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

Data Acquisition & Processing Report

Type of Survey:	Basic Hydrographic Survey
Project Number:	S-K922-NRT4-19
Time Frame:	May - December 2019

LOCALITY

State(s):	Texas
General Locality:	Galveston Bay

2019

CHIEF OF PARTY
Dan Jacobs

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Date:

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Navigation Response Team 4
Chief of Party: Dan Jacobs
Year: 2019
Version: 1
Publish Date: 2019-05-01

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 S3008

Vessel Name	S3008	
Hull Number	LALMF056B516	
Description	NOAA Survey Vessel S3008 is a 30 foot, aluminum hulled fire boat modified for NOAA hydrographic survey operations. Its powered by dual 225 horsepower Honda outboard engines. A Kohler 7.5 EKD generator supplies AC power for two workstations, 5 monitors, one POS system, one multibeam echosounder system, and one side scan sonar system.	
Dimensions	*LOA*	10 meters
	Beam	2.4 meters
	Max Draft	0.5 meters
Most Recent Full Static Survey	*Date*	2017-02-24
	Performed By	National Geodetic Survey

Figure 1: Navigation Response Team 4 - S3008

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM2040C

The Kongsberg EM2040C system is a digital recording multibeam echo sounder which is capable of operating at 200kHz, 300kHz, 400kHz, or in a Frequency Modulation (FM) Chirp. The system is comprised of a receiver unit that is hull mounted, a Hydrographic Work Station (HWS), and a Processor Unit (PU). The EM2040C is operated through Seafloor Information System (SIS) software; version 4.3.2. The EM2040C is used to acquire full and partial bottom bathymetric coverage throughout a survey area to determine least depths over critical items such as wrecks, obstructions, dangers-to-navigation, and general object detection. 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.

While operating in partial coverage, the EM2040C collects data concurrently with the EdgeTech 4125 without acoustic interference, commonly referred to as "skunk striping". NRT4 operates the EM2040C at a frequency of 300kHz for normal operations, as specified in the Kongsberg operator's manual. This configuration provides an ideal mix of resolution and range for surveying within NRT4's operational area. The specifications below reflect this mode of operation.

<table>
<tr><td>Manufacturer</td><td colspan="5">Kongsberg</td></tr>
<tr><td>Model</td><td colspan="5">EM2040C</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">S3008</td><td>Component</td><td>Sonar Head</td><td>HWS Work Station</td><td>Processing Unit</td></tr>
<tr><td>Model Number</td><td>EM2040C</td><td>MP5810</td><td>CZC5503RFP</td></tr>
<tr><td>Serial Number</td><td>796</td><td>1049</td><td>1668</td></tr>
<tr><td>Frequency</td><td>200-400 kHz</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Calibration</td><td>2018-07-10</td><td>2018-07-10</td><td>2018-07-10</td></tr>
<tr><td>Accuracy Check</td><td>2018-07-10</td><td>2018-07-10</td><td>2018-07-10</td></tr>
</table>

Figure 2: Kongsberg EM2040C 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 4125

The Edgetech 4125 system includes a stainless steel towfish, topside processor unit (TPU) and 30 meters of Kevlar tow cable. The towfish's dimensions are 9.5cm in diameter, 97cm in length with an overall weight of 15kg (34 pounds). It has two frequency ranges, 400 and 900 kHz, and is capable of logging data in both frequencies simultaneously. 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. The towfish is pole mounted on a USM pole mount system that connects to a welded plate on the port side of the vessel. The pole mount system allows of easier, and safer, sidescan data collection in shallow areas or channels with high traffic. Data are collected while the vessel travels at, or near, 4kts. Sidescan data are logged using the Hypack HSX file format.

Manufacturer	Edgetech			
Model	4125			
Inventory	*S3008*	*Component*	Towfish	Processing Unit
		Model Number	4125	4125
		Serial Number	40425	40260
		Frequency	400/900 kHz	n/a
		Calibration	2019-03-26	2019-03-26
		Accuracy Check	2019-03-26	2019-03-26

Figure 3: 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

Lead weight is shackled to red tiller line. Line marked with centimeter graduations.

<table>
<tr><td>Manufacturer</td><td colspan="3">unkown</td></tr>
<tr><td>Model</td><td colspan="3">N/A</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S3008</td><td>Component</td><td>0</td></tr>
<tr><td>Model Number</td><td>0</td></tr>
<tr><td>Serial Number</td><td>0</td></tr>
<tr><td>Calibration</td><td>2019-04-01</td></tr>
</table>

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

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.

Manufacturer	Applanix					
Model	POS MV V5					
Inventory	*S3008*	*Component*	Topside Box	GNSS Antenna (2)	Inertial Measurement Unit	
		Model Number	POS MV V5	Trimble GA530	IMU 7	
		Serial Number	PCS-5910	14793/14811	3075	
		Calibration	2019-03-26	2019-03-26	2019-03-26	

Figure 4: POS MV V5 system components: IMU, POS Computer System, and two GNSS antennas.

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

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

The CastAway-CTD is a small, rugged CTD designed for profiling to depths of up to 100m. 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.

Manufacturer	SonTek		
Model	CastAway-CTD		
Inventory	*Component*	CastAway CTD	CastAway CTD
	Model Number	400100	400000
	Serial Number	CC1232007	CC1433008
	Calibration	2019-02-01	2018-09-20

Figure 5: SonTek CastAway CTD System

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic MicroX with SVXchange

The AML MicroX instrument with an SVXchange 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.

<table>
<tr><td>Manufacturer</td><td colspan="3">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="3">MicroX with SVXchange</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S3008</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>205757</td></tr>
<tr><td>Calibration</td><td>2019-06-25</td></tr>
</table>

Figure 6: AML MicroX Sound Speed Sensor

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

Manufacturer	*Software Name*	*Version*	*Use*
Teledyne CARIS	HIPS and SIPS	11.1.4	Acquisition
Teledyne CARIS	BASE Editor	5.4.2	Processing
Applanix	POSView	9.29	Acquisition
Applanix	POSPac MMS	8.4	Processing
NOAA, Hydrographic Systems and Technology Branch (HSTB)	Pydro Explorer	18.1.r7731	Processing
Hypack	Hypack 2018	2018	Acquisition
Kongsberg	SIS	4.3.2	Acquisition
Edgetech	Discover 4125	9	Acquisition

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Unknown None

Custom manufactured bottom grabber, clam shell style.

Figure 7: Clam Shell-style, 4 inch bottom grabber

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

The transducer face is the Reference Point (RP) for hull S3008. Offsets from the transducer face reside in POSViews "Reference to IMU Target" and "Reference to Primary GNSS Lever Arm" sections and are populated with the vessels 2017 NGS survey values. Additionally, the vessel offset values and associated uncertainty are stored in "TPU values" of CARIS HVF but with sign changes to account for the CARIS Coordinate Reference Frame. Please reference the NGS survey results table accompanying this report. Values are verified with steel tape ahead of each field season.

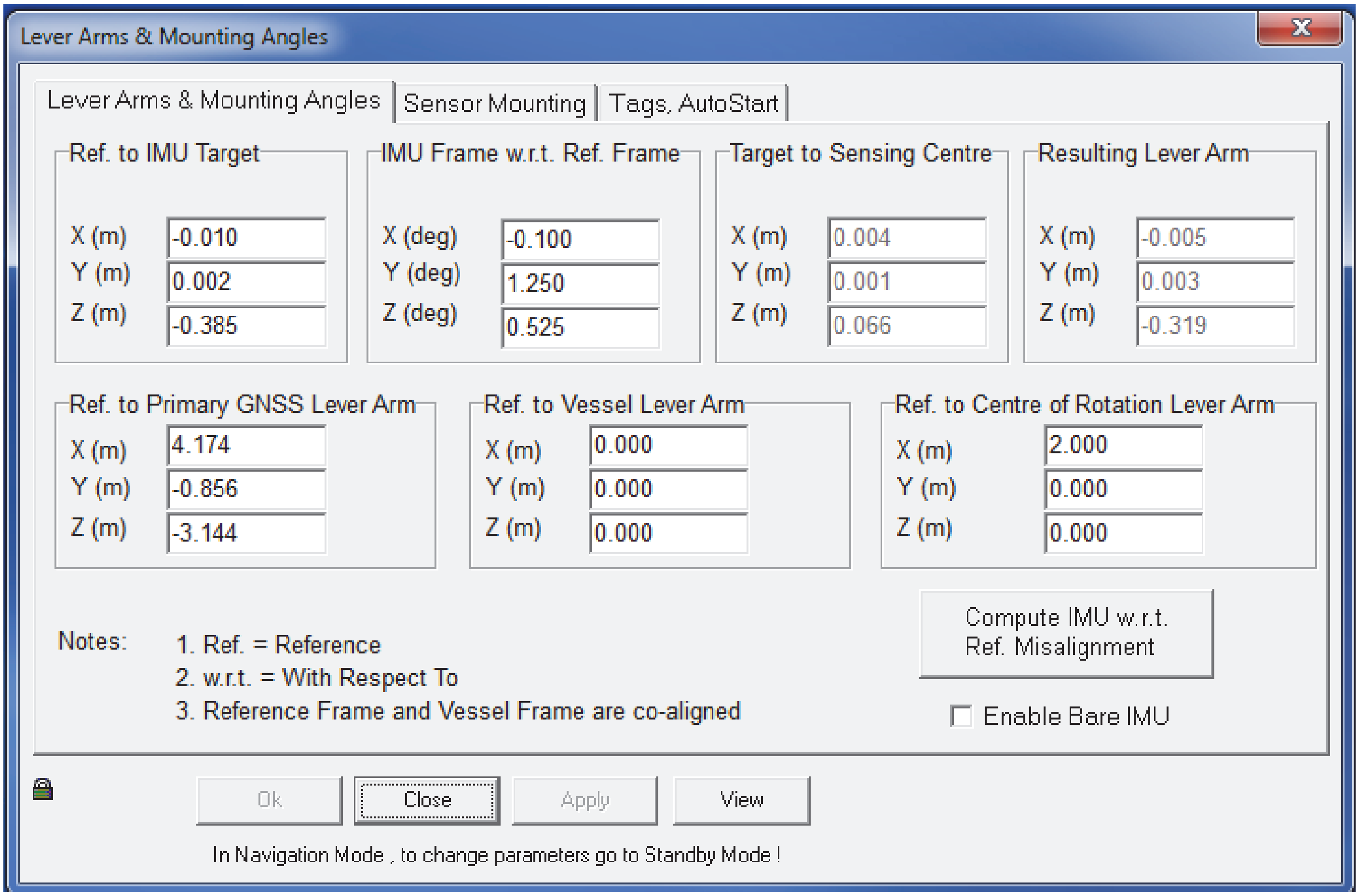


Figure 8: S3008 POSView Offsets

B.1.1.1 Vessel Offset Correctors

Vessel	S3008			
Echosounder	Kongsberg Maritime EM2040C			
Date	2019-03-15			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	-0.002 meters	0.010 meters
		y	0.010 meters	0.010 meters
		z	0.385 meters	0.010 meters
	Nav to Transducer	*x*	0.856 meters	0.010 meters
		y	-4.174 meters	0.010 meters
		z	3.144 meters	0.010 meters
	Transducer Roll	*Roll*	0.000 degrees	

B.1.2 Layback

NONE - Towfish is pole mounted via Universal Sonar Mount (USM). Offsets from origin are recorded in CARIS hvf.

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

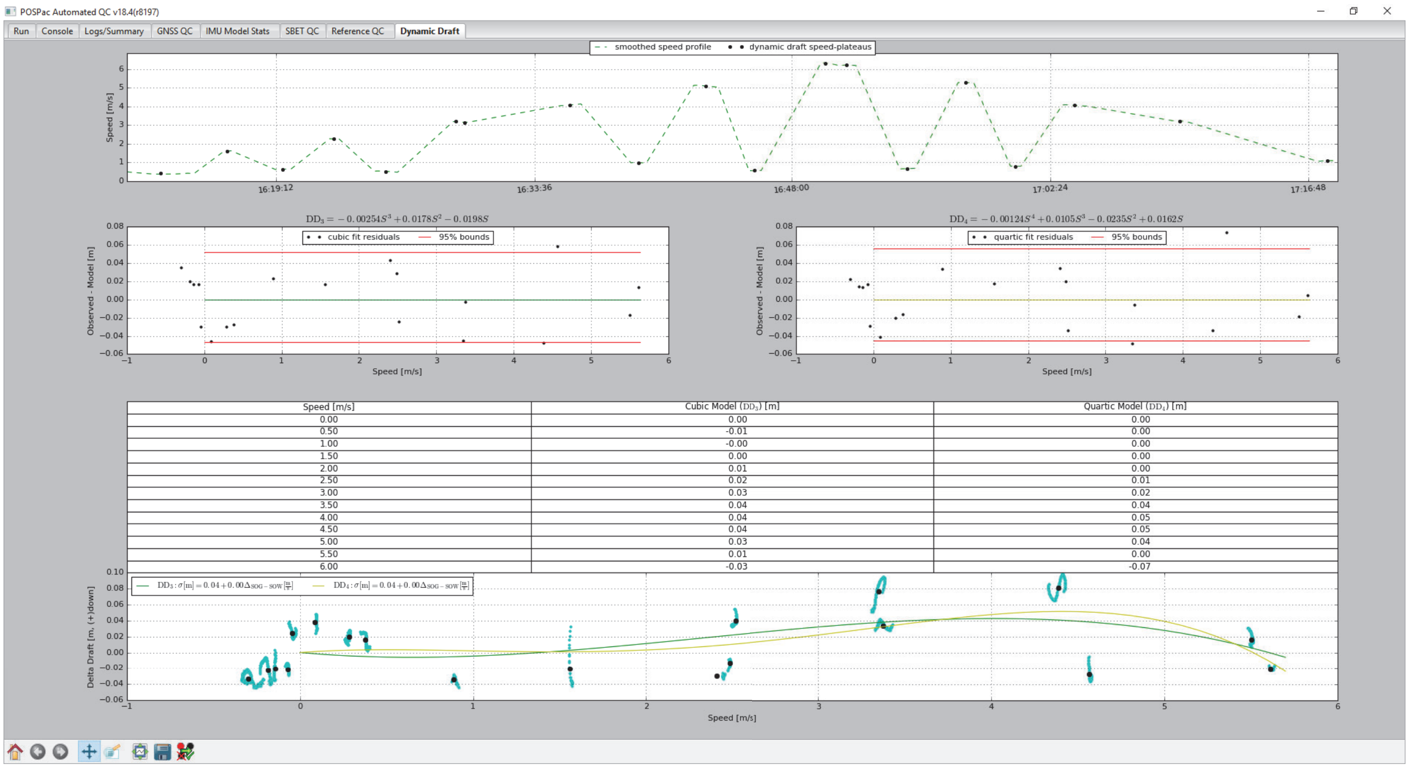
Vessel		S3008
Date		2019-03-08
Loading		0.015 meters
Static Draft	*Measurement*	-0.510 meters
	Uncertainty	0.024 meters

B.2.2 Dynamic Draft

In April 2018, NRT4 acquired dynamic draft survey lines in Galveston Bay, just outside of Houston, TX. 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 base stations, smartbase quality check, Applanix Smart Base, and GNSS Inertial Processor. In Pydro the POSPac AutoQC tool 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. A 4th order polynomial regression was determined from the test and the outputs are normally entered into the Caris HVF.

The calculated dynamic draft values for NRT4 were compared to other response teams with the same platform. It was found that there may have been an issue with the tide data as the numbers were quite different than the other teams. It was suggested that all teams should use the same dynamic draft values from a team with the highest confidence in their results. It was suggested that NRT 1 had the best results and that it would be best to use their values. So the Dynamic Draft Correctors displayed in the table and entered into the HVF are from NRT1's 2018 Dynamic Draft measurements.

NRT4 will continue to use these values for the 2019 field season.



Speed [m/s]	Cubic Model (DD_3) [m]	Quartic Model (DD_4) [m]
0.00	0.00	0.00
0.50	-0.01	0.00
1.00	-0.00	0.00
1.50	0.00	0.00
2.00	0.01	0.00
2.50	0.02	0.01
3.00	0.03	0.02
3.50	0.04	0.04
4.00	0.04	0.05
4.50	0.04	0.05
5.00	0.03	0.04
5.50	0.01	0.00
6.00	-0.03	-0.07

Figure 9: Dynamic draft values.

B.2.2.1 Dynamic Draft Correctors

Vessel	S3008	
Date	2018-05-03	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
	0.50	0.03
	1.00	0.04
	1.50	0.04
	2.00	0.04
	2.50	0.05
	3.00	0.08
	3.50	0.12
	4.00	0.16
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.05	0.03

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

The 2019 field season patch test was conducted as part of the HSRR (see the Appendix for full report). The patch test determined any roll, pitch, and yaw biases (X, Y, and Z axis) and the time offset between the MBES reference frame and the navigational reference frame. All patch tests were conducted in accordance with the HSSD Section 5.2.4.1. The lines were post-processed implementing the CARIS Calibration Utility and analyzed by NRT4 crew members. The results of the three trials were averaged and the result is recorded in the "IMU Frame w.r.t. Ref. Frame" inputs located in the POS Installation: Lever Arms & Mounting Angles window, after converting the values from the CARIS to the POS M/V coordinate system. It should also be stated that since the purpose of this exercise is to zero out the biases, the inverse of the patch test values are entered into the POS M/V, so that the sum of the offset equals zero, eliminating the bias. As the POS M/V is outputting the position at the EM2040 transducer head, no offsets are needed in the CARIS HVF file to correct the position. Therefore, the navigation offsets in the CARIS HVF file are all zero. Accidentally placing the offsets into the HVF would cause them to "double apply" and introduce significant biases.

B.3.1.1 System Alignment Correctors

Vessel	S3008
Echosounder	Kongsberg Maritime EM2040C
Date	2019-03-15
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.010 seconds
Navigation Time Correction	0.000 seconds	0.010 seconds
Pitch	1.250 degrees	0.020 degrees
Roll	-0.100 degrees	0.020 degrees
Yaw	0.525 degrees	0.020 degrees
Pitch Time Correction	0.000 seconds	0.010 seconds
Roll Time Correction	0.000 seconds	0.010 seconds
Yaw Time Correction	0.000 seconds	0.010 seconds
Heave Time Correction	0.000 seconds	0.010 seconds

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Kongsberg multibeam data is logged using SIS in the ".all" format. The hydrographer scans the real time SIS data for system wide errors, anomalies, and dropouts. Display windows such as Sea Bed Image, Time Series, Water Fall, and Beam Intensity aid in this task. SIS data is also fed through HYPACKS's HYSWEEP for the coxswain's display. This secondary interface acts as another real time monitoring tool. During acquisition, the hydrographer reviews the real time data and provides feedback to the coxswain in order to ensure acquired data will meet coverage requirements set forth in the Project Instructions and HSSD Section 5.2.2. EM2040C outer beam noise is prevalent due to S3008s hull design and mounting location. As such, the outer 5 degrees of port and starboard beams, were disabled in SIS to suppress systematic noise and reduce data cleaning time during post processing.

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
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. Georeference (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

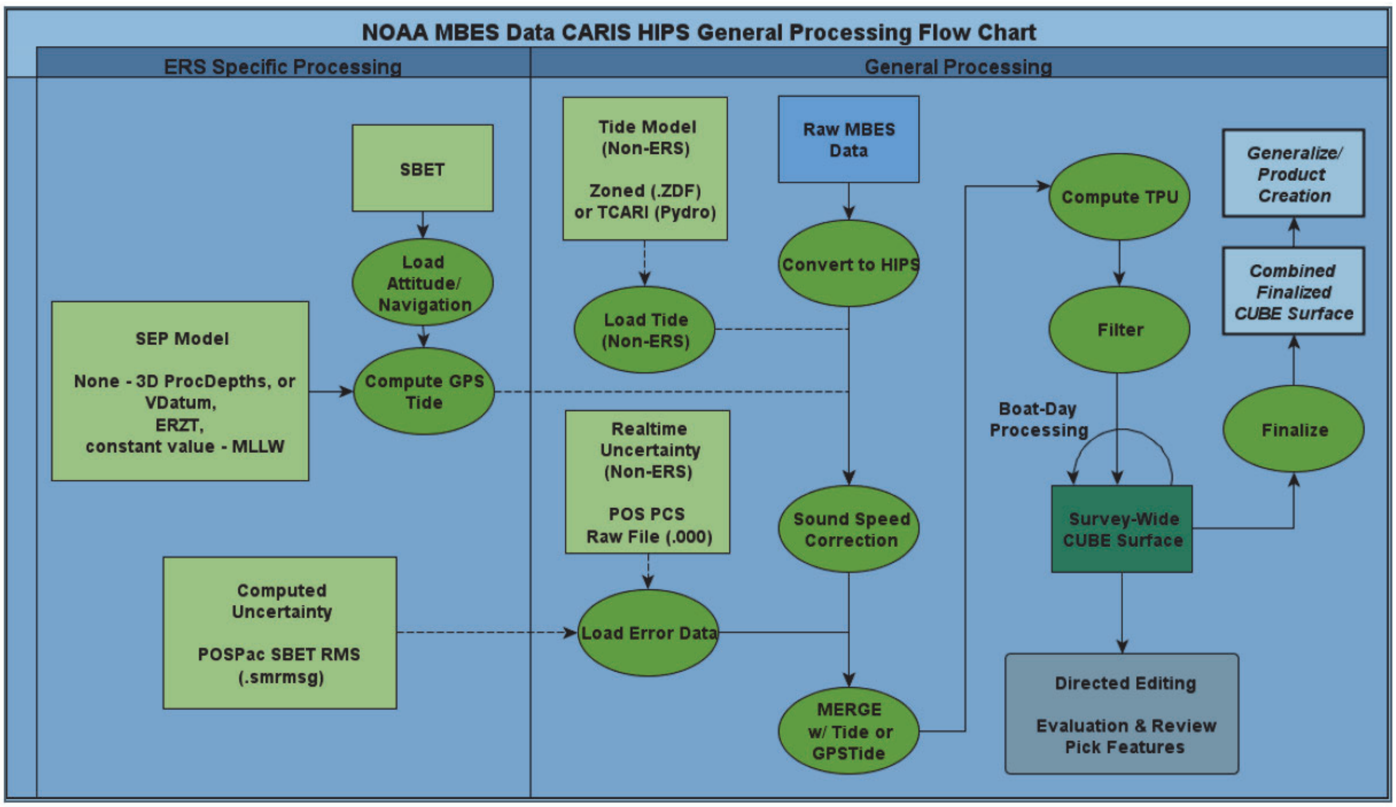


Figure 10: NRT4 MBES Workflow

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

MBES data are gridded using CARIS HIPS Combined Uncertainty and Bathymetric Estimator (CUBE) algorithm and is processed as described in FPM Section 4.2.1.1, using methods described above in Section C.1.1. The CUBE surface is also created using a grid resolution determined by coverage type and depth, as required by the Project Instructions and specified in the HSSD, Section 5.2.2. The "Depth" layer is reviewed for holidays (gaps in coverage) or erroneous soundings. Any erroneous soundings, known as fliers, are flagged as rejected and removed from the surface so the surface more accurately represents the seafloor. Any least depth on a feature that is not accurately reflected in the surface is flagged as “designated” in order to force the surface to reflect that shoaler depth in accordance with HSSD Section 5.2.1.2.3. NRT4 rarely operates in depths greater than 20 meters as such depths are uncommon for bays and harbors in the US Western Gulf of Mexico region. As such, only single resolution CUBE Surfaces are typically submitted with NRT4's projects.

C.1.4.2 Depth Derivation

See Above

C.1.4.3 Surface Computation Algorithm

See Above

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 on a Universal Sonar Mount (USM) arm fixed to a plate welded onto the port side gunwale near the stern. The arm can be rotated 90 degrees and brought back on board S3008 when acquisition is complete.
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/HSX data to the HDCS data format
2. Digitize 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 iaw 2019 HSSD, 6.1.1.

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. S3008 utilizes 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 Ethernet logging feature. Data are logged to the acquisition computers hard drive and are approximately 12-Megabyte (MB) files. Each file has a unique identifier for the year, Julian day number, and the vessel number (ex. 2017_214_S3007.000). The multiple POS files that are created from logging in this way are each distinguished 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 check box 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

The POS/MV file is recorded during acquisition and saved to the network RAW drive. The POS/MV file is loaded, applied to, and merged with the raw sonar data in CARIS via Charlene, using the "Import Auxiliary Data" utility as part of the standard processing flow.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

The CastAway CTD is the primary instrument to acquire sound velocity profiles, unless otherwise stated in the Descriptive Report. CARIS HIPS then utilizes the concatenated sound velocity data as a corrector . Casts are acquired every 2-4 hours during MBES acquisition. Profiles are collected more frequently when current and weather conditions warrant or when SIS indicates a new cast is needed.

Data Processing Methods and Procedures

All SVP casts are processed using HydrOffice's Sound Speed Manager and exported into SIS to be used in real time beam pattern formation. In CARIS, the "Nearest in Distance Within Time of Four Hours" option is used when correcting the data for sound speed unless otherwise noted in the DR.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed data is directly measured by AML's MicroX SV probe.

Data Processing Methods and Procedures

The Kongsberg EM2040C uses the sound velocity profile from the CTD profile for its beam forming equation and only depends on the surface sound speed as a comparison tool to ensure accuracy. This accuracy check is performed by comparing the continuous reading from the surface sound speed profiler to the CTD reading. The reading from the surface sound speed sensor can be applied to the data during processing.

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

C.6.2.1 A Priori Uncertainty

Vessel		S3008
Motion Sensor	Gyro	0.02 degrees
	Heave	5.00% 0.05 meters
	Roll	0.02 degrees
	Pitch	0.02 degrees
Navigation Sensor		1.00 meters

C.6.2.2 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_Features_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

Bottom sample data was not acquired.

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

Since the calculated depth for each grid node of a BASE surface is influenced by multiple soundings, the least depth of a feature may not always be accurately represented in the gridded data. Poor sounding density, noisy data, strong filters, and improper data cleaning, can all exacerbate this issue. Therefore, prior to creating a finalized BASE surface, the hydrographer must systematically review significant feature least depths to ensure they are accurately portrayed by the BASE surface. Additional data (including local knowledge, diver investigations, or sidescan sonar) should be reviewed in concert with the depth soundings. If the hydrographer finds that a specific least depth sounding should be represented in the weighted mean-depth calculation for the associated BASE surface grid node, that sounding should be flagged “Designated”. A designated sounding is required to be the shoalest sounding of a feature that sits at least 1m above the seafloor and the gridded surface is shown to exceed the allowable TVU at that depth (see Figure 5.1 in section 5.2.1.2.3 of the HSSD). The designated sounding must also be at least 2mm away, at survey scale, from any other shoaler sounding.

D.1.3 Holiday Identification

This survey is a "skunk-stripe" style survey with sidescan sonar data collected concurrently. The survey line spacing was based sidesan range settings. Due to the shallow nature of the survey area the multibeam data did not reach 100% coverage. Therefore identifying holidays in the multibeam data is not required as long as 200% sidescan data coverage was achieved.

D.1.4 Uncertainty Assessment

NRT4'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. Uncertainty graphs and scatter plots are derived implementing Pydro 3.1.2. QC Tools where the "QA" script analyzes CUBE surfaces for object detection density and TVU compliance.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Cross-lines with a linear nautical total of at least 8% 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 requirement 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

NONE

D.2 Imagery data Integrity and Quality Management

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

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.

The entire survey is adequate to supersede previous data.

NONE

Approver Name	Approver Title	Date	Signature
Dan Jacobs	Team Lead	05/03/2019	JACOBS.DAN.L.1151633478 Digitally signed by JACOBS.DAN.L.1151633478 Date: 2020.01.03 08:55:35 -06'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	NRT4_WiringDiagram.jpg
Sound Speed Sensor Calibration	AML_Cal_2018.pdf AML_CAL_2019.pdf SonTek_Cal_Cert.pdf CC1232007.pdf
Vessel Offset	NGS_S3008_Survey.xlsx
Position and Attitude Sensor Calibration	NRT4_GAMS_CAL_2019.pdf
Echosounder Confidence Check	NRT4_2019_SSS_Confidence_DN085.xlsx
Echosounder Acceptance Trial Results	N/A