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Data Acquisition and Processing Report

CCOM/JHC
Chief of Party: Semme Dijkstra and Andrew Armstrong
Year: 2014
Version: 1
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A Equipment

A.1 Survey Vessels

A.1.1 R/V Coastal Surveyor

<table>
<tr><td>Name</td><td>R/V Coastal Surveyor</td></tr>
<tr><td>Hull Number</td><td>R/V Coastal Surveyor</td></tr>
<tr><td>Description</td><td>R/V Coastal Surveyor is designed specifically for coastal multibeam hydrography.</td></tr>
<tr><td>Utilization</td><td>Survey</td></tr>
<tr><td>Dimensions</td><td><table><tr><td>LOA</td><td>12.2 meters</td></tr><tr><td>Beam</td><td>3.6 meters</td></tr><tr><td>Max Draft</td><td>1.13 meters</td></tr></table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td>Full static survey was not performed.</td></tr>
<tr><td>Most Recent Partial Static Survey</td><td>Partial static survey was not performed.</td></tr>
<tr><td>Most Recent Full Offset Verification</td><td>Full offset verification was not performed.</td></tr>
<tr><td>Most Recent Partial Offset Verification</td><td><table><tr><td>Date</td><td>2014-06-06</td></tr><tr><td>Method Used</td><td>measuring tape, laser, plumb line</td></tr><tr><td>Discussion</td><td>vertical and horizontal offsets were measured after EM2040 installation and compared to 2009 full offset verification</td></tr></table></td></tr>
</table>

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. 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 1: R/V Coastal Surveyor

A.1.2 R/V Cocheco

Name	R/V Cocheco
Hull Number	R/V Cocheco

Description	Research vessel designed primarily for towing oceanographic equipment with its hydraulic A-frame and cable winch.	
Utilization	Survey	
Dimensions	*LOA*	10.4 meters
	Beam	3.6 meters
	Max Draft	1.7 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.	

R/V Cocheco	Vessel Specifications	
	**Length**	10.4 m
	Beam	3.6 m
	Maximum Draft	1.7 m
	Flag	U.S.
	Top Speed	16 knots
	GPS	Garmin GPS17, WAAS Enabled
	GPS Antennas	Trimble 27207
	Differential GPS	Trimble DSM212h
	Bottom Sampler	Wildco Shipek Grab Sampler
	Data Acquisition Software	Hypack

Figure 2: R/V Cocheco

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 EM 2040

<table>
<tr><td>Manufacturer</td><td colspan="2">Kongsberg</td></tr>
<tr><td>Model</td><td colspan="2">EM 2040</td></tr>
<tr><td>Description</td><td colspan="2">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) data acquisition machine.</td></tr>
<tr><td rowspan="7">Serial Numbers</td><td>Vessel Installed On</td><td>R/V Coastal Surveyor</td></tr>
<tr><td>Processor s/n</td><td>263</td></tr>
<tr><td>Transceiver s/n</td><td>140</td></tr>
<tr><td>Transducer s/n</td><td>1368</td></tr>
<tr><td>Receiver s/n</td><td>165</td></tr>
<tr><td>Projector 1 s/n</td><td>None</td></tr>
<tr><td>Projector 2 s/n</td><td>None</td></tr>
</table>

Specifications	*Frequency*	400 kilohertz	
	Beamwidth	*Along Track*	0.7 degrees
		Across Track	0.7 degrees
	Max Ping Rate	50 hertz	
	Beam Spacing	*Beam Spacing Mode*	Equidistant
		Number of Beams	400
	Max Swath Width	140 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 on 6/16/2014 (Julian Day 167). This measurement was taken adjacent and in-line with the sonar head to facilitate direct comparison. The lead line depth was 5.16 meters and the echo sounder depth (corrected to water surface) was 5.21 meters.
Serial Numbers	
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.

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

<table>
<tr><td>Model</td><td>POS/MV</td></tr>
<tr><td>Description</td><td>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 (to be applied in real-time). The EM2040 multibeam system used this information for sonar beam steering correction, minimizing vessel movement artifacts.</td></tr>
<tr><td>PCS</td><td><table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>320 V.4</td></tr>
<tr><td>Description</td><td>POS Computer System comprises the processor, GPS receivers and interface cards necessary to communicate with and process the IMU and GPS data.</td></tr>
<tr><td>Firmware Version</td><td>2.12</td></tr>
<tr><td>Software Version</td><td>3.4</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>R/V Coastal Surveyor</td></tr>
<tr><td>PCS s/n</td><td>2171</td></tr>
</table></td></tr>
</table></td></tr>
<tr><td>IMU</td><td><table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>IMU-200</td></tr>
<tr><td>Description</td><td>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.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>R/V Coastal Surveyor</td></tr>
<tr><td>IMU s/n</td><td>179</td></tr>
</table></td></tr>
<tr><td>Certification</td><td>IMU certification report was not produced.</td></tr>
</table></td></tr>
<tr><td>Antennas</td><td><table>
<tr><td>Manufacturer</td><td>Trimble</td></tr>
<tr><td>Model</td><td>Zepher</td></tr>
<tr><td>Description</td><td>The two GPS antennas are located on the top of the vessel; the port side antenna is the primary antenna while the starboard antenna is a secondary antenna utilized for improving the accuracy of heading estimates.</td></tr>
<tr><td>Serial Numbers</td><td><table>
<tr><td>Vessel Installed On</td><td>Antenna s/n</td><td>Port or Starboard</td><td>Primary or Secondary</td></tr>
<tr><td>R/V Coastal Surveyor</td><td>6000 4297</td><td>Port</td><td>Primary</td></tr>
<tr><td>R/V Coastal Surveyor</td><td>6000 8122</td><td>Starboard</td><td>Secondary</td></tr>
</table></td></tr>
</table></td></tr>
</table>

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

A.5.1.1.1 Sea Bird Electronics Seacat SBE 19

Manufacturer	Sea Bird Electronics
Model	Seacat SBE 19
Description	The CTD was used to gather measurements of conductivity, temperature and pressure in the water column in the survey area

Serial Numbers	*Vessel Installed On*: R/V Coastal Surveyor *CTD s/n*: 192538
Calibrations	*CTD s/n*: 192538 *Date*: 2014-03-05 *Procedures*: Conductivity and temperature calibration

A.5.1.2 Sound Speed Profilers

No sound speed profilers were utilized for data acquisition.

A.5.2 Surface Sound Speed

A.5.2.1 Odom Digibar Pro DB1200

Manufacturer	Odom
Model	Digibar Pro DB1200
Description	The Digibar 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*: 98536
Calibrations	No CTD profiler calibrations were performed.

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

A.6.1.1 Base Station Equipment

Description	Two RTK base station were established to broadcast RTK corrections to R/V Coastal Surveyor. First base station is fitted permanently on the roof of the Seacoast Science Center at Odiorne State Park, New Hampshire. Second base was established at the Rye Harbor State Park station and most of data acquisition refer to RTK corrections from Rye Harbor station since it is located in survey area.	
GPS Antennas	*Manufacturer*	Trimble
	Model	Zepher Geodetic
	Description	Base station antenna at Rye Harbor State Park
	Serial Numbers	60073787
	Manufacturer	Trimble
	Model	Zepher 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 with frequency of 461.075 MHz. The Rye Harbor station operated during survey days only due to powered by generator to broadcast corrections with frequency of 464.500 MHz.
	Firmware Version	2.24
	Serial Numbers	220311827 220358293
UHF Antennas	*Manufacturer*	Trimble
	Model	24253-46
	Description	450-470MHz
	Serial Numbers	unknown
UHF Radios	No UHF antennas were installed.	

Solar Panels	No solar panels were installed.
Solar Chargers	No solar chargers were installed.
DQA Tests	No DQA tests were performed.

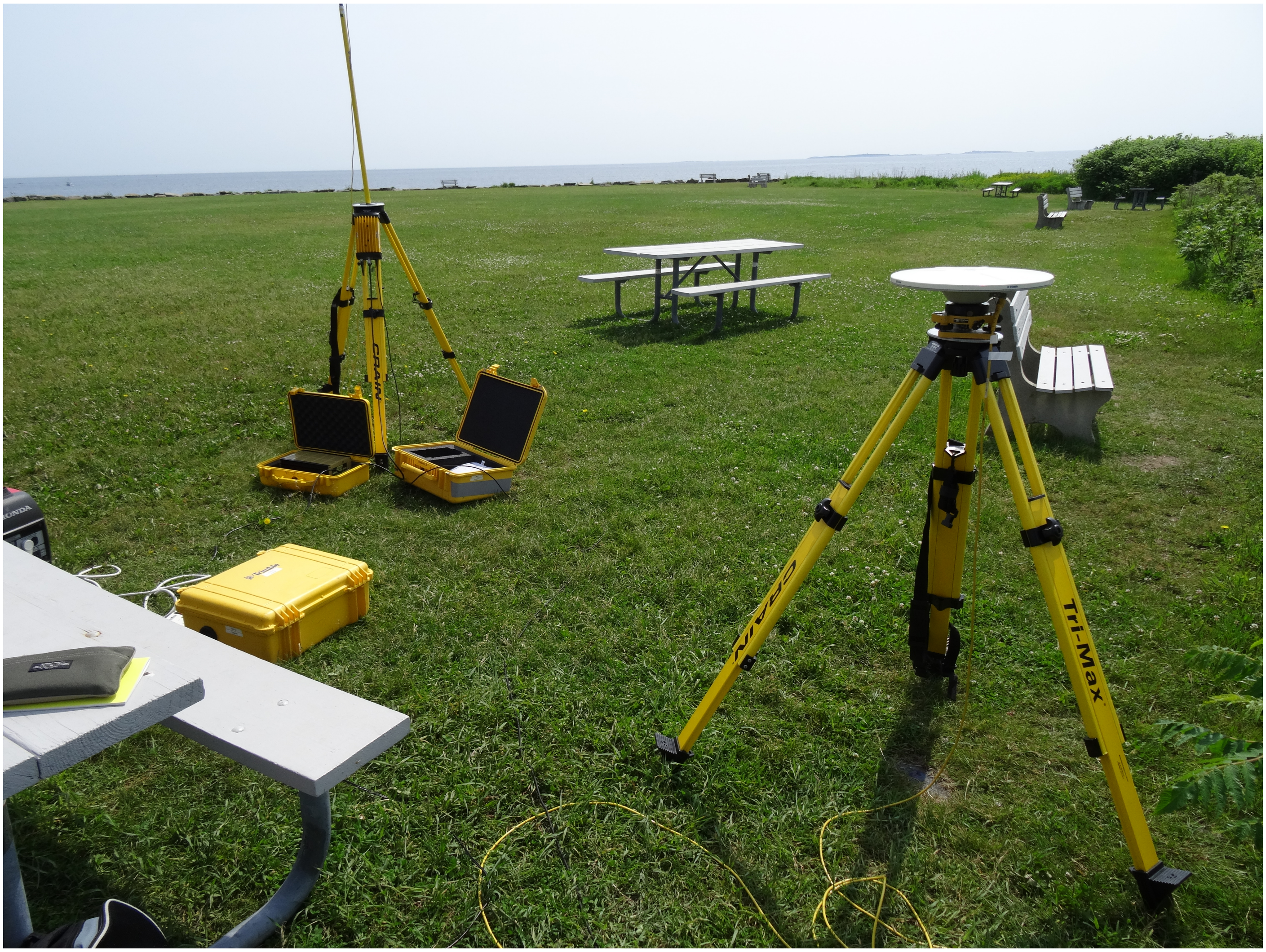

Figure 3: Rye RTK Base Station

Figure 4: Odiorne RTK Base Station

A.6.1.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.6.2 Vertical Control Equipment

No vertical control equipment was utilized for data acquisition.

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	N/A
Hotfix	N/A
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	N/A
Service Pack	N/A
Hotfix	N/A
Installation Date	2014-06-01
Use	Acquisition and Processing
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	N/A
Hotfix	N/A
Installation Date	2014-06-01
Use	Acquisition
Description	POSView was used for collecting positioning and attitude data

Manufacturer	Sea-Bird Electronics
Software Name	SeaTerm

Version	1.57
Service Pack	N/A
Hotfix	N/A
Installation Date	2014-06-01
Use	Acquisition
Description	SeaTerm was used for downloading the CTD sound speed profiles

Manufacturer	CARIS
Software Name	HIPS & SIPS
Version	8.1.7
Service Pack	N/A
Hotfix	N/A
Installation Date	2014-06-01
Use	Processing
Description	HIPS & SIPS was used for processing, cleaning, and analyzing the data.

Manufacturer	CARIS
Software Name	BathyDatabase
Version	4.0
Service Pack	N/A
Hotfix	N/A
Installation Date	2014-06-01
Use	Processing
Description	BDB was used for feature creation, chart comparison, and data analysis.

Manufacturer	Fledermaus
Software Name	FMGT
Version	7.3.6
Service Pack	N/A
Hotfix	N/A
Installation Date	2014-06-01
Use	Processing
Description	Fledermaus FMGT was used for creating the multibeam backscatter mosaic

Manufacturer	MathWorks

Software Name	MATLAB
Version	8.1.0.604
Service Pack	N/A
Hotfix	N/A
Installation Date	2014-06-01
Use	Processing
Description	MATLAB was used for converting the raw CTD files (.hex) to SIS compatible files (.asvp)

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Wildco Shipek

Manufacturer	Wildco
Model	Shipek
Description	The Grab Sampler was used for the purposes of sediment sampling. It consists of a sampler bucket, a trigger mechanism, a weight and a couple of springs. It was carried out by lowering the equipment into water at a required position and vertically hanged it by using a winch on board the vessel. Then it is launched dive to water until hit the bottom of the sea floor. Simultaneously, mechanical response between weight and trigger which it releases the bucket to catch sediment using a force generated by the torsion springs.

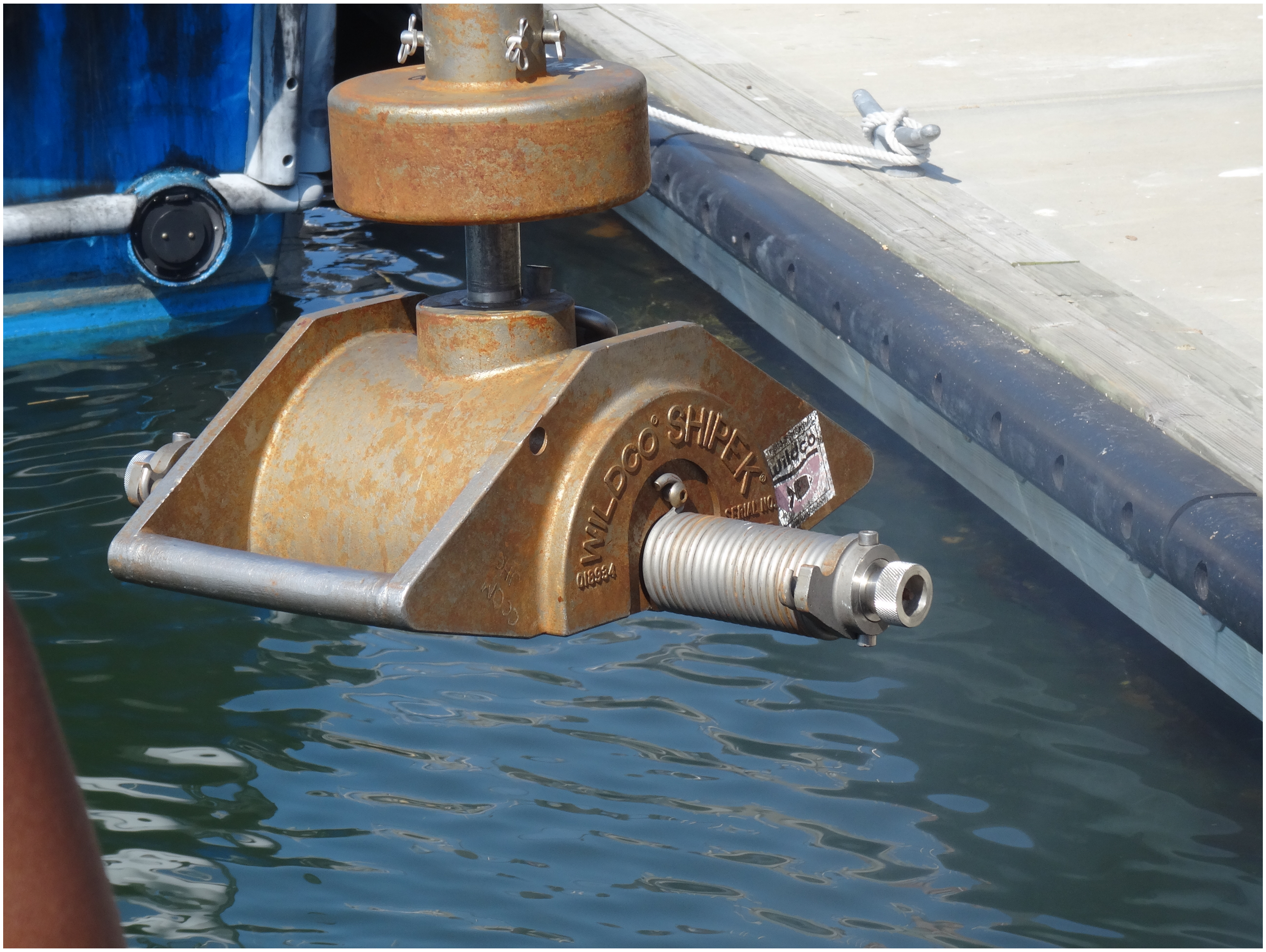

Figure 5: Wildco Shipek Grab Sampler

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 (tri-sector) with a frequency of 400 kHz and the pulse type was set to short CW (70 microseconds).

Figure 6: Kongsberg EM 2040 transducer installed on bow mount of R/V Coastal Surveyor

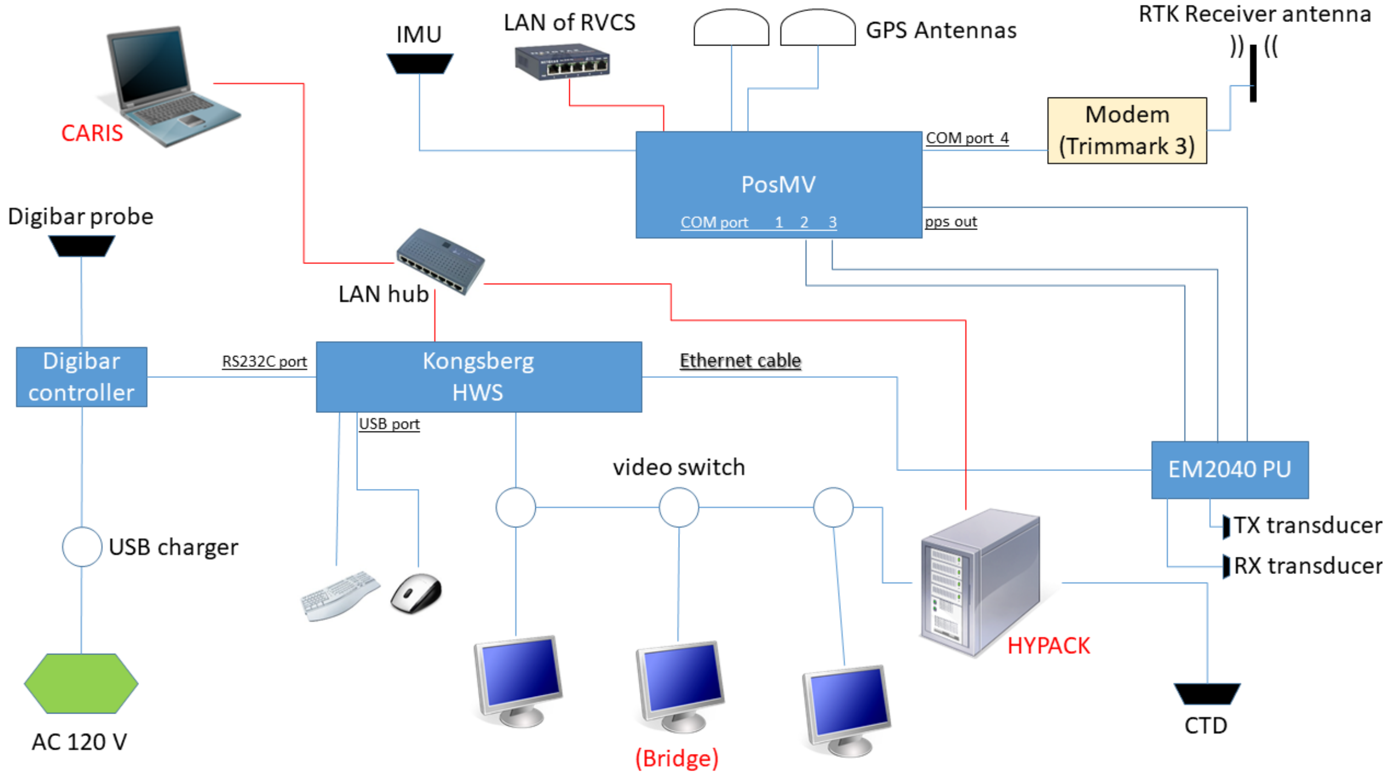

Figure 7: R/V Coastal Surveyor survey systems

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 EM2040 requires two types of sound speed inputs during survey: a surface sound speed and a sound speed profile. The surface sound speeds were determined by a Digibar sound speed sensor and the sound speed profiles were obtained by a Seabird SeaCat SBE19 CTD. The digibar 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; before to arrive to the survey area, the group made CTD cast, submerging it for 1 minute and after that submerging it until the sea floor; immediately and after each cast, the raw sound speed measurement file was downloaded from the instrument and converted to SIS .asvp file format using a matlab code, and loaded in to SIS. The sound speed measurement profile input into SIS from the digibar profiler during real-time acquisition was used by SIS for real-time ray tracing in conjunction with the real-time surface sound speed input.

Figure 8: Seabird 19 CTD

B.1.3.2 Surface Sound Speed

The Odom Digibar Pro was mounted directly on top of the EM2040 Transducer pod, and was connected to its topside unit, which was powered by a standard USB power adapter. The device was configured to measure SVP at 1Hz and transmit it directly to the Kongsberg SIS acquisition computer via serial interface (without logging data internally).

Figure 9: Digibar Pro (right) mounted on top of multibeam EM 2040 transducer

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

A 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 NAD83 coordinates (43-00-4.49071 N, 70-44-39.12139 W) obtained from NOAA OPUS results for June 12, 2014.

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 R/V Cocheco on June 30 and July 1, 2014. The sample locations were chosen based on the multibeam backscatter mosaic. The Wildco Shipek Grab Sampler was lowered over the stern of the vessel using the mechanical A-frame and allowed to free fall until the bottom was reached and the line went slack. The sampler was raised until there was tension in the line and then dropped a second time to help ensure a sample was collected. The samples were bagged and described.

B.1.7 Backscatter

Multibeam backscatter was collected using the Kongsberg EM 2040 echo sounder and was recorded in the .all files. A backscatter mosaic was created using Fledermaus FMGT.

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 140 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 and 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. A field sheet covering the entire survey area was created and a 50cm and 1m 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, there are numerous designated soundings selected and the grid resolutions were reduced based on the complete coverage requirements (50cm and 1m instead of 1m and 2m). 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 two finalized surfaces were combined in CARIS BDB using least depth as the combine rule. All chart comparisons, uncertainty and density analysis, and feature selection was performed on the combined 1m surface.

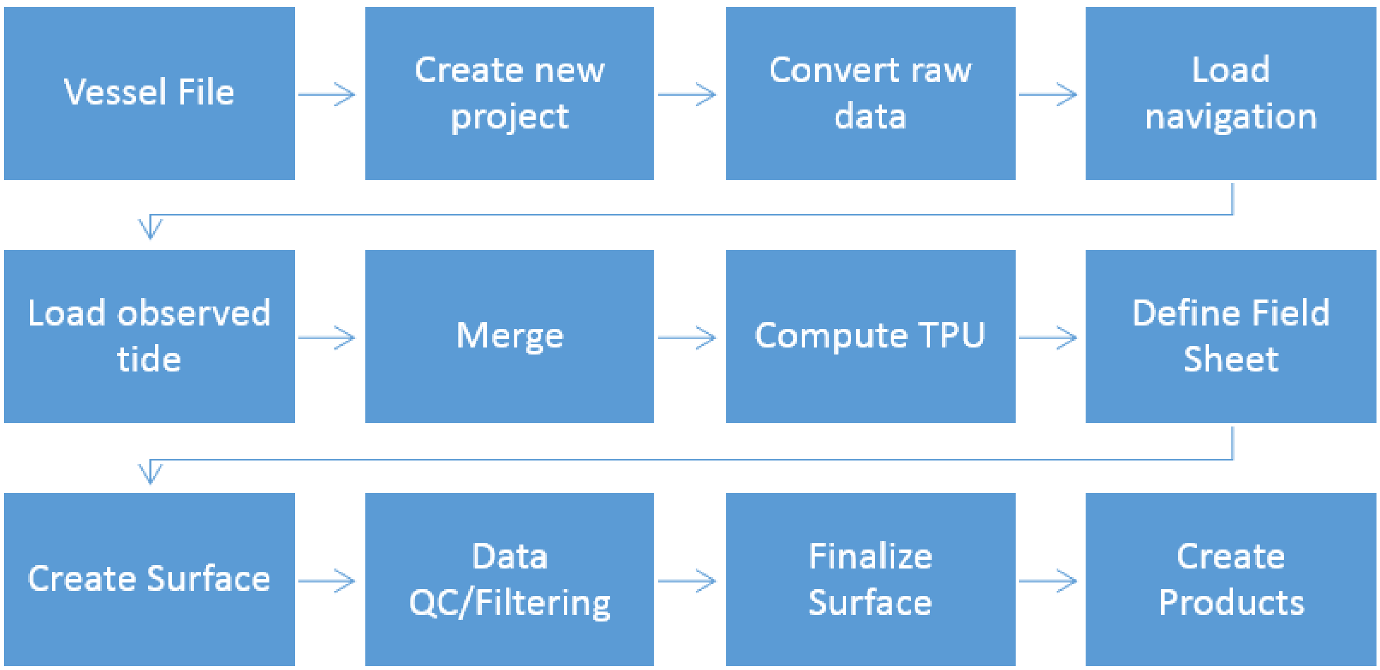

Figure 10: Processing Workflow

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 2014 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 Digibar-Pro located on the multibeam transducer POD and apply for sounding in Kongsberg SIS software. Sound speed profiles are measured by Sea-Bird SeaCAT Profiler CTD SBE 19plus V2 several times every day. Measured raw files (.hex files) are converted to sound speed profile files for SIS software (.asvp files). .asvp files are imported in SIS software after conversion, and sound speed correction is 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.

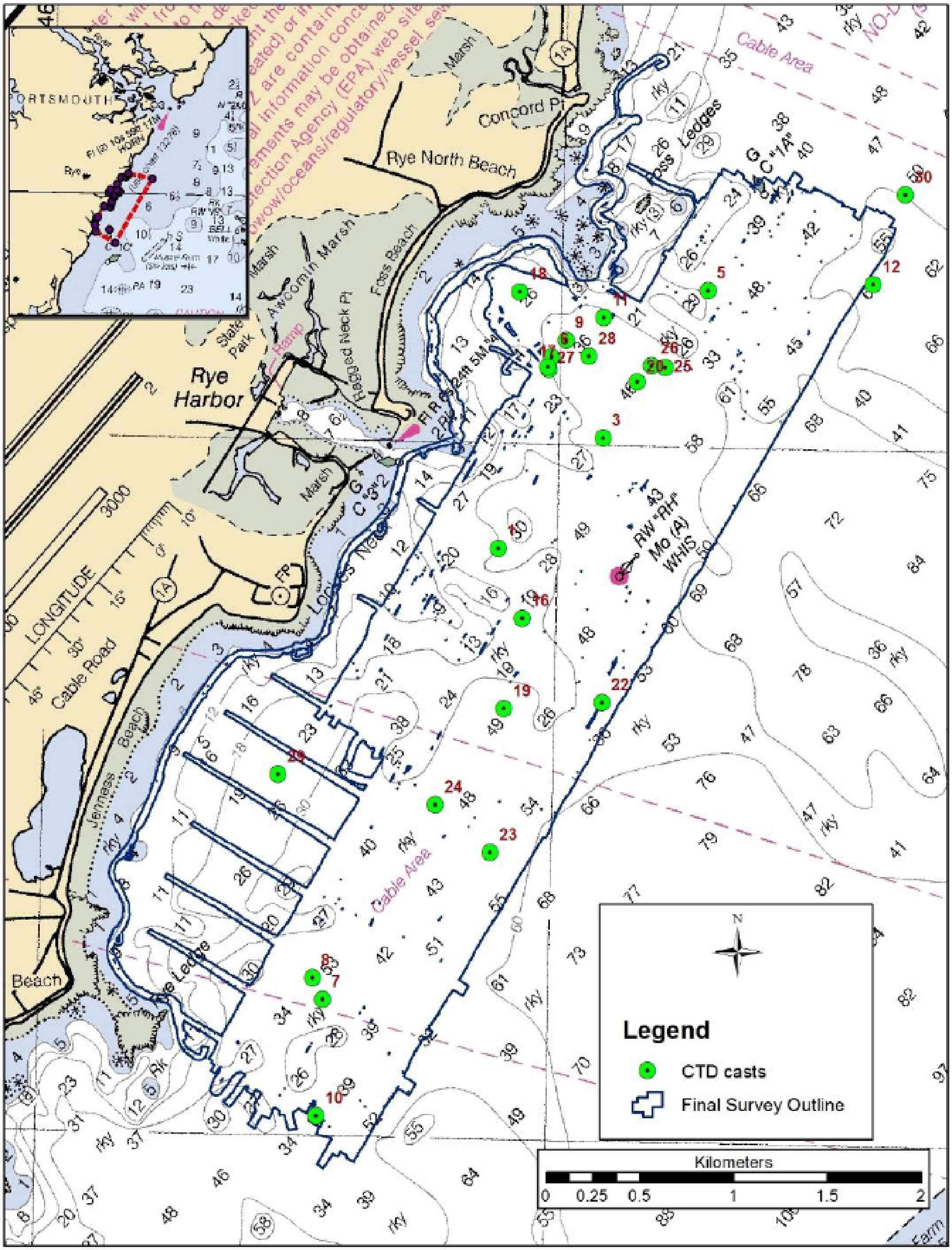

Figure 11: CTD cast locations

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.

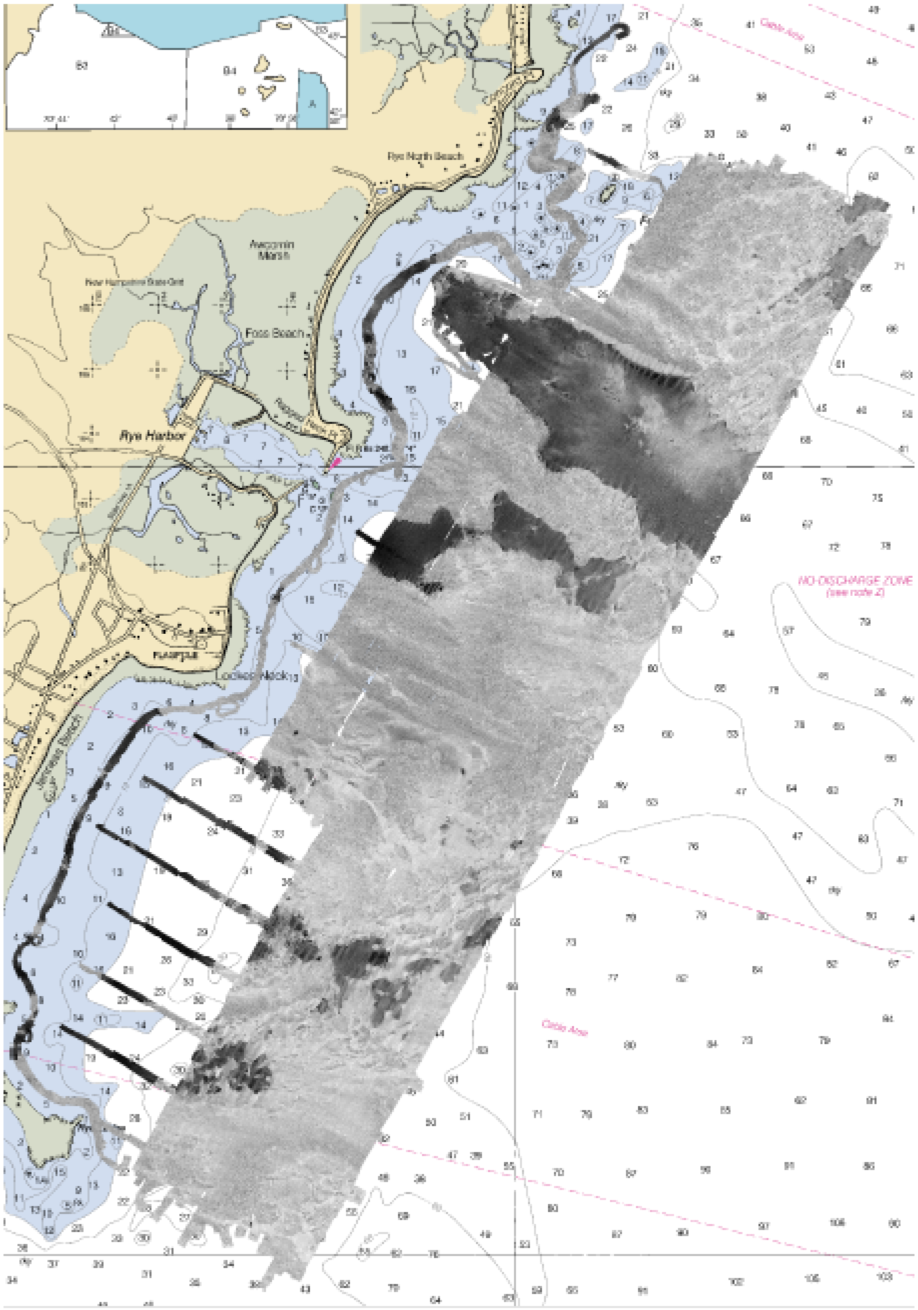

Figure 12: Backscatter mosaic 50cm

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 and designating soundings. 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="4">R/V Coastal Surveyor</td></tr>
<tr><td>Echosounder</td><td colspan="4">Kongsberg EM 2040 400 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 while the vessel is out of the water. 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 with the NOAA's 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	Coastal Surveyor.		
Echosounder	Kongsberg EM2040-7 400 kilohertz		
Date	2014-06-12		
Offsets	*MRU to Transducer*	*x*	0 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*	0.1 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

Dynamic draft table of R/V Coastal Surveyor that 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 ship configuration file (RVCS.hvf) and applied in CARIS post-processing for the whole data.

C.2.2.3 Dynamic Draft Correctors

Vessel	R/V Coastal Surveyor	
Date	2014-06-10	
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

	Speed	*Draft*
	0.514	-0.025

C.3 System Alignment

C.3.1 Description of Correctors

Patch Test

C.3.2 Methods and Procedures

Path test carried out on June 12, 2014 (DN163) about 1400 meters north of survey area (43° 01’ 22.65”N 070° 42’ 32.1”W). Time latency was examined through two sounding lines over a feature with same track and direction but differences speed which were 8 knots and 4 knots respectively. Pitch and roll was conducted over same track and speed but reciprocal direction. For yaw offset was determined through two survey lines tracked 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: 1.0 degrees
Roll: -0.6 degrees
Yaw: -1.4 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 EM 2040 400 kilohertz	
Date	2014-06-12	
Patch Test Values	*Navigation Time Correction*	0 seconds
	Pitch	0 degrees
	Roll	0 degrees
	Yaw	0 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 precisely positioning, two GNSS base stations are established at neighborhood of 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 is established at the Rye Harbor State Park to provide RTK corrections for the areas where are not covered by the first base station at Odiorne State Park. The reference point of the base station is located on the bedrock. The coordinates of reference point are provided by Online Positioning User Service (OPUS, http://www.ngs.noaa.gov/OPUS/) depending on 6 hours observation on June 12, 2014.

Exclusively we use the base station of Odiorne State Park for transit from the pier to survey area, and use the base station of Rye Harbor State Park for surveying.

Figure 13: RTK Base Station at Odiorne State park

Figure 14: RTK base station at Rye Harbor State Park

Figure 15: Rye Harbor reference point

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 results of the tide email to CO-OPs indicated the survey area fell within one tide zone with a range correction of 1x and a time correction of -6minutes. This time correction 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. There were some minor tide spikes in the observed file that should be removed in the verified tide file.

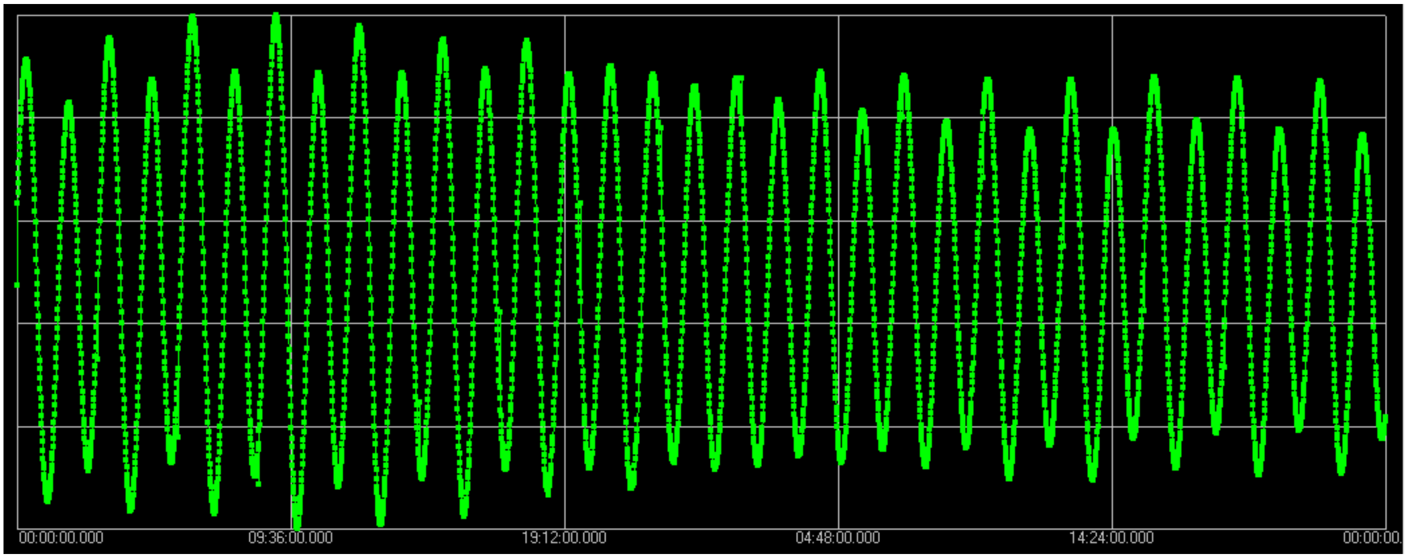

Figure 16: Fort Point observed tide file

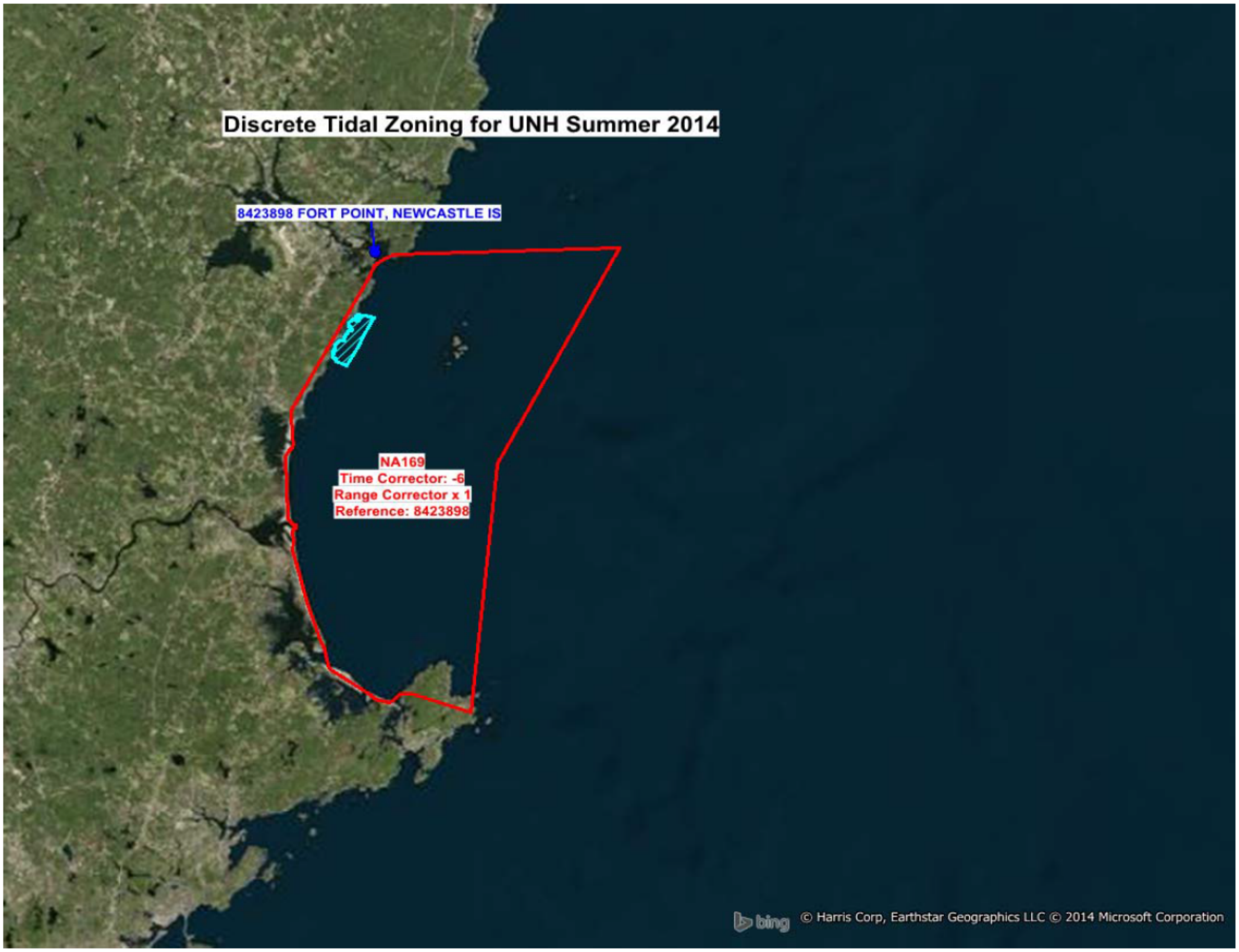

Figure 17: CO-OPS zone file correction

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

The sound speed profiles were obtained from CTD cast 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.