

*U.S. Department of Commerce
National Oceanic and Atmospheric Administration*

DATA ACQUISITION & PROCESSING REPORT

Type of Survey *Hydrographic*
Project No. *2016 NRT4 Field Season*

LOCALITY

Time Frame *June - October*
State *Texas*
Gen Locality *Galveston*

2016

TEAM LEAD

Dan Jacobs, NOAA NRT4

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Data Acquisition and Processing Report

Navigation Response Team 4

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A Equipment

A.1 Survey Vessels

A.1.1 S1211

<i>Name</i>	S1211	
<i>Hull Number</i>	S1211	
<i>Description</i>	NOAA Survey Vessel S1211 is a 32 foot, aluminum hulled, SeaArk Commander. Its powered by dual 200 horsepower Honda outboard engines. A Kohler 7.5e generator supplies AC power for a Dell workstation, 5 monitors, a multibeam echosounder and a side scan sonar.	
<i>Utilization</i>	Hydrographic Survey	
<i>Dimensions</i>	<i>LOA</i>	10 meters
	<i>Beam</i>	2.4 meters
	<i>Max Draft</i>	0.5 meters

<p><i>Most Recent Full Static Survey</i></p>	<p><i>Date</i></p>	<p>2009-06-25</p>
	<p><i>Performed By</i></p>	<p>National Geodetic Survey</p>
	<p><i>Discussion</i></p>	<p>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 S1211. The positions given for the POS GPS antennas (Zephyr Model 2 p/n 57970-00) are to the top center of the antenna. To correct the Z value provided in this report for each antenna to the electronic phase center, I recommend the following steps be taken; 1) Determine the physical height of the GPS antenna. This information is probably located on the antenna or with equipment documentation. 2) Investigate to find the electronic phase center offset of the antenna. This information is probably located on the antenna or with equipment documentation. This value may also be available at the NGS website for antenna modeling. 3) Subtract the total height of the antenna from the Z value for each antenna. This will give you a Z value for the antenna ARP (antenna reference point) 4) Then add to this value the electronic phase center offset value appropriate for the antenna model. The coordinates provided in this report for the single beam are to the center of the bottom of the sensor transducer. No correction has been applied to translate the Z value to the electronic phase center. The reference point for the side scan sonar (J-arm) was measured with the J-arm configured in the deployed position. A table of results for these sensors' location, relative to the Inertial Motion Unit may be found in the "Positioning and Attitude" section of this chapter.</p>
<p><i>Most Recent Partial Static Survey</i></p>	<p>Partial static survey was not performed.</p>	

<i>Most Recent Full Offset Verification</i>	Full offset verification was not performed.	
<i>Most Recent Partial Offset Verification</i>	Partial offset verification was not performed.	
<i>Most Recent Static Draft Determination</i>	<i>Date</i>	2016-03-03
	<i>Method Used</i>	Measurements from IMU Reference Point (origin)
	<i>Discussion</i>	See section "Correction to Echo Soundings."
<i>Most Recent Dynamic Draft Determination</i>	<i>Date</i>	2016-07-29
	<i>Method Used</i>	Post-Processed Kinematic (PPK) GPS
	<i>Discussion</i>	Post-Processed Kinematic (PPK) GPS performed on 07/29/2016. See section entitled "Corrections to Echo Soundings."



Figure 1: NOAA S1211

A.2 Echo Sounding Equipment

A.2.1 Side Scan Sonars

A.2.1.1 Edgetech 4125

<i>Manufacturer</i>	Edgetech			
<i>Model</i>	4125			
<i>Description</i>	<p>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.</p> <p>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</p>			
<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211		
	<i>TPU s/n</i>	40260		
	<i>Towfish s/n</i>	40423		
<i>Specifications</i>	<i>Frequency</i>	900 kilohertz		400 kilohertz
	<i>Along Track Resolution</i>	<i>Resolution</i>	24 centimeters	<i>Resolution</i> 80 centimeters
		<i>Min Range</i>	50 meters	<i>Min Range</i> 100 meters
		<i>Max Range</i>	75 meters	<i>Max Range</i> 150 meters
	<i>Across Track Resolution</i>	1.5 centimeters		2.3 centimeters
<i>Max Range Scale</i>	75 meters		150 meters	
<i>Manufacturer Calibrations</i>	Manufacturer calibration was not performed.			



Figure 2: Edgetech 4125

A.2.2 Multibeam Echosounders

A.2.2.1 Kongsberg EM3002

<i>Manufacturer</i>	Kongsberg
<i>Model</i>	EM3002
<i>Description</i>	The EM3002 is a 300 kHz (nominal) system with a characteristic operating depth range of 1 to 150meters water depth. Under ideal, cold water conditions, the range may extend to 200 meters. The swath width is 120°, and the nadir beam is 1.5° x 1.5°. The system has a maximum ping rate of 25 Hz. The processing unit (PU) performs beam forming and bottom detection and automatically controls transmit power, gain, and ping rate. The sonar processor incorporates real time surface sound

	speed measurements for initial beam forming and steering. The Seafloor Information System (SIS) application, designed to run under Microsoft Windows, provides control and monitoring of the EM3002. The EM3002 is hull-mounted.			
<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211		
	<i>Processor s/n</i>	1668		
	<i>Transceiver s/n</i>	1668		
	<i>Transducer s/n</i>	796		
	<i>Receiver s/n</i>	1668		
	<i>Projector 1 s/n</i>	Projector1 Blister Mount		
	<i>Projector 2 s/n</i>	None		
<i>Specifications</i>	<i>Frequency</i>	300 kilohertz		
	<i>Beamwidth</i>	<i>Along Track</i>	1 degrees	
		<i>Across Track</i>	120 degrees	
	<i>Max Ping Rate</i>	25 hertz		
	<i>Beam Spacing</i>	<i>Beam Spacing Mode</i>	Equidistant	
		<i>Number of Beams</i>	254	
	<i>Max Swath Width</i>	120 degrees		
	<i>Depth Resolution</i>	1 centimeters		
<i>Depth Rating</i>	<i>Manufacturer Specified</i>	200 meters		
	<i>Ship Usage</i>	50 meters		
<i>Manufacturer Calibrations</i>	Manufacturer calibration was not performed.			
<i>System Accuracy Tests</i>	<i>Vessel Installed On</i>	S1211		
	<i>Methods</i>	Lead Line-to-Multibeam Sonar Sounding Comparison		
	<i>Results</i>	A lead line-to-multibeam sonar sounding comparison was conducted on 3/05/16, 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.		
<i>Snippets</i>	Sonar does not have snippets logging capability.			



Figure 3: EM3002 Transducer

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.

Additional Discussion

In areas of soft sediment, the EM3002 data contain an along-track pair of depressions centered near nadir. Although the magnitude of the depressions can exceed 0.5m, the nominal magnitude is 0.1 to 0.15m. Overall, the artifact is not a significant source of error. Although the underlying PVDL may be quite noisy, the surface is minimally affected. The artifact stems from the acoustic characteristics of the sonar itself, not the overall system integration.

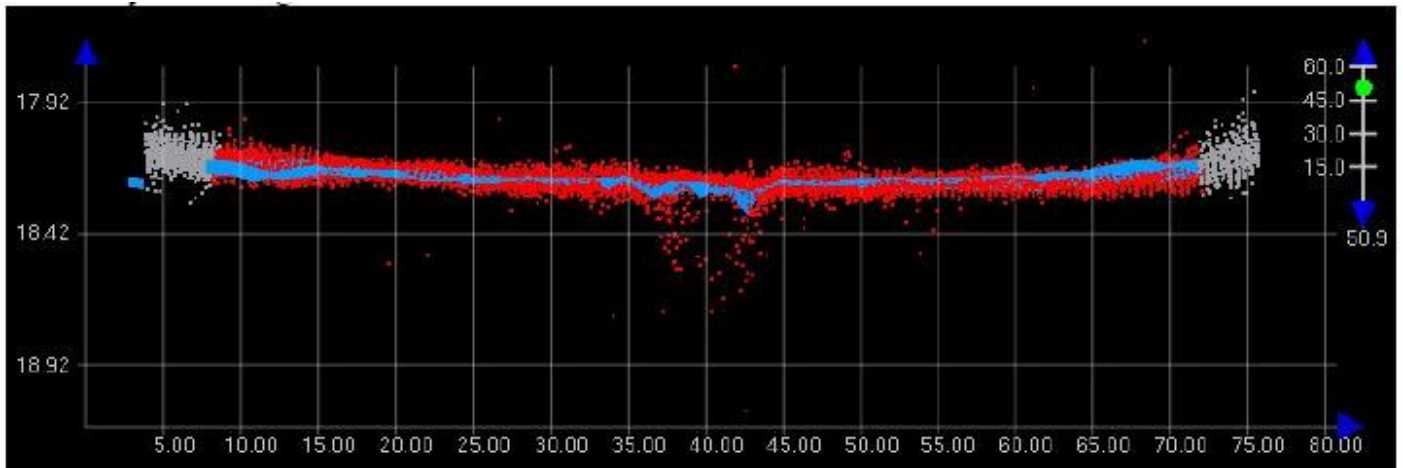


Figure 4: systematic artifact, EM3002

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
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<i>Model</i>	Unknown	
<i>Description</i>	Lead line is Nine (9) inch long lead ingot with flattened base shackled to tiller rope. The rope is 17 meters in length and marked with decimeter graduations (red tape).	
<i>Serial Numbers</i>	1211	
<i>Calibrations</i>	No calibrations were performed.	
<i>Accuracy Checks</i>	<i>Serial Number</i>	1211
	<i>Date</i>	2016-08-17
	<i>Procedures</i>	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.
<i>Correctors</i>	Correctors were not determined.	
<i>Non-Standard Procedures</i>	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

<i>Manufacturer</i>	Applanix
<i>Model</i>	POS MV5
<i>Description</i>	S1212 is equipped with an Applanix POS/MV 5 which replaced a POS/MV 320 version 4 in 2013. The POS/MV 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.

<i>Manufacturer</i>	Applanix	
<i>Model</i>	POS MV5	
<i>Description</i>	The Pos MV5 Computer System comprises the processor, GNSS receivers and interface cards necessary to communicate with and process the IMU and GNSS data.	
<i>Firmware Version</i>	5.03	
<i>Software Version</i>	7.60	
<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211
	<i>PCS s/n</i>	5610

PCS

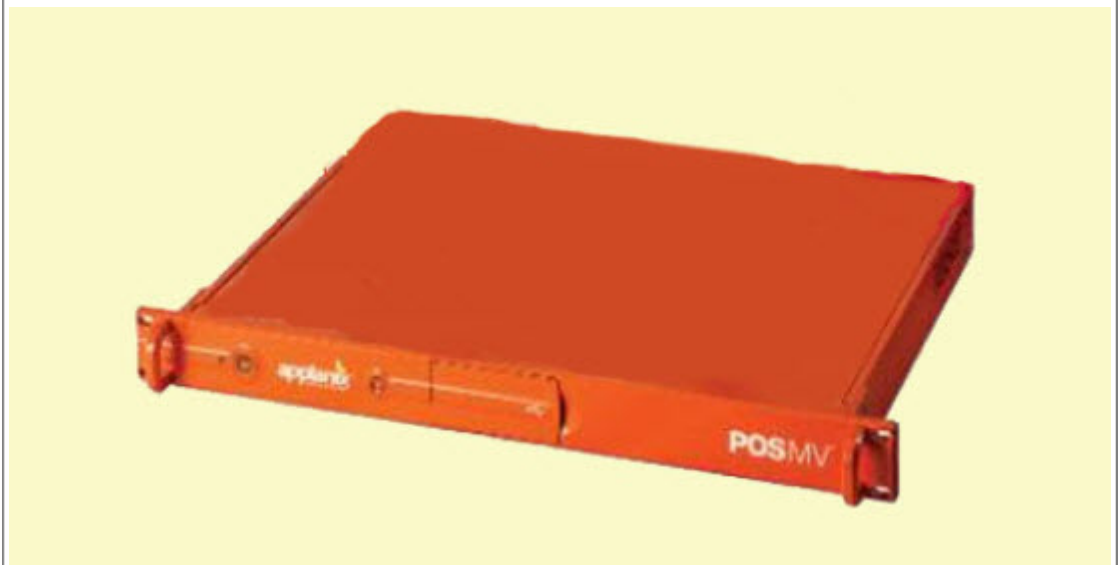


Figure 5: POS MV5 Computer System

<i>Manufacturer</i>	Applanix	
<i>Model</i>	POS MV 5	
<i>Description</i>	Inertial Motion Unit (IMU)	
<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211
	<i>IMU s/n</i>	5434
<i>Certification</i>	IMU certification report was not produced.	

IMU

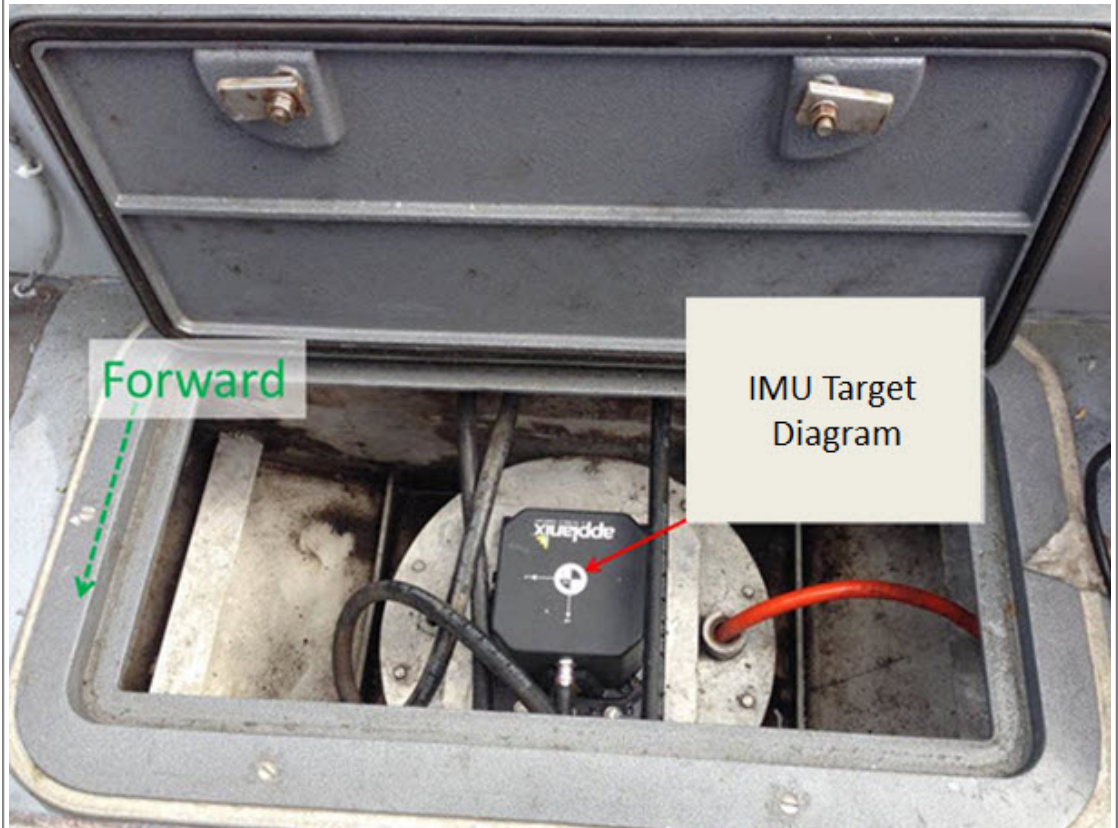


Figure 6: Inertial Motion Unit (IMU)


<i>Antennas</i>	No POS/MV antennas were installed.	
<i>GAMS Calibration</i>	<i>Vessel</i>	S1211
	<i>Calibration Date</i>	2016-07-26
<i>Configuration Reports</i>	<i>Vessel</i>	S1211
	<i>Report Date</i>	2016-07-26




Figure 7: POS MV GPS antennae

A.4.2 DGPS

<p><i>Description</i></p>	<p>S1211 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.</p>
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<i>Antennas</i>	<i>Manufacturer</i>	Trimble		
	<i>Model</i>	GA530		
	<i>Description</i>	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 S1211's radio mast. The unit is fully sealed and 100 percent humidity proof. Its frequency reception capabilities include L1, L2, OmniSTAR, Beacon and SBAS.		
	<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211	
		<i>Antenna s/n</i>	14811	
				
<i>Figure 8: Trimble GA530 antenna</i>				

<i>Receivers</i>	<i>Manufacturer</i>	Trimble		
	<i>Model</i>	SPS312		
	<i>Description</i>	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.		
	<i>Firmware Version</i>	1.73		
	<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211	
		<i>Antenna s/n</i>	5331K63794	
				
<i>Figure 9: Trimble SPS312 DGPS Receiver</i>				

A.4.3 Trimble Backpacks

<i>Manufacturer</i>	Trimble
<i>Model</i>	GeoXH/GeoExplorer 2008 Series
<i>Description</i>	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.
<i>Serial Numbers</i>	S/N 4928419526
<i>Antennas</i>	No antennas were installed.
<i>Receivers</i>	No receivers were installed.

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



Figure 10: GeoXH GPS

A.4.4 Laser Rangefinders

<i>Manufacturer</i>	TruPulse
<i>Model</i>	360B

<i>Description</i>	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.
<i>Serial Numbers</i>	044710
<i>DQA Tests</i>	DQA test was not performed.



Figure 11: 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

<i>Manufacturer</i>	YSI	
<i>Model</i>	CastAway	
<i>Description</i>	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.	
<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211
	<i>CTD s/n</i>	CC1232007
<i>Calibrations</i>	<i>CTD s/n</i>	CC1232007
	<i>Date</i>	2016-08-17
	<i>Procedures</i>	Sensor Calibration

A.5.1.2 Sound Speed Profilers

No sound speed profilers were utilized for data acquisition.

A.5.2 Surface Sound Speed

A.5.2.1 Odom Digibar Pro

<i>Manufacturer</i>	Odom	
<i>Model</i>	Digibar Pro	
<i>Description</i>	NRT4 uses a Digibar Pro sound velocity profiler for realtime surface sound speed monitoring. The unit is mounted on S1211'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 "AML" 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.	
<i>Serial Numbers</i>	<i>Vessel Installed On</i>	S1211
	<i>Sound Speed Sensor s/n</i>	DBP98150
<i>Calibrations</i>	<i>Sound Speed Sensor s/n</i>	DBP98150
	<i>Date</i>	2015-08-12
	<i>Procedures</i>	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

<i>Manufacturer</i>	Dell
<i>Model</i>	Precision T5500
<i>Description</i>	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.

<i>Serial Numbers</i>	<i>Computer s/n</i>	<i>Operating System</i>	<i>Use</i>
	CD000409857	Windows 7	Acquisition

<i>Manufacturer</i>	Dell		
<i>Model</i>	Precision 1650		
<i>Description</i>	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.		
<i>Serial Numbers</i>	<i>Computer s/n</i>	<i>Operating System</i>	<i>Use</i>
	CD0004101898	Windows 7	Processing
	CD0004101849	Windows 7	Processing

A.7.2 Computer Software

<i>Manufacturer</i>	CARIS
<i>Software Name</i>	HIPS and SIPS
<i>Version</i>	9.1.7
<i>Service Pack</i>	1
<i>Hotfix</i>	1
<i>Installation Date</i>	2016-08-08
<i>Use</i>	Processing
<i>Description</i>	CARIS 9.1.7 is the primary software utilized post processing of NRT4's hydrographic data.

<i>Manufacturer</i>	Hypack
<i>Software Name</i>	Hypack
<i>Version</i>	2014
<i>Service Pack</i>	1
<i>Hotfix</i>	1
<i>Installation Date</i>	2016-08-08
<i>Use</i>	Acquisition
<i>Description</i>	Hypack (and Hysweep) are the primary software used for data collection using the "paint-the-bottom" navigation method.

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

<i>Manufacturer</i>	Kongsberg
<i>Software Name</i>	Seafloor Info System (SIS
<i>Version</i>	4.3.0
<i>Service Pack</i>	0
<i>Hotfix</i>	0
<i>Installation Date</i>	2016-06-01
<i>Use</i>	Acquisition
<i>Description</i>	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 MapInfo.

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 where 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 12: NRT4 Multibeam Processing Workflow

Figure 13: 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
- ZDA-synchronized attitude of the vessel RP
- roll-stabilized raw angles and ranges

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, water line, and RP--to--transducer-lever-arm correctors. 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 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 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

<i>Methods Used</i>	Gridding Parameters
	Surface Computation Algorithms
<i>Description</i>	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."

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.

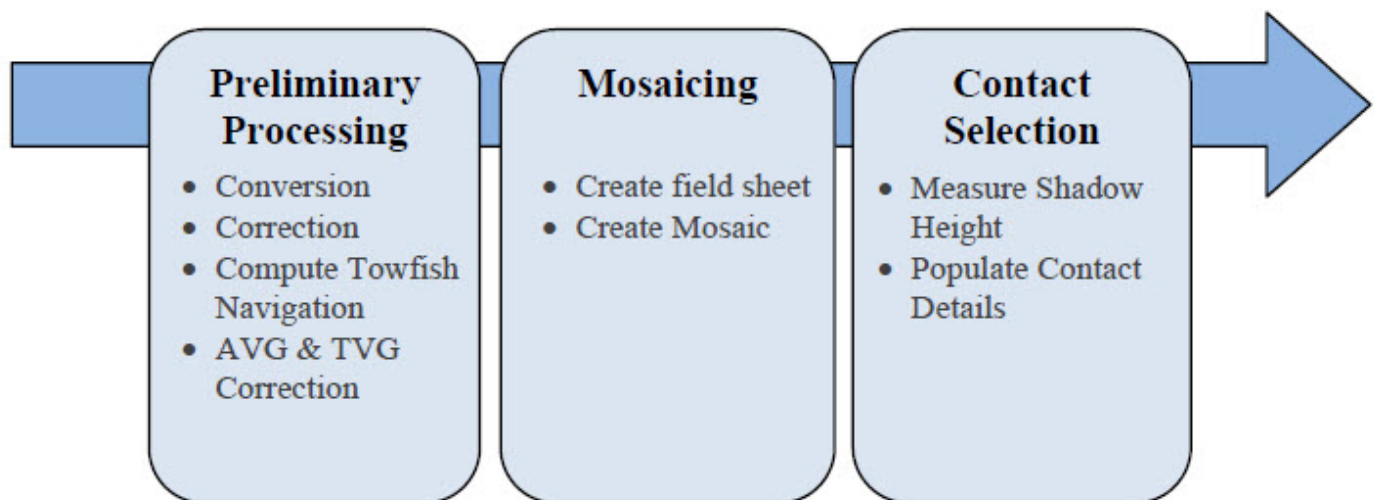


Figure 14: Side Scan Processing Workflow

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%
 - _____ At least 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 15: Excerpt 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 $\pm\sqrt{a^2+(b*d)^2}$ 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

<i>Vessel</i>	S1211		
<i>Echosounder</i>	Kongsberg EM3002 300 kilohertz		
<i>TPU Standard Deviation Values</i>	<i>Motion</i>	<i>Gyro</i>	0.02 degrees
		<i>Heave</i>	5 % Amplitude
			5 centimeters
		<i>Pitch</i>	0.02 degrees
	<i>Roll</i>	0.02 degrees	
	<i>Navigation Position</i>	0.5 meters	
	<i>Timing</i>	<i>Transducer</i>	0.01 seconds
		<i>Navigation</i>	0.01 seconds
		<i>Gyro</i>	0.01 seconds
		<i>Heave</i>	0.01 seconds
		<i>Pitch</i>	0.01 seconds
		<i>Roll</i>	0.01 seconds

<i>Offsets</i>	<i>x</i>	0.001 meters
	<i>y</i>	0.001 meters
	<i>z</i>	0.001 meters
<i>MRU Alignment</i>	<i>Gyro</i>	0.2 degrees
	<i>Pitch</i>	0.05 degrees
	<i>Roll</i>	0.05 degrees
<i>Vessel</i>	<i>Speed</i>	0.03 meters/second
	<i>Loading</i>	0.01 meters
	<i>Draft</i>	0.03 meters
	<i>Delta Draft</i>	0.03 meters

B.4.2 Deviations

RP to EM3002 blunder, February 2017: Subsequent to submission of H12387 PHB discovered a blunder in the RP(Bullseye on IMU)-to-EM3002 offset value. A value of 0.52 meters was erroneously entered into SIS rather than the correct measurement of, 0.489 meters. This 0.031 meter difference proceeded from the installation of a new, shorter IMU in the Spring of 2014. However, it was determined that this value fell within the allowable uncertainty range, thus no reprocessing was required.

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 S1211's static offsets.

C.1.1.2 Methods and Procedures

Vessel Lever-Arms:

The Reference Point (RP)-to-EM3002 lever arm was measured using a tape measure on 3/03/16, in Galveston, TX, while the boat was on the trailer in a parking lot. The height of the static draft reference plane above the parking lot was determined by taking the average of the heights of the port and starboard static draft reference points. The height of the EM3002 above the parking lot was determined by taking the average of the heights of the port and starboard sides of the transducer.

Water Line:

A static draft check was performed on 3/03/16 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 S1212's hull. The scum line (scum "area," more precisely) 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 2.1 cm scum line.

Static Draft:

To determine the static draft (i.e., the height of the waterline above/below the reference point), two new benchmarks and an easily repeatable method were established. A benchmark (BM) was established on the port and starboard rub-rails, closely aligned with the reference point (RP) in the along-ship dimension. First, a pipe was placed athwartship, over the RP, to provide a reference line that could be used to tie the benchmarks into the vessel coordinate frame. The pipe was assumed to be straight and orthogonal to the z-axis of the vessel coordinate frame. The vertical offset (relative to the RP) of each benchmark was calculated by subtracting the waterline-to-pipe distance from the RP-to-pipe distance. See "Waterline and Benchmarks" graphic, below. Next, graduated ruler measurements from BM-to-WL and BM-to-Pipe were taken to further authenticate the Pipe-to-WL distance made in the first step. Averages of these port and starboard dimensions were added together reconfirming the average WL height of 0.742m (Green callout box in Figure.) Accordingly, the separation value of 0.079m between IMU and WL was successfully reproduced.

Induced Heave:

Finally, an induced heave value was subtracted from the preliminary waterline value to account for a non-zero static pitch during the measurements. The induced heave (calculated assuming the vessel center of rotation was level with the water surface) was estimated by multiplying the along-ship component of the heave lever arm by a nominal pitch value noted at the time of the waterline measurements. The waterline calculations are summarized in figure entitled "Static Draft Induced Heave, S1211."

The resulting induced heave value was entered into Kongsberg's SIS (Sensor Setup ->Locations ->Waterline).

NOAA Survey Vessel S1211 was surveyed by the National Geodetic Survey in June, 2009 to determine the spatial relationship between various hydrographic sensors using the Applanix IMU as the primary reference point (RP). S1211'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 report findings below.

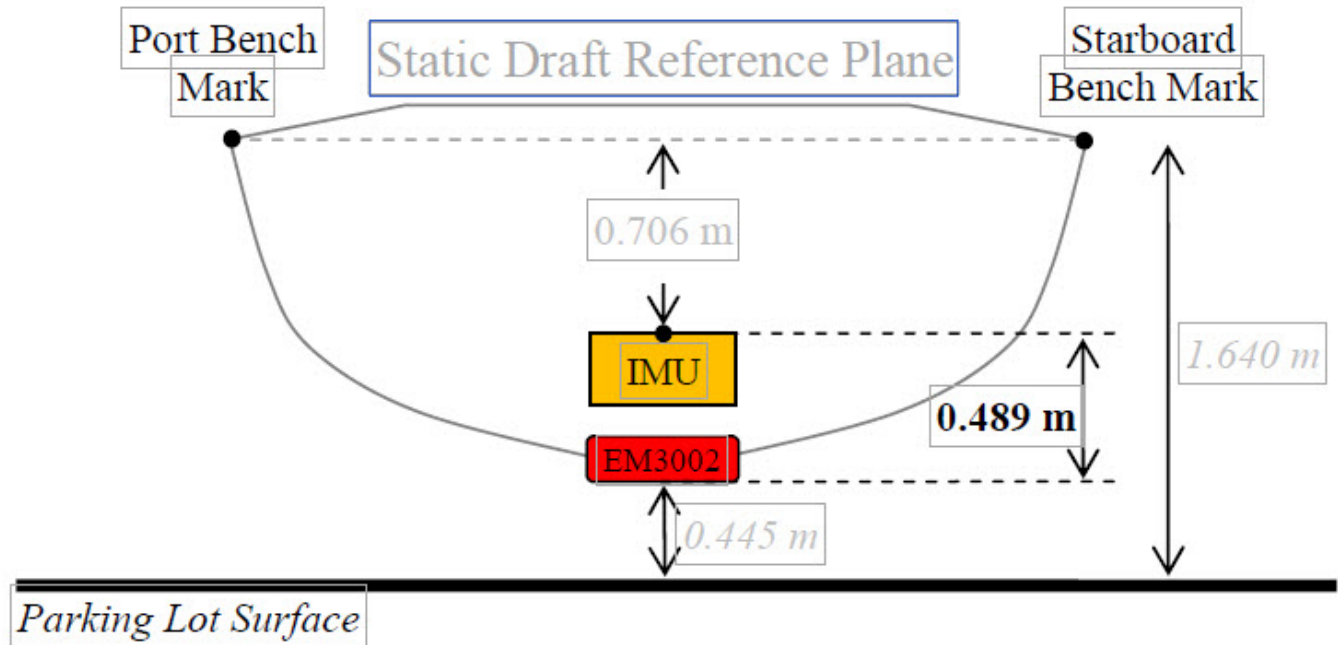


Figure 16: RP (bullseye on top of IMU) to face of Kongsberg EM3002, S1211.

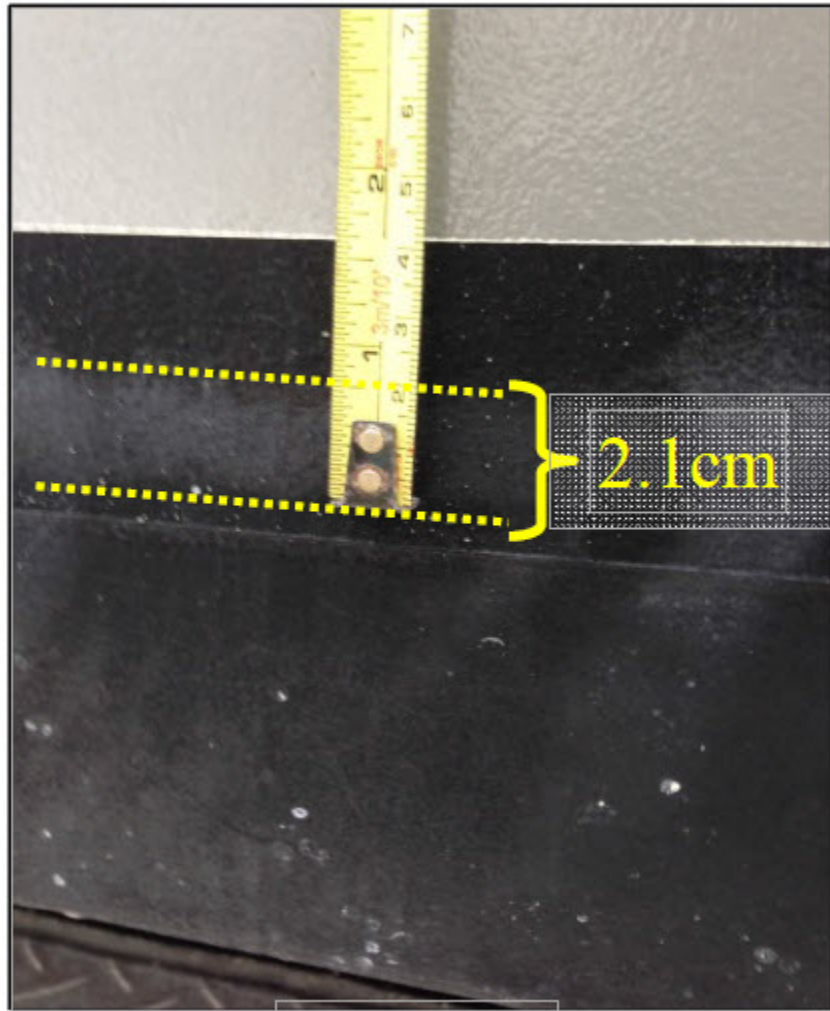


Figure 17: Scum Line, S1211.

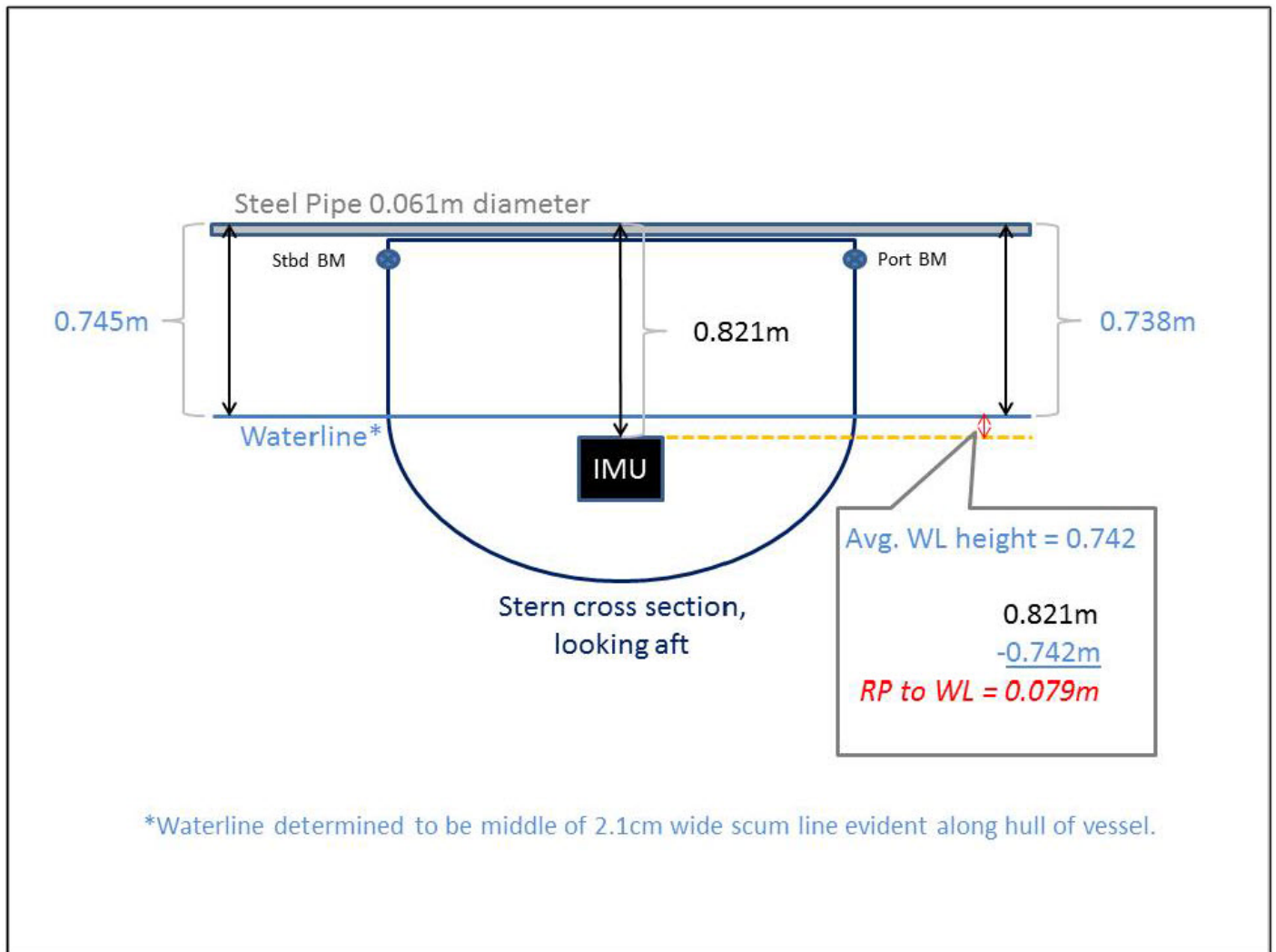


Figure 18: Waterline and Benchmarks, S1211.

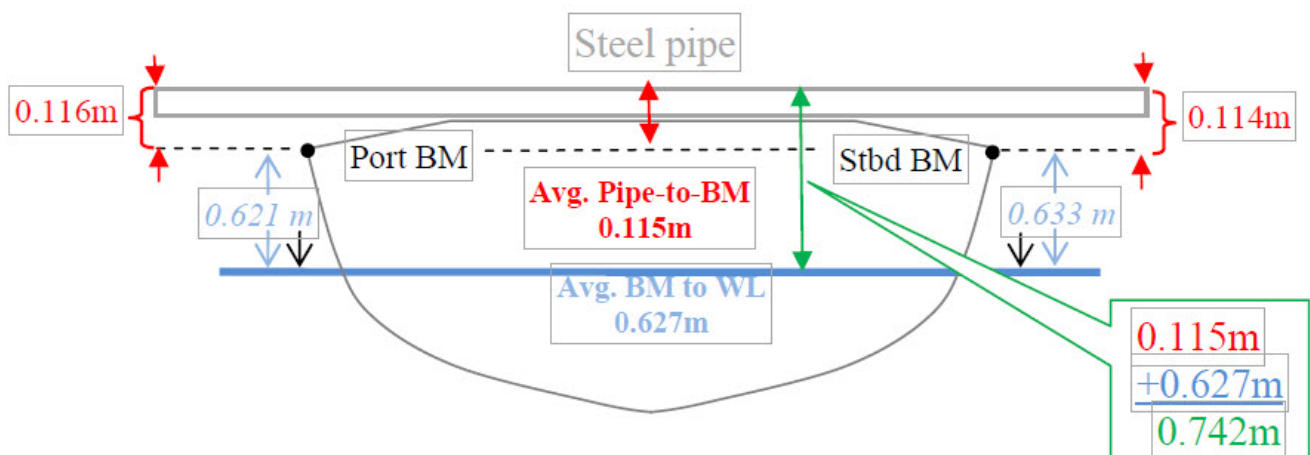
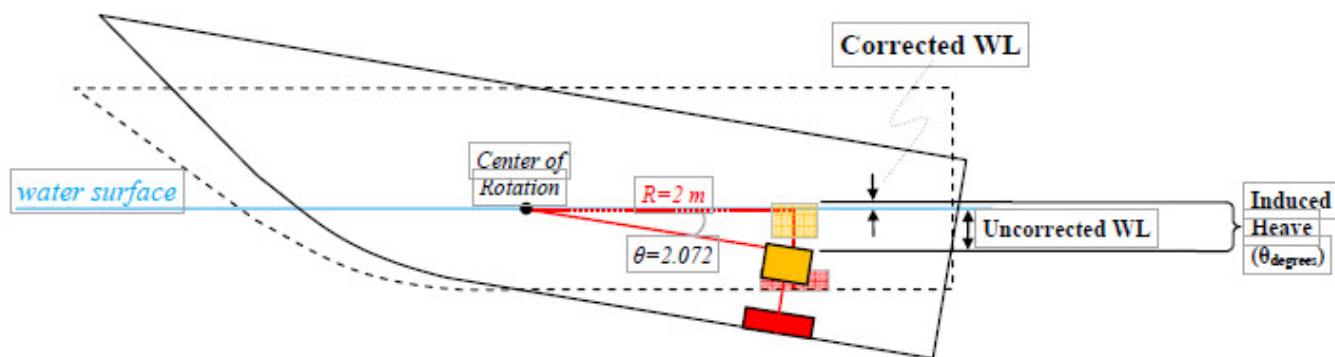


Figure 19: Height waterline above/below the RP, S1211.



Uncorrected WL	Induced Heave Due to Static Pitch	Corrected WL
-0.079	0.072 m	-0.007 m

Figure 20: Static Draft Induced Heave, S1211.

C.1.1.3 Vessel Offset Correctors

Vessel	S1211		
Echosounder	Kongsberg EM3002 300 kilohertz		
Date	2016-08-17		
Offsets	MRU to Transducer	x	0 meters
		y	0 meters
		z	0.489 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters
	Nav to Transducer	x	0 meters
		y	0 meters
		z	0 meters
		x2	0 meters
		y2	0 meters
		z2	0 meters

<i>Transducer Roll</i>	<i>Roll</i>	0 degrees
	<i>Roll2</i>	0 degrees

C.1.2 Layback

C.1.2.1 Description of Correctors

NRT4's Side Scan Sonar layback is not reckoned via conventional means as S1211's Dynapar Cable Counter is not serially compatible with EdgeTech's Discovery 2 software. As such, cable out is calculated via the NRB approved "serial_manipulator" Python script written by Phil Sparr in 2013. The "cable out" value appended to the .JSF file in Discovery 2 is applied during post processing in CARIS via the process command "Recompute Towfish Navigation."

C.1.2.2 Methods and Procedures

NRT4's Side Scan Sonar layback is not reckoned via conventional means as S1211's Dynapar Cable Counter is not serially compatible with EdgeTech's Discovery 2 software. As such, cable out is calculated via the NRB approved "serial_manipulator" Python script written by Phil Sparr in 2013. The "cable out" value appended to the .JSF file in Discovery 2 is applied during post processing in CARIS via the process command "Recompute Towfish Navigation."

C.1.2.3 Layback Correctors

<i>Vessel</i>	S1211 (Towpoint correctors applied realtime in EdgeTech's Discovery 2.)		
<i>Echosounder</i>	Kongsberg EM3002 Multibeam Echosounder 300 megahertz		
<i>Date</i>	2016-08-17		
<i>Layback</i>	<i>Towpoint</i>	<i>x</i>	1.992 meters
		<i>y</i>	-0.683 meters
		<i>z</i>	-2.486 meters
	<i>Layback Error</i>	0 meters	

C.2 Static and Dynamic Draft

C.2.1 Static Draft

C.2.1.1 Description of Correctors

S1211's static draft values are applied in Kongsberg's SIS software.

C.2.1.2 Methods and Procedures

S1211's static draft values are applied in Kongsberg's SIS software.

C.2.2 Dynamic Draft

C.2.2.1 Description of Correctors

Dynamic Draft testing occurred on D211 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.”

C.2.2.3 Dynamic Draft Correctors

<i>Vessel</i>	S1211	
<i>Date</i>	2016-07-29	
<i>Dynamic Draft Table</i>	<i>Speed</i>	<i>Draft</i>
	0	0
	0.5	-0.01
	1	-0.01
	1.5	-0.01
	2	0.00
	2.5	0.02
	3.0	0.03
	3.5	0.04
	4.0	0.06
	4.5	0.07
	5.0	0.08
	5.5	0.08

<i>Speed</i>	<i>Draft</i>
6.0	0.07
6.5	0.06
7.0	0.04
7.5	0.04

C.3 System Alignment

C.3.1 Description of Correctors

A patch test was performed on 01/08/2016 in the vicinity of Bolivar Roads, near Galveston, TX.

C.3.2 Methods and Procedures

S1211's 2016 patch test process occurred in CARIS 9.1.7 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 the Swath1 sensor of the HVF.

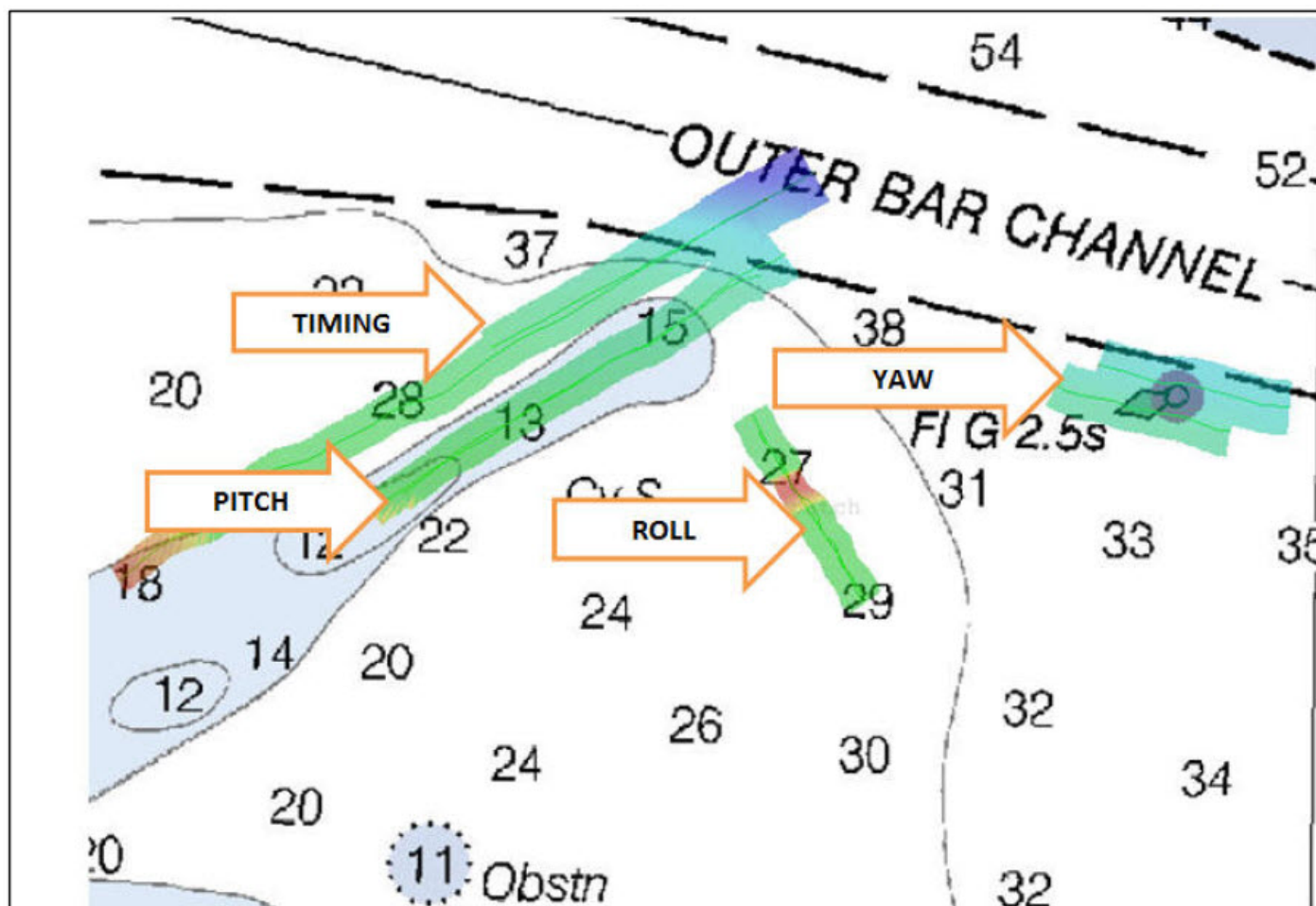


Figure 21: NRT4 Patch Test Location, 2016

C.3.3 System Alignment Correctors

<i>Vessel</i>	S1211	
<i>Echosounder</i>	Kongsberg EM3002 300 kilohertz	
<i>Date</i>	2016-11-03	
<i>Patch Test Values</i>	<i>Navigation Time Correction</i>	0.00 seconds
	<i>Pitch</i>	3.4 degrees
	<i>Roll</i>	0.4 degrees
	<i>Yaw</i>	0.320 degrees
	<i>Pitch Time Correction</i>	0.00 seconds
	<i>Roll Time Correction</i>	0.00 seconds
	<i>Yaw Time Correction</i>	0.00 seconds
	<i>Heave Time Correction</i>	0.00 seconds

C.4 Positioning and Attitude

C.4.1 Description of Correctors

POS M/V "Delayed Heave" was logged POS View software during data acquisition and post processed in CARIS via the "Import Auxiliary Data" function.

C.4.2 Methods and Procedures

Delayed Heave data is appended to soundings during the CARIS "SVP Correction" and applied to soundings during the CARIS "Merge" process.

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 Digibar Pro's serial AML output. 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 2016 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,

Dan Jacobs

Team Lead, NOAA NRT4