U.S. Department of Commerce

National Oceanic and Atmospheric Administration

DATA ACQUISITION & PROCESSING REPORT

Type of Survey	*Hydrographic*
Project No.	*2017 NRT4 Field Season*

LOCALITY

Time Frame	*December-January*
State	*Texas*
Gen Locality	*Galveston*

2017

TEAM LEAD

Dan Jacobs, NOAA NRT4

Library and Archives

DATE ***October, 2017***

Table of Contents

List of Figures

Data Acquisition and Processing Report

Navigation Response Team 4
Chief of Party: Dan Jacobs
Year: 2017
Version: 1
Publish Date: 2017-11-29

A Equipment

A.1 Survey Vessels

A.1.1 S3008

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 a Dell workstation, 5 monitors, a multibeam echosounder system and a side scan sonar system.
Utilization	Hydrographic Survey Operations
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
	Discussion	The primary purpose of the survey was to precisely determine the spatial relationship between various hydrographic surveying sensors, and the components of a POS MV navigation system aboard the NOAA survey vessel S3008. The points are observed in an assumed coordinate system with a 0°00'00" azimuth between two temporary points set on the ground. The instrument is set on the 0,0,0 temp point (assumed coordinate system). All data are collected using a TSC2 data controller running the SurveyPro field software platform which interfaces with the GPT-30002LW Theodolite via bluetooth. The software generates two files 1. The .job file - this contains N, E, U coordinates only. 2. The .raw file - this contains the H/V Angles and Distance measurements. The .job file and .raw files are used in post-processing to rotate all points to a centerline azimuth of 0°00'00", then transform all points to the reference point (multibeam) with coordinate 0,0,0. Point names and rod heights are also recorded in a field book, but angles and distances are not.
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	*Date*	2017-05-10
	Method Used	Measurements from MBES Transducer Face Reference Point (origin)
	Discussion	See section "Correction to Echo Soundings."

Most Recent Dynamic Draft Determination	*Date*	2017-10-02
	Method Used	Post-Processed Kinematic (PPK) GPS
	Discussion	Post-Processed Kinematic (PPK) GPS performed on 05/10/2017. See section entitled "Corrections to Echo Soundings."

Figure 1: NOAA S3008

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Edgetech 4125

<table>
<tr><td>Manufacturer</td><td>Edgetech</td></tr>
<tr><td>Model</td><td>4125</td></tr>
<tr><td>Description</td><td>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; 400-900 kHz and 600-1600 kHz and is capable of logging data in both frequencies, simultaneously. However, typical frequencies used for NRT4 in the Gulf of Mexico are 400 or 900 kilohertz. Vertical beam width is 50 degrees. The towfish is typically towed at or near 6kts at 4-25 meters water depth.
The TPU contains a network card for transmission of the sonar data to the acquisition workstation. Sidescan data were logged using the JSF file format. A Dynapar cable counter data was configured to send data directly into the TPU through the acquisition computer (refer to the wiring diagram
On September 1st, 2017, NRT4 swapped out the the towfish winch and cable drum for a Universal Sonar Mount (USM) mounted atop the aft, portside gunnel. Its measurement offsets can be found in "Corrections to Echo Soundings" section of this document.</td></tr>
<tr><td>Serial Numbers</td><td>
<table>
<tr><td>Vessel Installed On</td><td>S3008</td></tr>
<tr><td>TPU s/n</td><td>40260</td></tr>
<tr><td>Towfish s/n</td><td>40423</td></tr>
</table>
</td></tr>
<tr><td>Specifications</td><td>
<table>
<tr><td>Frequency</td><td>900 kilohertz</td><td>400 kilohertz</td></tr>
<tr><td>Along Track Resolution</td><td>
<table>
<tr><td>Resolution</td><td>24 centimeters</td></tr>
<tr><td>Min Range</td><td>50 meters</td></tr>
<tr><td>Max Range</td><td>75 meters</td></tr>
</table>
</td><td>
<table>
<tr><td>Resolution</td><td>80 centimeters</td></tr>
<tr><td>Min Range</td><td>100 meters</td></tr>
<tr><td>Max Range</td><td>150 meters</td></tr>
</table>
</td></tr>
<tr><td>Across Track Resolution</td><td>1.5 centimeters</td><td>2.3 centimeters</td></tr>
<tr><td>Max Range Scale</td><td>75 meters</td><td>150 meters</td></tr>
</table>
</td></tr>
</table>

Manufacturer Calibrations	Manufacturer calibration was not performed.

Figure 2: Edgetech 4125

A.2.2 Multibeam Echosounders

A.2.2.1 Kongsberg EM2040C

Manufacturer	Kongsberg
Model	EM2040C
Description	The EM 2040C is the natural successor to Kongsberg Maritime's established compact multibeam, the EM 3002. The EM 2040C features high resolution and a wide frequency range from 200 to 400 kHz, with frequency selection in steps of 10 kHz. It

<table>
<tr><td></td><td colspan="3">uses Frequency Modulated (FM) chirp to extend range and offers a maximum depth of 490m with a beam width of 1° x 1° at 400 kHz. In dual configuration, with two Sonar Heads tilted to each side, 200° total coverage can be achieved, which enables surveying to the water surface or up to 10 times water depth on flat bottoms.</td></tr>
<tr><td rowspan="7">Serial Numbers</td><td>Vessel Installed On</td><td colspan="2">S3008</td></tr>
<tr><td>Processor s/n</td><td colspan="2">20099</td></tr>
<tr><td>Transceiver s/n</td><td colspan="2">20099</td></tr>
<tr><td>Transducer s/n</td><td colspan="2">5810</td></tr>
<tr><td>Receiver s/n</td><td colspan="2">20099</td></tr>
<tr><td>Projector 1 s/n</td><td colspan="2">Projector1 Blister Mount</td></tr>
<tr><td>Projector 2 s/n</td><td colspan="2">None</td></tr>
<tr><td rowspan="10">Specifications</td><td>Frequency</td><td colspan="2">300 kilohertz</td></tr>
<tr><td rowspan="2">Beamwidth</td><td>Along Track</td><td>1 degrees</td></tr>
<tr><td>Across Track</td><td>120 degrees</td></tr>
<tr><td>Max Ping Rate</td><td colspan="2">25 hertz</td></tr>
<tr><td rowspan="2">Beam Spacing</td><td>Beam Spacing Mode</td><td>Equidistant</td></tr>
<tr><td>Number of Beams</td><td>254</td></tr>
<tr><td>Max Swath Width</td><td colspan="2">120 degrees</td></tr>
<tr><td>Depth Resolution</td><td colspan="2">1 centimeters</td></tr>
<tr><td rowspan="2">Depth Rating</td><td>Manufacturer Specified</td><td>200 meters</td></tr>
<tr><td>Ship Usage</td><td>50 meters</td></tr>
<tr><td>Manufacturer Calibrations</td><td colspan="3">Manufacturer calibration was not performed.</td></tr>
<tr><td rowspan="3">System Accuracy Tests</td><td>Vessel Installed On</td><td colspan="2">S3008</td></tr>
<tr><td>Methods</td><td colspan="2">Lead Line-to-Multibeam Sonar Sounding Comparison</td></tr>
<tr><td>Results</td><td colspan="2">A lead line-to-multibeam sonar sounding comparison was conducted on 5/10/17, while stationary in calm backwaters adjacent to the Galveston Channel, Galveston, TX. The measurements agreed to the sub-decimeter level with a consistent reading of 2.5 meters. Figure below shows the multibeam data in Subset Editor with its reference surface (teal color) turned on.</td></tr>
<tr><td>Snippets</td><td colspan="3">Sonar does not have snippets logging capability.</td></tr>
</table>

Figure 3: EM2040C

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	Unknown	
Model	Unknown	
Description	Lead line is Nine (9) inch long lead ingot with flattened base shacked to tiller rope. The tiller rope is 17 meters in length and marked with decimeter graduations (red tape).	
Serial Numbers	3008	
Calibrations	*Serial Number*	3008
	Date	2017-05-10
	Procedures	The Lead Line was compared with a millimeter-accuracy, steel tape. Lead Line Corrector values recorded in Excel document entitled "HSRR_2017_Leadline_Calibration Values," in NRT4's 2017 System Certs folder.
Accuracy Checks	*Serial Number*	S3008
	Date	2016-08-17
	Procedures	NRT4 personnel compared lead line tape marks with a millimeter-accuracy, steel tape. Taped intervals had maximum difference of (+/-) 0.005 meters. Through its entire length (17 meters) lead line compared to steel tape showed a 0.003 meter difference.
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
Model	POS MV5
Description	S3008 is equipped with an Applanix POS/MV 5 which consists of dual Trimble BD950 GPS receivers (with corresponding Zephyr2 antennas), an inertial motion unit (IMU), and a POS computer system (PCS). The two antennas are mounted approximately 1.9 meters apart atop the launch cabin. The primary receiver (on the port side) is used for position and velocity, and the secondary receiver is used to provide heading information as part of the GPS azimuthal measurement sub-system (GAMS). The new IMU contains three solid-state linear accelerometers and three solid-state gyros, which together provide a full position and orientation solution. The IMU is mounted on the top of the sonar housing, beneath a deck hatch, forward of the generator compartment. The new IMU's base plate bolt holes matched the original.

PCS

Manufacturer	Applanix	
Model	POS MV5	
Description	The Pos MV5 Computer System comprises the processor, GNSS receivers and interface cards necessary to communicate with and process the IMU and GNSS data.	
Firmware Version	5.03	
Software Version	7.60	
Serial Numbers	*Vessel Installed On*	S3008
	PCS s/n	5610

Figure 4: POS MV5 Computer System

IMU	*Manufacturer*	Applanix	
	Model	POS MV 5	
	Description	Inertial Motion Unit (IMU)	
	Serial Numbers	*Vessel Installed On*	S3008
		IMU s/n	5434
	Certification	IMU certification report was not produced.	

Figure 5: Inertial Motion Unit (IMU)

Antennas	No POS/MV antennas were installed.	
GAMS Calibration	*Vessel*	S3008
	Calibration Date	2016-07-26
Configuration Reports	*Vessel*	S3008
	Report Date	2016-07-26

Figure 6: POS MV GPS antennae

A.4.2 DGPS

Description	S3008 is equipped with a Trimble DSM312. The unit is used for differential correction to all GPS signals overhead. Typically NRT4 is tuned to the USCG's 301 kHz broadcast in Angleton, TX while operating within the greater Houston/ Galveston region.

Antennas	*Manufacturer*	Trimble	
	Model	GA530	
	Description	The Trimble GA530 Antenna has a diameter of 15.2 , a height of 7.4 cm and weighs 1.45 lbs. It is mounted to the top station of S3008's radio mast. The unit is fully sealed and 100 percent humidity proof. Its frequency reception capabilities include L1, L2, OmniSTAR, Beacon and SBAS.	
	Serial Numbers	*Vessel Installed On*	S3008
		Antenna s/n	14811

Figure 7: Trimble GA530 antenna

<table>
<tr><td rowspan="7">Receivers</td><td>Manufacturer</td><td colspan="2">Trimble</td></tr>
<tr><td>Model</td><td colspan="2">SPS312</td></tr>
<tr><td>Description</td><td colspan="2">The SPS312 Integrated IALA Beacon capability allows the use of free MSK Beacon correction transmissions without extra receiver or antenna. It uses DGPS RTCM corrections via radio or cellular connection to extend the DGPS range when Beacon coverage is not available. The unit's ethernet and browser interface provides remote access over the internet or by cable for data monitoring and configuration.</td></tr>
<tr><td>Firmware Version</td><td colspan="2">1.73</td></tr>
<tr><td rowspan="2">Serial Numbers</td><td>Vessel Installed On</td><td>S3008</td></tr>
<tr><td>Antenna s/n</td><td>5331K63794</td></tr>
<tr><td colspan="3">

Figure 8: Trimble SPS312 DGPS Receiver</td></tr>
</table>

A.4.3 Trimble Backpacks

Manufacturer	Trimble
Model	GeoXH/GeoExplorer 2008 Series
Description	NRT4's GeoXH "Hand Held GPS" is used for shoreline verification i.e. non-bathymetric features such as piles, piers, dolphins and vertical benchmarks. . NRT4 typically uses the GeoXH with a Trimble Zephyr antenna mounted on a 2-meter, bipod-equipped range pole. The Trimble GeoXH combines an L1/L2 GPS receiver with a field computer powered by Microsoft Windows Mobile. TerraSync software is used to acquire data, and Pathfinder software is used to post-process data and applies differential corrections.
Serial Numbers	S/N 4928419526
Antennas	No antennas were installed.
Receivers	No receivers were installed.

Field Computers	No field computers were utilized for data acquisition.
DQA Tests	DQA test was not performed.

Figure 9: GeoXH GPS

A.4.4 Laser Rangefinders

Manufacturer	TruPulse
Model	360B

Description	The TruPulse laser range finder may be paired via Bluetooth to NRT4's GeoXH GPS to capture distance and bearing offsets for recorded positions. This capability greatly enhances shoreline verification of hard-to-access features. The unit is 5x2x3.5 inches, weighs 10 ounces, and has a 1000 meter maximum range to non-reflective targets. Several measurement modes are available including Slope Distance, Horizontal Distance and Vertical Distance.
Serial Numbers	044710
DQA Tests	DQA test was not performed.

Figure 10: TruPulse Laser Range Finder

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 YSI CastAway

<table>
<tr><td>Manufacturer</td><td colspan="2">YSI</td></tr>
<tr><td>Model</td><td colspan="2">CastAway</td></tr>
<tr><td>Description</td><td colspan="2">A YSI CastAway CTD was used to obtain sound speed profiles of the water column. The raw file, containing conductivity, temperature, and pressure data, was first uploaded to the acquisition computer and then processed using CastAway software, which generated .svp files to be used in CARIS post-processing.</td></tr>
<tr><td rowspan="2">Serial Numbers</td><td>Vessel Installed On</td><td>S3008</td></tr>
<tr><td>CTD s/n</td><td>CC1232007</td></tr>
<tr><td rowspan="3">Calibrations</td><td>CTD s/n</td><td>CC1232007</td></tr>
<tr><td>Date</td><td>2017-04-28</td></tr>
<tr><td>Procedures</td><td>Sensor Calibration</td></tr>
</table>

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 AML Oceanographic Micro X

Manufacturer	AML Oceanographic
Model	Micro X
Description	NRT4 uses a Micro X sound speed profiler for realtime surface sound speed monitoring. The unit is mounted on S3008's transom between the outboard engines by way of clamps and PVC tubing. The "sing-around" technology compensates for all factors influencing sound speed including salinity, depth, and temperature. An "CV" sound speed datagram is sent via RS 232 cabling from the digibar computer display to Kongsberg's multibeam sonar processing unit, facilitating accurate beam formation.
Serial Numbers	*Vessel Installed On*: S3008 *Sound Speed Sensor s/n*: 205757
Calibrations	*Sound Speed Sensor s/n*: 205757 *Date*: 2017-04-01 *Procedures*: Sensor Calibration

A.6 Horizontal and Vertical Control Equipment

A.6.1 Horizontal Control Equipment

No horizontal control 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

Manufacturer	Dell
Model	Precision T5500
Description	The Dell Precision T5500 workstation is a productivity machine with 64-bit multi-core Intel Xeon processors. Memory is scalable up to 72GB with DDR3 ECC registered DIMMs (RAM). It holds Dual-native, PCIe Generation 2 graphics slots.

Serial Numbers	*Computer s/n* / *Operating System* / *Use* CD000409857 / Windows 7 / Acquisition

Manufacturer	Dell
Model	Precision 1650
Description	The Dell Precision 1650 uses 3rd Generation Intel Core Processors and Intel Xeon Processor E301200v2 Family with optional Intel vPro Technology. Memory is scalable up to 32GB of dual-channel ECC or 16GB of non-ECC RAM.
Serial Numbers	*Computer s/n* / *Operating System* / *Use* CD0004063571 / Windows 10 / Processing CD0004063570 / Windows 10 / Processing

A.7.2 Computer Software

Manufacturer	CARIS
Software Name	HIPS and SIPS
Version	10.2
Service Pack	1
Hotfix	1
Installation Date	2017-05-08
Use	Processing
Description	CARIS 9.1.7 is the primary software utilized post processing of NRT4's hydrographic data.

Manufacturer	Hypack
Software Name	Hypack
Version	2017
Service Pack	1
Hotfix	1
Installation Date	2016-04-27
Use	Acquisition
Description	Hypack (and Hysweep) are the primary software used for data collection using the "paint-the-bottom" navigation method.

Manufacturer	Applanix

Software Name	POS View
Version	7.2
Service Pack	1
Hotfix	1
Installation Date	2016-11-07
Use	Acquisition
Description	POS View interfaces NRT4's IMU and Primary/Secondary Antennae to the POS M/V 5.

Manufacturer	Kongsberg
Software Name	Seafloor Info System (SIS
Version	4.3.2
Service Pack	0
Hotfix	0
Installation Date	2016-04-18
Use	Acquisition
Description	SIS interfaces with POS M/V5 positioning information.

A.8 Bottom Sampling Equipment

No bottom sampling equipment was utilized for data acquisition.

B Quality Control

B.1 Data Acquisition

B.1.1 Bathymetry

B.1.1.1 Multibeam Echosounder

Mainscheme multibeam data, the intent of which is to obtain bathymetry over an entire area, are acquired using one of two methods – "skunk-stripe" or "paint-the-bottom."

Skunk-Stripe – The skunk-stripe scheme refers to the pattern of MBES coverage resulting from running MBES concurrently with sidescan sonar (SSS) operations. Because SSS operations are conducted with a set line-spacing optimized for sidescan coverage, the corresponding MBES coverage is often a series of parallel, non-overlapping swaths. Skunk-stripe MBES data are acquired using a Hypack line plan originally created in Hypack Line Editor or ArcMap.

Paint-the-Bottom – The paint-the-bottom scheme is used during complete or object detection MBES operations. Unlike a traditional line-plan approach, paint-the-bottom is an adaptive line-steering technique, whereby the coxswain viewed a real-time coverage map in Hysweep and accordingly adjusted line steering to ensure adequate overlap. Because of the operational efficiency afforded by the real-time coverage map, holidays, or gaps in the coverage, are often addressed the same day. When holidays are not addressed the same day, they were acquired based on a traditional line plan. The coxswain strove to avoid abrupt changes in direction and speed, but abrupt changes in direction and speed were unavoidable in certain areas due to current and/or confined areas. In areas were abrupt changes in direction were unavoidable speed was reduced to minimize motion-related artifacts.

Developments
The intent of development operations is to obtain the least depth of a particular feature or shoal. Development data are acquired using a pattern of tightly spaced short lines that are run with enough overlap to ensure the least depth comes from the near-nadir region of the swath. Developments can be run for features originally identified in either SSS or MBES data.

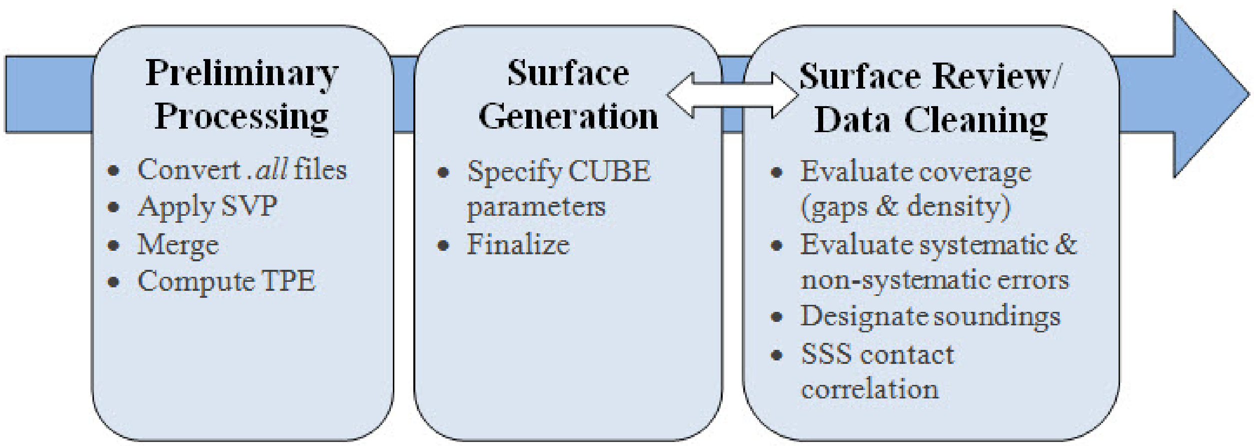

Figure 11: NRT4 Multibeam Processing Workflow

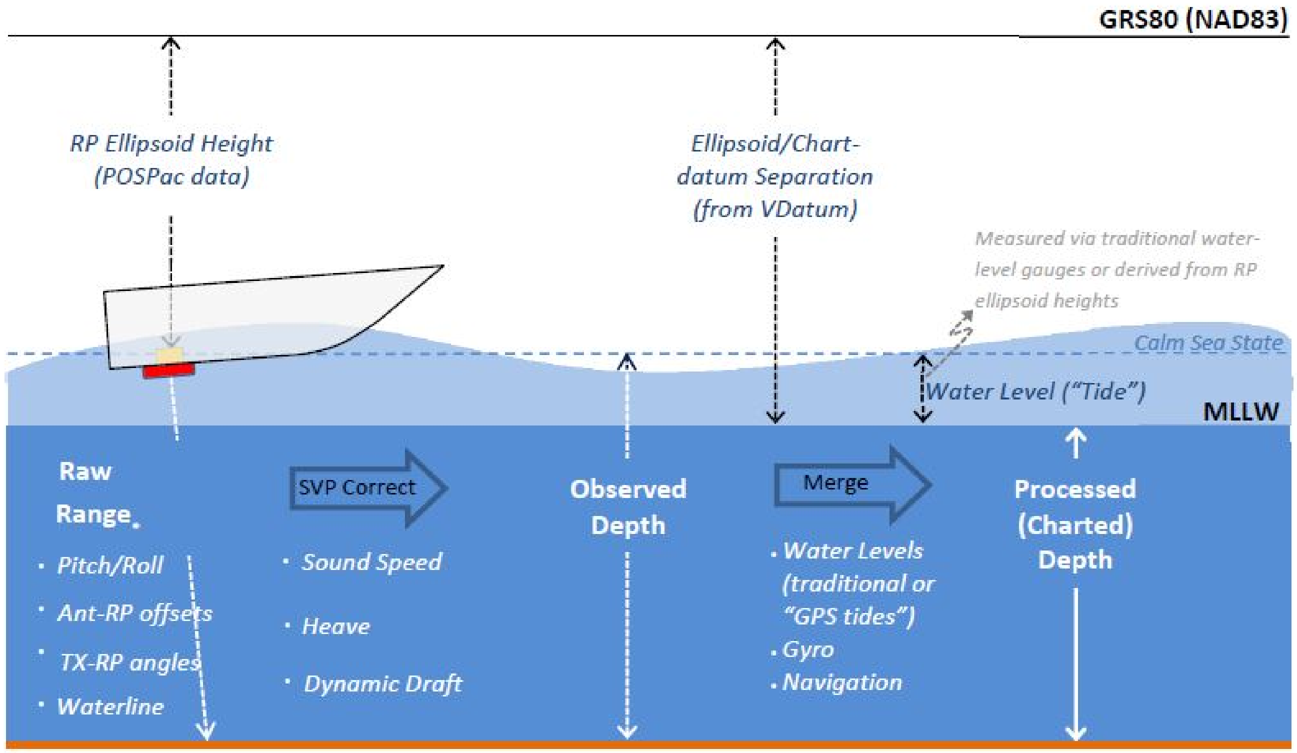

Figure 12: NRT4 Multibeam Processing Workflow, additional graphic.

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

Sidescan Sonar Data Acquisition Operations

The SSS towfish was deployed from a davit arm located on the starboard quarter using an electric winch spooled with approximately 25 meters of cable. The tow cable at the winch was connected electro-mechanically to a deck cable through a slip ring assembly. Cable out was controlled manually and was computed by the DynaPro cable counter by the number of revolutions of the cable drum sheave. Cable-out was adjusted to 4.0 meters before deployment of the towfish to account for the distance from the towfish-to-towpoint, which was defined to be the top of the sheave.

Line spacing for side scan sonar (SSS) operation was prepared as directed in the NOAA Field Procedures Manual and Spec's and Deliverables. To minimize towing gear stress, and reduce strumming, towed SSS operations were typically limited to approximately 6 knots speed-over-ground. During left turns, speed was increased (after ensuring adequate cable out) to prevent the tow cable from swinging into the outboard propellers; the higher speed created a force on the cable that kept the cable at a safe distance from the outboard propellers. A towfish altitude of 8-20% of the range scale was maintained during data acquisition. Altitude was adjusted by cable out and vessel speed.

Confidence checks were performed daily by observing changes in 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.

Processing Workflow

Sidescan processing was based on the boat-day concept documented in section 4.3 of the Field Procedures Manual (Imagery Processing). The sidescan processing workflow had three main components: preliminary processing, mosaicking, and contact selection. Feature classification and correlation is addressed in section B.3, "Feature Data."

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

Sound speed profiles are collected at 4 hour intervals in accordance with FPM. Profiles are typically taken in the deepest location of the survey area each day. Profiles are post-processed using the "nearest-in-distance, within-time, 4 hours" option in Caris. Sound profiles are performed more frequently as physical conditions warrant. Such conditions usually include fresh water demarcation lines at the river-and-sea interface and/or surface sound speed disparities between the real time surface speed sensor and the cast surface speed.

B.1.3.2 Surface Sound Speed

Surface sound speed data were not acquired.

B.1.4 Horizontal and Vertical Control

B.1.4.1 Horizontal Control

Horizontal control data were not acquired.

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

Bottom sampling data were not acquired.

B.1.7 Backscatter

Backscatter data were not acquired.

B.1.8 Other

No additional data were acquired.

B.2 Data Processing

B.2.1 Bathymetry

B.2.1.1 Multibeam Echosounder

Processing consisted of converting the raw, SIS-logged .all data to CARIS HDCS format, applying a number of correctors via the Apply Tides, Apply SVP, and Merge functions, and calculating a priori horizontal and vertical total propagated uncertainties (TPU) for each sounding. Each is described below.

Conversion
Raw multibeam .all data were converted to HDCS format in CARIS HIPS. As noted in section A.2.1.1, the overall MBES acquisition system is configured such that three main datagrams are converted into CARIS:
- ZDA-synchronized position of the vessel RP (center of EM2040C Sonar face).
- ZDA-synchronized attitude of the vessel RP
- roll-stabilized raw angles and ranges (waterline taken into account in CARIS and SIS).

Applying SVP
The SVP-correction process in CARIS generates ray-traced along-track and across-track depths relative to the sonar head (the observed depths). To achieve accurately ray-traced depths, the SVP algorithm positions the transducer at the proper depth and orientation in the water column by applying the attitude (including delayed heave), dynamic draft. Typically, multiple SVP casts are concatenated into a single file, with an

appropriate cast-selection method specified during SVP correction. The “nearest in distance within time” option is generally used, but the distribution of casts occasionally calls for another cast-selection method.

Applying TCARI Tides
The data were tide corrected in Pydro using the TCARI grid from CO-OPS. The grid utilizes 6-min MSL tide data (predicted, preliminary, or verified) for each station in the survey area. When run, Pydro creates tidal reducers for the HDCS lines and places the data in each line folder. Any data points outside the TCARI grid will generate an error report that can be saved for future reference. Once this process is complete the data should be merged.

Merging
The merge process in CARIS combines the observed depths (updated during SVP correction) with the loaded tide file, the navigation data, and the HVF swath1 angular offsets (patch test values) to compute the final processed depths.

Computing TPE
The TPE computation process assigns each sounding a horizontal and vertical uncertainty, or estimate of error, based on the uncertainties of the various data components, such as position, sound speed, and loading conditions.

Surface Generation
The multibeam sounding data were modeled using the CUBE BASE surface algorithm implemented in CARIS HIPS. CUBE BASE surfaces were generated using the parameters outlined in Hydrographic Surveys Technical Directive 2009-02 (CUBE Parameters). The resolutions of the finalized surfaces were based on the complete MBES coverage resolution requirements specified in the Specs and Deliverables (5.2.2.2). The deeper limit of certain ranges was extended to avoid gaps between surfaces on particularly steep slopes. Surfaces are finalized with the “Greater of the Two” option, to maintain a conservative error estimate.

Surface Review/Data Cleaning
Rather than a traditional line-by-line review and a full subset-cleaning, the data cleaning/quality review process for NRT4 consisted of a combination of the directed-editing approach described in FPM section 5.2 and a full subset-review (not full subset-cleaning). All the sounding data were viewed in subset, but unlike in the traditional work flow, where every sounding deemed to be “noise” is rejected, only the soundings that negatively impacted the CUBE surface were rejected. Surface review also consisted of evaluating holidays (both coverage and density holidays) and systematic errors and designating soundings. Sounding designation was in accordance with Specs and Deliverable section 5.2.1.2.

In general, the hydrographer referenced the SSS data when cleaning MBES data and designating soundings. In situations where the MBES data were ambiguous, consulting the SSS data often helped to determine a course of action. If consulting SSS data did not resolve the issue, more MBES were acquired over the item in question.

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

Data integrity is maintained by adhering to the HSSD's rigorous Folder/File data structure throughout the acquisition, processing, analysis, and submission pipelines and by implementing the Hydrographic Survey Quality Control Checklist, Page 611, Field Procedures Manual dated April, 2014.

B.2.1.4.2 Methods Used to Generate Bathymetric Grids

The multibeam sounding data were modeled using the CUBE BASE surface algorithm implemented in CARIS HIPS. CUBE BASE surfaces were generated using the parameters outlined in Hydrographic Surveys Technical Directive 2009-02 (CUBE Parameters). The resolutions of the finalized surfaces were based on the complete MBES coverage resolution requirements specified in the Specs and Deliverables (5.2.2.2). The deeper limit of certain ranges was extended to avoid gaps between surfaces on particularly steep slopes. Surfaces are finalized with the “Greater of the Two” option, to maintain a conservative error estimate.

B.2.1.4.3 Methods Used to Derive Final Depths

Methods Used	Gridding Parameters Surface Computation Algorithms
Description	NRT4 utilizes the "Combined Uncertainty and Bathymetric Estimator" (CUBE) algorithm for ascertaining depths, gridded at 50cm. Gridded parameters for this algorithm reside in an xml file called "CUBEParams_NOAA_17."

B.2.2 Imagery

B.2.2.1 Side Scan Sonar

Preliminary processing consisted of conversion, slant-range correction, AVG/TVG correction, and towfish navigation computation.

Raw sidescan data (.jsf) were converted to HDCS format in CARIS HIPS/SIPS. The overall SSS acquisition system is configured such that vessel navigation, vessel gyro, towfish depth, towfish altitude, cable out, and raw sidescan data are converted into CARIS SIPS.

Slant-range correction is no longer an element in the SSS processing workflow as CARIS 8.1 automatically makes this calculation during the Conversion process or “on-the-fly” should the seabed trace require editing, after conversion.

Towfish navigation was calculated in CARIS SIPS, which uses the “follow-the-dog” algorithm(see CARIS HIPS & SIPS 7.0 Users Guide). During this computation, the towfish depth, cable out, HVF Tow Point Z-value, and vessel course-made-good are used to calculate the towfish position. Contact positions were recomputed whenever towfish navigation was recomputed.

After creating a Field Sheet, mosaics of varying resolution and bin parameters are created. Note: it is no longer necessary to generate“GeoBars” in advance to mosaicking in CARIS 8.1 or subsequent versions.

Sidescan contacts were selected as per the Specs and Deliverables section 6.3.2 and the Field Procedures Manual section 4.3.4.1. Once selected, contacts were exported from CARIS, including a speed-corrected, geo-referenced, and raw image of the contact. The shadow-height field for every contact was populated, but the length, width, and remarks field were populated only when deemed informative by the hydrographer.

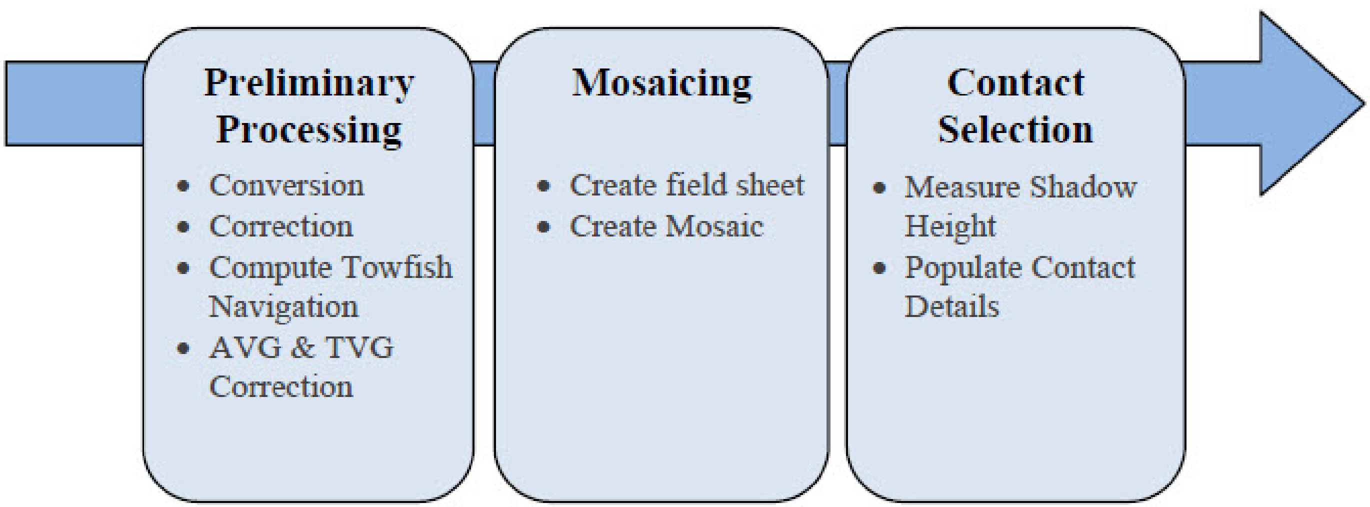

Figure 13: Side Scan Processing Workflow

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

Data integrity is maintained by adhering to the HSSD's rigorous Folder/File data structure throughout the acquisition, processing, analysis, and submission pipelines and by implementing the Hydrographic Survey Quality Control Checklist, Page 611, Field Procedures Manual dated April, 2014.

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

Edgetech 4125 is engineered to detect objects less than half a meter across. NRT4's horizontal accuracy is checked annually during its confidence radius check per FPM.

B.2.2.3.3 Methods Used to Verify Swath Coverage

The Hydrographer employed the "Shine Through" method for evaluating 100 and 200 percent sidescan coverage. For this method, the CARIS map window's background was assigned a salient color such as red or purple before loading grayscale mosaic overlays. After the mosaic is loaded, any break in coverage (holiday) was visually called out by this background color shining through. Holidays are typically reacquired with object detection multibeam sonar.

B.2.2.3.4 Criteria Used for Contact Selection

Objects with shadows measuring one meter or more in 20 meters depth or less are typically selected as a contact. The shadow-height field for every contact was populated, but the length, width, and remarks field were populated only when deemed informative by the hydrographer.

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

Sound speed profiles were collected at 4 hour intervals in accordance with FPM. Profiles are typically taken in the deepest location of the survey area each day. Profiles are post-processed using the "nearest-in-distance, within-time, 4 hours" option in Caris. Sound profiles are performed more frequently as physical conditions warrant. Such conditions usually include fresh water demarcation lines at the river-and-sea interface and/or surface sound speed disparities between the real time surface speed sensor and the cast surface speed.

B.2.3.1.1 Specific Data Processing Methods

B.2.3.1.1.1 Caris SVP File Concatenation Methods

Concatenation of SVP files were performed daily via the "cut-and-paste" method of data (header, depth and speed) into a "master" file.

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 were not processed.

B.2.7 Other

No additional data were processed.

B.3 Quality Management

Rather than a traditional line-by-line review and a full subset-cleaning, the data cleaning/quality review process for NRT4 consisted of a combination of the directed-editing approach described in FPM section 5.2 and a full subset-review (not full subset-cleaning). All the sounding data were viewed in subset, but unlike in the traditional workflow, where every sounding deemed to be “noise” is rejected, only the soundings that negatively impacted the CUBE surface were rejected. Surface review also consisted of evaluating holidays (both coverage and density holidays) and systematic errors and designating soundings. Sounding designation was in accordance with Specs and Deliverable section 5.2.1.2. In compliance with the Field Procedures Manual dated April, 2014 NRT4 utilized the the Hydro Survey QC Checklist listed in Chapter 5 Appendices to ensure accuracy in daily processing, documentation, post acquisition and submission of hydrographic data.

Hydrographic Survey Quality Control Checklist

Survey: HXXXXX ________ **Project:** OPR-XXXX-FA ________ **Survey PIC:** ________

SURVEY PLANNING **Completed:** ________ INITIAL ________ DATE

________ Read and Understand the project Instructions
- ______ Letter Instructions
- ______ Standing Instructions

________ Start filling in Survey Log
- ______ pertinent Chart scales listed

________ Shoreline Prep
- ______ Shoreline files prepped
- ______ Boat sheets produced
- ______ TIF/TFWs opened and checked in TerraSync
- ______ Initial TIF/TFWs produced for MBES launches in Isis

________ Cross Lines
- ______ Plan to run crosslines early, prior to MS if possible
- ______ Plan to obtain 10%
- ______ Atleast 5% collected

________ Multibeam Polygons produced and updated
- ______ DO NOT send multibeam boats inshore of the eight meter curve until shoreline has been run in area
- ______ Initially create SHIP & LAUNCH polygons only - Launch polygons can be driven by any Cox'n
- ______ NEAR_SHORE & HIGH_WATER_ONLY polygons not created until shoreline has been run in area
  - ______ Discuss NEAR_SHORE & HIGH_WATER_ONLY areas with FOO/CST - run by experienced Cox'ns only
- ______ Polygons converted to shp format and put in R/Transfer and on Launch hard drive

________ Bottom Samples Prepped
- ______ Bottom Sample chartlet/boat sheet produced
- ______ Create a tif/tfw of your bottom sample sites
- ______ TIF/TFWs opened and checked in TerraSync

DAILY CHECKS **Completed:** ________ INITIAL ________ DATE

________ Quality Control of Survey Data
- ______ Review BASE surfaces
- ______ Review data in subset mode for SV error, tide problems, holidays & noise
- ______ Check coverage and update polygons
- ______ Check for immediate DTONs and notify FOO
  - ______ Immediate DTONs submitted

________ Review Acquisition and Processing logs
- ______ Check for issues/problem data in both Acquisition and Processing sections
- ______ Make sure the SV application method is documented (e.g. NIDWT-4hrs)
- ______ Note if True Heave could not be applied & document in DR

Figure 14: Excerp of the Hydrographic Survey Quality Control Checklist, Page 611, Field Procedures Manual dated April, 2014.

B.4 Uncertainty and Error Management

NRT4 standards for Total Vertical Uncertainty (TVU) in hydrographic surveys apply to general water depths and least depths over wrecks and obstructions. By extension, they also apply to the elevations of rocks or other features which uncover at low water and to the measurement of overhead clearances. Per 2016 HSSD, Chapter 5.1.3. the formula $\pm\#a^2+(b*d)^2$ was used to compute the maximum allowable TVU for all depth estimates included in bathymetric data products or feature attribution after application of correctors for all systematic and system specific errors. At least 95% of geographically distributed grid nodes shall meet this specification and the percentage of nodes that do not meet the maximum allowable TVU shall be discussed in the Descriptive Report. Similarly, Total Horizontal Uncertainty (THU) positioning of soundings will not exceed 5 m + 5 % of the depth at the 95 percent confidence level per 2016 HSSD, Chapter 3.1.1.

B.4.1 Total Propagated Uncertainty (TPU)

B.4.1.1 TPU Calculation Methods

TPU Calculations are additive.

B.4.1.2 Source of TPU Values

Per manufacturer's specification for each sensor, i.e. Kongsberg EM3002, Applanix POS/MV5 and EdgeTech 4125.

B.4.1.3 TPU Values

<table>
<tr><td>Vessel</td><td colspan="3">S3008</td></tr>
<tr><td>Echosounder</td><td colspan="3">Kongsberg 2040C 300 kilohertz</td></tr>
<tr><td rowspan="13">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>0.015 centimeters</td></tr>
<tr><td>Pitch</td><td>0.02 degrees</td></tr>
<tr><td>Roll</td><td>0.02 degrees</td></tr>
<tr><td>Navigation Position</td><td colspan="2">1 meters</td></tr>
<tr><td rowspan="6">Timing</td><td>Transducer</td><td>0.01 seconds</td></tr>
<tr><td>Navigation</td><td>0.01 seconds</td></tr>
<tr><td>Gyro</td><td>0.01 seconds</td></tr>
<tr><td>Heave</td><td>0.01 seconds</td></tr>
<tr><td>Pitch</td><td>0.01 seconds</td></tr>
<tr><td>Roll</td><td>0.01 seconds</td></tr>
</table>

	Offsets	*x*	0.01 meters
		y	0.01 meters
		z	0.01 meters
	MRU Alignment	*Gyro*	0.2 degrees
		Pitch	0.2 degrees
		Roll	0.2 degrees
	Vessel	*Speed*	0.05 meters/second
		Loading	0.015 meters
		Draft	0.024 meters
		Delta Draft	0.03 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 following section describes the determination and evaluation of S3008's static offsets.

C.1.1.2 Methods and Procedures

Vessel Lever-Arms:
The Reference Point (RP)-to-EM2040C lever arm was measured with the aid of the National Geodetic Survey total station and field personnel on February 24, 2017. A figure of all offsets related to the EM2040C Sonar Face is listed below.

Water Line:
A static draft check was performed on 5/15/2017 in the parking lot of the USACE facility, Galveston, TX. The draft check was accomplished as the vessel lay stationary and level on its trailer. This unconventional, yet practical measurement method exploited the occurrence of a well-defined, 2.1cm wide scum line distinctly evident along S3008’s hull. The scum encompassed the full range of water lines derived from variations in vessel loading; i.e. fuel level, equipment, supplies, personnel, etc. while at rest. The “actual” water line was taken to be the center of this scum line.

Static Draft:
To determine the static draft (i.e., the height of the waterline above/below the reference point), several measurements were taken as the vessel rested on its trailer in a level asphalt parking lot. Vertical distances from the RP-to-Parking Lot were made and averaged. Likewise, vertical measurements extending from the Waterline-to-Parking Lot were taken and averaged about the aft port and starboard reference points. Thus, the distance of 0.51 meters (waterline to the sonar head) was deduced by subtraction. This value was input into Kongsberg's Seafloor Information System v 4.3.2 as "-0.51" accounting for the "Z-Down" coordinate frame convention. It was also input into the vessel's HVF (See corrections to Echo Soundings section of this document).

NOAA Survey Vessel S3008 was surveyed by the National Geodetic Survey on February 24, 2017 to determine the spatial relationship between various hydrographic sensors using EM2040C Sonar Face's center as the primary reference point (RP). S3008's port side, primary POS antenna's offset calculation was entered into POS View's Lever Arms and Mounting Angles in the field "Ref. to Primary GPS Lever Arm." Please reference the NGS's field report, accompanying this document.

S3008 BOAT SURVEY 2017			
NAME	X (METERS)	Y (METERS)	Z (METERS)
CL1	6.371	0.017	-1.726
CL2	3.798	0.030	-2.841
CL3	0.418	0.017	-0.677
CL4	-0.466	0.017	-0.634
MPP	-0.022	-0.422	-0.661
MPS	-0.016	0.453	-0.649
IMU	-0.010	0.002	-0.385
BM STERN STAR	-1.586	1.180	-1.344
BM STERN PORT	-1.588	-1.130	-1.371
GPS BM STAR	3.817	0.885	-2.712
GPS STAR ARP	4.177	0.951	-3.115
GPS BM PORT	3.818	-0.813	-2.739
GPS PORT ARP	4.174	-0.856	-3.144
MULTIBEAM	0.000	0.000	0.000
SS RM	-0.832	2.110	-2.697
NOTE: Z VALUES ARE POSITIVE DOWNWARD			

Figure 15: NGS Full Survey, S3008.

MULTIBEAM

Figure 16: EM2040C Vessel Reference Point

Figure 17: Scum Line, S3008

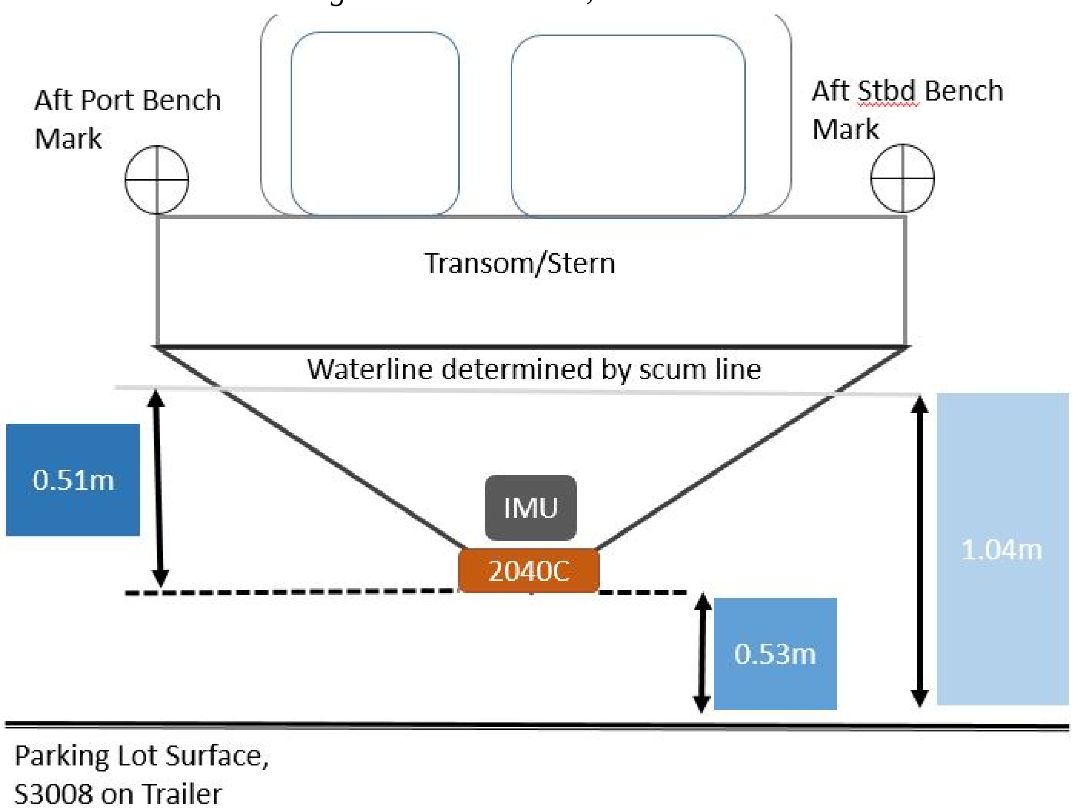

Figure 18: Waterline and Benchmarks, S3008.

C.1.1.3 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="3">S3008</td></tr>
<tr><td>Echosounder</td><td colspan="3">Kongsberg EM2040C 300 kilohertz</td></tr>
<tr><td>Date</td><td colspan="3">2018-09-08</td></tr>
<tr><td rowspan="14">Offsets</td><td rowspan="6">MRU to Transducer</td><td>x</td><td>-0.002 meters</td></tr>
<tr><td>y</td><td>0.010 meters</td></tr>
<tr><td>z</td><td>0.385 meters</td></tr>
<tr><td>x2</td><td>0 meters</td></tr>
<tr><td>y2</td><td>0 meters</td></tr>
<tr><td>z2</td><td>0 meters</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.856 meters</td></tr>
<tr><td>y</td><td>-4.174 meters</td></tr>
<tr><td>z</td><td>3.144 meters</td></tr>
<tr><td>x2</td><td>0 meters</td></tr>
<tr><td>y2</td><td>0 meters</td></tr>
<tr><td>z2</td><td>0 meters</td></tr>
<tr><td rowspan="2">Transducer Roll</td><td>Roll</td><td>0 radians</td></tr>
<tr><td>Roll2</td><td>0 degrees</td></tr>
</table>

C.1.2 Layback

C.1.2.1 Description of Correctors

A winch, drum and J-arm were installed aboard S3008 in July 2017 for towing the EdgeTech 4125 Side Scan Sonar. However, the winch and drum configuration placed the side scan sonar too close to the vessel's propellers while surveying in < 5 meters depths. Consequently, on September 1st, 2017, NRT4 swapped out the the towfish winch and cable drum for a Universal Sonar Mount (USM) mounted atop S3008's aft, portside gunnel.

C.1.2.2 Methods and Procedures

The Edgetech's/USM measurement offsets in the deployed position measured X-1.6m; Y-0.978; Z-0.455. (Caris Coordinate Reference Frame). These values passed the field season's confidence radius test.

C.1.2.3 Layback Correctors

<table>
<tr><td>Vessel</td><td colspan="3">S3008</td></tr>
<tr><td>Echosounder</td><td colspan="3">EdgeTech 4125 300 megahertz</td></tr>
<tr><td>Date</td><td colspan="3">2016-08-17</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>-1.6 meters</td></tr>
<tr><td>y</td><td>-0.978 meters</td></tr>
<tr><td>z</td><td>-0.455 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">0 meters</td></tr>
</table>

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

S3008's static draft value is applied in Kongsberg's SIS software and in CARIS HIPS. See additional discussion on this topic in Patch Test section of this document.

C.2.1.2 Methods and Procedures

S3008's static draft value is applied in Kongsberg's SIS software and CARIS HIPS.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

Dynamic Draft testing occurred on D129 in the Galveston Ship Channel commencing at Buoy 26 and extending northward.

C.2.2.2 Methods and Procedures

Dynamic draft was measured using the ellipsoidally referenced dynamic draft model (ERDDM)method, described in Appendix 4 of the 2014 Field Procedures Manual. The test was performed on DN211 during a moderately smooth sea state in the vicinity of Galveston Channel.A “single-base” PPK solution was based on the TXGA CORS station.Results were attained by invoking Pydro script “ProcSBETDynamicDraft.py” and using the Polynomial-fit order of “4rd Order.” The dynamic draft values are applied to soundings during post-processing in CARIS 10.2 by executing the "SVP Correct" process.

C.2.2.3 Dynamic Draft Correctors

Vessel	S3008	
Date	2017-05-11	
Dynamic Draft Table	*Speed*	*Draft*
	0	0
	0.5	0.030
	1	0.040
	1.5	0.040
	2	0.040
	2.5	0.050
	3.0	0.080
	3.5	0.120
	4.0	0.160
	4.5	0.160
	5.0	0.050

C.3 System Alignment

C.3.1 Description of Correctors

A patch test was performed 06/15/2017 in the vicinity of Bolivar Roads, near Galveston, TX.

C.3.2 Methods and Procedures

S3008 patch test process occurred in CARIS 10.2 and consisted of comparing pairs of lines within a defined subset, rotating the subset parallel or perpendicular to the lines depending on sensor values being examined. The process was repeated for all sensors. Each team member processed the patch test to obtain individual results. The individual results were then averaged and the averages were then entered into POSView>Lever Arms and Mounting Angles>"IMU Frame w.r.t. Ref. Frame."

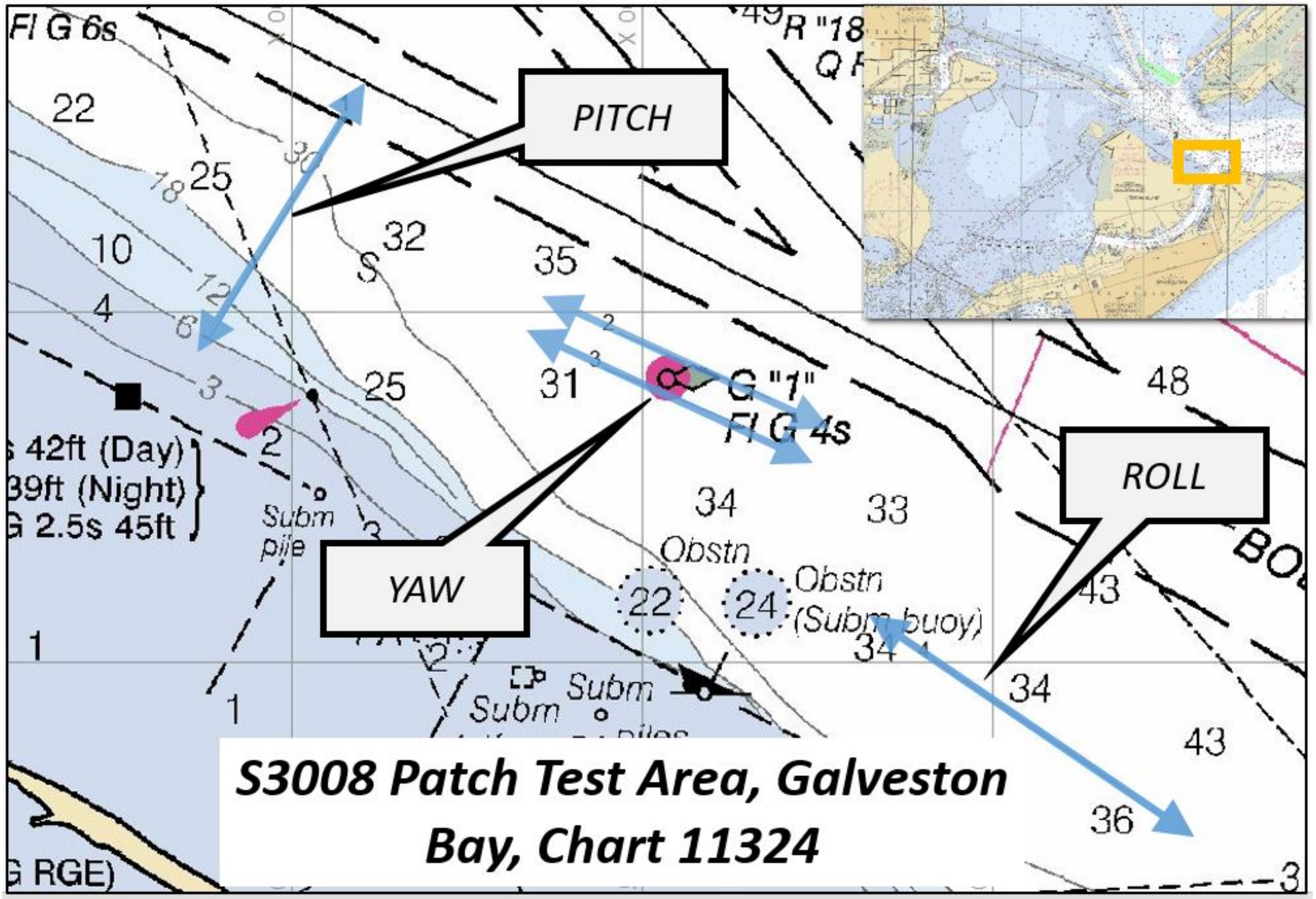

Figure 19: NRT4 Patch Test Location, 2017

C.3.3 System Alignment Correctors

Vessel	S3008	
Echosounder	Kongsberg EM4020C 300 kilohertz	
Date	2017-06-16	
Patch Test Values	*Navigation Time Correction*	0.00 seconds
	Pitch	-0.200 degrees
	Roll	-0.07 degrees
	Yaw	-0.71 degrees
	Pitch Time Correction	0.00 seconds
	Roll Time Correction	0.00 seconds
	Yaw Time Correction	0.00 seconds
	Heave Time Correction	0.00 seconds

Additional Discussion

NRT4 2017 Patch Test values are accounted for in POS/View's "IMU Frame w.r.t. Ref. Frame" entry boxes under the "Lever Arms and Mounting Angles" tab. This offset entry is a departure from past field season methods as angular offsets had traditionally been accounted for in Caris software during post processing.

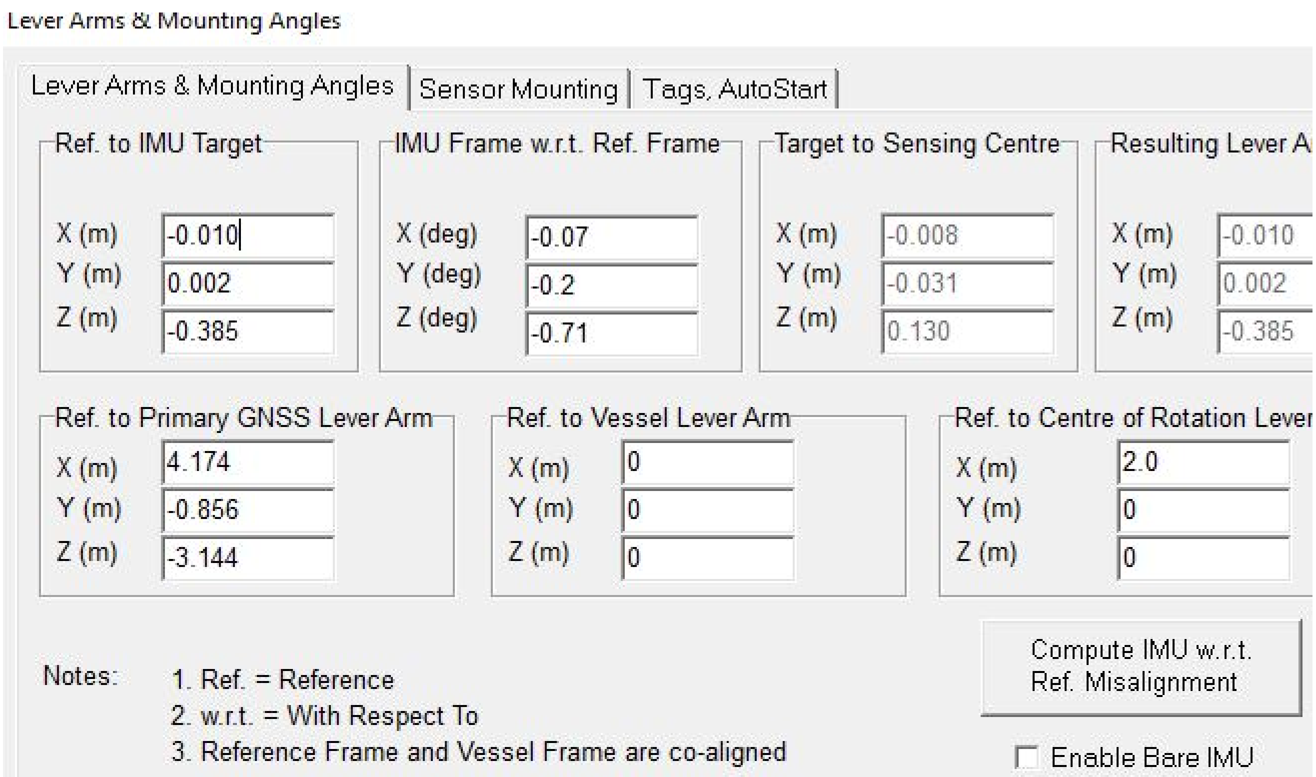

Figure 20: Patch Values Entered in PosView instead of CARIS HVF

Additional Discussion

PHB discovered erroneous null entries in NRT4's Multibeam HVF/TPU Offsets during SAR. There had been previous discussion on this topic between Team Lead and NRB folks however it was thought at that time that these values should be zero. Accordingly, subsequent to the project's resubmission, NRT4 populated the HVF's "MRU-Trans" and "NAV-Trans" offset entries and their associated error values. This way, a valid TPU calculation could occur to those offsets. Additionally, Team Lead had accounted for the waterline measurement (-0.51m) in Seafloor Information Systems (SIS) but was unaware this value also required entry into the HVF. NRT4 made these necessary offset changes to the multibeam sonar's HVF and then re SVP'd, re merged the data and recomputed TPU. The 50cm finalized surface passed its IHO test above the 99 CI. All correspondence pertaining to these matters have been documented in the Project Correspondence folder. In those correspondences, the waterline measurement was cited as "0.665" (perhaps a measurement from another NRT?) however, NRT4's steel tape measurement was -0.51m during that year's HSRR.

C.4 Positioning and Attitude

C.4.1 Description of Correctors

POS M/V "Delayed Heave" was logged with POS View software during data acquisition and then loaded in CARIS via the "Import Auxiliary Data" function. Delayed Heave is applied to soundings during the CARIS "SVP Correction."

C.4.2 Methods and Procedures

POS M/V "Delayed Heave" was logged with POS View software during data acquisition and then loaded in CARIS via the "Import Auxiliary Data" function. Delayed Heave is applied to soundings during the CARIS "SVP Correction."

C.5 Tides and Water Levels

C.5.1 Description of Correctors

Tide correctors were applied to soundings by way of the "Discrete Tidal Zoning" method as prescribed in the project instruction's Water Level Instructions.

C.5.2 Methods and Procedures

Tide correctors were applied to soundings by way of the "Discrete Tidal Zoning" method as prescribed in the project instruction's Water Level Instructions.

C.6 Sound Speed

C.6.1 Sound Speed Profiles

C.6.1.1 Description of Correctors

Sound speed casts were acquired as per HSSD section 5.2.3.3.

C.6.1.2 Methods and Procedures

Although sound-speed correctors are applied in CARIS post processing (see section B.1.2.2), casts were often loaded in SIS for the cosmetic purpose of minimizing refraction artifacts in the real-time display.

C.6.2 Surface Sound Speed

C.6.2.1 Description of Correctors

Surface sound speed correctors are applied realtime to Kongsberg's SIS software for the purposes of beam forming (flat-faced transducer).

C.6.2.2 Methods and Procedures

Surface sound speed correctors are applied realtime to Kongsberg's SIS software implementing a Micro X serial "'SV" sentence. Sound Speed casts are taken when surface readings differ from cast readings by 4 or more meters per second.

D. Approval Sheet

Data Acquisition and Processing Report

Navigation Response Team 4

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.

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

Respectfully,

JACOBS.DAN.L.1151633478

Digitally signed by JACOBS.DAN.L.1151633478
Date: 2019.02.01 10:14:17 -06'00'

Dan Jacobs

Team Lead, NOAA NRT4