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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	2017-18
Time Frame:	August - August 2018

LOCALITY

State(s):	Florida Georgia Texas
General Locality:	true

2017

CHIEF OF PARTY
James L. Kirkpatrick

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Data Acquisition and Processing Report

NRT2
Chief of Party: James L. Kirkpatrick
Year: 2017
Version: 1
Publish Date: 2017-10-19

A System Equipment and Software

A.1 Survey Vessels

A.1.1 S3009

Vessel Name	S3009	
Hull Number	S3009	
Description	Aluminum Hydrographic Survey Vessel	
Dimensions	*LOA*	31 ft
	Beam	8.5 ft
	Max Draft	1.5 ft
Most Recent Full Static Survey	*Date*	2017-03-28
	Performed By	Kevin Jordan, National Geodetic Survey, Field Operations Branch
Most Recent Full Offset Verification	*Date*	2017-03-28
	Method	The TOPCON GPT 3000 Series Theodolite was used to position all points on the vessel. A SECO 25 mm Mini Prism System configured to have a zero mm offset was used as target sighting and distance measurements. A network of temporary control was established in the lot consisting or two marks set on solid ground about 66 meters apart. These points were named TP 1 and TP 2. All final observations were made from TP 1. Full offset report is attached to this document.

Figure 1: S3009

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg 2040C

Manufacturer	Kongsberg
Model	2040C
Description	S3009 is equipped with a hull-mounted Kongsberg 2040C, which operates at sonar frequencies in the 200 to 400 kHz range. The system has an output sample rate up to 60 kHz. Maximum angular coverage is 130 degrees allowing coverage of 4.3 times water depth. The system is roll and pitch stabilized. The system has water column logging capabilities.

Inventory	*S3009*	*Component*	Sonar Head	Kongsberg Topside Processor	Hydrographic Work Station
		Model Number	EM2040C	EM2040	Dell 570
		Serial Number	1433	3542	CZC5502SYS
		Frequency	330	NA	NA
		Calibration	2017-08-14	2017-10-03	2017-08-14
		Accuracy Check	2017-10-02	2017-10-03	2017-10-02

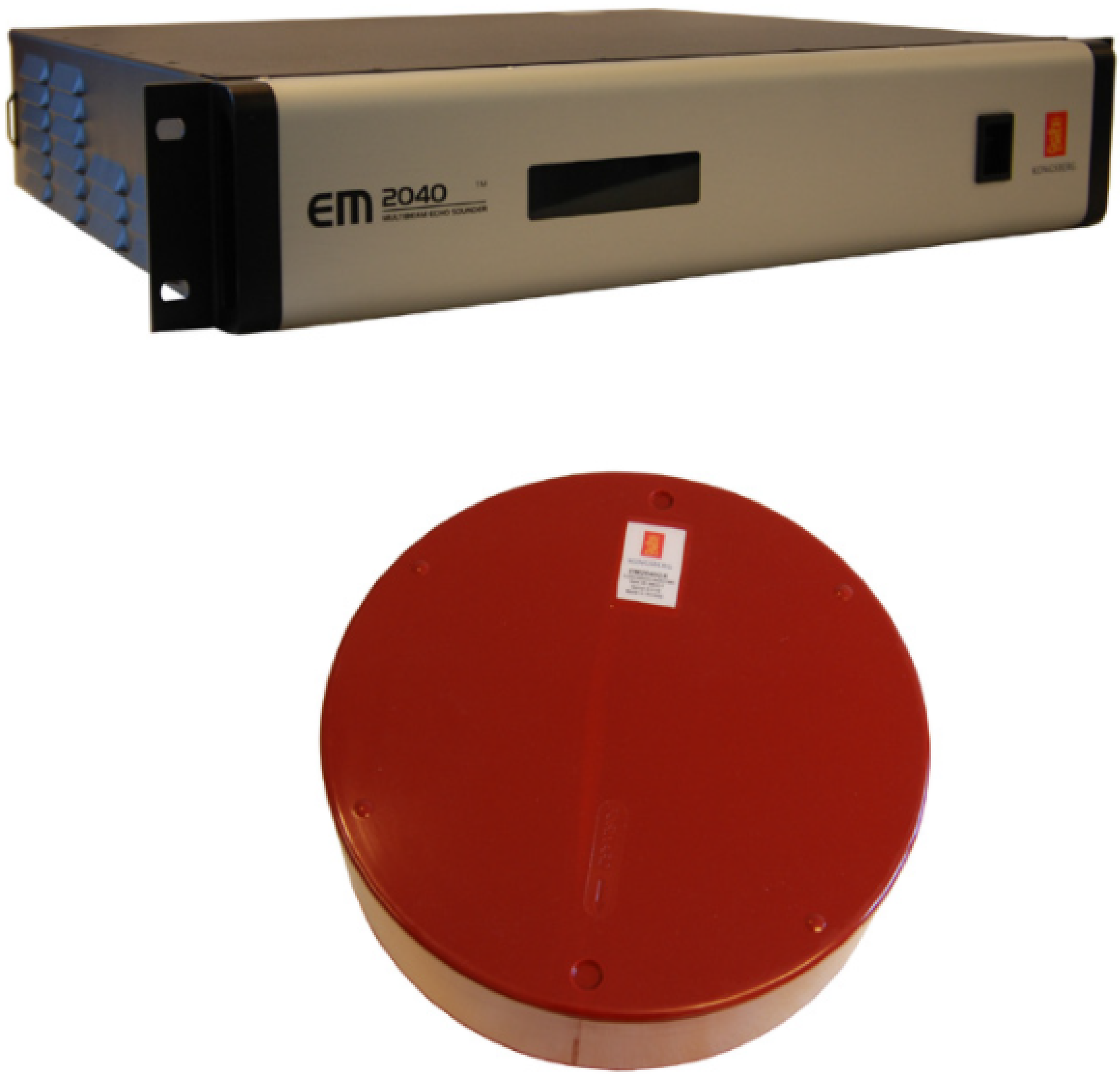


Figure 2: Kongsberg EM2040C

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

<table>
<tr><td>Manufacturer</td><td colspan="2">Edgetech</td></tr>
<tr><td>Model</td><td colspan="2">4125</td></tr>
<tr><td>Description</td><td colspan="2">The 4125 utilizes EdgeTech’s Full Spectrum® CHIRP technology which provides higher resolution imagery. Operated at 400 and 900 kHz to collect imagery and detect obstructions on the sea floor.</td></tr>
<tr><td>Inventory</td><td>S3009</td><td>
<table>
<tr><td>Component</td><td>Tow Fish</td><td>Edgetech Topside Processor</td></tr>
<tr><td>Model Number</td><td>4125</td><td>NA</td></tr>
<tr><td>Serial Number</td><td>40425</td><td>40256</td></tr>
<tr><td>Frequency</td><td>400</td><td>NA</td></tr>
<tr><td>Calibration</td><td>2017-08-08</td><td>2017-10-03</td></tr>
<tr><td>Accuracy Check</td><td>2017-10-02</td><td>2017-10-03</td></tr>
</table>
</td></tr>
</table>

Figure 3: Edgetech 4125

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

<table>
<tr><td>Manufacturer</td><td>NRT2</td></tr>
<tr><td>Model</td><td>Custom</td></tr>
<tr><td>Description</td><td>Standard 13m with mushroom anchor. Only used during HSRR verification.</td></tr>
<tr><td>Inventory</td><td><table><tr><td>S3009</td><td><table>
<tr><td>Component</td><td>Lead Line</td></tr>
<tr><td>Model Number</td><td>1234</td></tr>
<tr><td>Serial Number</td><td>1234</td></tr>
<tr><td>Calibration</td><td>2017-08-08</td></tr>
</table></td></tr></table></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-320 V-5

Manufacturer	Applanix
Model	POS MV-320 V-5

Description	POS MV blends GNSS data with angular rate and acceleration data from an IMU and heading from GNSS Azimuth Measurement System (GAMS) to produce a robust and accurate full six degrees of freedom Position and Orientation solution. The POS/MV 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, the POS/MV software displays HDOP and the number of satellites used in position computation. Data acquisition is generally halted when an HDOP of 2.5 is exceeded or the number of satellites available drop below four. However, because positional accuracy can be maintained by the POS/MV through short GPS outages with the help of the IMU, data acquisition is not halted during short periods of time when the HDOP and number of satellites used exceeded stated parameters. When using differential correctors, the POS/MV generates positional data to an accuracy of 0.5-2 meters. In addition to position, the Applanix 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. The Heave Bandwidth filter was configured with a damping coefficient of 0.707. The cutoff period of the high pass filter was determined by estimating the swell period encountered on the survey grounds. These values ranged from 8 seconds (flat water) to 20 seconds (long period ocean swell), with values of 8 or 12 seconds typically. Heading accuracy is monitored by the crew and survey operations are temporarily suspended in the event that the error exceeds 0.08°. Applanix "TrueHeave" values are also recorded. The TrueHeave algorithm uses a delayed filtering technique to eliminate many of the artifacts present in real time heave data. When using differential correctors, the POS/MV generates heave measurements with an accuracy of 2 cm or 2% of the measured vertical displacement (whichever is greater) for movements that have a period of up to 35 seconds. Full POSPac data are also recorded on NRT2. These data are used to post process POS/MV data to produce superior position and attitude data and can be used to produce a Post-Processed Kinematic (PPK) GPS solution. When using PPK methods, the POS/MV generates roll and pitch data with an accuracy of 0.008° and heading data with an accuracy of 0.02°. Horizontal position is accurate to +/- 8 mm + 1 ppm x baseline length while vertical position is accurate to +/- 15 mm + 1 ppm x baseline length.

Inventory	*S3009*	*Component*	IMU	PCS	Antenna
		Model Number	7	320	SPS MSK
		Serial Number	2436	5805	14597
		Calibration	2017-10-03	2017-08-08	2017-08-08

Figure 4: POS MV 5

A.5.2 DGPS

A.5.2.1 Trimble SPS 361

Manufacturer	Trimble			
Model	SPS 361			
Description	Provides DGPS correctors.			
Inventory	*S3009*	*Component*	Receiver	Antenna
		Model Number	SPS-361	SPS MSK
		Serial Number	5330K63697	14597
		Calibration	2017-08-08	2017-10-03

Figure 5: Trimble SPS-361

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

Manufacturer	Sontek

Model	Castaway
Description	Measures conductivity and temperature of seawater versus pressure in depths up to 100 meters. GPS enabled for positioning, data is uploaded via bluetooth to an onboard laptop. Primary sound speed measurement device.
Inventory	*Component*: CTD *Model Number*: Castaway *Serial Number*: CC1433010 *Calibration*: 2017-07-12

Figure 6: Sontek Castaway

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic Micro-X

<table>
<tr><td>Manufacturer</td><td colspan="3">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="3">Micro-X</td></tr>
<tr><td>Description</td><td colspan="3">Used in real time for Kongsberg EM2040C beam steering based on surface sound speed.</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S3009</td><td>Component</td><td>SSP</td></tr>
<tr><td>Model Number</td><td>Micro-X</td></tr>
<tr><td>Serial Number</td><td>203523</td></tr>
<tr><td>Calibration</td><td>2016-03-02</td></tr>
</table>

Figure 7: AML Micro-X SV

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 Caris Base Editor

Manufacturer	Caris
Software Name	Base Editor
Version	4.3
Installation Date	2017-06-07
Use	Processing

A.7.2 Caris HIPS and SIPS

Manufacturer	Caris
Software Name	HIPS and SIPS
Version	10.3.3
Installation Date	2017-07-12
Use	Processing

A.7.3 NOAA PydroGIS

Manufacturer	NOAA
Software Name	PydroGIS
Version	17.06
Installation Date	2017-10-02
Use	Processing

A.7.4 Xylem Hypack

Manufacturer	Xylem
Software Name	Hypack
Version	2017
Installation Date	2017-06-14
Use	Acquisition

A.7.5 Trimble POS View

Manufacturer	Trimble
Software Name	POS View

Version	9.13
Installation Date	2017-07-17
Use	Acquisition

A.7.6 Applanix POSPAC MMS

Manufacturer	Applanix
Software Name	POSPAC MMS
Version	7.2
Installation Date	2016-03-09
Use	Acquisition

A.7.7 Kongsberg SIS

Manufacturer	Kongsberg
Software Name	SIS
Version	4.3.2
Installation Date	2017-10-05
Use	Processing

A.7.8 Edgetech Discover

Manufacturer	Edgetech
Software Name	Discover
Version	36.0.1.120
Installation Date	2017-10-05
Use	Acquisition

A.7.9 NOAA Velocipy

Manufacturer	NOAA
Software Name	Velocipy
Version	17.06
Installation Date	2017-10-02
Use	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Custom Clam Shell

Manufacturer	Custom
Model	Clam Shell
Description	4" penetration grab sampler designed to collect unconsolidated bottom material.

Figure 8: NRT2 Bottom Sampler

B System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

All vessel offsets values are stored in the Caris HVF. The MBES phase center is defined as Reference Point (RP). Ideally the RP should be as close as possible to the center of rotation for the vessel as feasible and this fact was taken into account when positioning the IMU. Since the IMU is the source for all heave, pitch, roll, gyro, and navigation values, all of these sensors have X-Y-Z values of 0,0,0. Only SVP 1 requires non-zero offset values entered. Vessel offsets were surveyed to 0.001 meter accuracy by NGS.

B.1.1.1 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="4">S3009</td></tr>
<tr><td>Echosounder</td><td colspan="4">Kongsberg EM2040C</td></tr>
<tr><td>Date</td><td colspan="4">2017-09-01</td></tr>
<tr><td rowspan="8">Offsets</td><td rowspan="4">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>y</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td>z</td><td>0.000 meters</td><td>0.000 meters</td></tr>
<tr><td rowspan="3">Nav to Transducer</td><td>x</td><td>-0.006 meters</td><td>0.001 meters</td></tr>
<tr><td>y</td><td>0.005 meters</td><td>0.001 meters</td></tr>
<tr><td>z</td><td>-0.347 meters</td><td>0.001 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.00 degrees</td><td></td></tr>
</table>

B.1.2 Layback

Layback correctors are stored in the Caris HVF. Cable out is input into Discover during acquisition and towfish position is calculated using depth and cable out values.

B.1.2.1 Layback Correctors

<table>
<tr><td>Vessel</td><td colspan="3">S3009</td></tr>
<tr><td>Echosounder</td><td colspan="3">Edgetech 4125</td></tr>
<tr><td>Frequency</td><td colspan="3">400 kHz</td></tr>
<tr><td>Date</td><td colspan="3">2017-10-02</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>-0.858 meters</td></tr>
<tr><td>y</td><td>-2.113 meters</td></tr>
<tr><td>z</td><td>-2.695 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">5.900 meters</td></tr>
</table>

B.2 Static and Dynamic Draft

B.2.1 Static Draft

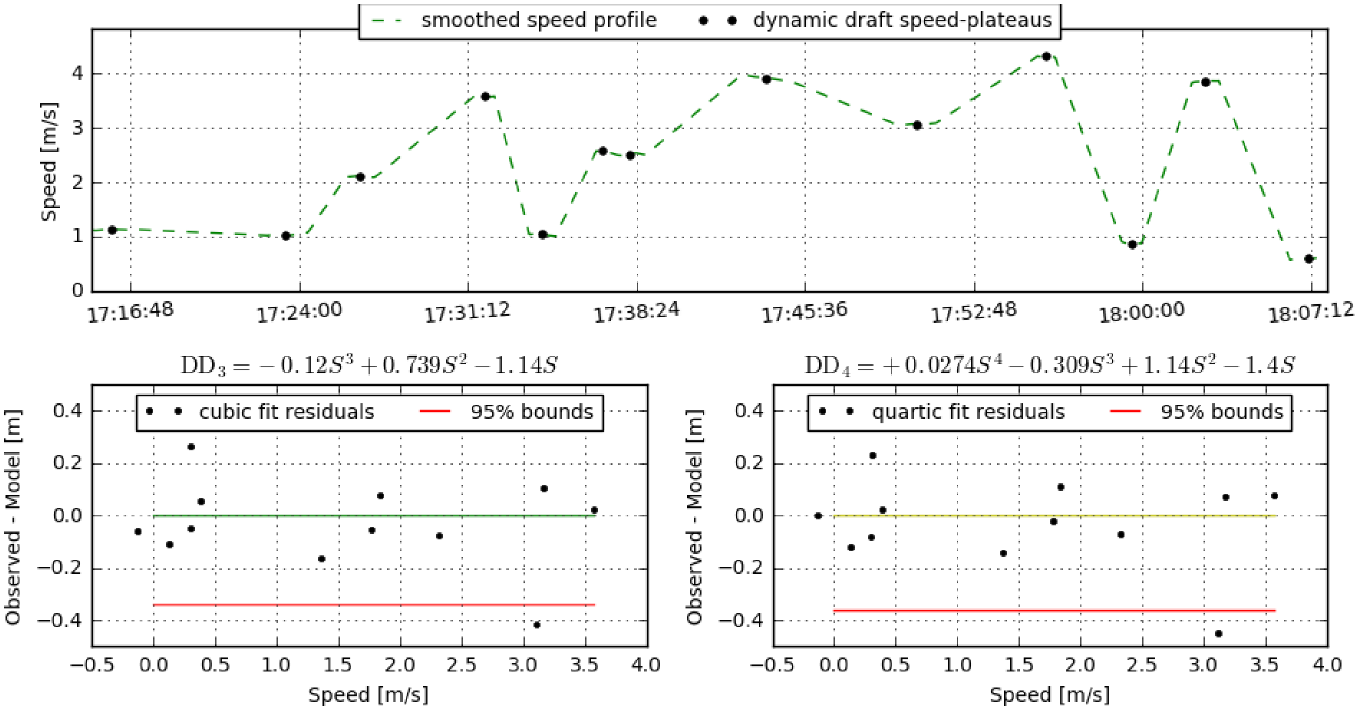
All static draft values are stored in the Caris HVF as the waterline value. This value is measured during the annual HSRR and used for the entire field season, barring any significant equipment or loading changes. Value was measured using a level and steel tape by 2 members of NRT2.

B.2.1.1 Static Draft Correctors

<table>
<tr><td colspan="2">Vessel</td><td>S3009</td></tr>
<tr><td colspan="2">Date</td><td>2017-08-08</td></tr>
<tr><td colspan="2">Loading</td><td>0 meters</td></tr>
<tr><td rowspan="2">Static Draft</td><td>Measurement</td><td>-0.340 meters</td></tr>
<tr><td>Uncertainty</td><td>0.010 meters</td></tr>
</table>

B.2.2 Dynamic Draft

DDSM was performed using the ellipsoid referenced dynamic draft measurement and was processed using the Pydro add on "POSPAC AutoQC" tool. A 4th order polynomial regression was determined from the test and outputs were entered into the Caris HVF.



Speed [m/s]	Cubic Model (DD_3) [m]	Quartic Model (DD_4) [m]
0.00	0.00	0.00
0.50	-0.40	-0.45
1.00	-0.52	-0.55
1.50	-0.46	-0.44
2.00	-0.29	-0.28
2.50	-0.11	-0.14
3.00	-0.02	-0.07
3.50	-0.09	-0.08
4.00	-0.43	-0.14

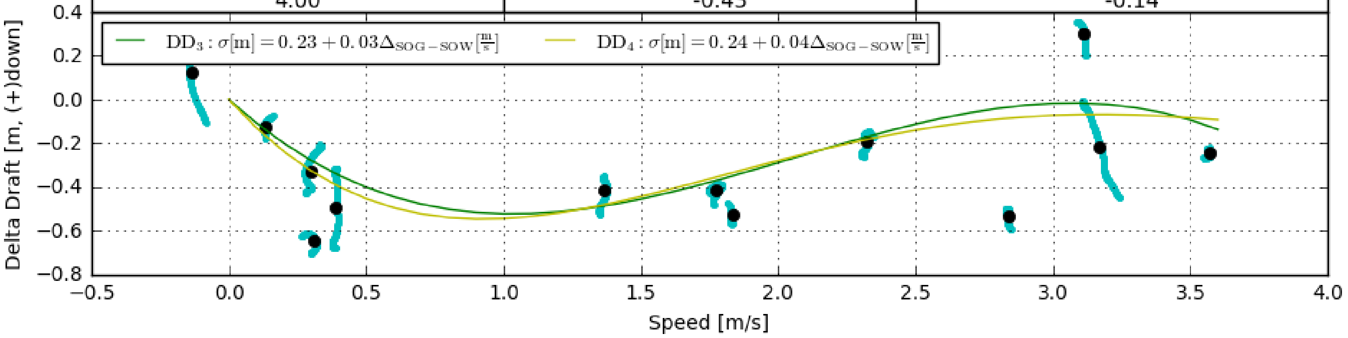


Figure 9: NRT2 Dynamic Draft

B.2.2.1 Dynamic Draft Correctors

Vessel	S3009	
Date	2017-10-03	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
	0.50	-0.45
	1.00	-0.55
	1.50	-0.44
	2.00	-0.28
	2.50	-0.14
	3.00	-0.07
	3.50	-0.09
	4.00	-0.14
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.01	0.01

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

As part of the annual HSRR , NRT2 conducted an MBES calibration test for the EM2040C

B.3.1.1 System Alignment Correctors

<table>
<tr><td>Vessel</td><td>S3009</td></tr>
<tr><td>Echosounder</td><td>Kongsberg EM2040C</td></tr>
<tr><td>Date</td><td>2017-08-01</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>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.100 seconds</td></tr>
<tr><td>Pitch</td><td>2.65 degrees</td><td>0.10 degrees</td></tr>
<tr><td>Roll</td><td>0.38 degrees</td><td>0.10 degrees</td></tr>
<tr><td>Yaw</td><td>-2.32 degrees</td><td>0.10 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 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

NRT2's Kongsberg EM2040C acquisition of multibeam data was monitored in real time with the SIS acquisition software. Data were displayed using 2-D and 3-D data display windows. Traditional line planning using Hypack guides NRT2 's acquisition of MBES data, usually based on 200% SSS coverage. Adjustable parameters common for the 2040C are range scale, power, gain and pulse width. Also adjustable are many filtering and data cleaning settings that are not employed by NRT2.

Data Processing Methods and Procedures

Following acquisition, multibeam sonar data were processed using CARIS HIPS and SIPS. The steps below are the standard procedure for MBES data processing.
1. Convert the “raw” SIS data to the HDCS data format.
2. Load True Heave (referred to as Delayed Heave in CARIS)
3. Load tides.
4. Load and apply sound velocity files.
5. “Merge” data to apply position, attitude, and dynamic draft correctors to bathymetry and compute the corrected depth and position of each sounding.
6. Compute Total Propagated Uncertainty (TPU).

7. Create CUBE surface.

Preliminary data cleaning is performed in Subset editor as well as Swath editor. Surfaces are then reviewed by the team lead and any final cleaning or re acceptance of soundings is performed. Surfaces are examined for holidays and any additional line planning is done at this time.

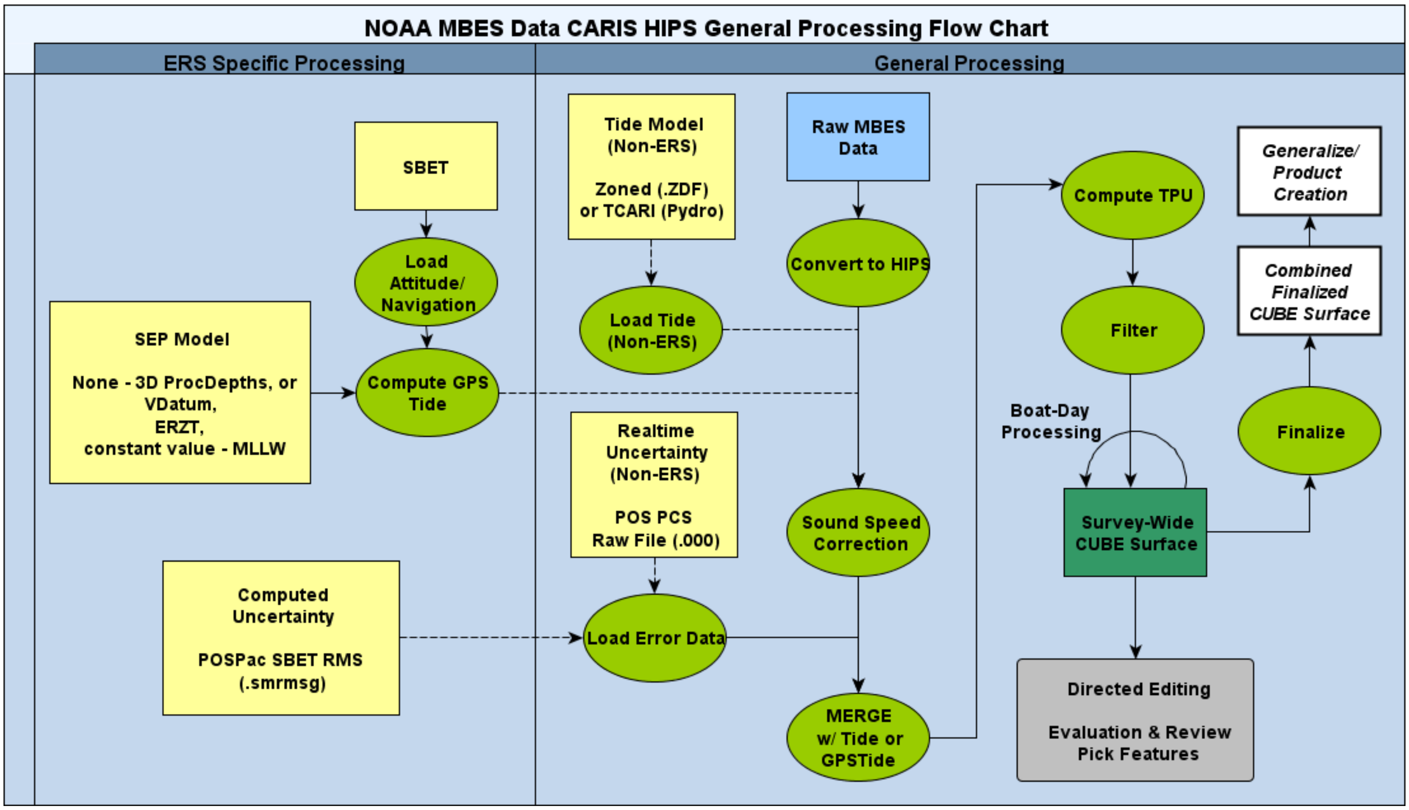


Figure 10: MBES work flow

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 in surface creation:
• Surface Type – CUBE

• IHO S-44 Order – Order 1a
• Include status – check 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).
• NRT2 rarely surveys in depths greater than 20m and therefore always uses a base surface resolution of 0.5 to 1m.

C.1.4.2 Depth Derivation

NRT2 does not employ any cleaning filters.

C.1.4.3 Surface Computation Algorithm

NRT2 uses the CARIS CUBE BASE surface algorithms for the generation of all surfaces generated for final submission. The exact behavior of CUBE is determined by the values set in the CUBE parameters file, a xml file which can be selected by the user in the CARIS Tools --> Options --> Environment tab. The NOAA Office of Coast Survey (OCS) has created and provided a customized CUBE parameters file (CubeParams_NOAA.xml) with new CUBE parameters that are required for each grid resolution. During the creation of CUBE surfaces, the user is given the option to select parameter configurations based upon surface resolution which have been tuned to optimize the performance of the CUBE algorithm. The advanced options configuration is manipulated based on the grid resolution of the CUBE surface being generated.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

Backscatter is acquired through the Kongsberg SIS and is automatically burned into the .all file.

Data Processing Methods and Procedures

NRB is exempt from processing backscatter data at this time.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

As per manufacturer and NOAA protocols within the FPM and Specs and Deliverables.
Primary instrument being used is the Edgetech 4125. Operated normally on the 50-100m range scale and

processing 900kHz data. 400kHz data is also logged, it is only processed and used where warranted by better quality data than the HF.

Data Processing Methods and Procedures

All side scan sonar imagery is converted from JSF formats to CARIS format using CARIS JSF converters. After conversion the data is opened in CARIS Navigation Editor, Attitude Editor, and Side Scan Editor. Survey personnel then check vessel attitude, cable out, gyro, and sonar height. Due to the higher rate of current data logging of position 25-50Hz some minor noise is present in the speed data, these are left unedited due to their insignificance. Data showing speed jumps may be rejected with interpolation. Survey personnel then confirm the validity of the vessel navigation, cable out, and towfish depth values. Towfish nav is not recomputed in Caris since layback is automatically burned into the .jsf file. Side scan sonar data is examined in CARIS Side Scan Editor. Survey personnel correct errors in bottom tracking, slant range correction is done automatically in Caris. Data is examined for significant contacts. Mosaics are then generated to show coverage at 30cm resolution. A 1m mosaic is created for submission.

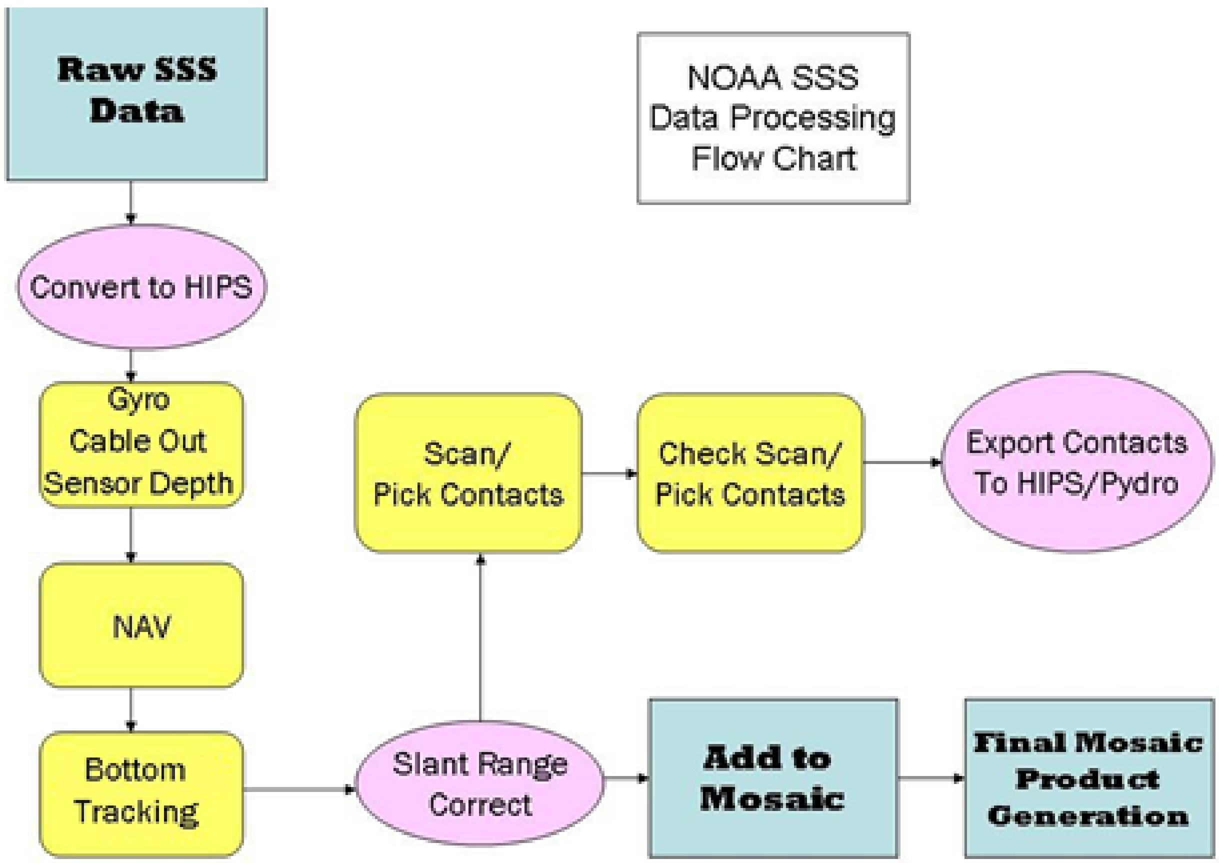


Figure 11: SSS work flow

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

Data Acquisition Methods and Procedures

Real-Time Differential GPS:

The Differential Global Positioning System (DGPS) is an augmentation to Global Positioning System that provides improved location accuracy, from the 15-meter nominal GPS accuracy to about 3 meters in case of Rainier's implementation. DGPS uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the GPS satellite systems and the known fixed positions. These stations broadcast the difference between the measured satellite pseudo ranges and actual (internally computed) pseudo ranges. The United States Coast Guard (USCG) and Canadian Coast Guard (CCG) each run such systems in the U.S. and Canada on the longwave radio frequencies between 285 kHz and 325 kHz near major waterways and harbors. NRT2 is equipped with a DGPS Beacon Receiver that acquires differential error correction messages (RTCM SC104 format) broadcast by US Coast Guard and feeds them to the Applanix POS/MV to produce real time differentially corrected positions. DGPS correctors are applied by the Trimble SPS-361 receiver.

Data Processing Methods and Procedures

All real time position and attitude data are acquired using POSView and post processed using POSPac MMS. For further details on individual processing methodology, refer to the HVCR of the appropriate project.

The POS/MV .000 files are collected daily, beginning at least five minutes before the collection of bathymetric data and ending at least five minutes after the conclusion of bathymetric data collection. Logging is started by opening the MV-POSView window and selecting "Ethernet Realtime…" from the Logging menu. In the Ethernet Realtime Output Control window only the following message groups are selected: 3, 7, 20, 102, 111 and 113. The Output Control rate is also set to '50 Hz'. It is also important not log through UTC Midnight on Saturdays, the end of the GPS week. In the event that a line would cross over UTC Midnight, Hypack/Hysweep logging and POS file logging is stopped and a new POS file with a new day number is started after UTC midnight.

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, and applied in postprocessing
during SVP Correct and Merge in CARIS HIPS.

NRT2 utilizes a heave filter integration method known as
“TrueHeave” as described in Section 3 of the 2014 Field Procedures Manual. This dramatically reduces the filter settling time as compared to the traditional heave filter, almost completely eliminating the need for steadying up on lines before logging can begin.

TrueHeave data were logged throughout the survey day, independent of line changes. A new POS file need be created only in the event that the acquisition computer crashes. Every “POS” file is named in such a manner to be easily identifiable with the applicable yea (ex: 2017_214.000). TrueHeave files are transferred to the “POS” folder of the CARIS preprocessed data drive for later submission. In the event of computer crashes, multiple POS files have their names appended with “A”, “B”, and so on in the order they were collected. 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.

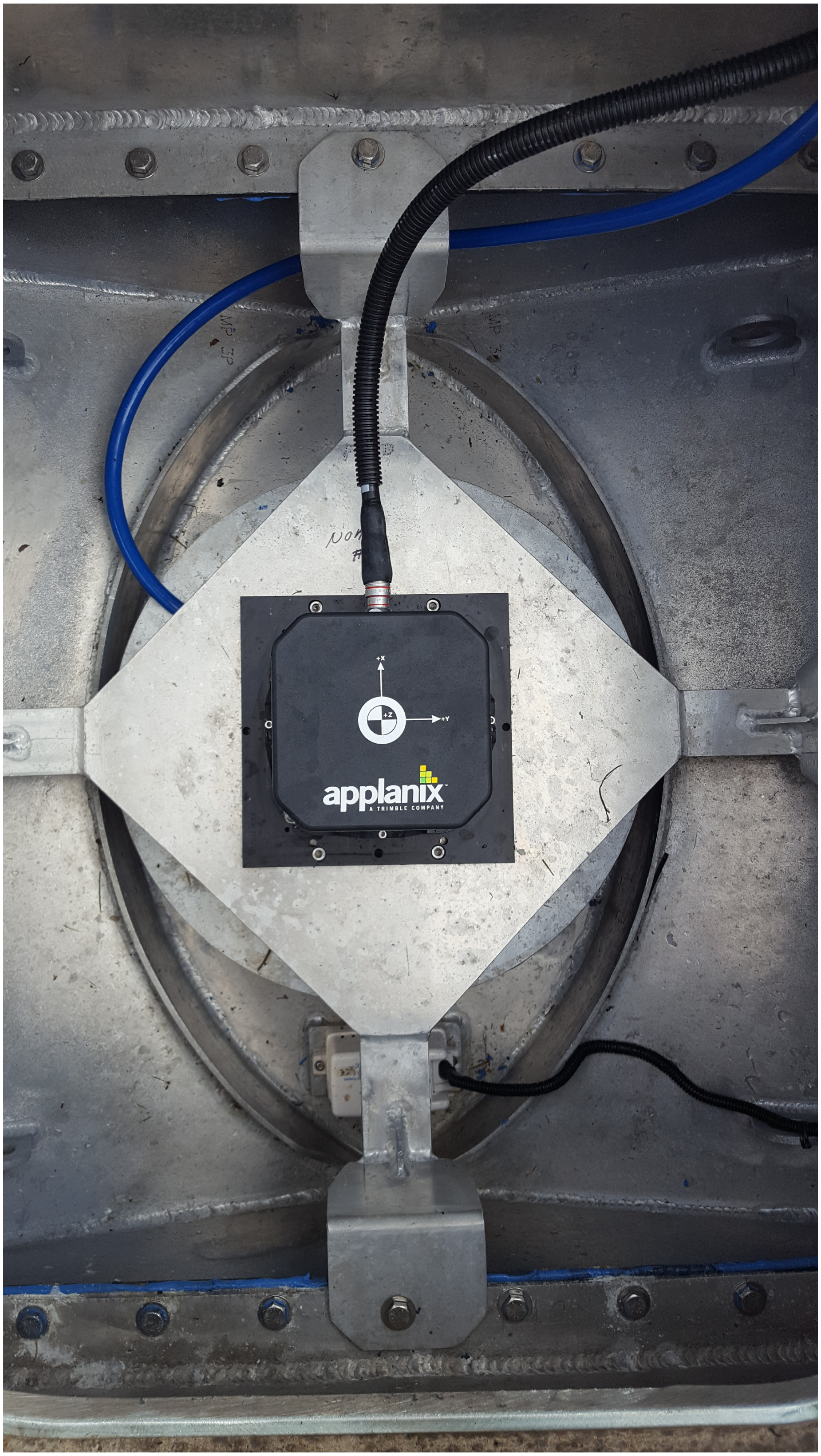


Figure 12: POS IMU orientation

Data Processing Methods and Procedures

NRT2 utilizes Post Processed Kinematic (PPK) methods for the horizontal positioning of bathymetric data. The exact method selected is based upon the availability, or lack thereof, of Continually Operating Reference Stations (CORS) near the project area. The three methods available in order of preference are 1) Smart Base, 2) Single Base, and finally 3) Precise Point Positioning (PPP).
Smart Base:
Smart Base is the preferred method when a minimum of four (six recommended) CORS stations are available for selection near the project area. In situations with a maximum baseline of 70 km, an optimal horizontal accuracy of 3-10 cm should be achieved. Applanix POSPac software is used to produce a Smoothed Best Estimate of Trajectory (SBET) file. The SBET file consists of GPS position and attitude data corrected and integrated with inertial measurements and reference station correctors, exported into WGS84. The SBET is created using the Applanix proprietary “SmartBase” algorithm, which generates a Virtual Reference Station (VRS) on site from a network of established reference stations surrounding the project area, generally the Continually Operating Reference Station (CORS) network. 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. For further details on the CORS network stations utilized in addition to processing methodology, refer to the HVCR of the appropriate project.

Single Base is the preferred method when there are not enough CORS stations to form a SmartBase network. In a short baseline situation with a maximum baseline
of 20-30 km to the control station, an optimal horizontal accuracy of <10 cm should be achieved. The Single Base solution of processing SBETs requires the input of attitude data acquired by the POS/MV in addition to simultaneously collected base station data. Vessel kinematic data is post-processed using Applanix POSPac processing software, POSGNSS processing software and Single Base processing methods. These SBET navigation and attitude files are applied to all lines in CARIS and supersede initial positioning and attitude data.

Precise Point Positioning (PPP) is used as a last resort when Smart Base or Single Base is not available.

• Single Base Station Processing
1) Open Applanix POSPac™ Mobile Mapping Suite and set up the project
2) Load the Applanix .000 file
3) Load the satellite data logged by the base station
4) Once the coordinate manager window opens, the true ITRF coordinates from the OPUS report is input. The same ITRF coordinates are used throughout the project and are checked against "new" OPUS solutions to maintain consistency.
5) Both the SBET (in ITRF format) and smrmsg error data files are created.

• Smart Base Processing

1) Open Applanix POSPac™ Mobile Mapping Suite and set up the project
2) Load the Applanix .000 file
3) Select the "Find Base Stations" option which will generate a list of nearby CORS stations and then click on the "Smart Select" button.

4) POSPac will need the Internet to access and download the base station data it finds as the best option to import. It will need a minimum of 4 stations as well as adequate ephemeris data to continue. This process is done automatically.
5) Once the base stations and ephemeris data have been downloaded, the Raw Data Check-In window will appear automatically, click OK. Once you click OK, POSPac will create a triangulated network of all the base stations it has chosen for processing.
6) Next run the SmartBase Quality Check. POSPac will run the quality check to see if the data downloaded is good enough for processing and generate a Results Summary. If the data is inferior, it will recommend to Re-run the SmartBase Quality Check processor or that there is not enough adequate data to continue.
7) Occasionally you have to override the system and see if the SBET generated is up to spec. This is done by running the Applanix SmartBase processor.
8) Once the Applanix SmartBase processor has finished, the outline of the triangulated network will be highlighted in yellow. This means that you are ready for processing and that the appropriate base stations have been designated and set.

• POSPac SBET Quality Control -- Once the POSPac project has completed processing successfully, quality control of the SBETs (Smoothed Best Estimated Trajectories) is performed.
• Exporting Custom SBET -- Once the QC is complete and the processing log updated, the next step is to export a custom SBET in WGS84.

For both a Single Base or Smart Base solution, SBETs are applied in CARIS by loading both the SBET files and error data files in smrmsg format. For every SBET file generated during single base station processing there is an associated smrmsg file.

1) Process --> Load Attitude/Navigation data… Load the WGS84 SBET files. Import data for Navigation, Gyro, Pitch, Roll, and GPS Height are all selected for vessel.
2) Process --> Load Error data… Load the smrmsg error data file. Import data for Position RMS, Roll RMS, Pitch RMS, and Gyro RMS are selected for the vessel. Vertical RMS is not selected since HIPS will default to using the trueheave RMS values.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

Sound velocity profiles are acquired with the YSI Castaway CTD. Casts are taken approximately every 2 hours or when there is a noticeable change in environment or survey area. Realtime surface sound speed is also monitored and additional casts are taken if the value varies by more than 2 m/s. SIS also 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

Cast data is processed via Velocipy and the cast data is extended using "most probable slope" method. The cast to be used for the survey data is then exported to a Caris SVP file, concatenated and applied within Caris process " Apply SVP". Each Survey has one SVP file named as the master file such as " H12345.SVP" which
would contain all SVP cast for that survey.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed is acquired by the AML Oceanographic Micro-X sensor. The original configuration of the sensor was in a PVC tube attached to the stern, extended below the water line, between the two outboards. This configuration proved to be less than ideal due to the nature of S3009's hull and cavitation from the motors. Many surface sound speed blow outs were observed during the first few trials of the vessel. In the short term the sensor is being placed in a bucket of seawater, freshened after every line. This solution is not ideal as the water may heat above the actual sea surface temperature quickly over time. NRB is actively seeking a resolution for this issue and this document will be updated when that occurs.

Data Processing Methods and Procedures

Surface sound speed data is not processed.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

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 Field Procedures Manual. All timing values were set to 0.005 seconds as outlined for setups with Ethernet connections and precise timing.

C.6.2 Uncertainty Components

A Priori Uncertainty

Vessel		S3009
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

Real-Time Uncertainty

Real-time uncertainty was not applied.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

Source shoreline data is typically supplied by NRB Project Manager in a single Composite Source file (CSF) in both S-57 .000 and .hob formats. The CSF is delivered with the Project Instructions and is to be used as the only
shoreline data for use in the field. The composite source file is compiled from all available source shoreline files (i.e. ENC, Geographic Cells, lidar, RNC, and Prior Surveys) into a single file in an S-57 .000 format. Additionally, a Project Reference file (PRF) is supplied containing sheet limits, maritime boundary points, and recommended bottom sample sites.

Shoreline verification is performed using several different methods, depending on the nature of the feature. Underwater features are verified or disproven using MBES and SSS. Above water features such as platforms or piers are verified using Hypack detached positions.
In the absence of direction to the contrary, the NALL was the furthest offshore of the following:
• The 4m depth contour at MLLW.
• A line seaward of the MHW line by the ground distance equivalent to 0.8mm at the scale of the largest scale raster chart of the area.

Features are addressed in the following manner:
• Offshore of the NALL:
• A feature found within 2mm at survey scale of the composite source position has its height/depth determined.
• A feature outside 2mm at survey scale of the composite source position has its field position revised in addition to a heights/depth determination.
• Features with any linear dimension greater than 1mm at survey scale are treated as an area and

delineated.
• New features not in the Composite Source file.
• Maritime boundary points and other features specifically identified for investigation.

Inshore of the NALL:
• Assigned maritime boundary points only if they are safe to approach.
• Navigationally significant features as defined below.

Navigationally Significant features were defined as the following:
• All features within the limits of safe navigation (i.e., offshore of the NALL).
• Features inshore of the NALL which:
• are sufficiently prominent to provide a visual aid to navigation (landmarks). Note that rocks awash are almost never landmarks, but distinctive islets or other features visible at MHW can be useful for visual navigation.
• significantly (a ground unit distance equivalent to 0.8mm at the scale of the largest scale chart of the area) deflect this limit. Common examples of these features include foul areas and large reef/ledge structures.
• are man-made permanent features connected to the natural shoreline (such as piers and other mooring facilities) larger than the resolution specified for the survey. Seasonal features will be evaluated by the Command.
• are man-made permanent features disconnected from the shoreline, such as stakes, pilings, and platforms, regardless of size.

Small, private mooring facilities (piers and buoys) suitable for pleasure craft are not generally considered navigationally significant. Areas with a high density of mooring buoys for these vessels are delineated, but the features themselves not individually positioned.

Data Processing Methods and Procedures

Following a day of shoreline verification, NRT2 copies the HXXXXX_Final_Features_File.hob used on the vessel in addition to any digital photos taken and the trackline hob file. These file are then placed in the appropriate locations in the working projects directory.

S-57 Attribution

With the advent of custom CARIS support files supplied by OCS, Bathy DataBASE now supports feature flags previously available only in Pydro. All feature flagging can now be accomplished in BDB while Pydro used for generating reports and performing QC. Features are selected for investigation by NRB OPS based on distance from MHW. Project Instructions require that “All features with attribute asgnmt populated with 'Assigned' shall be verified even if they are inshore of NALL.”

NRT2 will not venture inshore of the NALL, even for assigned investigation items, if there is a question of safety or potential equipment damage. If the feature in question is exposed, time and height attributes are assigned while driving past. If the feature is not evident while driving the NALL during shoreline verification, a remark of “inshore of NALL not investigated” is made with a recommendation of "Retain as charted".

Feature attribution is completed for all 'Assigned' and any newly discovered items. Unassigned features are left untouched. Submerged features, such as wrecks and submerged piles designated in CARIS HIPS are also be brought into
BDB for attribution.

All features marked as “primary” are edited to have their object/attribute instances describe each feature as completely as possible. Object attributes assigned to each feature conform to direction located within both the 2016 HSSD and the CARIS “IHO S-57/ENC Object and Attribute Catalogue”. S-57 attribution is not required for those features flagged as "secondary" nor for unassigned features.

NOAA specific attribution in BDB includes “descrp” with a drop-down menu which is edited to reflect the hydrographer recommendations as follows:
• descrp - new -- A new feature is identified during survey operations. The hydrographer recommends adding the feature to the chart. Also, in cases in which the geographic position of an existing point feature is modified; the newly proposed feature is characterized as "new", while the original feature is flagged as "delete".
• descrp - update -- The feature was found to be portrayed incorrectly on the chart. Update is also used in the case where the feature was found to be attributed incorrectly or insufficiently and is modified to reflect the additional or corrected attribution. Also, for cases in which the geographic extents/position of an existing line feature are modified; the newly proposed feature is characterized as "update".
• descrp - delete -- The feature is disproved using approved search methods and guidelines. The hydrographer recommends removing it from the chart. Also, for cases in which the geographic position of an existing point object is modified; the newly proposed feature is characterized as "new", while the original feature was flagged as "delete".
• descrp - retain -- The feature is found during survey operations to be positioned correctly and no additional attribution was required. The hydrographer recommends retaining the feature as charted.
• descrp – not addressed -- The feature is not investigated during shoreline acquisition, typically because it is either inshore of the NALL or unsafe to approach. The hydrographer recommends retaining the feature as charted.

Features described as "new" and "update" are updated with the SORIND/SORDAT attribution of the current survey.

Features described as "delete", "retain", and "not addressed" have their SORIND/SORDAT attribution remain unchanged.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

The clam shell style bottom sampler is set for deployment by placing the attached pin between the hinge. The device is allowed to free fall to the bottom and upon contact the line is jerked up sharply to snap the jaws shut. Bottom material is transferred from the clam shell into a plastic bin where it is examined for type, color and texture.

Data Processing Methods and Procedures

Typically NRB 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. In the event that no sample is obtained after three attempts, the sample site's NATSUR is characterized as “unknown”. The observations are recorded to the boat notebook or directly to the .hob file. 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

Depth, Standard Deviation, Hypothesis Strength and Hypothesis Count models derived from the surface are viewed with appropriate vertical exaggeration and a variety of sun illumination angles to highlight potential problem areas.

D.1.2 Designated Sounding Selection

In some instances, due to the nature of the weighting algorithm, a BASE surface does not accurately represent the least depth of a navigationally significant feature (typically a fine item such as a tall, narrow coral head or a shipwreck’s mast). In such cases, a sounding can be flagged as Designated to force the nearest BASE surface grid node to honor the depth of the designated sounding.

Since the calculated depth at 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. Prior to creating a finalized BASE surface collection, the hydrographer must systematically review significant feature least depths to ensure they are accurately portrayed by the BASE surface. If a specific least depth sounding is preferred over the weighted mean-depth calculation for the associated BASE surface grid node, that sounding should be flagged Designated. The Designated flag can be applied in either HIPS or Pydro. If a sounding is made Designated in one software package, this flag will automatically carry through to the other application. Designated soundings shall be selected in accordance with section 5.2.1 and 5.2.2 of the HSSD.

A common area of confusion is the preferred spatial density of designated soundings. It is easy to lose ones sense of scale when viewing data in subset editor. Sand ripples can look like mountains and small rocks appear like house sized boulders. The hydrographer shall take a holistic view of the surrounding bathymetry to help determine the hydrographic significance of a feature before designating a sounding. When there are a group of features near each other (e.g. they would be shown as a single sounding or charted feature at the scale of the survey), only the shoalest sounding on the feature with the most representative shoal depth shall be selected.

As discussed in the Specifications and Deliverables section 5.2.1.2, the hydrographer should use discretion in designating soundings on features.

D.1.3 Holiday Identification

Holidays are defined as gaps in mainscheme data or areas where accuracy requirements have not been met. Holidays may be caused by various events, such as vessel maneuvering, survey equipment problems, unexpected
shoals, or rejection of poor quality data during post-processing. Holiday line plans are typically developed to address these data gaps as mainscheme acquisition progresses, rather than at the end of mainscheme operations.
This practice will minimize transit time required to revisit each area of the survey with a holiday and the time required to acquire, process, and manage additional sound speed profiles. If the field unit uses a real-time coverage map during mainscheme data acquisition, most holidays can be identified and addressed prior to ceasing operations that day, thus increasing survey efficiency. NRT2 makes every effort to identify potential holidays during acquisition. Upon initial office review of the data holidays are identified visually by examining the surface or by using the Pydro QC tools "Holiday Finder".

D.1.4 Uncertainty Assessment

NRT2's primary bathymetric data review and quality control tool are the CARIS CUBE (Combined Uncertainty and Bathymetry Estimator) BASE surfaces as implemented in CARIS HIPS. The CUBE algorithm generates a surface consisting of multiple hypotheses that represent the possible depths at any given position. The BASE surface is a grid of estimation nodes where depth values are computed based on the horizontal and vertical uncertainty of each contributing sounding as follows:

• Soundings with a low vertical uncertainty are given more influence than soundings with high vertical uncertainty
• Soundings with a low horizontal uncertainty are given more influence than soundings with a high horizontal uncertainty.
• Soundings close to the node are given a greater weight than soundings further away from the node.

As soundings are propagated to a node, a hypothesis representing a possible depth value is developed for the node. If a sounding's value is not significantly different from the previous sounding then the same or modified hypothesis is used. If the value does change significantly, a new hypothesis is created. A node can contain more than one hypothesis. As node-to-node hypotheses are combined into multiple surfaces through methodical processing, a final surface that is the best representation of the bathymetry is created.

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.

• Tide values measured uncertainty value error ranges from 0.01m to 0.05 m dependent upon the accuracy of the tide gauges used and the duration of their deployment. NRT2 is using a value of 0.0 since the Tide Component Error Estimation section of the Hydrographic Survey Project Instructions now includes the estimated gauge measurement error in addition to the tidal datum computation error and tidal zoning error.

• Tide values zoning is unique for each project area and typically provided in Appendix II of the Hydrographic Survey Project Instructions, Water Level Instructions. In section 1.3.1.1 of the Water Level Instructions, Tide Component Error Estimation, the tidal error contribution to the total survey error budget is provided at the 95% confidence level, and includes the estimated gauge measurement error, tidal datum computation error, and tidal zoning error. Since this tidal error value is given for two sigma, the value must be divided by 1.96 before it can be entered into CARIS (which expects a one sigma value). If TCARI grids are assigned to the project area, this value is set at 0.0 since TCARI automatically calculates the error associated with water level interpolation and incorporates it into the residual/harmonic solutions.

• Measured sound speed value error ranges from 0.5 to 4 m/s, dependent on temporal/spatial variability. FPM recommends a value of 4 m/s 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.

All other error estimates are read from the Hydrographic Vessel File (HVF) and Device Model file. 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. The HVF specifies which type of sonar system the vessel is using, referencing the appropriate entry from the Device Model file.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Crossline data are used to identify any systematic data problems by comparing it to mainscheme data acquired at different times, water levels, and line azimuths. Ideally, crosslines should be acquired prior to mainscheme data, in areas of gently sloping bottom, and when water levels are as close to survey datum (MLLW) as practicable. Two separate surfaces are created for mainscheme and crosslines. These surfaces are then differenced in Caris HIPS and SIPS. The resulting difference surface is examined for statistical variations.

D.1.5.2 Junctions

Junctioning surveys are evaluated by differencing the overlapping surfaces and examined for statistical variations.

D.1.5.3 Platform to Platform

NRT2 rarely has the opportunity to compare data across platforms.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

NRT2 performs 200% coverage SSS regularly. To achieve this coverage careful line planning, taking into account the water depth and range scale, is required. 10 meter overlap of SSS coverage is the goal in each percentage to ensure adequate coverage. Any SSS holidays are discovered by turning on a bright red background in Caris and overlaying each percentage's mosaic.

D.2.2 Contact Selection Methodology

Imagery data is reviewed twice using CARIS SIPS Side Scan Editor. The initial review process is referred to as “scanning” the data. The second review is performed by a different person and is called “check scanning.” The initial reviewer should identify any object that warrants further investigation, often referred to as a “significant contact”, and record these items into the digital data. The second review serves as a quality control, and should add any significant contacts that were overlooked during the initial check. SIPS provides several tools to assist in determining if a contact is significant. Two of the most frequently used are “Measure Shadow” and “Measure Distance.”

“Measure Shadow” can be used to determine the height of an object by measuring its acoustic shadow and calculating the object’s approximate elevation off the seafloor. This tool can only be used when viewing data in slant
range corrected mode. “Measure Distance” is used to measure the distance between two points. This tool is helpful in determining the overall size of contacts, which may determine significance. For example, a very large item, even if it does not protrude significantly from the seafloor, may be listed in the AWOIS database and should therefore be investigated. The Measure Distance tool can be used when viewing both “raw” (i.e., not slant range corrected) and slant range corrected data.

All significant contacts are recorded in the digital data by creating a contact in SIPS. The general NRT2 practice for determining significance of an imagery contact is stated in the HSSD.The hydrographer must always consider the location of a contact when determining significance. For example, in a major channel where vessels transit with minimal underkeel clearance, a contact less than one meter high could be significant.

When a contact is recorded in SIPS, the item is geo-coded and attributes are attached to it in the Side Scan Editor. Each contact should be attributed as thoroughly as possible. A contact file is created for each survey line and is
stored in the line folder within the Project directory structure.

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	NRT2_WiringDiagram_2018.png
Sound Speed Sensor Calibration	AML_Calibration.pdf Castaway_Cal_Report.pdf
Vessel Offset	NRT%20S3009%202017.pdf
Position and Attitude Sensor Calibration	POS-MV_Cal_Report_2017.pdf
Echosounder Confidence Check	2017_MBES_Cal_Table.pdf
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.

Survey adequacy is provided in the individual survey Descriptive Reports.

Approver Name	Approver Title	Date	Signature
James Kirkpatrick	Team Lead	10/18/2017	KIRKPATRICK.JAMES.LEROY.IV.1400487398 Digitally signed by KIRKPATRICK.JAMES.LEROY.IV.1400487398 Date: 2018.04.05 14:39:22 -04'00'