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Data Acquisition and Processing Report

CCOM/JHC
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Year: 2015
Version: 1
Publish Date: 2015-07-10

A Equipment

A.1 Survey Vessels

A.1.1 R/V COASTAL SURVEYOR

Name	R/V COASTAL SURVEYOR	
Hull Number	R/V COASTAL SURVEYOR	
Description	R/V COASTAL SURVEYOR is specifically designed for coastal multibeam hydrography.	
Utilization	Survey	
Dimensions	*LOA*	12.2 meters
	Beam	3.6 meters
	Max Draft	1.13 meters
Most Recent Full Static Survey	Full static survey was not performed.	
Most Recent Partial Static Survey	Partial static survey was not performed.	
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	*Date*	2015-06-04
	Method Used	measuring tape, laser, plumb line
	Discussion	Vertical and horizontal offsets were measured after EM2040 installation and compared to 2014 partial offset verification

Most Recent Static Draft Determination	*Date*	2014-06-12
	Method Used	tube
	Discussion	Static draft is determined by the height difference between the reference point of the IMU and waterline of the vessel. The height difference is measured daily at the beginning and end of survey. This procedure was performed close to the pier in calm waters and free floating. The unobstructed tube from the bottom of the vessel is located next to the reference point of the IMU so the height difference can be measured with a meter stick.
Most Recent Dynamic Draft Determination	Dynamic draft determination was not performed.	

Length	12.2 m
Beam	3.6 m
Maximum Draft	1.13 m
Flag	U.S.
Registry	U.S. Coastwise and Registry
Top Speed	10 knots
Roll Stabilization	Niad Active Fins
GPS	Garmin GPS17, WAAS Enabled
GNSS Antennas (GPS)	2 Trimble Zephyr Antennas
Telemetry	Trimble Trimark 3
GNSS Receiver (RTK GPS)	Applanix POSMV 320 V4 with IMU 200
Attitude	Applanix POSMV 320 V4 with IMU 200
Data acquisition software	Hypack
Sound Speed measurement	Digibar Pro – Profile Casts
Primary Echosounder	Kongsberg EM2040

Figure : R/V COASTAL SURVEYOR

A.1.2 R/V Galen J

Name	R/V Galen J
Hull Number	R/V Galen J

Description	This small vessel was used to conduct bottom samples on July 2, 2015	
Utilization	Bottom Sampling	
Dimensions	*LOA*	6.7 meters
	Beam	2.4 meters
	Max Draft	0.6 meters
Most Recent Full Static Survey	Full static survey was not performed.	
Most Recent Partial Static Survey	Partial static survey was not performed.	
Most Recent Full Offset Verification	Full offset verification was not performed.	
Most Recent Partial Offset Verification	Partial offset verification was not performed.	
Most Recent Static Draft Determination	Static draft determination was not performed.	
Most Recent Dynamic Draft Determination	Dynamic draft determination was not performed.	

Figure : Galen J

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

No side scan sonars were utilized for data acquisition.

A.2.2 Multibeam Echosounders

A.2.2.1 Kongsberg EM2040

Manufacturer	Kongsberg
Model	EM2040
Description	The transducer pod is mounted on the R/V Coastal Surveyor's bow ram. The transmit and receive transducer are interfaced to the PU via Ethernet to the SIS (seafloor information system) Hydrographic Workstation (HWS).
Serial Numbers	*Vessel Installed On*: R/V COASTAL SURVEYOR *Processor s/n*: 263 *Transceiver s/n*: 140 *Transducer s/n*: 1368 *Receiver s/n*: 165 *Projector 1 s/n*: None *Projector 2 s/n*: None

Specifications	*Frequency*	300 kilohertz	
	Beamwidth	*Along Track*	0.5 degrees
		Across Track	1 degrees
	Max Ping Rate	50 hertz	
	Beam Spacing	*Beam Spacing Mode*	In-between
		Number of Beams	400
	Max Swath Width	150 degrees	
	Depth Resolution	26 millimeters	
	Depth Rating	*Manufacturer Specified*	meters
		Ship Usage	meters
Manufacturer Calibrations	Manufacturer calibration was not performed.		
System Accuracy Tests	*Vessel Installed On*	R/V COASTAL SURVEYOR	
	Methods	Patch Test	
	Results	Patch Test results entered in SIS software for real time data corrections	
Snippets	Sonar does not have snippets logging capability.		

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

Manufacturer	N/A
Model	N/A
Description	For purposes of quality control, a lead line depth measurement was taken every day. This measurement was taken adjacent and in-line with the sonar head to facilitate direct comparison. The vertical offset of the transducer (Z axis) applied on SIS during the first day of data acquisition (June 10) was 10 cm less than the true value of that offset. On June 11th this problem was realized and that value was corrected before starting the data acquisition. In order to fix that problem, only for the first survey day, an offset of +10 cm was inserted in the vessel configuration file used for the data processing in CARIS. Note, the lead line measurements were not performed while docked at the UNH pier due to the presence of a muddy seafloor along the pier. Using a lead line to measure depth in these conditions will always result in a deeper false measurement.
Serial Numbers	0-01-05
Calibrations	No calibrations were performed.
Accuracy Checks	No accuracy checks were performed.
Correctors	Correctors were not determined.
Non-Standard Procedures	Non-standard procedures were not utilized.

Figure : Lead Line used for quality control

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Positioning and Attitude Equipment

A.4.1 Applanix POS/MV

Manufacturer	Applanix

Model	POS/MV
Description	The R/V COASTAL SURVEYOR was outfitted with an Applanix POS M/V 320 v4 which was used to provide accurate attitude, heading, heave, position, and velocity which was applied in real-time. The EM2040 multibeam system used this information for sonar beam steering corrections and to properly account for vessel movement.

PCS

Manufacturer	Applanix
Model	320 V4
Description	The POS Computer System comprises the processor, GPS receivers, and interface cards necessary to communicate and process the IMU and GPS data.
Firmware Version	2.12
Software Version	3.4.0.0
Serial Numbers	*Vessel Installed On*: R/V Coastal Surveyor *PCS s/n*: 2171

IMU

Manufacturer	Applanix
Model	IMU-200
Description	IMU input provides active beam steering for effective compensation of roll, pitch, and yaw vessel movements. The center target on the top of the Applanix IMU was used as the vessel's reference point.
Serial Numbers	*Vessel Installed On*: R/V COASTAL SURVEYOR *IMU s/n*: 179
Certification	IMU certification report was not produced.

Antennas

Manufacturer	Trimble
Model	Zephyr
Description	The two GPS antennas are located on the top of the vessel; the port side antenna is primary while the starboard antenna is secondary utilized for improving the accuracy of heading estimates.

Serial Numbers

Vessel Installed On	*Antenna s/n*	*Port or Starboard*	*Primary or Secondary*
R/V Coastal Surveyor	6000 4297	Port	Primary
R/V Coastal Surveyor	6000 8122	Starboard	Secondary

GAMS Calibration	GAMS calibration was not performed.

Configuration Reports	POS/MV configuration reports were not produced.

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 additional positioning and attitude equipment was utilized for data acquisition.

A.5 Sound Speed Equipment

A.5.1 Sound Speed Profiles

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

Manufacturer	Odom
Model	Digibar PRO
Description	This sound speed sensor was deployed over the side of the vessel and acquired the sound speed profile of the water column. This information was then imported into the Kongsberg SIS software to actively beam steer the bathymetric data.
Serial Numbers	*Vessel Installed On*: R/V COASTAL SURVEYOR *Sound Speed Profiler s/n*: DB98139
Calibrations	No CTD profiler calibrations were performed.

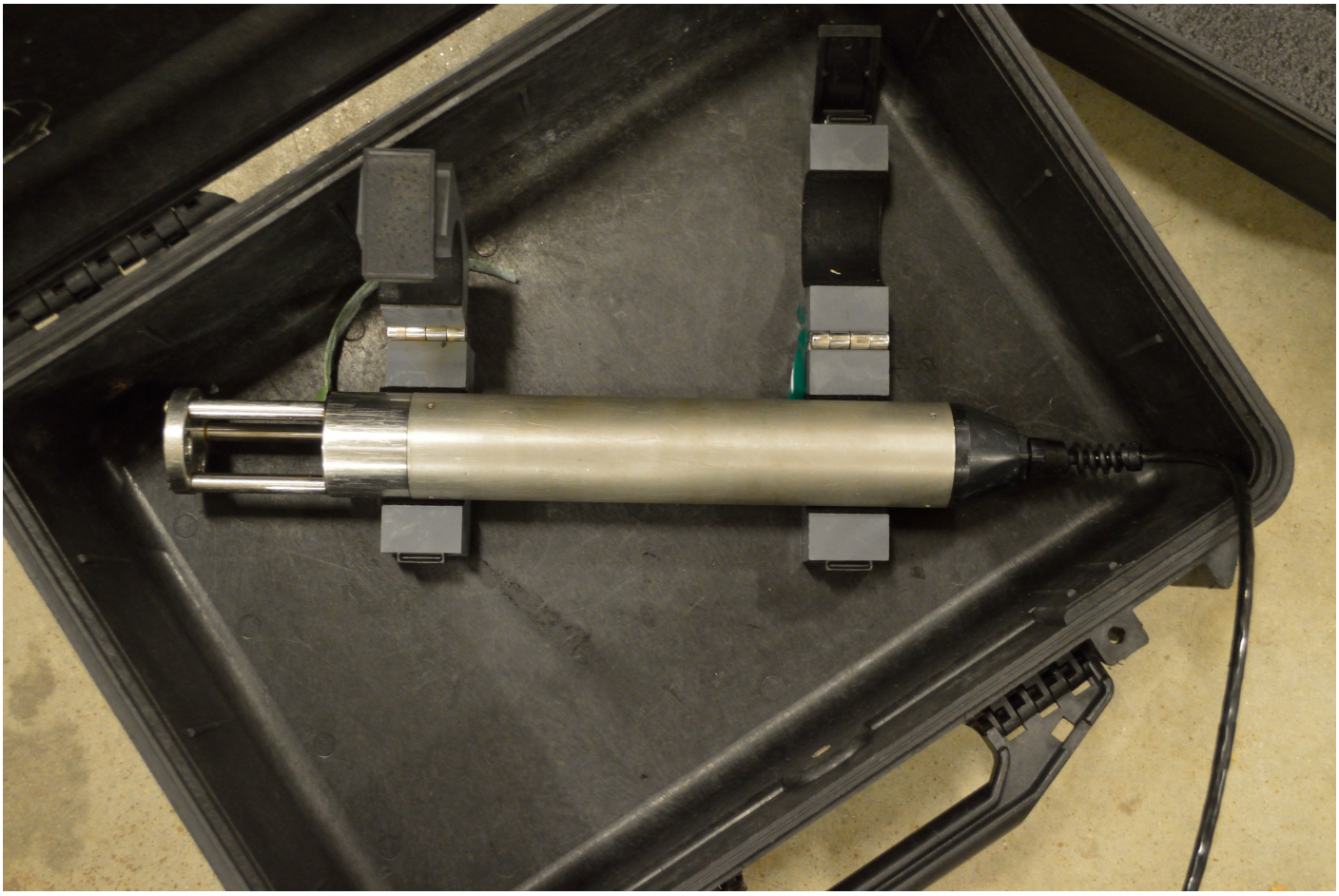

Figure : Odom Digibar PRO

A.5.2 Surface Sound Speed

A.5.2.1 AML Oceanographic Smart SV&T

Manufacturer	AML Oceanographic
Model	Smart SV&T
Description	The AML was used to gather measurements of sound speed at the location of the EM 2040.
Serial Numbers	*Vessel Installed On*: R/V Coastal Surveyor *Sound Speed Sensor s/n*: 5274
Calibrations	No CTD profiler calibrations were performed.

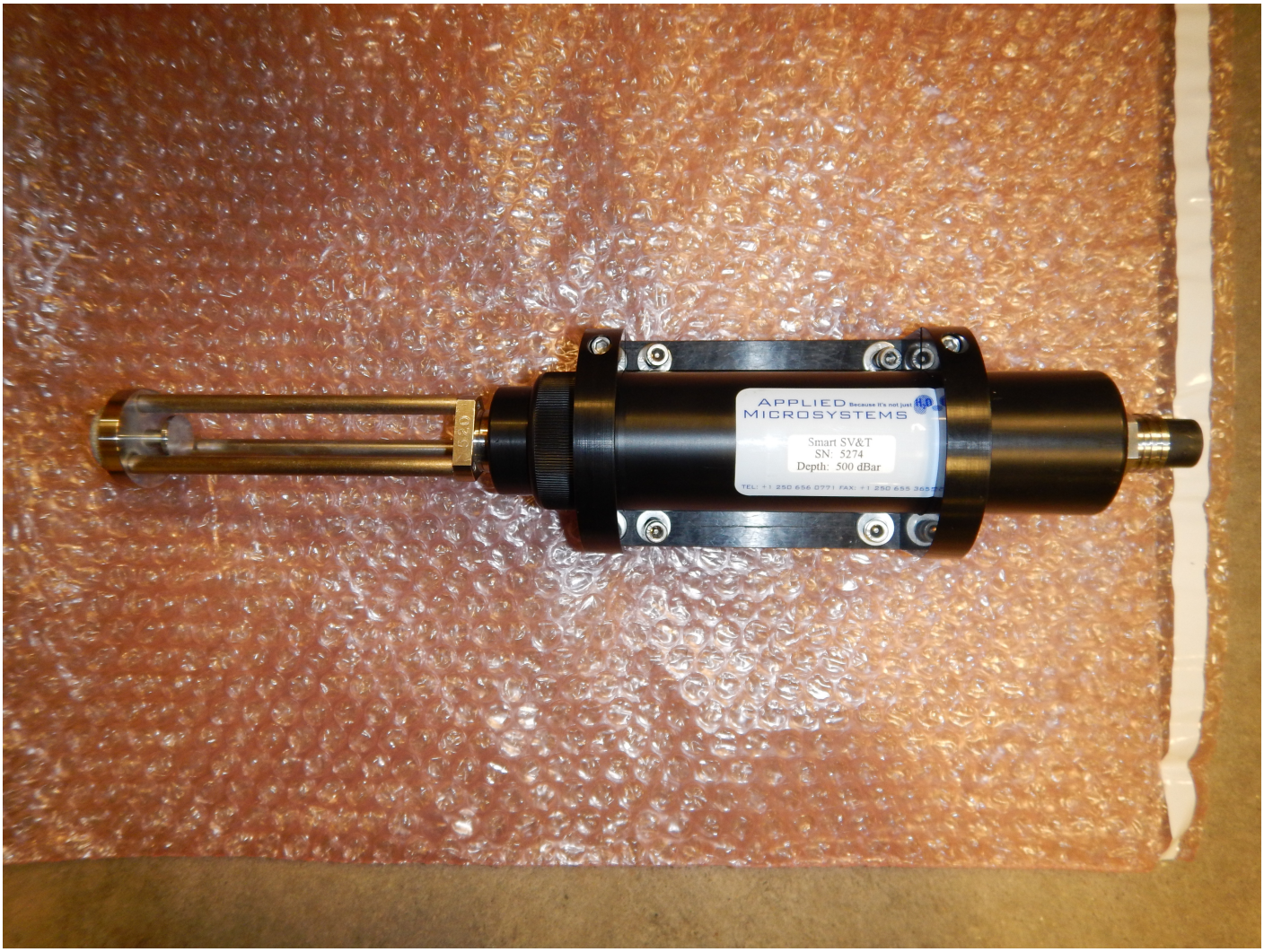

Figure : AML Oceanographic Smart SV&T

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

A.6.1.1 Base Station Equipment

Description	Two RTK base stations were established to broadcast RTK corrections to R/V COASTAL SURVEYOR. The first base station is fitted permanently on the roof of the Seacoast Science Center at Odiorne State Park, New Hampshire. The second base was established at the Rye Harbor State Park. Most of the data acquired refer to the Rye Harbor base station due to its proximity to the survey area.	
GPS Antennas	*Manufacturer*	Trimble
	Model	Zephyr Geodetic
	Description	Base station antenna at Rye Harbor State Park
	Serial Numbers	60073787
	Manufacturer	Trimble
	Model	Zephyr Geodetic
	Description	Base station antenna at Seacoast Science Center (Odiorne)
	Serial Numbers	unknown

GPS Receivers	*Manufacturer*	Trimble
	Model	5700
	Description	Odiorne Point station is powered A/C supply from Seacoast Science building and continuously broadcasts RTK corrections in CMR+ format via UHF radio at a frequency of 461.075 MHz. The Rye Harbor station was setup and broken down for each survey day, was powered by and electrical outlet, and broadcasted corrections at a frequency of 462.3750 MHz.
	Firmware Version	2.24
	Serial Numbers	220311827 (Seacoast Science Center at Odiorne State Park) 220358293 (Rye Harbor Station)
UHF Antennas	*Manufacturer*	Trimble
	Model	24253-46
	Description	The CMR+ formated correctors were broadcasted on UHF antennas. These antennas are able to transmit and receive at frequencies 450-470 MHz
	Serial Numbers	unknown
UHF Radios	*Manufacturer*	Trimble
	Model	TrimMark 3
	Description	The modem for broadcasting corrections from the RTK base stations
	Firmware Version	unknown
	Serial Numbers	unknown
Solar Panels	No solar panels were installed.	
Solar Chargers	No solar chargers were installed.	
DQA Tests	No DQA tests were performed.	

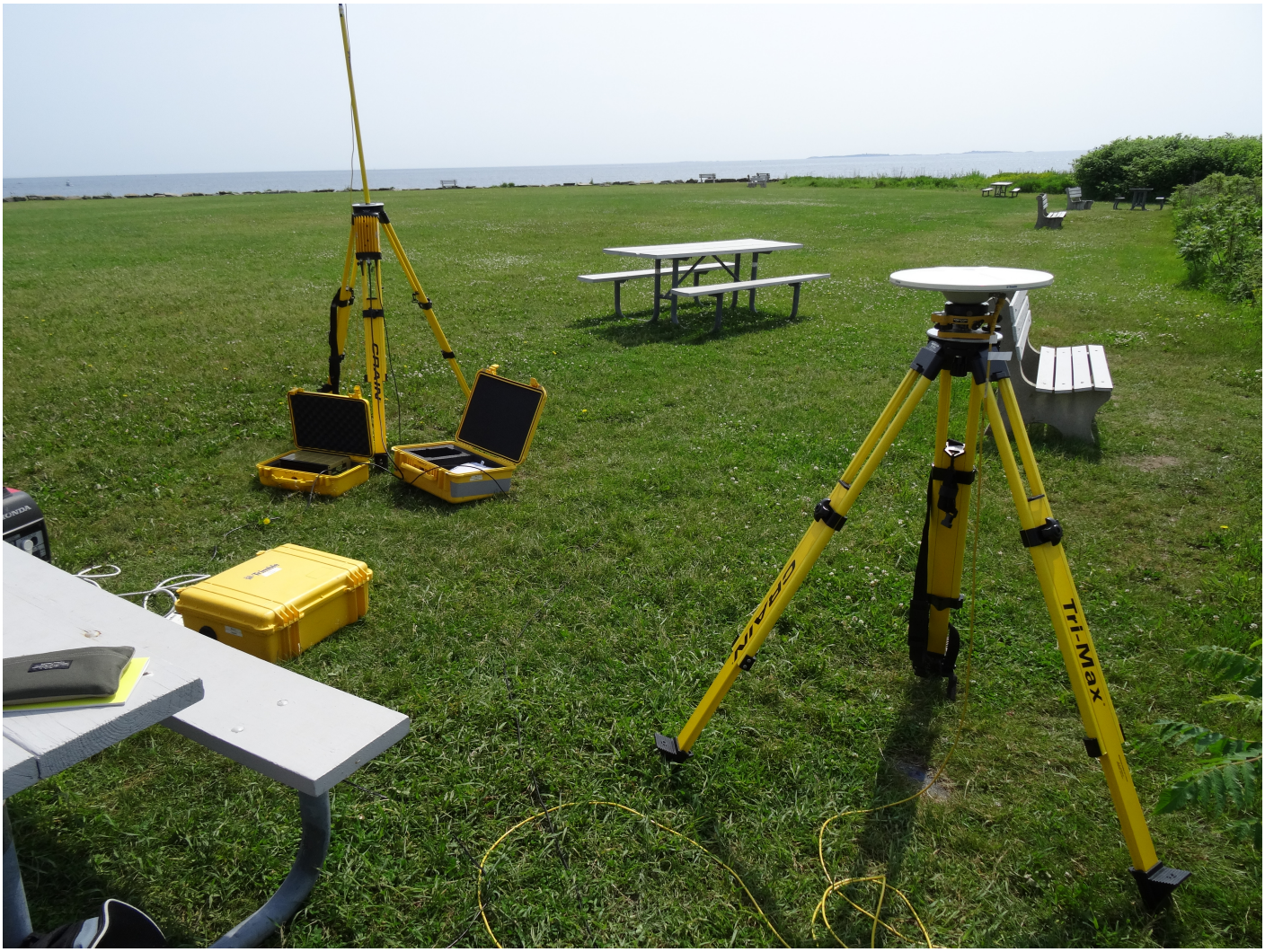

Figure : Rye RTK Base Station

Figure : Odiorne RTK Base Station

A.6.1.2 Rover Equipment

Description	No description was provided.

UHF Radios	*Manufacturer*	Trimble
	Model	TrimMark 3
	Description	No description was provided.
	Serial Numbers	*Vessel Installed On*: R/V COASTAL SURVEYOR *UHF Radio s/n*: 4516152631
UHF Antennas	*Manufacturer*	Trimble
	Model	24253-46
	Description	The CMR+ formated correctors were received on UHF antennas. These antennas are able to transmit and receive at frequencies 450-470 MHz
	Serial Numbers	*Vessel Installed On*: R/V COASTAL SURVEYOR *UHF Antenna s/n*: unknown

A.6.2 Vertical Control Equipment

A.6.2.1 Water Level Gauges

Manufacturer	WaterLog
Model	H-3611
Description	The radar water level sensor was used to measure the tides within Rye Harbor, NH.
Serial Numbers	D900291508D
Calibrations	No calibrations were performed.

Figure : Radar water level unit

A.6.2.2 Leveling Equipment

Manufacturer	Carl Zeiss
Model	NI2 Automatic Level
Description	This automatic level was used to measure the vertical offsets between all benchmarks installed at the tide station.
Serial Numbers	JHC 0016S
Calibrations	No calibrations were performed.
Kukkamaki	No Kukkamaki procedures were performed.

Figure : Carl Zeiss NI2 Automatic Level

A.7 Computer Hardware and Software

A.7.1 Computer Hardware

No computer hardware was utilized for data acquisition.

A.7.2 Computer Software

Manufacturer	Hypack Inc
Software Name	Hypack 2012
Version	12.0.0.1
Service Pack	NA
Hotfix	NA
Installation Date	2014-06-01
Use	Acquisition

Description	Hypack was used for line planning and data acquisition. No data was collected via Hypack.

Manufacturer	Kongsberg Maritime
Software Name	SIS
Version	4.1.5
Service Pack	NA
Hotfix	NA
Installation Date	2014-06-01
Use	Acquisition
Description	SIS was used for data acquisition and for shorelining. All data was collected via SIS. Real-time processing of waterline, vessel offsets and sound speed values were applied to soundings.

Manufacturer	Applanix
Software Name	POSView
Version	3.4.0.0
Service Pack	NA
Hotfix	NA
Installation Date	2014-06-01
Use	Acquisition
Description	POSView was used for collecting positioning and attitude data

Manufacturer	CARIS
Software Name	HIPS & SIPS
Version	9.0.13
Service Pack	NA
Hotfix	NA
Installation Date	2014-06-01
Use	Processing
Description	HIPS & SIPS was used for processing, cleaning, and analyzing the data.

Manufacturer	Fledermaus
Software Name	FMGT
Version	7.4.2
Service Pack	NA

Hotfix	NA
Installation Date	2014-06-01
Use	Processing
Description	Fledermaus FMGT was used for creating the multibeam backscatter mosaic

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Wildco Ponar Dredge 9" Scoops

Manufacturer	Wildco
Model	Ponar Dredge 9" Scoops
Description	This type of grab sampler is very versatile for all types of hard bottoms such as sand, gravel and clay. It is a modified Van Veen type type self tripping sampler features center hinged jaws and a spring loaded pin that releases when the sampler makes impact with the bottom. The top is covered with a stainless screen with neoprene rubber flaps which allows water to flow through for a controlled decent and less interference with the sample. The specification of the model used are: Empty weight: 23 kg; Full weight: 34 kg; Sample area: 229 x 229 mm; and Volume: 8.2 L.

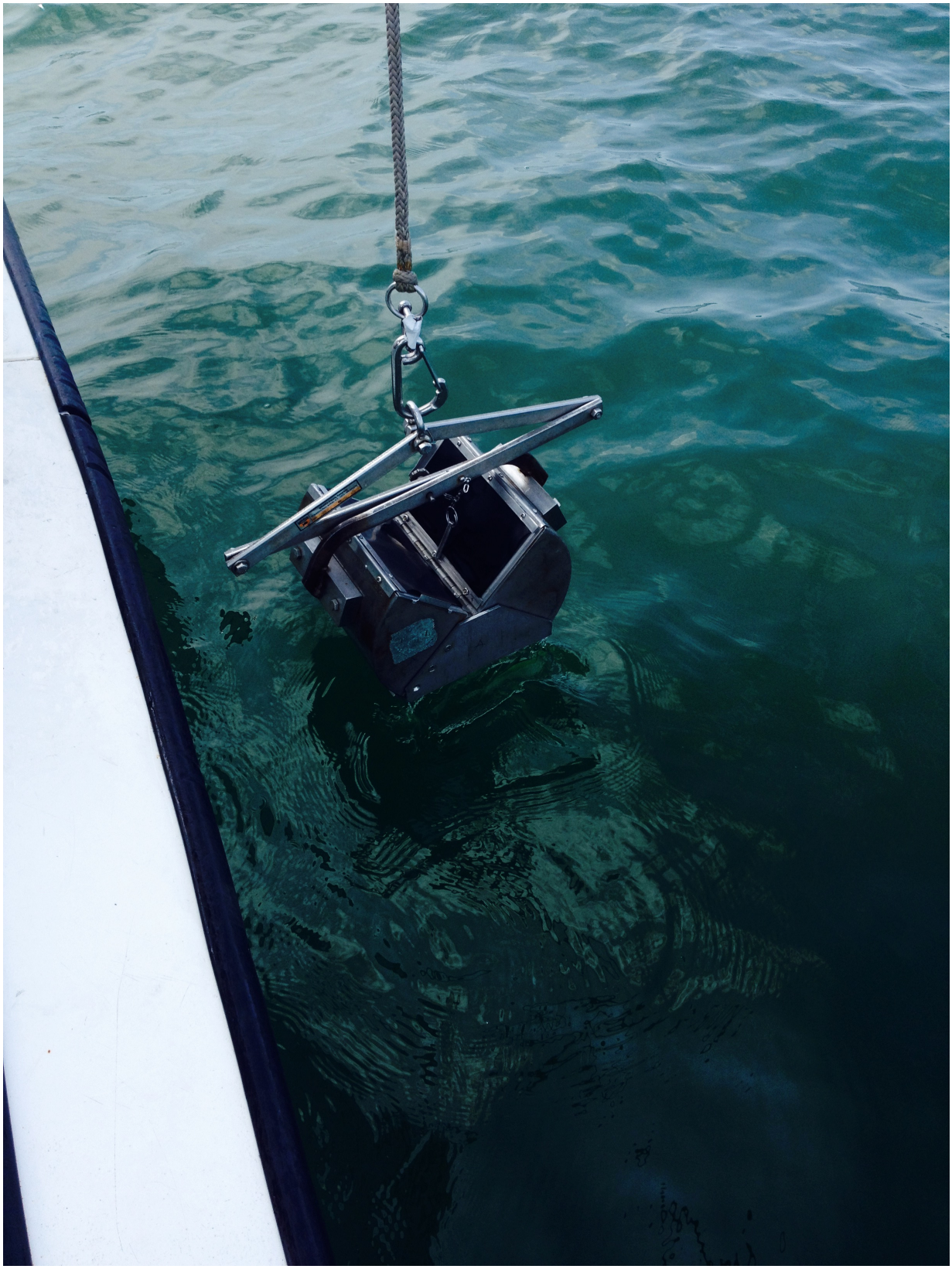

Figure : Wildco Ponar Grab Sampler

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

A Kongsberg EM 2040 multibeam echo sounder was used for the entire survey area. The operational mode used was normal mode with a frequency of 300 kHz and the pulse type was set to medium CW (200 microseconds).

Figure : Kongsberg EM 2040 transducer installed on bow mount of R/V COASTAL SURVEYOR

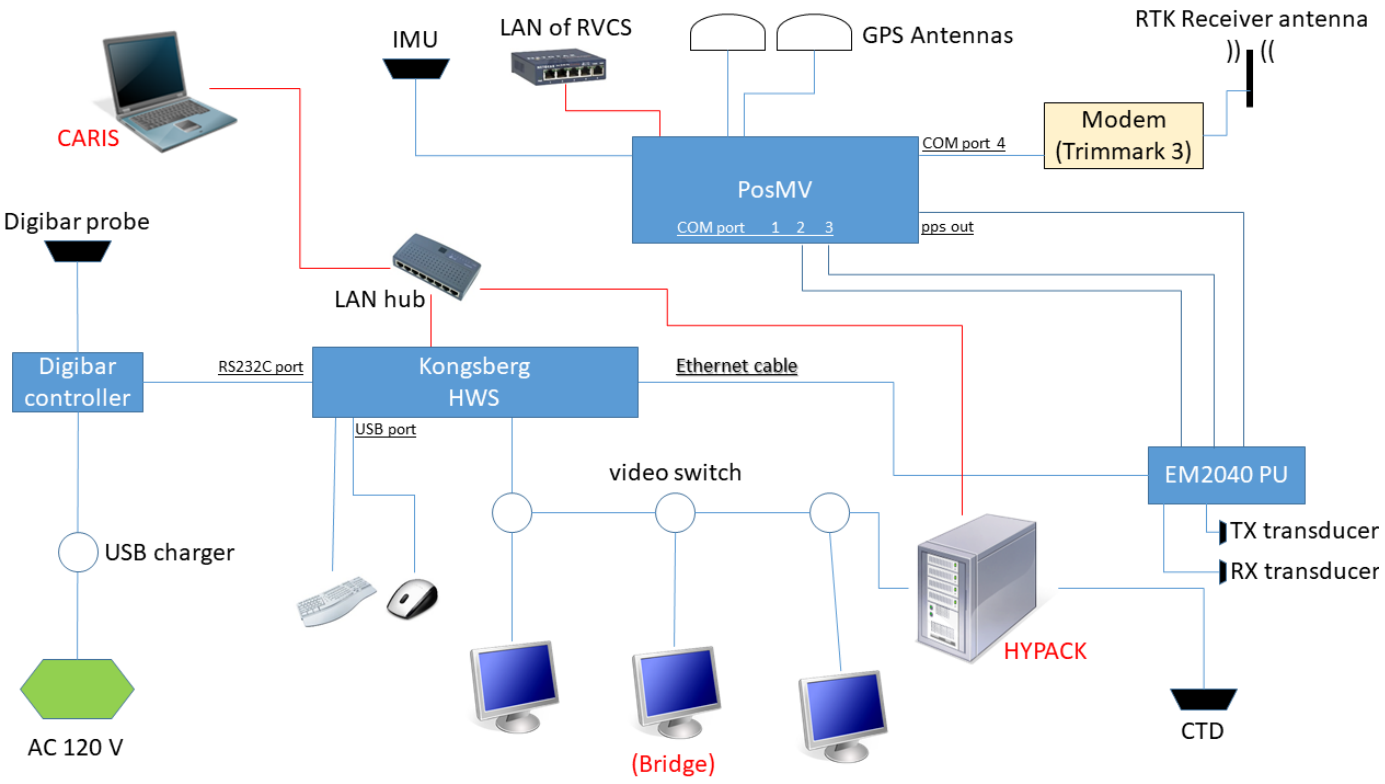

Figure : R/V COASTAL SURVEYOR survey systems

B.1.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

B.1.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

B.1.2 Imagery

B.1.2.1 Side Scan Sonar

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

The Multibeam EM 2040 requires two types of sound speed inputs during survey: a surface sound speed and a sound speed profile. The surface sound speeds were acquired by an AML sound speed sensor and the sound speed profiles were acquired by using a Digibar PRO sound speed profiler. The AML surface sound speed sensor was mounted to the EM 2040 sonar head to provide continuous surface sound speed measurements to SIS for real-time beam steering and ray tracing. A sound speed cast was conducted before commencing acquisition for each day and again throughout the day as needed. The information was then downloaded via Wcom utility suppled by Hypack and converted to .asvp file format to be imported into SIS.

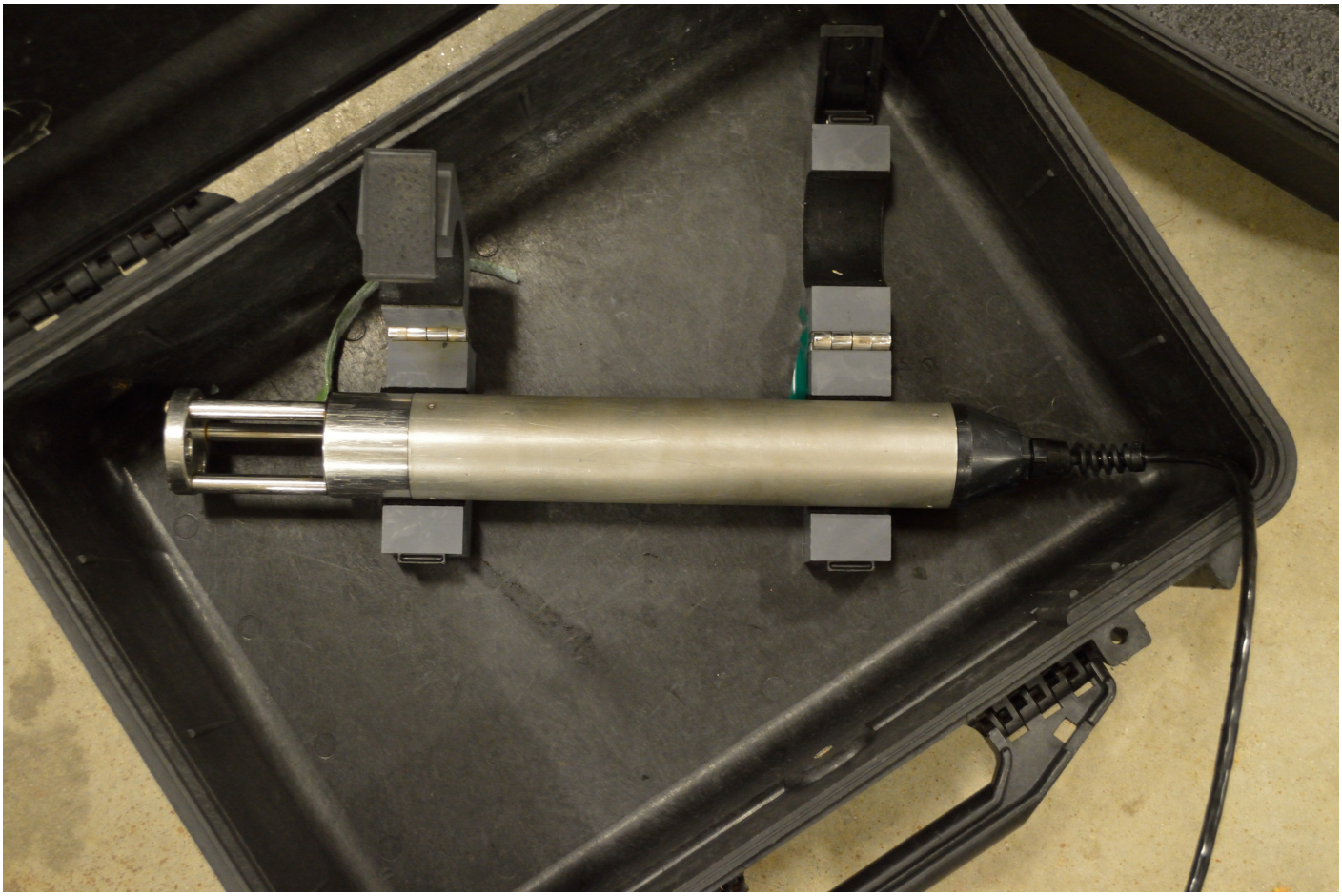

Figure : Digibar Pro

B.1.3.2 Surface Sound Speed

The AML Oceanographic Smart SV&T was mounted directly on top of the EM 2040 transducer pod, was connected to its topside unit, which was powered by a standard bus bar within the vessel. The device was configured to measure sound speed at 1Hz and transmit it directly to the Kongsberg SIS acquisition computer via serial interface.

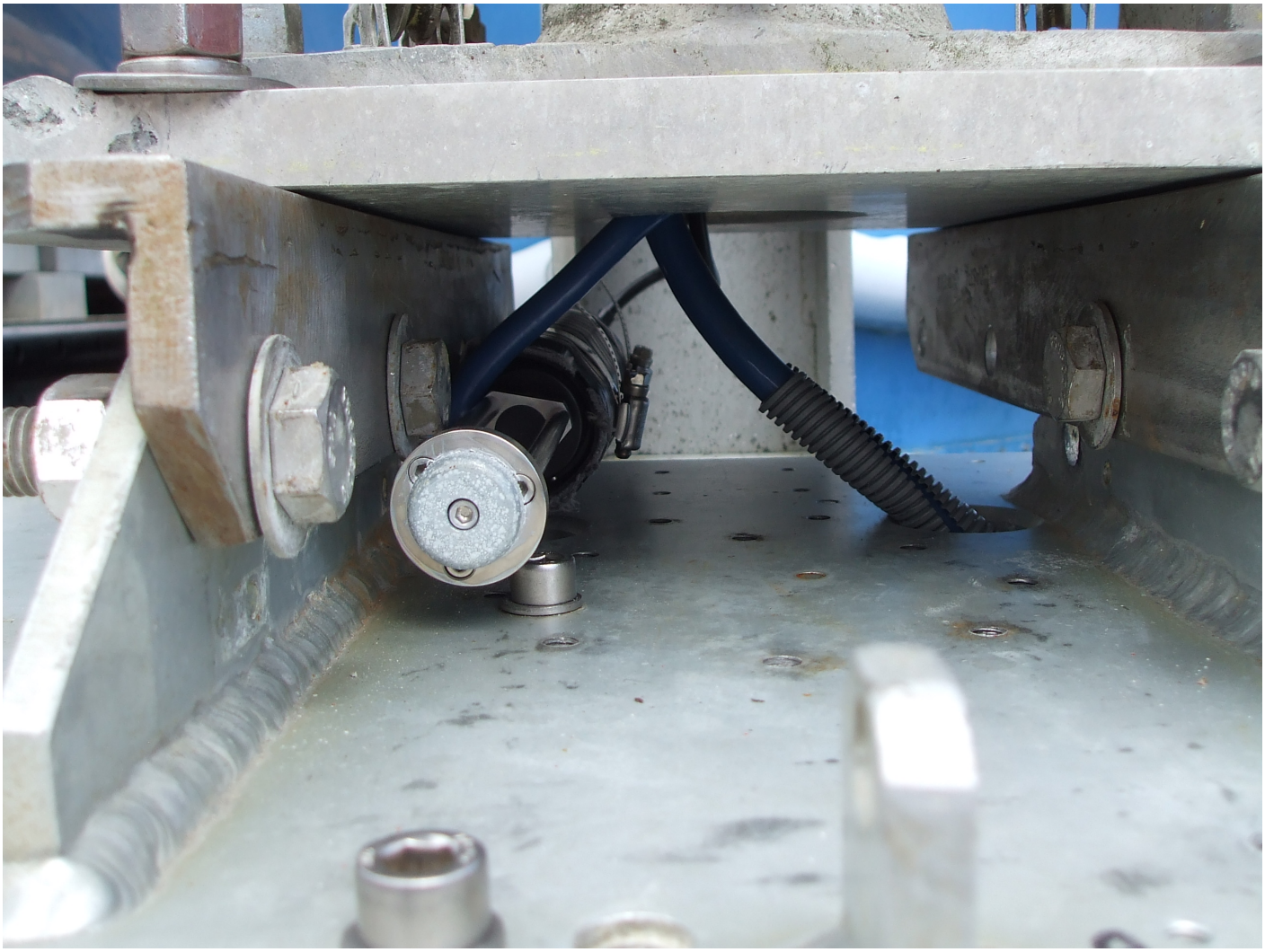

Figure : AML Oceanographic Smart SV&T mounted to the EM 2040 transducer pod

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

An RTK GPS base station was established daily at Rye Harbor State Park in Rye, NH. The data was recorded and downloaded daily. The coordinates used were WGS84 coordinates (43 00’ 5.73129” N , 070 44’ 38.77763” W, Elevation: -22.887m) obtained from NOAA OPUS results for June 8, 2015.

B.1.4.2 Vertical Control

Vertical control data were not acquired.

B.1.5 Feature Verification

Feature verification data were not acquired.

B.1.6 Bottom Sampling

The bottom samples were collected on the Galen J on July 2, 2015. The sample locations were chosen based on the multibeam backscatter mosaic generated from the data acquired during the Summer Hydro 2015 class. The Ponar Type Grab Sampler was lowered over the starboard side of the vessel by hand and allowed to free fall until the bottom was reached and the line went slack. The sampler was then retrieved by using a 'pot puller' next to the helm of the vessel. Refer to the final feature file for bottom sample descriptions. In addition, a drop camera was used to get video of the bottom for further classification.

B.1.7 Backscatter

Multibeam backscatter was collected using the Kongsberg EM 2040 echo sounder and was recorded in the .all files. The backscatter data from EM2014 was processed using FMGeocoder Toolbox (FMGT) and a mosaic was created with a 0.5m resolution. This surface was used to choose bottom sample locations for sea floor characterization.

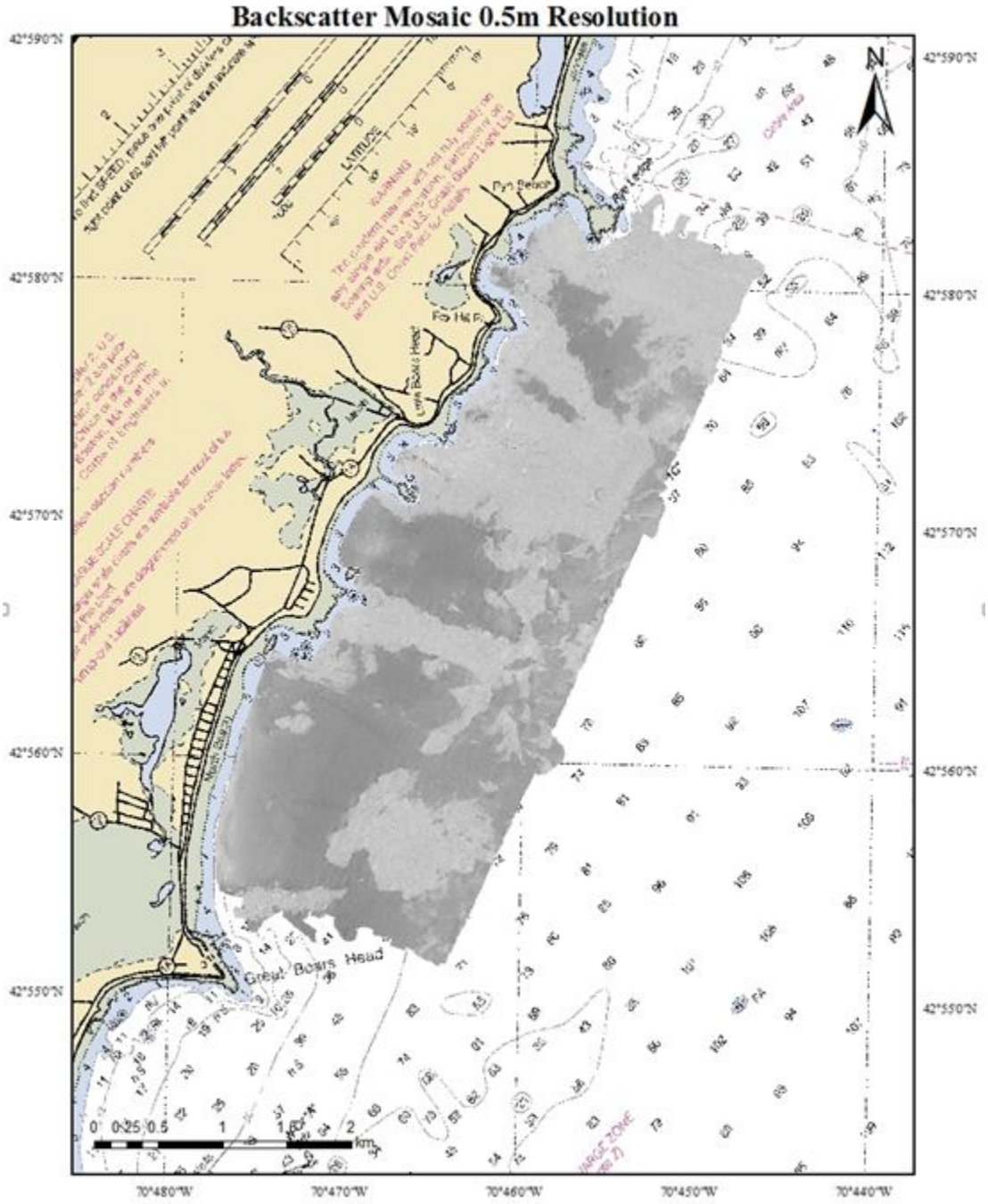

Figure : Backscatter mosaic at 0.5m resolution

B.1.8 Other

No additional data were acquired.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

Multibeam data are logged locally on the SIS acquisition machine in .all format. The .all file format includes sounding solutions, navigation, attitude, and backscatter data. The ship navigation and survey line monitoring are done in Hypack as well as SIS, although no bathymetry data was logged in Hypack.
All multibeam data was collected in equidistant beam steering mode. The opening angle was set to 150 degrees and was selected based on analysis of coverage, speed and expected sound speed refraction errors for the survey. Real-time processing in CARIS was performed to check for coverage and systematic errors.

All of the .all files were transfered to an external hard drive and copied onto the network at CCOM for final processing. The .all files were converted using CARIS HIPS. For Kongsberg EM2040, the vessel file (.hvf) has the following settings; 1. x/y/z offsets are zero because Simrad data acquisition applies static draft and shifts the swath profile to the vessel reference point (IMU); 2. roll/pitch/yaw transducer mounting rotations are zero because Simrad data acquisition applies patch test calibration results; 3. apply is set to NO for heave, pitch and roll; 4. waterline value apply is set to NO. In CARIS HIPS, the .all files were converted with GPS Height set to EM Height (not GGA). Next, navigation was loaded for each day by selecting the POS/MV file with the RTK corrections per day and importing navigation and GPS Height values. An observed tide file with a -6min time correction was loaded for all lines and then data was merged for the loaded correctors to be applied to the data. Estimated total propagated uncertainty was then calculated. CUBE base surface was created using 2009 NOAA cube parameters. The resulting surface was reviewed for quality control using subset editor. Where the surface differed from the data by more than 1/2 the allowable TVU at depth, a sounding was designated. Due to the rocky nature of this survey, the grid resolutions were reduced based on the complete coverage requirements (50 cm and 1 m instead of 1 m and 2 m). The two CUBE surfaces were then finalized and designated soundings were applied and the uncertainty layer set to be greater of the two, standard deviation and uncertainty. The chart comparison was conducted on a combined 1m surface. The uncertainty and density analysis were conducted on the 0.5 m and 1 m surfaces separately.

Figure : Processing Workflow

B.2.1.2 Single Beam Echosounder

Single beam echosounder bathymetry 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

Review of processing log and detailed line query to ensure all correctors applied. Exceeded complete coverage requirements.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

All methods used to generate final bathymetric grids follow the best practices in the 2015 FPM

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Gridding Parameters Surface Computation Algorithms
Description	2009 NOAA cube parameters

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 imagery was not processed.

B.2.2.3 Specific Data Processing Methods

B.2.2.3.1 Methods Used to Maintain Data Integrity

Processing logs are used to record and communicate problems from acquisition to final processing

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

n/a

B.2.2.3.3 Methods Used to Verify Swath Coverage

Swath coverage was verified through real time processing. The outer portions of the swath were monitored for refraction artifacts.

B.2.2.3.4 Criteria Used for Contact Selection

n/a

B.2.2.3.5 Compression Methods Used for Reviewing Imagery

No compression methods were used for reviewing imagery.

B.2.3 Sound Speed

B.2.3.1 Sound Speed Profiles

Surface sound speed is measured in real-time by the AML Smart SV&T located on the multibeam transducer POD and applied for beam steering in the Kongsberg SIS software. Sound speed profiles are measured by Digibar Pro several times every day. The sound speed measurements were converted to sound speed profile files for SIS software (.asvp files) using the Hypack Wcom utility. The .asvp files were imported into the SIS software and sound speed corrections were applied for echo soundings in SIS software.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

Caris SVP files were not concatenated.

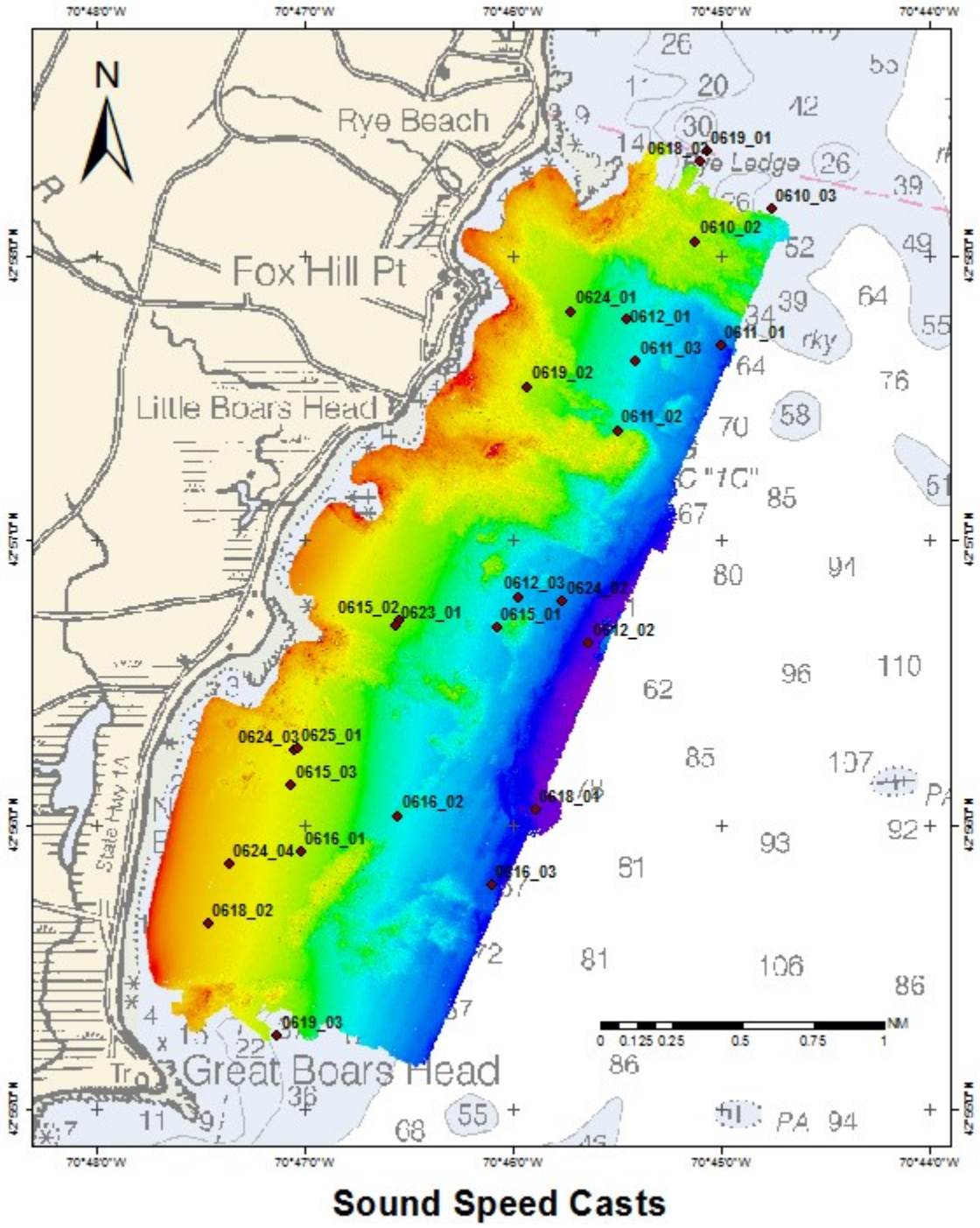

Figure : Sound speed cast locations

B.2.3.2 Surface Sound Speed

Surface sound speed data were not processed.

B.2.4 Horizontal and Vertical Control

B.2.4.1 Horizontal Control

Horizontal control data were not processed.

B.2.4.2 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 are logged locally on the SIS acquisition machine in .all format. .all files are imported to QPS FMGeocorder Toolbox 7.3.6 to make a mosaic image of 0.5 m resolution. The generated mosaic image is exported to a geotiff file.

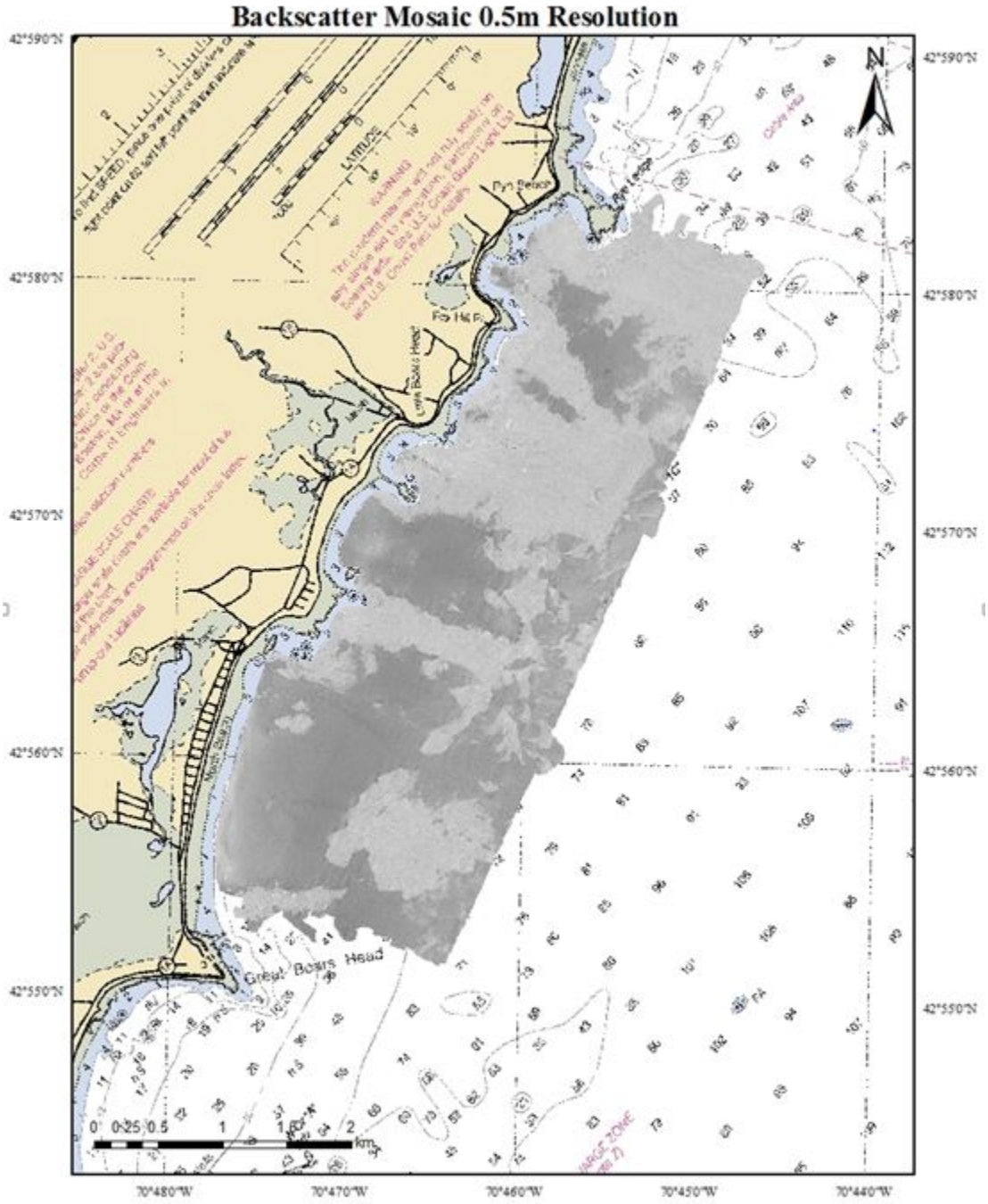

Figure : Backscatter mosaic 50cm

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Quality control was performed in near real-time by transferring .all files onto a processing laptop and converting, loading predicted tide, merge, compute tpu and add to CUBE base surface. The CUBE surface was used to confirm coverage and each line added was compared to existing crosslines to check for systematic errors.
At CCOM, the raw .all files were transfered to the network and additional conversion and correctors applied before cleaning. For this post-processing of the data, detailed line querys were performed to confirm appropriate corrector files were loaded and applied to the appropriate days.
Data acquisition and processing logs were maintained to record and communication problems from acquisition to final processing.

B.4 Uncertainty and Error Management

TPU values calculated in CARIS HIPS during the calculate TPU step. The estimated uncertainty values from the finalized surface is populated as the greater value from standard deviation and uncertainty. The finalized uncertainty child layer was evaluated against the total allowed vertical uncertainty at each depth node. High uncertainty nodes were investigated in CARIS subset editor for flyers or designating real features.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

Calculated in CARIS HIPS

B.4.1.2 Source of TPU Values

Caris HVF

B.4.1.3 TPU Values

<table>
<tr><td>Vessel</td><td colspan="3">R/V COASTAL SURVEYOR</td></tr>
<tr><td>Echosounder</td><td colspan="3">Kongsberg EM2040 300 kilohertz</td></tr>
<tr><td rowspan="5">TPU Standard Deviation Values</td><td rowspan="5">Motion</td><td>Gyro</td><td>0.02 degrees</td></tr>
<tr><td rowspan="2">Heave</td><td>5 % Amplitude</td></tr>
<tr><td>0.05 meters</td></tr>
<tr><td>Pitch</td><td>0.02 degrees</td></tr>
<tr><td>Roll</td><td>0.02 degrees</td></tr>
</table>

Navigation Position	1 meters	
Timing	*Transducer*	0.01 seconds
	Navigation	0.01 seconds
	Gyro	0.01 seconds
	Heave	0.01 seconds
	Pitch	0.01 seconds
	Roll	0.01 seconds
Offsets	*x*	0.01 meters
	y	0.01 meters
	z	0.01 meters
MRU Alignment	*Gyro*	0 degrees
	Pitch	0 degrees
	Roll	0 degrees
Vessel	*Speed*	0.154 meters/second
	Loading	0.01 meters
	Draft	0.01 meters
	Delta Draft	0.01 meters

B.4.2 Deviations

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

C Corrections To Echo Soundings

C.1 Vessel Offsets and Layback

C.1.1 Vessel Offsets

C.1.1.1 Description of Correctors

The R/V COASTAL SURVEYOR offsets are obtained annually by the Summer Hydro students. Static offsets of a vessel and its instrumentation are measured for the purpose of establishing a local reference frame to which all soundings and positions will be tied. Thus, errors in these measurements will directly translate to errors in survey data acquired by that vessel.

C.1.1.2 Methods and Procedures

The following items shall be positioned as part of any static offset survey: permanent benchmarks, sonar transducers, GPS antennas, reference points, center of motion, IMU, etc.
According to the NOAA Field Procedures Manual, the method used to determinate the offsets was the advanced method, which employs precision survey equipment such as theodolites, laser range finders, total stations and optical levels. One advantage of using these optical techniques is that measurements are independent of the vessel's attitude and alignment. Since the surveying instrument can be positioned anywhere convenient, measurements between benchmarks can often be accomplished with a single setup, thereby minimizing error.

C.1.1.3 Vessel Offset Correctors

Vessel	R/V COASTAL SURVEYOR		
Echosounder	Kongsberg EM2040 300 kilohertz		
Date	2014-06-12		
Offsets	*MRU to Transducer*	*x*	8.78 meters
		y	0 meters
		z	0 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Nav to Transducer	*x*	0 meters
		y	0 meters
		z	0 meters
		x2	N/A
		y2	N/A
		z2	N/A
	Transducer Roll	*Roll*	0 degrees
		Roll2	N/A

C.1.2 Layback

Layback correctors were not applied.

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

Daily water level

C.2.1.2 Methods and Procedures

Waterline indicator (water tube) is located beneath POS/MV IMU of R/V Coastal Surveyor. Water level is measured with respect to the reference level of IMU. The measurement have been carried out before and on completion of survey every day. The waterlines were entered into the SIS acquisition system for real-time corrections during sounding.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

A dynamic draft table of R/V COASTAL SURVEYOR that was generated during Summer Hydro 2006 was used for this survey.

C.2.2.2 Methods and Procedures

The values of dynamic draft were entered into the vessel configuration file and applied in CARIS post-processing.

C.2.2.3 Dynamic Draft Correctors

Vessel	R/V COASTAL SURVEYOR	
Date	2015-06-10	
Dynamic Draft Table	*Speed*	*Draft*
	5.144	0.239
	4.630	0.166
	4.116	0.104
	3.601	0.053
	3.087	0.012
	2.572	-0.017
	2.058	-0.035
	1.543	-0.043
	1.029	-0.04
	0.514	-0.025

C.3 System Alignment

C.3.1 Description of Correctors

Patch Test

C.3.2 Methods and Procedures

A path test was conducted on June 8, 2015 on the 'G5' buoy block within Portsmouth Harbor. Latency was examined through two sounding lines over a feature with same track and direction but differences speed which were 4 knots and 8 knots. Pitch and roll was conducted over same track and speed but reciprocal direction. Yaw offsets were determined through two survey lines over a feature that been detected from same outer beam from each pass. The offsets were entered into the SIS acquisition system for real-time corrections. The SIS patch test results are:
Time latency: 0 seconds
Pitch: 1.83 degrees
Roll: -0.81 degrees
Yaw: -1.12 degrees

Additional patch tests were run by each group to evaluate in CARIS HIPS. No additional patch test corrections were added to the HVF.

C.3.3 System Alignment Correctors

Vessel	R/V COASTAL SURVEYOR	
Echosounder	Kongsberg EM2040 300 kilohertz	
Date	2014-06-12	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	1.83 degrees
	Roll	-0.81 degrees
	Yaw	-1.12 degrees
	Pitch Time Correction	0 seconds
	Roll Time Correction	0 seconds
	Yaw Time Correction	0 seconds
	Heave Time Correction	0 seconds

C.4 Positioning and Attitude

C.4.1 Description of Correctors

RTK

C.4.2 Methods and Procedures

For precise positioning, two GNSS base stations were established near the survey area for broadcasting RTK corrections to R/V COASTAL SURVEYOR via Trimble Trimmark 3 radio Modems in CMR+ format. One is located on the roof of the Seacoast Science Center at Odiorne State Park, New Hampshire.
Another base station was established at the Rye Harbor State Park to provide RTK corrections for the entire survey area. The reference point of this base station was a orange stake that was driven into the ground . The coordinates of reference point are provided by Online Positioning User Service (OPUS, http://www.ngs.noaa.gov/OPUS/) depending on 2 hours observation on June 8, 2014.

C.5 Tides and Water Levels

C.5.1 Description of Correctors

Observed Tides

C.5.2 Methods and Procedures

Observed tide data was downloaded from CO-OPs for the primary station Fort Point, NH. The zone definition file received from CO-OPS from last year was used. This time correction (-6min) was applied to the Fort Point tide file and loaded to the data in CARIS HIPs 'load tide' process and applied in the merge step.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

The sound speed profiles were obtained from a Digibar Pro and applied to data in SIS

C.6.1.2 Methods and Procedures

Sound speed profile correctors were integrated into the SIS machine for real-time ray tracing.

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

Applied to data in SIS

C.6.2.2 Methods and Procedures

Surface sound speed correctors collected by the digibar were integrated into the SIS machine for real-time beam formation.