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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-B396-NRT5-17
Time Frame:	July - November 2017

LOCALITY

State(s):	New York
General Locality:	Hudson River

2018

CHIEF OF PARTY
LTJG Dylan Kosten, NOAA

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Navigation Response Team 5
Chief of Party: LTJG Dylan Kosten, NOAA
Year: 2018
Version: 1
Publish Date: 2018-03-05

A System Equipment and Software

A.1 Survey Vessels

A.1.1 NRT5

<table>
<tr><td>Vessel Name</td><td>NRT5</td></tr>
<tr><td>Hull Number</td><td>S3007</td></tr>
<tr><td>Description</td><td>Aluminum Lake Assault</td></tr>
<tr><td>Dimensions</td><td><table><tr><td>LOA</td><td>10.38 meters</td></tr><tr><td>Beam</td><td>2.59 meters</td></tr><tr><td>Max Draft</td><td>0.60 meters</td></tr></table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td><table><tr><td>Date</td><td>2016-04-27</td></tr><tr><td>Performed By</td><td>Kevin Jordan, National Geodetic Survey</td></tr></table></td></tr>
<tr><td>Most Recent Partial Offset Verification</td><td><table><tr><td>Date</td><td>2017-04-03</td></tr><tr><td>Method</td><td>Verification measurements were conducted using steel tapes, carpenter levels, and plum-bobs.</td></tr></table></td></tr>
</table>

Figure 1: NOAA NRT5 (S3007)

A.1.2 NRT5

<table>
<tr><td>Vessel Name</td><td colspan="2">NRT5</td></tr>
<tr><td>Hull Number</td><td colspan="2">S3002</td></tr>
<tr><td>Description</td><td colspan="2">Aluminum-hull SeaArk Commander</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>9.65 meters</td></tr>
<tr><td>Beam</td><td>2.58 meters</td></tr>
<tr><td>Max Draft</td><td>0.32 meters</td></tr>
<tr><td rowspan="2">Most Recent Full Static Survey</td><td>Date</td><td>2009-08-05</td></tr>
<tr><td>Performed By</td><td>Kevin Jordan, National Geodetic Survey</td></tr>
</table>

Most Recent Partial Offset Verification	*Date*	2017-04-03
	Method	Verification measurements were conducted using steel tapes, carpenter levels, and plum-bobs.

Figure 2: NOAA NRT5 (S3002)

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg Simrad EM3002

Manufacturer	Kongsberg Simrad
Model	EM3002
Description	The EM 3002 uses frequencies in the 300 kHz band (293, 300, 307 kHz) and has an operating depth range of 1 to 150 meters water depth. Under ideal, cold water conditions, the range may extend to 200 meters. The maximum angular coverage is 130°. For deeper waters the swath width will be reduced due to reduced signal-to- noise margin. The nadir beam width is 1.5° x 1.5°. The system has a maximum ping rate of 40 Hz. The processing unit (PU) performs beam forming and bottom detection and automatically controls transmit power, gain, and ping rate. The sonar processor incorporates real time surface sound speed measurements for initial beam forming and steering. SVP correction is also performed in real time. The Seafloor Information System (SIS) application, designed to run under Microsoft Windows, provides control and monitoring of the EM 3002.

Inventory	*S3002*	*Component*	Sonar Head	Processing Unit
		Model Number	EM3002	N/A
		Serial Number	563	N/A
		Frequency	300	N/A
		Calibration	2017-10-03	2017-10-03
		Accuracy Check	2017-10-03	2017-10-03

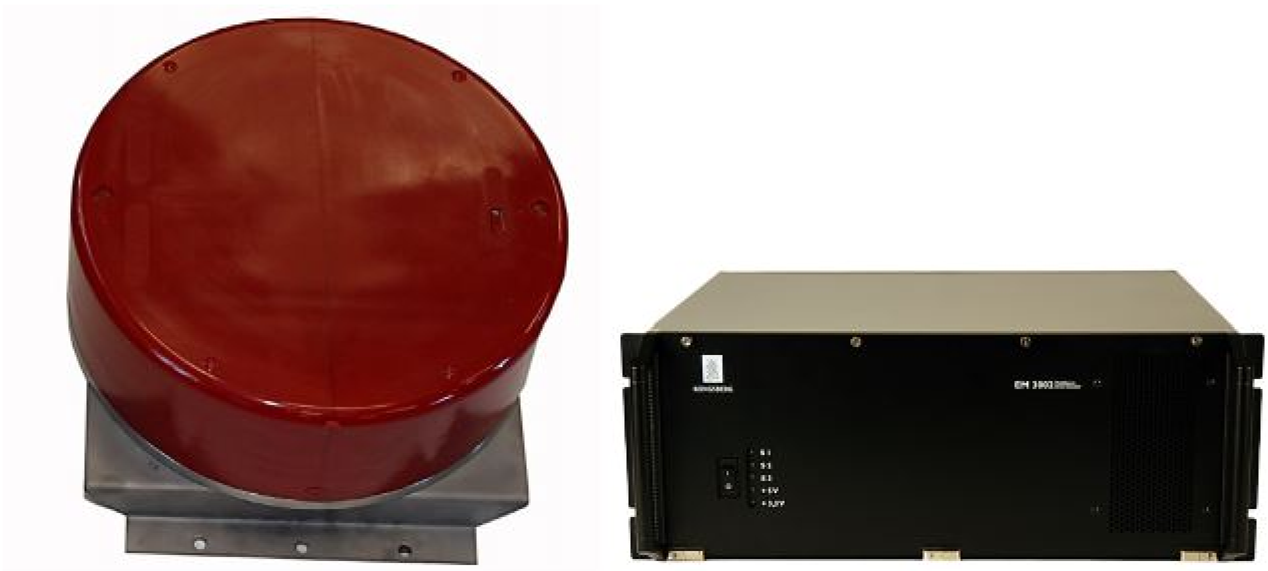

Figure 3: EM 3002 sonar head and processing unit

A.2.1.2 Kongsberg Simrad EM 2040C

Manufacturer	Kongsberg Simrad
Model	EM 2040C

Description	The EM 2040C operating frequency range is from 200 to 400 kHz with frequency selection in steps of 10 kHz, enabling the user to choose on the fly the best operating frequency for the application. The maximum depth range for a single head system in cold ocean water is 520 m at 200 kHz with a swath width up to 580 m. The angular coverage for 200 to 320 kHz is 130° with one sonar head, allowing coverage 4.3 times water depth. For frequencies above 320 kHz the angular coverage per head is gradually decreasing to 70° at 400 kHz. The nadir beam width is 1° x 1° at 400 kHz. The system has a maximum ping rate of 50 Hz with 400 soundings per ping. Components of the EM 2040C include a sonar head, a processing unit, and a hydrographic workstation. Motion sensor and positioning data from the POSMV system, as well as sound speed profile data are input to the EM 2040C. All electronics are contained in the sonar head which is interfaced to the processing unit via GBit Ethernet. The processing unit also supplies 48 VDC power via the same cable. Operator control, data quality inspection, and data storage is handled by the hydrographic workstation running SIS software.

Inventory	*S3007*	*Component*	Sonar Head	Processing Unit	Hydrographic Workstation
		Model Number	Dual EM 2040C	Processing Unit 2U	HP RP5 Retail System Model 5810
		Serial Number	1435	20097	CZC5503RFP
		Frequency	200-400 kHz	N/A	N/A
		Calibration	2017-10-03	2017-10-03	2017-10-03
		Accuracy Check	2017-10-03	2017-10-03	2017-10-03

Figure 4: EM 2040C sonar head and processing unit

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

A.2.3.1 EdgeTech 4215

<table>
<tr><td>Manufacturer</td><td colspan="4">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="4">4215</td></tr>
<tr><td>Description</td><td colspan="4">The EdgeTech 4125 dual-frequency (400/900 kHz) side scan sonar system is a frequency-modulated (FM), dual-frequency, side scan sonar that uses EdgeTech's proprietary Full Spectrum "chirp" technology to generate high-resolution side scan imagery. Frequencies are transmitted as linearly-swept, wide-band, high energy acoustic pulses, and the received echoes are processed into high signal-to-noise (SNR) images that can be directly displayed as shades of gray color on a computer monitor. Operating ranges are 150 m at 400 kHz and 75 m at 900 kHz. Horizontal beam widths are 0.46° at 400 kHz and 0.28° at 900 kHz. The vertical beam width is 50°. Across-track resolution is 2.3 cm at 400 kHz and 1.0 cm at 900 kHz.

Components of the 4125 system are a rugged stainless steel towfish and a rack-mounted topside processing unit. The towfish contains the sonar tansducer arrays and the electronics required to transmit and receive the sonar signals; to receive the downlink commands from the topside processor; and to provide the uplink side scan data, sensor data, and status information to the topside processor. The rack mount interfaces with a user supplied computer over a 10/100BaseT Ethernet connection.</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">S3002, S3007</td><td>Component</td><td>Towfish</td><td>Processing Unit</td></tr>
<tr><td>Model Number</td><td>4125</td><td>4125 Rack Mount Topside</td></tr>
<tr><td>Serial Number</td><td>40421</td><td>40257</td></tr>
<tr><td>Frequency</td><td>400/900 kHz</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2017-10-03</td><td>2017-10-03</td></tr>
<tr><td>Accuracy Check</td><td>2017-10-03</td><td>2017-10-03</td></tr>
</table>

Figure 5: EdgeTech 4125 towfish and rack mount processing unit.

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

No lead lines were utilized for data acquisition.

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 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix POS MV V5

<table>
<tr><td>Manufacturer</td><td>Applanix</td></tr>
<tr><td>Model</td><td>POS MV V5</td></tr>
<tr><td>Description</td><td>The POS MV V5 is a GNSS-aided inertial navigation system, which provides a blended position solution derived from both an Inertial Motion Unit (IMU) and an integrated GNSS receiver. The IMU and GPS receiver are complementary sensors, and data from one are used to filter and constrain errors from the other. This inter-dependence results in higher position accuracy and fewer errors. Position accuracy is displayed in real time by the POS MV software and is monitored to ensure that positioning accuracy requirements as outlined in the NOS Hydrographic Surveys Specifications and Deliverables (HSSD) were not exceeded.

In addition to position, the POS MV also provides accurate navigation and attitude data to correct for the effects of heave, pitch, roll and heading. When using differential correctors, the POS MV generates attitude data in three axes (roll, pitch and heading) to an accuracy of 0.02° or better. Heave measurements supplied by the POS MV maintain an accuracy of 5 cm or 5% of the measured vertical displacement (whichever is greater) for movements that have a period of up to 20 seconds.</td></tr>
<tr><td>Inventory</td><td><table><tr><td>S3007 and S3002</td><td><table>
<tr><td>Component</td><td>POS Computer System</td><td>GNSS antenna</td><td>GNSS antennas</td><td>Inertial Measurement Unit</td></tr>
<tr><td>Model Number</td><td>POS MV V5</td><td>Trimble Zephyr 2</td><td>Trimble GA530</td><td>IMU 7</td></tr>
<tr><td>Serial Number</td><td>5909</td><td>60269191</td><td>14777</td><td>2437</td></tr>
<tr><td>Calibration</td><td>2017-10-03</td><td>2017-10-04</td><td>2018-01-04</td><td>2017-10-04</td></tr>
</table></td></tr></table></td></tr>
</table>

Figure 6: POS MV V5 system components: IMU, POS Computer System, and two GNSS antennas

A.5.2 DGPS

A.5.2.1 Trimble SPS361 DGPS Receiver

Manufacturer	Trimble		
Model	SPS361 DGPS Receiver		
Description	The POS MV can be set to receive differential (RTCM) correctors from a Trimble SPS361 DGPS receiver that includes a dual-channel low-noise MSK beacon receiver, capable of receiving U.S. Coast Guard (USCG) differential correctors. The SPS361 can also accept RTCM messages from an external source, such as a user-established DGPS reference station.		
Inventory	*S3002*	*Component*	DGPS Receiver
		Model Number	Trimble SPS361
		Serial Number	5331K63795
		Calibration	N/A

A.5.3 GPS

GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

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

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

No moving vessel profilers were utilized for data acquisition.

A.6.2 CTD Profilers

A.6.2.1 SonTek CastAway-CTD

Manufacturer	SonTek
Model	CastAway-CTD
Description	The CastAway-CTD is a small, rugged CTD designed for profiling to depths of up to 100 m. The system achieves a 5 Hz response time, fine spatial resolution, and high accuracy, with sound speed measurements accurate within ±0.15 m/s. It uses a six electrode flow-through conductivity cell with zero external field coupled with a rapid response thermistor to attain high measurement accuracies. The instrument is simple to deploy, does not require a pump and is hydrodynamically designed to free fall rate of 1 m/s. Each CastAway-CTD cast is referenced with both time and location using its built-in GPS receiver. Latitude and longitude are acquired both before and after each profile. Plots of conductivity, temperature, salinity and sound speed versus depth can be viewed immediately on the CastAway's integrated color LCD screen. Raw data is downloaded via Bluetooth to the launch acquisition computer for analysis and to export into SIS.

<table>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>CTD</td></tr>
<tr><td>Model Number</td><td>400100</td></tr>
<tr><td>Serial Number</td><td>CC1433009</td></tr>
<tr><td>Calibration</td><td>2017-10-03</td></tr>
</table>

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic Micro•X with SV•Xchange

<table>
<tr><td>Manufacturer</td><td colspan="3">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="3">Micro•X with SV•Xchange</td></tr>
<tr><td>Description</td><td colspan="3">The AML Micro•X instrument with an SV•Xchange sensor-head provided surface sound speed data to the Kongsberg EM 2040C for beam forming and steering. The unit is mounted in a removable pole that is inserted into a bracket mounted on the transom between the two motors. The unit is configured to output an AML datagram to SIS.</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S3002 and S3007</td><td>Component</td><td>Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>Micro•X</td></tr>
<tr><td>Serial Number</td><td>10313</td></tr>
<tr><td>Calibration</td><td>2017-10-03</td></tr>
</table>

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

A.7.1 Teledyne CARIS HIPS and SIPS

Manufacturer	Teledyne CARIS
Software Name	HIPS and SIPS
Version	10.4

Installation Date	2017-10-02
Use	Acquisition and Processing

A.7.2 Applanix Corporation POSPac MMS

Manufacturer	Applanix Corporation
Software Name	POSPac MMS
Version	7.2.5934.15637
Installation Date	2017-10-04
Use	Processing

A.7.3 NOAA, Hydrographic Systems and Technology Branch (HSTB) Pydro Explorer

Manufacturer	NOAA, Hydrographic Systems and Technology Branch (HSTB)
Software Name	Pydro Explorer
Version	18.1
Installation Date	2018-01-02
Use	Processing

A.7.4 Xylem HYPACK Survey

Manufacturer	Xylem
Software Name	HYPACK Survey
Version	2017
Installation Date	2017-10-04
Use	Acquisition

A.7.5 Xylem HYSWEEP

Manufacturer	Xylem
Software Name	HYSWEEP
Version	2017
Installation Date	2017-10-04
Use	Acquisition

A.7.6 Kongsberg Maritime Seafloor Information System

Manufacturer	Kongsberg Maritime
Software Name	Seafloor Information System
Version	4.1.4
Installation Date	2017-10-04
Use	Acquisition

A.7.7 EdgeTech DISCOVER 4125

Manufacturer	EdgeTech
Software Name	DISCOVER 4125
Version	v.1
Installation Date	2017-10-04
Use	Acquisition and Processing

A.7.8 Applanix Corporation MV-POSView

Manufacturer	Applanix Corporation
Software Name	MV-POSView
Version	9.29
Installation Date	2017-10-04
Use	Acquisition

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 WILDCO Petite Ponar 6"x6" All Stainless Steel

Manufacturer	WILDCO
Model	Petite Ponar 6"x6" All Stainless Steel
Description	The WILDCO Petite Ponar is a Ponar type grab sampler, a commonly used sampler that is very versatile for all types of bottom sediments such as sand, gravel, and clay. This sampler features center-hinged jaws and a spring loaded pin that releases when the sampler makes impact with the bottom. It also includes an underlip attachment that cleans gravel from the jaws that would normally prevent lateral loss of sample.

	The top is covered with a stainless steel screen with neoprene rubber flaps which allows water to flow through for a controlled descent and less interference with the sample. It is constructed of stainless steel with zinc plated steel arms and weights. A simple pin prevents premature closing.

Figure 7: Petite Ponar 6"x6" Bottom Sampler

B System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

For NRT 5, all vessel offset values are stored in the CARIS HVF. The transmit transducer phase center is defined as the Reference Point (RP).

B.1.1.1 Vessel Offset Correctors

Vessel	NRT5_S3002_EM3002			
Echosounder	Kongsberg Simrad EM3002			
Date	2017-04-03			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	-0.058 meters	0.010 meters
		y	-0.158 meters	0.010 meters
		z	0.508 meters	0.010 meters
	Nav to Transducer	*x*	0.755 meters	0.010 meters
		y	-3.195 meters	0.010 meters
		z	2.400 meters	0.010 meters
	Transducer Roll	*Roll*	0.00 degrees	

Vessel	NRT5_S3007_EM2040C			
Echosounder	Kongsberg Simrad EM2040C 300kHz			
Date	2017-09-08			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	0.006 meters	0.010 meters
		y	-0.005 meters	0.010 meters
		z	0.366 meters	0.010 meters
	Nav to Transducer	*x*	0.864 meters	0.010 meters
		y	-4.225 meters	0.010 meters
		z	3.150 meters	0.010 meters
	Transducer Roll	*Roll*	0.00 degrees	

B.1.2 Layback

A side scan sonar towfish was not utilized with the surveys submitted with this report.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Static draft corrector values are entered in the Kongsberg SIS Installation Parameters window. In addition to being entered into the SIS Installation Parameters window, waterline values are also entered in the CARIS HVF. This waterline value in CARIS will only be used during Sound Velocity Correction. The Apply switch is also set to “No”. If it is set to “Yes”, the waterline value will be applied twice, once in SIS and again in Merge.

B.2.1.1 Static Draft Correctors

Vessel		NRT5_S3002_EM3002	NRT5_S3007_EM2040C
Date		2016-06-27	2017-09-08
Loading		0.010000 meters	0.015000 meters
Static Draft	*Measurement*	-0.031000 meters	-0.544982 meters
	Uncertainty	0.030000 meters	0.024000 meters

B.2.2 Dynamic Draft

NRT5 acquired dynamic draft survey lines in the Thames River, just outside of New London, CT. While logging a POS file, two straight lines were run north and south at 4, 6, 8, and 10 knots for approximately 3 minutes. The POS file was imported into POSPac and the following processes were run: finding basestations, smartbase quality check, Applanix Smart Base, and GNSS Inertial Processor. POSPac AutoQC was used to open the project to see the results by directing the program to the extract folder, and adding a tide file and HVF file. The resulting Dynamic Draft tab shows a table that correlates speed with vessel draft, which can be input into the vessel file. NRT5 used the Quartic Model values to input into the vessel file.

B.2.2.1 Dynamic Draft Correctors

Vessel	NRT5_S3002_EM3002		NRT5_S3007_EM2040C	
Date	2017-04-05		2017-09-08	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*	*Speed (m/s)*	*Draft (m)*
	0.00	0.00	0.00	0.00
	1.21	0.01	0.50	0.01
	1.59	0.01	1.00	0.02
	2.47	0.01	1.50	0.02
	2.98	0.03	2.00	0.03
	3.73	0.04	2.50	0.05
	4.27	0.04	3.00	0.07
			3.50	0.09
			4.00	0.12
			4.50	0.16
			5.00	0.19
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.03	0.03	0.05	0.03

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

Data was converted in CARIS HIPS using a HVF file with heave, pitch, roll and timing values set to zero. True heave, water levels, the most recent dynamic draft, and sound velocity profiles were applied and the data merged before cleaning via Subset Editor. Biases were determined using the CARIS HIPS Calibration tool. The values determined for each bias by individual testers were examined, and obvious outliers were rejected before and average was determined. This average value was then applied to the bias in question and applied to the data before moving on to the next bias determination. Bias values were determined in the following order: timing, pitch, roll, and yaw. These averaged values were established as the final correctors and were added to th CARIS HVF.

B.3.1.1 System Alignment Correctors

<table>
<tr><td>Vessel</td><td>NRT5_S3002_EM3002</td></tr>
<tr><td>Echosounder</td><td>Kongsberg Simrad EM3002</td></tr>
<tr><td>Date</td><td>2017-04-03</td></tr>
<tr><td>Patch Test Values</td><td><table>
<tr><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Pitch</td><td>-0.55 degrees</td><td>0.20 degrees</td></tr>
<tr><td>Roll</td><td>0.04 degrees</td><td>0.20 degrees</td></tr>
<tr><td>Yaw</td><td>-1.22 degrees</td><td>0.20 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>Vessel</td><td>NRT5_S3007_EM2040C</td></tr>
<tr><td>Echosounder</td><td>Kongsberg Maritime Simrad EM2040C 300kHz</td></tr>
<tr><td>Date</td><td>2017-09-08</td></tr>
<tr><td>Patch Test Values</td><td><table>
<tr><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.035 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Pitch</td><td>-0.99 degrees</td><td>0.20 degrees</td></tr>
<tr><td>Roll</td><td>0.025 degrees</td><td>0.20 degrees</td></tr>
<tr><td>Yaw</td><td>0.70 degrees</td><td>0.20 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.010 seconds</td></tr>
</table></td></tr>
</table>

C Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Multibeam data from the EM 3002 on S3002 and the EM 2040C on S3007 were monitored in real-time with the acquisition software, SIS (Seafloor Information System). Data were displayed using 2-D and 3-D data display windows in the real-time screen display. Mainscheme data were acquired using either planned lines, or an adaptive line steering approach, whereby the coxswain viewed a real-time coverage map in Hysweep and accordingly adjusted line steering to ensure coverage requirments were being met.

Data Processing Methods and Procedures

Following acquisition, multibeam sonar data were processed either using CARIS HIPS and SIPS manually or by using the automated Pydro Explorer application, Charlene, to perform the same steps. The standard data processing steps are as follows:

1. Convert raw Kongsberg (.all) data to the HDCS data format
2. Load delayed heave/SBET
3. Load and apply sound velocity correctors
4. Compute GPS tide to transform data from the ellipsoid to the tidal datum using a separation model
5. Merge data to apply position attitude, and dynamic draft correctors to bathymetry and compute the corrected depth of each sounding
6. Compute Total Propagated Uncertainty (TPU)
8. Add data to a CUBE surface encompassing the entire survey
9. Data quality control and analysis

C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

The following options are selected when CUBE surfaces were created:

- Gridding Method – CUBE
- Bounding Polygon Type - Buffered
- IHO Order – S44 Order 1a
- Include status – Accepted, Examined and Outstanding
- Disambiguation method - Density & Locale (this method selects the hypothesis that contains the greatest number of soundings and is also consistent with neighboring nodes).
- Advanced Configuration – CUBEParams_NOAA_2017

C.1.4.2 Depth Derivation

Designated soundings were applied to the final grid to force the CUBE surface to the hydrographer's selected sounding. The depth values were restricted as needed according to the object detection grid-resolution thresholds as a function of depth range.

C.1.4.3 Surface Computation Algorithm

The uncertainty weighting for final grids is set to "Greater of the two values," where whatever is greater, the uncertainty or the standard deviation (scaled to the 95% confidence interval), will be selected as the uncertainty source.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Multibeam backscatter imagery was not acquired.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

The SSS towfish is deployed from a davit arm located on the starboard quarter using a Dayton electric winch spooled with approximately 30 meters of cable. Tow cable is lead from the winch upward along the davit arm. The tow cable at the winch is connected electro-mechanically to a deck cable through a slip ring assembly. Cable out is controlled manually and is computed by the Rugged Controls LCI-80x cable counter by the number of revolutions of the cable drum sheave. The cable counter data is transmitted to the Discover I acquisition computer via serial connection.

Line spacing for side scan sonar (SSS) operations is determined by range scale. A towfish altitude of 8-20% of the range scale is maintained during data acquisition. Altitude is adjusted by cable out, and vessel speed. The range scales of the Edgetech 4125's high and low frequencies can be set independently.

Confidence checks are performed daily by observing changes in linear bottom features extending to the outer edges of the digital side scan image, features on the bottom in survey area, and by passing aids to navigation. Daily rub tests are also conducted.

Data Processing Methods and Procedures

Following acquisition, side scan sonar data were processed either using CARIS HIPS and SIPS manually or by using the automated Pydro Explorer application, Charlene, to perform the same steps. The standard data processing steps are as follows:

1. Convert raw Edgetech JSF data to the HDCS data format
2. Digitze towfish height as needed

3. Recompute towfish navigation to compute the position of the towfish in relation to the vessel
4. Review lines for contacts and designate soundings in corresponding multibeam data as needed
5. Create mosaics and evaluate for coverage gaps

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

DGPS data was not acquired.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Water level data was not acquired.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

Attitude and Heave data were measured with the sensors described in Section A.5, and applied in post-processing during SVP Correct and Merge in CARIS HIPS.

S3002 and S3007 both utilize a heave filter integration method known as “TrueHeave” as described in Section 3.4.1.2 of the 2014 Field Procedures Manual. This filter almost completely eliminates the need for steadying up on lines before logging can begin.

TrueHeave data were logged throughout the day via the POS MV's USB logging feature. Data are logged to the removable media in approximately 12-Megabyte (MB) files. The multple POS files that are created from logging in this way are each distunguished by the numbering found in the file type (e.g, 000, 001, 002, etc.). After regular CARIS data conversion, the TrueHeave file was separately loaded into HIPS, replacing the unfiltered heave values recorded in the raw data. TrueHeave is actually applied to the data, if the checkbox is marked, during the sound velocity correction process.

It is standard procedure to begin logging the POS MV Applanix .000 file at least 5 minutes before starting bathymetric data acquisition and letting it run for at least 5 minutes afterward. Although the filter that produces the true heave values by looking at a long series of data to create a baseline needs only 3 minutes before and after the acquisition of bathymetric data, SBET processing which uses the same .000 file, requires logging for 5 minutes before and after bathymetric acquisition.

Timing and attitude biases were determined in accordance with Section 1.5 of the Field Procedures Manual, and are described in Section B of this report.

Data Processing Methods and Procedures

NRT5 utilizes Real Time Kinematic (RTK) and Post Processed Kinematic (PPK) methods for the horizontal positioning of bathymetric data.

The New York State Department of Transportation (NYSDOT) operates a network of continuously operating GNSS reference stations (CORS), as a part of the New York State Spatial Reference Network (NYSNet). S3002 and S3007, were equipped with a Sierra Wireless cellular internet Wi-Fi modem that provides steady, always-on internet connectivity to its computers. Using Lefebure software to perform network transport of RTCM data over IP (NTRIP), the RTK correctors were passed to the POS MV via serial cable. During survey acquisition, the Lefebure window, which shows the status of the incoming data stream, was monitored to ensure continuous reception RTK. If the cellular signal was lost, logging would be halted as immediately as possible and the line would be re-logged over the section where RTK correction loss was encountered.

Under circumstances where the the usage of NYSNet was not a viable option, positioning and attidue data (POS files) would be processed in post via Applanix POSPac MMS software, providing a PPK solution.

A Smoothed Best Estimate of Trajectory (SBET) is created using Applanix's proprietary SmartBase application. This software application generates a Virtual Reference Station (VRS) from a network of established reference stations surrounding the project area, generally the Continually Operating Reference Station (CORS) network. For the SmartBase method, an optimal network consists of six to eight reference stations evenly distributed around the surveyed area and separated by 50 to 70 km. A minimum of four stations are required for Applanix SmartBase processing. The resulting SBET file consists of GPS position and attitude data corrected and integrated with inertial measurements and reference station correctors. Reference station data is downloaded with the POSPac MMS download tool and usually available within 24 hours. These SBET navigation and attitude files are applied to all lines in CARIS and supersede initial positioning and attitude data.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

NRT5 uses the SonTek CastAway CTD to acquire sound speed data. Sound speed casts were taken at a minumum of every four hours. When taking a cast while the vessel is at rest, the 15 meter deployment line included with the CastAway CTD would first be tied off to a point on the aft deck. Using the LCD interface on the CastAway, a starting GPS location would then be recorded. The CastAway CTD would then be lowered just beneath the water surface for approximately 10 seconds to allow the sensors to stabilize to the water conditions. After waiting for the sensors to stabilize, the CTD would be allowed to free fall through the water column. When the CTD reaches the bottom, or when the the deployment line is completely paid out, the CTD is retreived to the surface at a rate of about 1 m/s. Once the CTD is at the surface, data collection is ceased and the ending GPS location is recorded.

SIS monitors changes in the surface sound speed vs. the value obtained with the last cast in real-time. The user is then warned for the need of a new cast by highlighting both the “SV Profile” and “SV Used numerical displays in yellow with a difference greater than 3 m/s and red for a difference greater than 5 m/s.

Data Processing Methods and Procedures

After the CastAway GPS location is recorded and the device is in range of the USB Bluetooth adapter inserted in the acquisition computer, the cast data is automatically downloaded into the CastAway CTD software. The data can then be exported to an ASCII format for import into Pydro's Sound Speed Manager application. Sound Speed Manager can then transmit this sound velocity data directly into SIS, and can convert the sound velocity files into a CARIS usable format.

All sound velocity profiles for CARIS are concatenated into a vessel-wide or sheet-wides files in order of ascending time/date. These concatenated file(s) are then applied to all HDCS data acquired with the option “Nearest in distance within time (4 Hours)” selected under the “Profile Selection Method”.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

The multibeam systems utilized aboard NRT5 require a sound velocity probe to be interfaced with the sonar acquisition unit for use in projector steering computations. During all survey operations, surface sound velocity probes are on at all times. In the event of a velocity probe failure, survey operations immediately cease until the failure is corrected.

An AML Micro X provided surface sound speed data to the sonar processing unit for beam steering and beam forming. The surface sound speed measurment unit is mounted in a removable pole that is inserted into a bracket mounted on the transom between the two motors. The unit is configured to output an AML datagram to SIS, which is installed on the acquisition computer.

Data Processing Methods and Procedures

The Kongsberg multibeam systems utilized require a sound velocity probe to be interfaced with the sonar acquisition unit for use in projector steering computations. A surface sound velocity probe is utilized to feed real time SV values directly into the acquisition computer for use in beam steering calculations. SIS monitors changes in the surface sound speed vs. the value obtained with the last cast in real-time. The user is then warned for the need of a new cast by highlighting both the “SV Profile” and “SV Used” numerical displays in yellow with a difference greater than 3 m/s and red for a difference greater than 5 m/s.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

There are two places in CARIS where the user directly defines uncertainty values for use in CARIS to calculate TPU values, in the HVF and the direct input of SV and tide values during the TPU computation.

TPU values for all motion, navigation position and timing values are taken directly from Appendix IV (Uncertainty values for use in CARIS with vessels equipped WITH an attitude sensor) of the FPM. All timing values were set to 0.01 seconds as outlined for setups with Ethernet connections and precise timing. All offset values were chosen to be 0.01 meters based on the accuracy provided by professional surveys.

All MRU alignment values are derived from the patch test. The gyro value is taken directly from the standard deviation of the yaw values. The pitch/roll value is combined as one in the HVF and is computed as the square root of pitch standard deviation squared plus roll standard deviation squared.

C.6.2 Uncertainty Components

A Priori Uncertainty

Vessel		NRT5_S3002_EM3002	NRT5_S3007_EM2040C
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees
	Heave	5.00% 0.05 meters	5.00% 0.01 meters
	Roll	0.02 degrees	0.02 degrees
	Pitch	0.02 degrees	0.02 degrees
Navigation Sensor		1.00 meters	1.00 meters

Real-Time Uncertainty
Real-time uncertainty was not applied.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

In preparation for shoreline verification, the Survey Manager copies the project wide composite source file (CSF) and crops it to include only items contained on their assigned sheet. This cropped file is then saved as a HOB file named HXXXXX_Final_Feature_File.hob. It is to this final features HOB file that any edits are performed.

Shoreline verification is conducted during daylight periods near predicted MLLW tides of +0.5m or less. A line is run along the shore approximating the position of the Navigational Area Limit Line (NALL). Features are examined in accordance with the limited verification guidelines in the FPM. In the field, CARIS HIPS and SIPS is used to acquire DPs and/or modify S-57 attribution of existing features. The hydrographer both investigates assigned features and scans the area for new features to be addressed.

Data Processing Methods and Procedures

Features are generally documented and given S-57 attribution in real time. To increase efficiency during the limited shoreline window, the Survey Manager may forgo S-57 attribution with HIPS and SIPS while in the field and instead take thorough notes for later attribution.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Typically HSD Operations provides the field unit with a number of recommended bottom sample sites included as part of the shoreline project reference file (PRF). These proposed sample sites, which are encoded as S-57 SPRINGS, are examined and potentially culled based on the actual depths found during survey operations.

Data Processing Methods and Procedures

Samples are collected by using the bottom sampler described in section A.8 of this report. Once obtained, samples are analyzed for sediment type and classified with S57 attribution, with the most prevalent sediment type listed first. In the event that no sample is obtained after three attempts, the sample site's NATSUR is characterized as “unknown”. Samples are then discarded after field analysis is complete.

D Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

The CUBE surface child layers: uncertainty, standard deviation, and node standard deviation were primarily used to help focus directed editing to soundings that were negatively affecting the BASE surface.

Another method to check the quality of sounding data prior to submission is the Pydro QCTools “Flier Finder”. This software scans the CUBE surface for potential anomalous grid data. Lowering the flier height value will increase the sensitivity of the flier finder, resulting in more nodes being flagged. Fliers are then exported as .000 S-57 files that can be imported into CARIS HIPS and SIPS to aid in further cleaning. If desired, the user can set a new tolerance (“Flier height”) and rerun Flier finder.

D.1.2 Designated Sounding Selection

On occasion, the resolution of the CUBE surface may not be sufficient to capture the high point of a feature. In less than 20m of water, any feature where the most probable accurate sounding is shoaler than the CUBE surface by greater than one half the allowable error under IHO S-44 Order 1 is considered inadequately captured by the CUBE surface. In greater than 20m of water, this allowable error is expanded to the full Order 1 error allowance at that depth. Although missed shoal points may occur on irregular shoals or rock pinnacles, man-made features such as piles and wrecks are of particular concern. These features have very slender high points that extend far above the surrounding seafloor as well as the CUBE surface. To ensure that these features are properly represented, the shoalest point is flagged “designated” in CARIS.

During the “finalization” process, the CUBE surface is forced to honor all soundings which have been flagged “designated”. In the case of a survey where the high points of many features (i.e. a boulder field) are not being captured by the CUBE surface, the hydrographer may decide to produce higher resolution CUBE surfaces to ensure that these features are being honored. Any such deviations from standard procedures will be noted in that survey’s Descriptive Report.

D.1.3 Holiday Identification

Most holidays are identified and addressed while in the field. During data acquisition, the display of the real-time swath coverage is based upon the matrix file, a polygon with user defined geographic bounds and resolution set up prior to data collection. The resolution of the matrix is selected to match depth range of the polygon currently being worked on. The launch coxswain uses this matrix display to adjust the line as it is driven so that the swath currently being collected overlaps the grid of previously collected data. In this way, insufficent overlap can be seen and adressed immediately.

The Pydro QCTools "Holiday Finder" is used to detect holidays in post-processing. This tool scans the grid, and any empty nodes surrounded by populated nodes are identified. The user can specify whether to search for holidays according to either Object Detecion or Full Coverage requirements. In the event of finding any holidays in post-processing, small polygons are made in HIPS to direct data acqusition to fill them in.

D.1.4 Uncertainty Assessment

NRT5's primary bathymetric data review and quality control tool is the CARIS CUBE surfaces. The CUBE algorithm generates a surface consisting of multiple hypotheses that represent the possible depths at any given position. The CUBE surface is a grid of estimation nodes where depth values are computed based on the horizontal and vertical uncertainty of each contributing sounding.

Any individual sounding’s uncertainty, or Total Propagated Uncertainty (TPU), is derived from the assumed uncertainty in the echosounder measurement itself, as well as the contributing correctors from sound speed, water levels, position, and attitude. TPU values for tide and sound velocity must be entered for each vessel during TPU computation, unless using TCARI, where uncertainty is added directly to survey lines by Pydro.

NRT5 is currently using the following uncertainty values:

• Tide measured uncertainty is set to a value of 0.0 with use of a VDatum separation model.

• Tide zoning uncertainty is unique to the separation model in use. A value of 0.094 m was used with 2017 Hudson River surveys.

• Measured sound speed uncertainty was set to a recommened value of 2 m/s as recommended by the FPM when 1 cast is taken every 4 hours.

• Surface sound speed value is dependent on the manufacturer specifications of the unit utilized to measure surface SV values for refraction corrections to flat-faced transducers. The AML Oceanographic Micro•X probe with an SV•Xchange sensore has a published accuracy of 0.025 m/s. Conservatively, a value of 0.5 m/s was used.

All other error estimates are read from the Hydrographic Vessel File (HVF). The HVF contains all offsets and system biases for the survey vessel and its systems, as well as error estimates for latency, sensor offset measurements, attitude and navigation measurements, and draft measurements. In addition, the HVF specifies which type of sonar system the vessel is using.

In addition to the usual a priori estimates of uncertainty, some real-time and post-processed uncertainty sources were also incorporated into the depth estimates. Real-time uncertainties from the Konsgberg EM2040C were recorded and applied in post-processing. Applanix TrueHeave files are recorded, which include an estimate of the heave uncertainty, and are applied during post processing. When RTK corrections are in use, uncertainties associated with vessel roll, pitch, gyro and navigation are recorded in real-time in the TrueHeave files. When RTK corrections were not available, these uncertainties associated are applied in CARIS HIPS and SIPS via an SBET and RMS files generated in POSPac.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Cross-lines with a linear nautical total of at least 4% of mainscheme multibeam lines were run on each survey. Then a CUBE surface was created using strictly the main scheme lines, while a second surface was created using only the crosslines. From these two surfaces, a surface difference was generated (at a 1 meter resolution). Statistics were then derived from the difference surface and documented within the Descriptive Report for each survey.

D.1.5.2 Junctions

Junction overlap areas are acquired so to be at least approximately one bathymetric swath width at the nominal depth of the junction, as per the HSSD. Junction areas are then evaluated to ensure they have met this overlap requirment and also to inspect the relative agreement of depths. When junctions share a common grid resolution, it is chosen to perform the junction analysis.

D.1.5.3 Platform to Platform

A platform to platform surface difference review was not formally conducted.

D.2 Imagery data Integrity and Quality Management

Imagery data integrity and quality management were not conducted for this survey.

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	2014_S3002_WiringDiagram.pdf S3007%20Wiring%20Diagram.pdf
Sound Speed Sensor Calibration	2017_AML_Calibration.pdf CastAway_Calibration.pdf
Vessel Offset	NOAA_S3002_09_NGS%20SURVEY.pdf NRT%20S3007%202016_NGS%20SURVEY.pdf S3007_vessel%20offsets%20wizard_TRANS_RP.pdf 2017HSRR_values_HVF_Patch_Dynamic%20Draft.pdf S3007%20ERDDM.pdf
Position and Attitude Sensor Calibration	2016_POS-MV_Cal_Report_S3002.pdf 2016_POS-MV_Cal_Report_S3002.pdf
Echosounder Confidence Check	N/A
Echosounder Acceptance Trial Results	N/A

E. Approval Sheet

As Chief of Party, I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

As Chief of Party, I have ensured that surveying and processing procedures were conducted in accordance with the Field Procedures Manual and that the submitted data meet the standards contained in the 2017 Hydrographic Surveys Specifications and Deliverables.

Approver Name	Approver Title	Date	Signature
LTJG Dylan Kosten	Team Lead, NOAA NRT5	03/07/2018	Dylan Kosten Digitally signed by KOSTEN.DYLAN.ANDREW.1504527405 Date: 2018.04.07 15:52:05 -04'00'