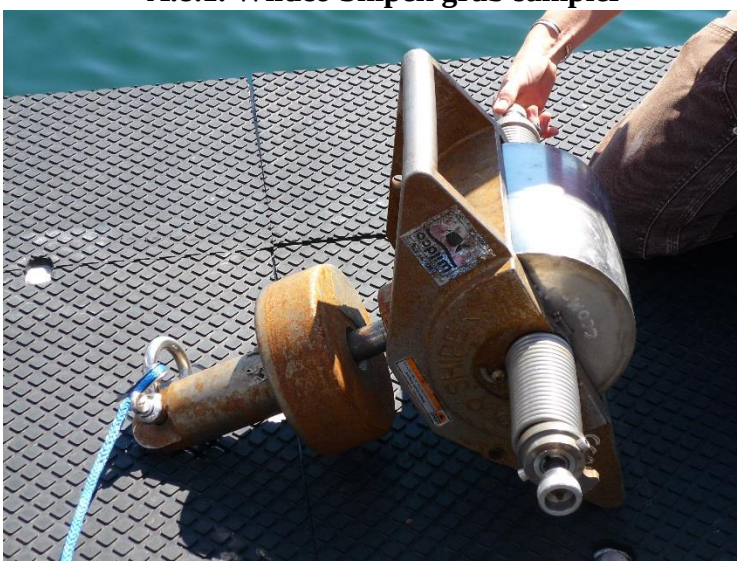

*Figure 12: Wildco Shipek grab sampler.*

| | |
|---|---|
| *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. |

SHIPEK Grab Sampler Specifications

### A.8.2. Drop Camera System

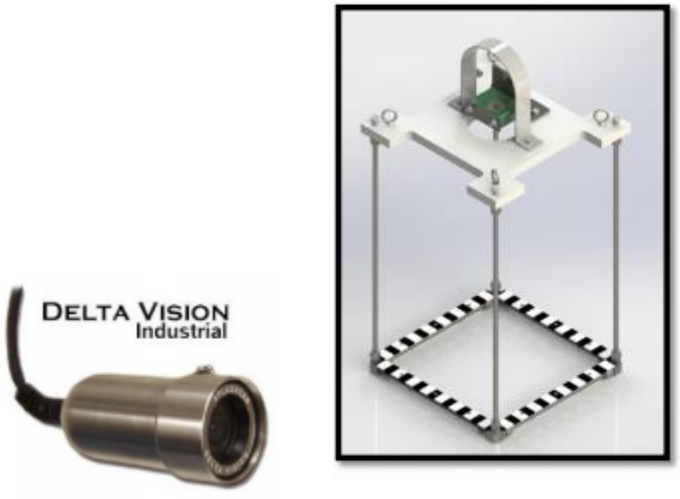


*Figure 13: Drop camera cage (right) and camera (left)*

| | |
|---|---|
| *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. |

*Table 11: Drop Camera*

## A.9.

# B. Quality Control

## B.1. Data Acquisition

### B.1.1. Survey Methodology

Mobilization

#### B.1.1.1) Vessel Mobilization

Mobilization, including sensors installation, and calibration of the R/V Gulf Surveyor occurred at the UNH Coastal Marine Lab pier in New Castle, NH. Vessel offsets and associated measurement uncertainties were calculated from monument marks located in the boat. 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 June, 18, 2018, in the vicinity of Cod Rock near Fort Point, New Castle, NH.

#### B.1.1.2) 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. 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. Planned line files were developed in Hypack. Adaptive line running was performed during holiday data acquisition.

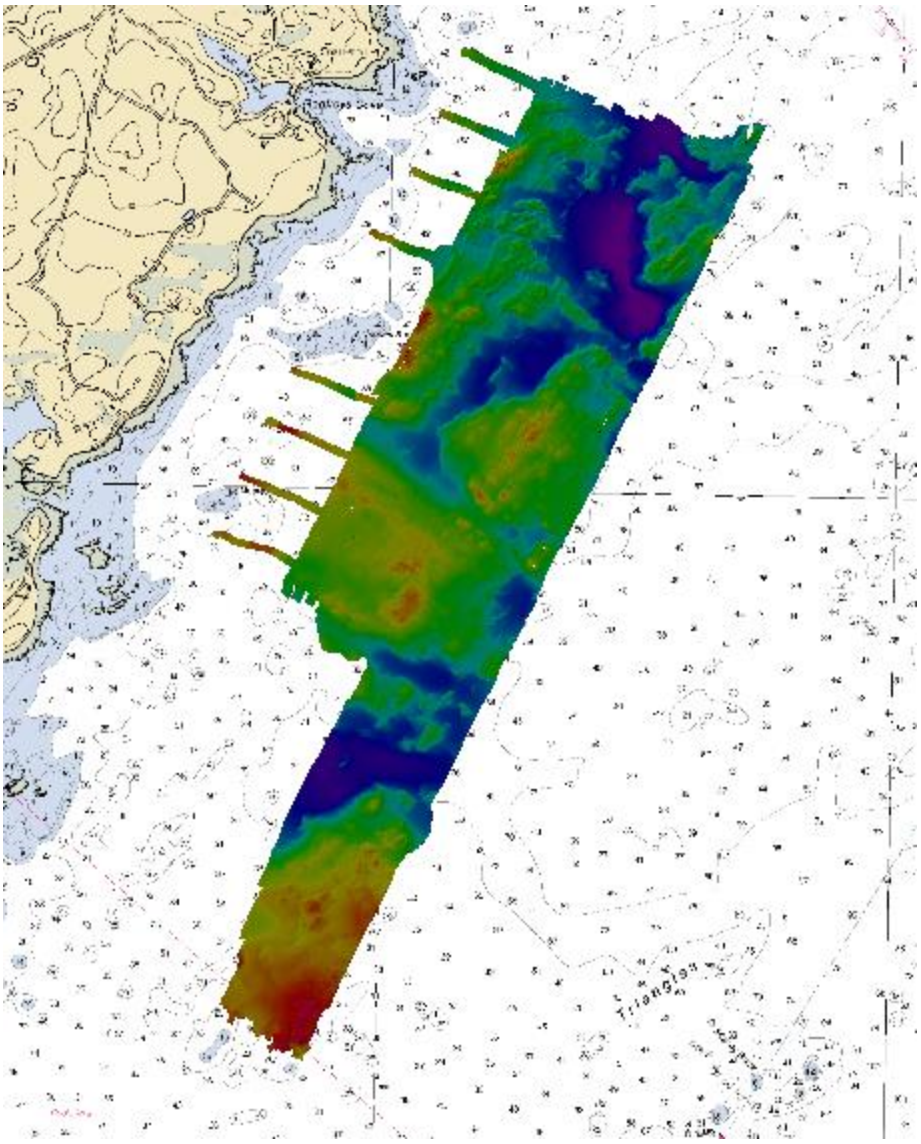

*Figure 14: Survey Area.*

The R2Sonic was strut-mounted in fixed position 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.

### B.1.2. Multibeam Echosounder Data

The R2Sonic 2024 was the primary echosounding equipment, which collected data throughout the survey operations at a frequency of 300 kHz. A middle CW pulse was used with a pulse length of 40µ. The speed of the vessel during survey operations was 8 knots. The vessel's hull mounted single beam echo sounder was found to interfere with MBES operations, and was turned off during survey operations.

### B.1.3. Sidescan Sonar Data

#### B.1.3.1) SSS Processing Workflow

The sidescan was not processed or included in the submission of this document.

### B.1.4. Feature Data

#### B.1.4.1) SSS Processing Workflow

No hydrographic features were identified in these data.

#### B.1.4.1) Shoreline Features

No shoreline features were identified in these data.

### B.1.5. Sound Speed

#### B.1.5.1) Sound Speed Profiles

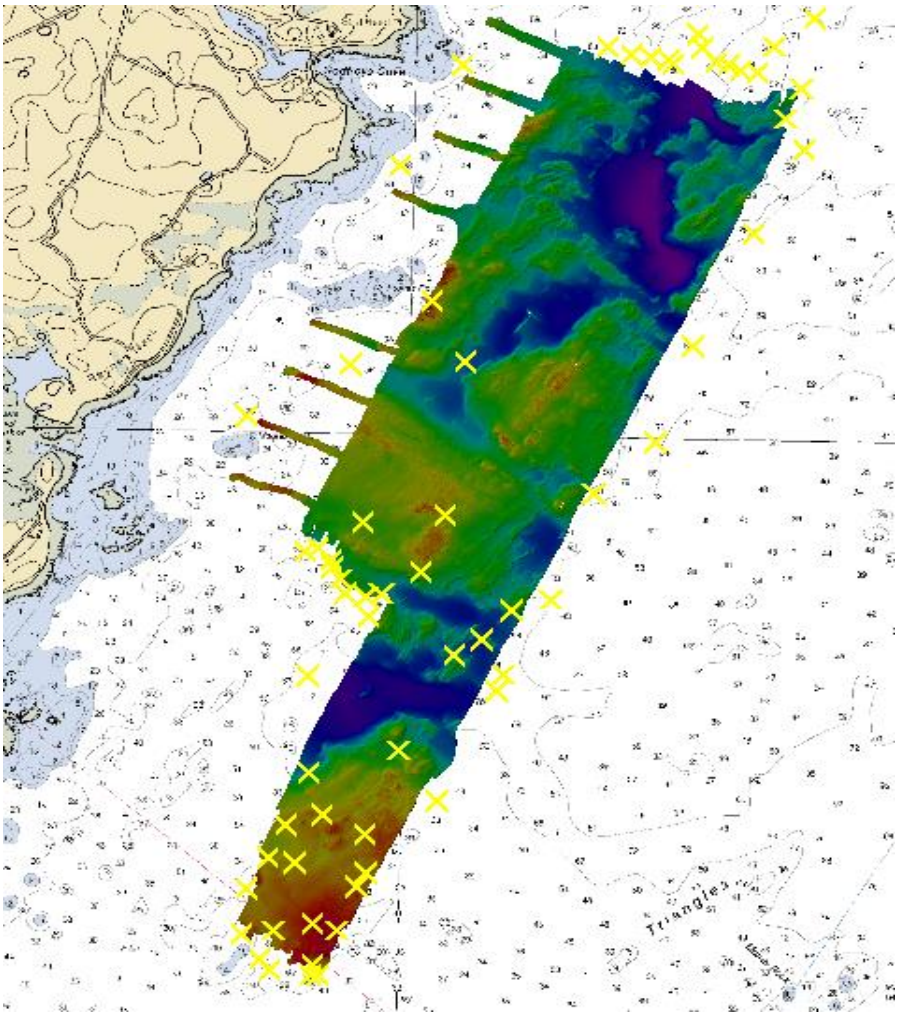

*Figure 15: MVP cast locations.*

Real-time sound speed corrections were applied to the R2Sonic 2024 data through Qinsy. Casts were taken using the MVP30 and the Teledyne ODOM Digi Bar Pro. The MVP30 consists of CTD sensors, attached to a tow fish, which was attached to a winch and deployed via the A-frame using a pulley system. The winch is attached to a deck controller unit, which is connected to the topside MVP interface and can be accessed via a dedicated laptop. MVP Controller software is used to instruct the tow fish as to

when to dive, and to monitor the data and status of the fish in real time. The sound speed profile is downloaded, using the software, and imported and applied in QINSy. Prior to importing the SSP into QINSy, the operator must QC the profile. The fish was programmed to remain 1m below the surface during survey line acquisition, and to dive to 2m above the seabed. The ODOM Digi Bar is a hand held unit, manually deployed over the side of the vessel. The device is then connected to the acquisition computer, and the cast downloaded and imported into QINSy.

#### B.1.5.1) Surface Sound Speed

Surface sound speed at the transducer head was collected by an AML Smart SV&P during survey operations. The sensor was placed in the mounting bracket, along with the Sonic2024. The probe was connected to the SIM unit, inside the cabin via cable. The device measured sound speed at a rate of 1 Hz.

### B.1.6. Backscatter

Multibeam backscatter was collected using the R2Sonic and recorded through Qinsy. FMGeocoder Toolbox (FMGT) was used to process the backscatter. The operational frequency of the MBES was set to 300 kHz, while the pulse length was 40µ. The power level and gain were set to full dynamic range in an attempt to prevent clipping; the saturation monitor was under constant surveillance.

### B.1.7. Bottom Sampling

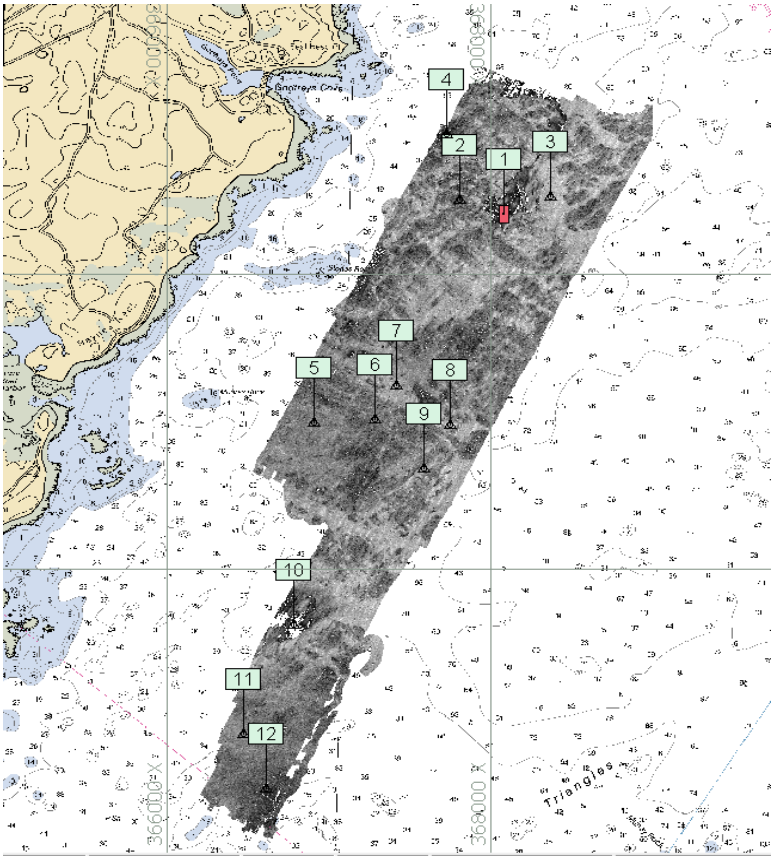


*Figure 16: Bottom and Video sample locations.*

Bottom samples and video grabs were collected on 07/10/2018 at 12 locations based on the backscatter mosaic.

## B.2. Data Processing

### B.2.1. MBES Processing Workflow

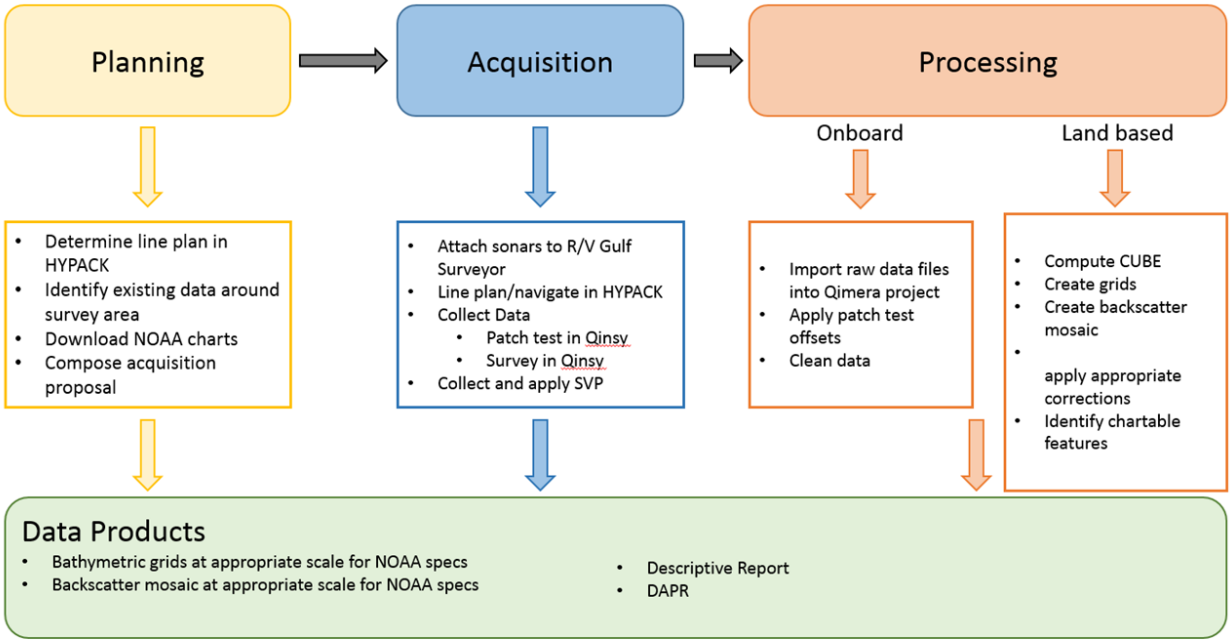


*Figure 17: MBES processing workflow*

During acquisition, .db files were logged utilizing QINSy acquisition software. The .db files contain both the bathymetry and snippets data, as well as attitude and position data form the Pos M/V. The .db files also contain the sound speed profiles that have been applied to the line during acquisition. Binary navigation data was also logged in Pos View. At the end of each survey day, the QINSy project, the Qimera project and the binary navigation files were all copied to an external hard drive. The data was then uploaded onto the CCOM network from the hard drive, for further processing.

As the data was acquired, the .db files were brought into Qimera to investigate any data holidays or systematic errors. Qimera automatically brings in the sound speed files associated with each line file. Sound speed parameters were set to nearest in time. In the office, the binary navigation was post processed using POSView and SBET files were produced for each survey day. This could then be applied to the data, though it has not been applied in this case.

Qimera version 1.5.7 was utilized to process all multibeam data. Post processing the MBES data includes computing the TPU, data cleaning and generating surfaces. The patch test angular offsets were also entered in Qimera.

The data was gridded at 0.5 and 1.0 meter resolution, with NOAA_0.5 and NOAA_1 CUBE settings correspondingly to increase the likelihood separate hypothesis creation for outer beams. Once the data was gridded a CUBE filter was applied to reject all soundings beyond two standard deviations from the CUBE surface.

### B.2.2. Specific Data Processing Methods

#### B.2.2.1) Methods Used to Maintain Data Integrity

Acquisition and processing logs were maintained on a daily basis, and reviewed each day to ensure correct lever arms, angular offsets, and other correctors were applied during collection or in post processing. In instances of data holidays, adaptive line planning was carried out.

#### B.2.2.2) Methods Used to Generate Bathymetric Grids

Methods follow the specifications laid out in the NOAA NOS Hydrographic Surveys Specifications and Deliverables (April 2017).

#### B.2.2.3) Methods Used to Derive Final Depths

Final depths were derived via CUBE gridding parameters in Qimera, including cleaning filters and surface comparison algorithms.

### B.2.3. Sound Speed

The data was collected in MVP Controller software. It was then imported into QINSy and applied to the data. In post processing of the multibeam data in Qimera, the SVP editor was utilized to visualize and QC the sound speed profiles. The SVP strategy was also applied in Qimera; Nearest in Time was the option which was employed for this processing.

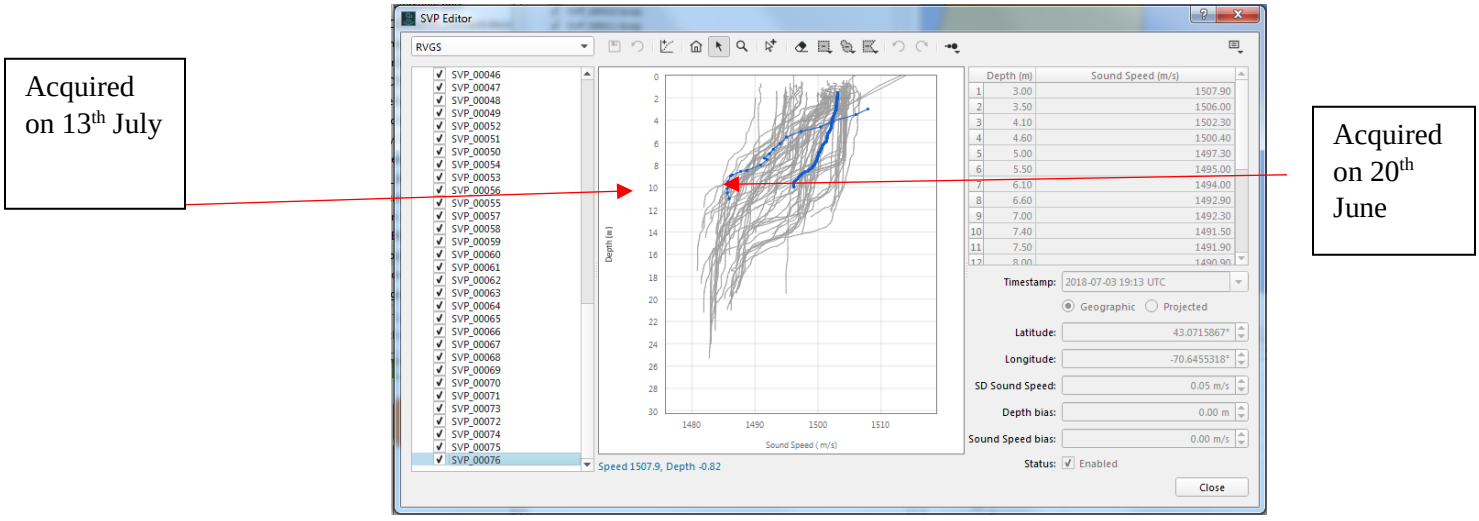


*Figure 18: Qimera SVP Editor displaying the range of profiles acquired, with the first and final cast highlighted*

### B.2.4. Backscatter

Backscatter data was extracted from snippet data, acquired in .db files in QINSy acquisition software. The .db files were brought into the Qimera project, where .qpd files are created. The

pair of .db file and corresponding .qpd file was then imported into files are then imported into FMGT software. The backscatter mosaic was then gridded at 0.5m and 2m resolution, with the 2m exported as a geotiff and used for imaging purposes. In figure 19 below, black represents areas of high intensity in the returning signals, while white represents low intensity

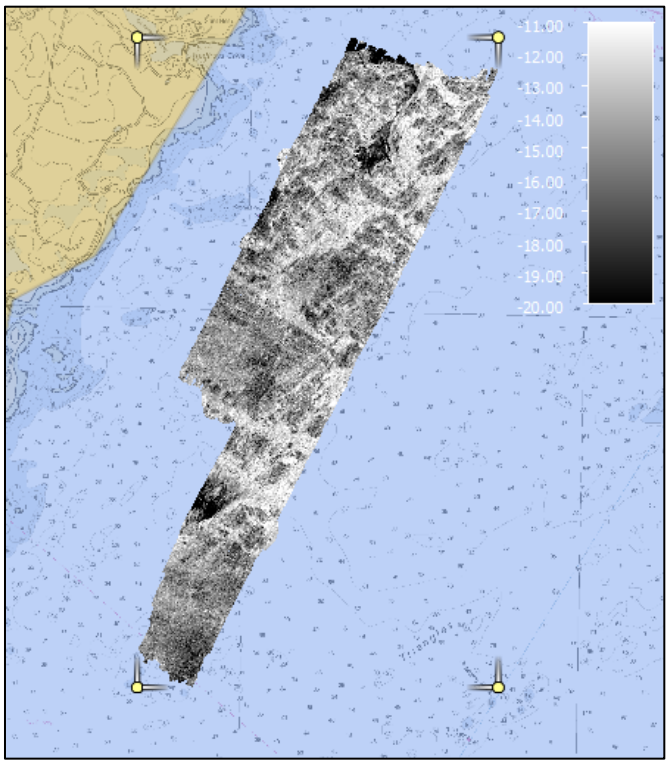


*Figure 19: 50cm Backscatter Mosaic.*

## B.3. Quality Management

Quality control was performed in near real-time by processing R2Sonic data collected in QPS Qinsy in QPS Qimera. The CUBE surface was used to confirm coverage and each line added was compared to existing crosslines to check for systematic errors. At CCOM, data were transferred to the network and additional conversion and correctors applied before cleaning. Data quality control and assessment was done on the CCOM network. Data acquisition and processing logs were maintained to record and communication problems from acquisition to final processing.

## 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 obtained from equipment specification sheets, Qimera, field data and expert advice.

#### B.4.1.3 TPU Values

| EQUIPMENT | FEATURE | | TPU |
|---|---|---|---|
| *R2Sonic* | *Echosounder* | *Pulse Length* | 0.015ms |
| | | *Sampling Length* | 0.020 m |
| | *Offsets* | *Roll* | 0.05 º |
| | | *Pitch* | 0.05 º |
| | | *Heading* | 0.05 º |
| | *Sound Velocity (AML MVP-30)* | *Surface Sound Speed* | 0.05 m/s |
| | *Stabilization* | *Roll stabilization* | 0.00 m |
| | | *Pitch stabilization* | 0.00 m |
| | | *Heave compensation* | 0.00 m |
| *Beam width* | | *Along* | 1 º |
| | | *Across* | 0.50 º |
| *APPLANIX POS/MV 320 V5* | *Motion* | *Roll* | 0.05º |
| | | *Pitch* | 0.05º |
| | | *Heading* | 0.05º |
| | | *Heave Fixed* | 0.05 m |
| | | *Heave Variable* | 5% |
| | | *Roll Offset* | 0.05º |
| | | *Pitch Offset* | 0.05º |
| | | *Heading Offset* | 0.05º |
| | *Position (IARTK mode, base station up to 15 km away)* | *Horizontal* | 0.5 m |
| | | *Vertical* | 1 m |
| *AML MVP30* | *Temperature / Conductivity* | *Temperature* | 0.005ºC |
| | | *Conductivity* | 0.01 mS/cm |
| *AML Smart SV&P* | *Sound Velocity* | *Sound Velocity* | 0.05 m/s |

*Table 12: TPU Values*

# C. Corrections to Echo Soundings

## C.1. Vessel Correctors

### C.1.1. Static Offsets

#### C.1.1.1) Vessel Lever-Arms

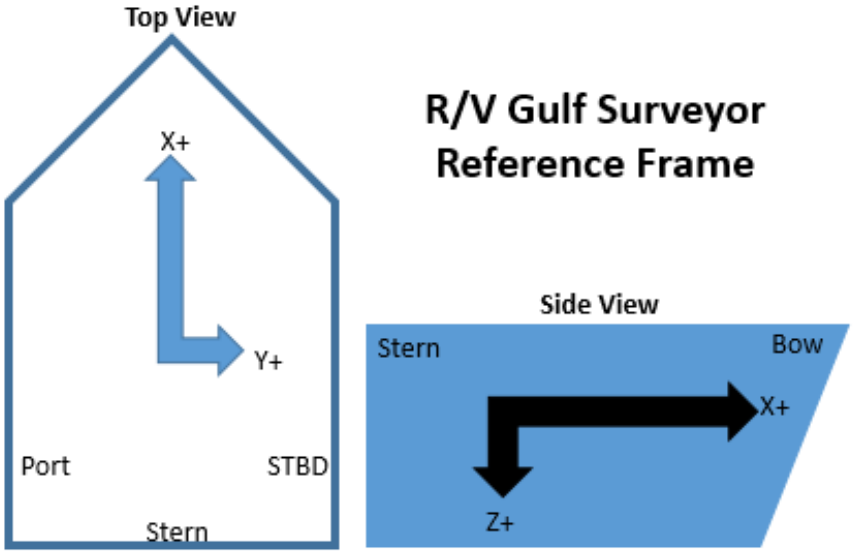


*Figure 20: RVGS Reference Frame Diagram.*

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

| *Vessel* | R/V Gulf Surveyor | | |
|---|---|---|---|
| *Date* | April 26, 2016 (initial survey), June 3, 2016 (final coordinates, June 6, 2016 (MBES ram offsets) | | |
| | Foreward (X) m | Starboard (Y) m | Downward (Z) m |
| R2 Sonic 2024 | -1.231 | 0.018 | 2.771 |
| IMU | -1.615 | 0.019 | 1.943 |
| Port Antenna (Primary) | 3.320 | -1.845 | -4.319 |
| Starboard Antenna | 3.320 | 1.895 | -4.319 |
| | | | |

*Table 12: Offsets from the Vessel Reference Point*

### C.1.2. Static and Dynamic Draft

#### C.1.2.1) 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 Qinsy.

#### C.1.2.1) Dynamic Draft

No dynamic draft corrections were applied to the data. Dynamic draft was not needed as the measurement were made relative to the ellipsoid.

## C.2. System Alignment

### C.2.1. Description of Corrector

Patch test

#### C.2.1.1) Patch Test Biases

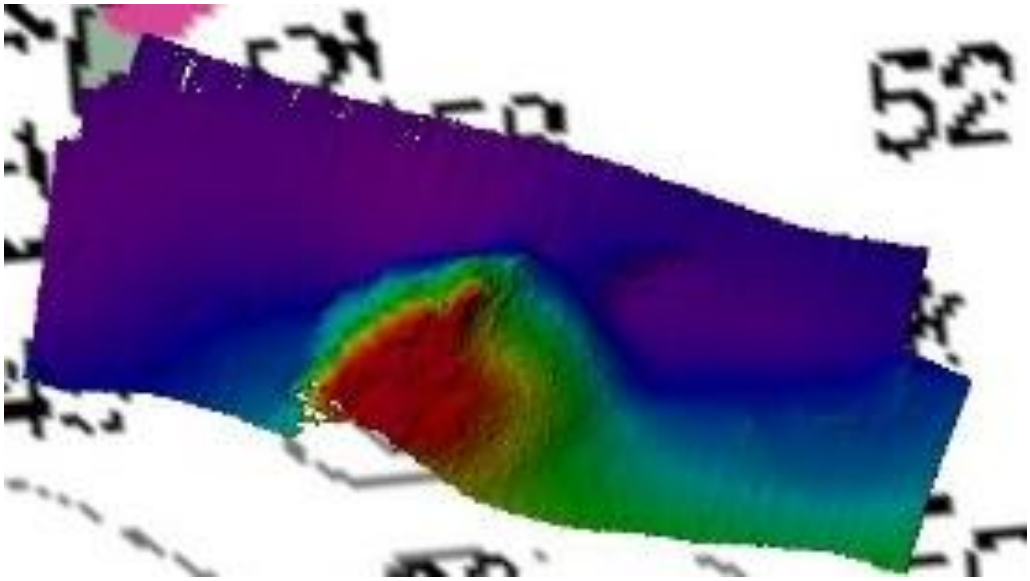

*Figure 21: Patch test raw data over Cod Rock (charted depth 17ft) in Portsmouth Harbor, NH*

The EM2040 data used for a patch test were acquired onboard the RVGS on June, 18, 2018 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. The following are the patch test values from Qimera upon completion of the Yaw (Heading), Pitch, and Roll bias tests. More information on the patch test are included in the Patch Test Report appendix submitted with this document.

#### C.2.1.1) Patch Test Results – Alignment Correctors

| Qimera | HyDrones and Manta |
|---|---|
| Roll | -0.18 |
| Pitch | 0.00 |
| Heading | 0.00 |

*Table 13: Patch test result summary of applied offsets*

## C.3. Positioning and Attitude

RTK correction data was collected from the GNSS base station established at Odiorne State Park. RTK corrections were broadcast from the roof of the Seacoast Science Center from a Trimble Trimmark 3 radio Modem via frequency 461.0750MHz at 4800 bps using TT450S Trimtalk protocol. They are provided in CMR+ format as 8 bit, 1 stop bit, and None Parity corrections with a 35W signal. The corrections are automatically brought into and applied in POSView.

## C.4. Sound Speed

### C.4.1. Sound Speed Profiles

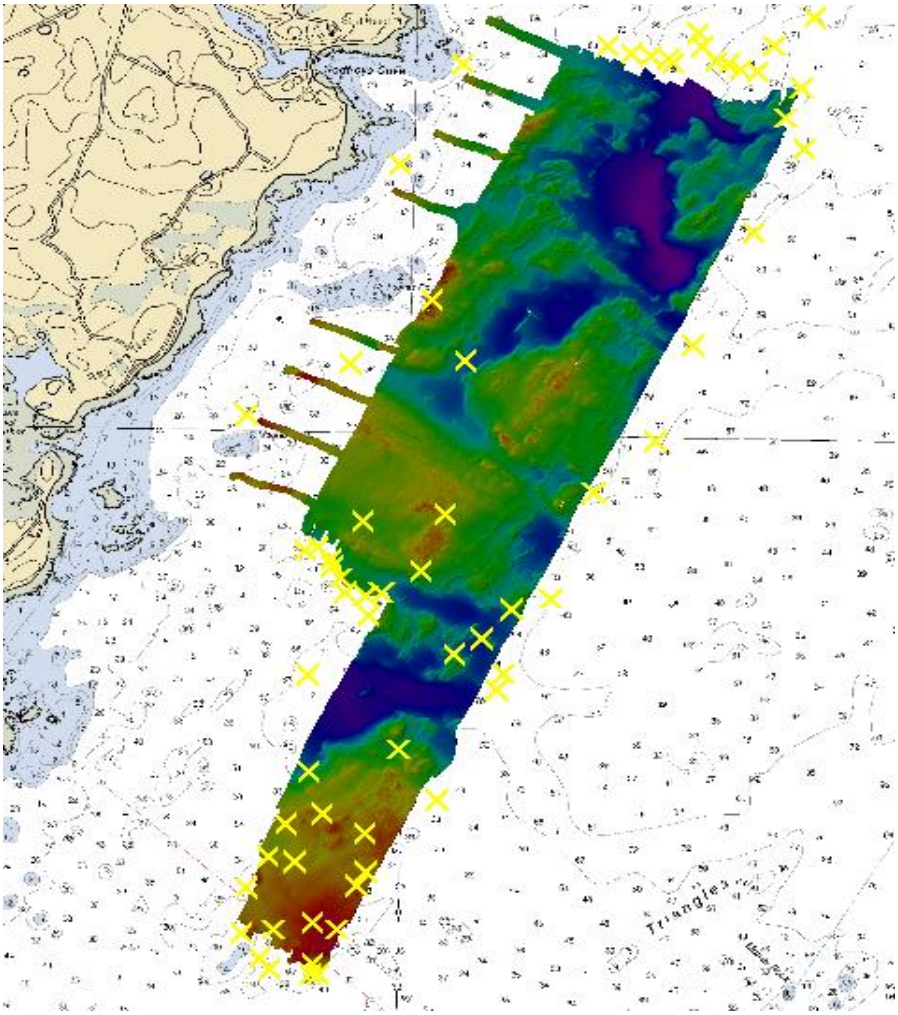

*Figure 22: MVP cast locations.*

Real-time sound speed corrections were applied to the R2Sonic 2024 data through Qinsy. Casts were taken using the MVP30 and the Teledyne ODOM Digi Bar Pro. The MVP30 consists of CTD sensors, attached to a tow fish, which was attached to a winch and deployed via the A-frame using a pulley system. The winch is attached to a deck controller unit, which is connected to the topside MVP interface and can be accessed via a dedicated laptop. MVP Controller software is used to instruct the tow fish as to

when to dive, and to monitor the data and status of the fish in real time. The sound speed profile is downloaded, using the software, and imported and applied in QINSy. Prior to importing the SSP into QINSy, the operator must QC the profile. The fish was programmed to remain 1m below the surface during survey line acquisition, and to dive to 2m above the seabed. The ODOM Digi Bar is a hand held unit, manually deployed over the side of the vessel. The device is then connected to the acquisition computer, and the cast downloaded and imported into QINSy.

### C.4.1. Surface Sound Speed

Surface sound speed at the transducer head was collected by an AML Smart SV&P during survey operations. The sensor was placed in the mounting bracket, along with the Sonic2024. The probe was connected to the SIM unit, inside the cabin via cable. The device measured sound speed at a rate of 1 Hz.