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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-D304-TJ-19
Time Frame:	October - November 2019

LOCALITY

State(s):	North Carolina Virginia
General Locality:	Approaches to Chesapeake Bay

2019

CHIEF OF PARTY
CDR Briana Welton Hillstrom, NOAA

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Date:

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NOAA Ship *Thomas Jefferson*
Chief of Party: CDR Briana Welton Hillstrom, NOAA
Year: 2019
Version: 1.0
Publish Date: 2019-12-27

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 NOAA Ship THOMAS JEFFERSON (WTEA)

Vessel Name	NOAA Ship THOMAS JEFFERSON (WTEA)	
Hull Number	S222	
Description	S222 is a steel hulled hydrographic survey ship built by Halter Marine, Inc., Moss Point, MS.	
Dimensions	*LOA*	63.4m
	Beam	13.7m
	Max Draft	4.6m
Most Recent Full Static Survey	*Date*	2016-09-01
	Performed By	The IMTEC Group, Ltd.

Figure 1: Thomas Jefferson underway from the starboard view.

A.1.2 Hydrographic Survey Launch 2903 (HSL 2903)

Vessel Name	Hydrographic Survey Launch 2903 (HSL 2903)	
Hull Number	2903	
Description	HSL 2903 is an aluminum hulled hydrographic survey launch built in 2017 by Willard Marine, Inc. HSL 2903 is equipped to collect bathymetric data, side scan imagery, and water column profiles.	
Dimensions	*LOA*	8.5m
	Beam	3m
	Max Draft	1.2m
Most Recent Full Static Survey	*Date*	2017-05-01
	Performed By	Kevin Jordan, National Ocean Service - National Geodetic Survey (NGS) - Field Operations Branch
Most Recent Partial Offset Verification	*Date*	2019-06-03
	Method	Physical confirmation of measurements.

Figure 2: 2903 and 2904 returning to S222

Figure 3: 2903 heading out for survey operations.

Figure 4: 2903 from starboard view.

A.1.3 Hydrographic Survey Launch 2904 (HSL 2904)

Vessel Name	Hydrographic Survey Launch 2904 (HSL 2904)	
Hull Number	2904	
Description	HSL 2904 is an aluminum hulled hydrographic survey launch built in 2017 by Willard Marine, Inc. HSL 2904 is equipped to collect bathymetric data, side scan imagery, and water column profiles.	
Dimensions	*LOA*	8.5m
	Beam	3m
	Max Draft	1.2m
Most Recent Full Static Survey	*Date*	2017-04-30
	Performed By	Kevin Jordan, National Ocean Service - National Geodetic Survey (NGS) - Field Operations Branch

Most Recent Partial Offset Verification	*Date*	2019-06-03
	Method	Physical confirmation of measurements.

Figure 5: 2904 from port view.

A.1.4 DriX

Vessel Name	DriX
Hull Number	DriX
Description	The DriX is a kevlar reinforced Unmanned Surface Vessel owned and operated by iXblue. The DriX is operated as fully autonomous, semi-autonomous, and through direct remote control. During operations the DriX lowers its keel and gondola; the gondola is where the DriX mission equipment is installed. For the THOMAS JEFFERSON 2019 field season the DriX was equipped to collect bathymetric data and water column profiles.

Dimensions	*LOA*	7.7m
	Beam	0.8m
	Max Draft	1.9m
Most Recent Full Static Survey	*Date*	2018-10-18
	Performed By	iXblue

Figure 6: DriX operating through direct remote control in Norfolk, VA with NOAA Ship THOMAS JEFFERSON in the background.

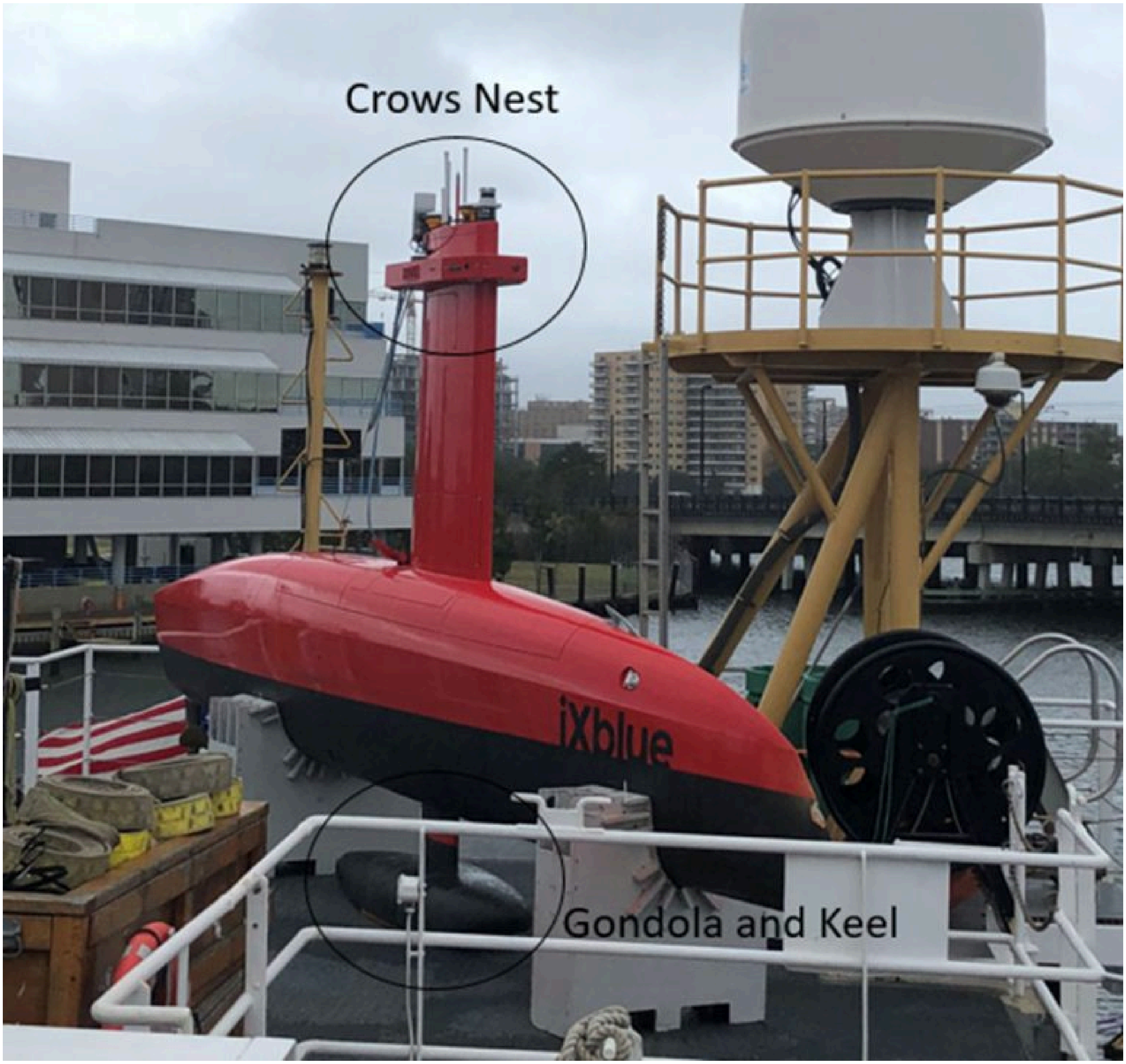

Figure 7: DriX resting aft on the second deck of NOAA Ship THOMAS JEFFERSON with the Gondola and Keel labled, along with the Crow's Nest.

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM2040

The Kongsberg EM2040 MBES is a high resolution shallow water MBES. The system is capable of operating at 200, 300, or 400 kHz frequencies, can provide across-track swath width up to 5.5 times water depth, provides single or multi-sector modes of operations, and can be used in depths up to 600 meters.

The EM2040 is operated at the 300 kHz frequency for normal shallow water operations.

For hydrographic survey collection, the EM2040 is set to a max angle of 65 degrees with angular coverage set to Auto. The beam spacing is set to high definition equal distant to obtain max swath width when operating in any depth. Dual swath mode is set to Dynamic. Dynamic mode is selected because it allows the along side angle between the two transmit fans to be determined based on the vessel speed, ping rate, and depth in order to provide a uniform along ship sampling of the sea floor. The frequency of the EM2040 is typically set to 300 kHz for normal survey operations, and will shift to 400 kHz for shallow water data collection. Pulse type set to auto with FM disabled.

Components of the EM2040 include a sonar head, a processing unit, and a hydrographic workstation. Motion sensor and positioning data from the POSMV system, with sound speed profile data being input to the EM 2040 via separate sound speed profiling equipment. All echo sounder electronics are contained in the sonar head which is interfaced to the processing unit via GBit Ethernet. The processing unit also supplies 48 VDC power via the same cable. Operator control, data quality inspection, and data storage is handled by the hydrographic workstation running SIS software.

The Sonar Acceptance Reports for the EM2040s on NOAA Ship THOMAS JEFFERSON and both Hydrographic Survey Launches can be found in the appendices.

Manufacturer	Kongsberg
Model	EM2040

Inventory

S222

Component	Processing Unit	Work Station	Transducer	Receiver
Model Number	EM2040	EM2040	EM2040	EM2040
Serial Number	40072	CZC3410L1L	236	334
Frequency	200-400 kHz	200-400 kHz	200-400 kHz	200-400 kHz
Calibration	2019-10-17	2019-10-17	2019-10-17	2019-10-17
Accuracy Check	2019-10-21	2019-10-21	2019-10-21	2019-10-21

2903

Component	Processing Unit	Work Station	Transducer	Receiver
Model Number	EM2040	EM2040	EM2040	EM2040
Serial Number	40143	CZC746864F	281	363
Frequency	200-400 kHz	200-400 kHz	200-400 kHz	200-400 kHz
Calibration	2019-09-26	2019-09-26	2019-09-26	2019-09-26
Accuracy Check	2019-10-10	2019-10-10	2019-10-10	2019-10-10

2904

Component	Processing Unit	Work Station	Transducer	Receiver
Model Number	EM2040	EM2040	EM2040	EM2040
Serial Number	40139	CZC7468666	282	393
Frequency	200-400 kHz	200-400 kHz	200-400 kHz	200-400 kHz
Calibration	2019-07-15	2019-07-15	2019-07-15	2019-07-15
Accuracy Check	2019-07-15	2019-07-15	2019-07-15	2019-07-15

DriX

Component	Processing Unit	Work Station	Transducer	Receiver
Model Number	EM2040	EM2040	EM2040	EM2040
Serial Number	40155	Unknown	410984	413538
Frequency	200-400 kHz	200-400 kHz	200-400 kHz	200-400 kHz
Calibration	2019-10-04	2019-10-04	2019-10-04	2019-10-04
Accuracy Check	2019-10-18	2019-10-18	2019-10-18	2019-10-18

Figure 8: Kongsberg EM2040 mounting configuration on 2903 and 2904

Figure 9: Kongsberg EM2040 and EM710 mounting configuration on S222

A.2.2 Single Beam Echosounders

A.2.2.1 Teledyne Odom Echotrac CV200

The Teledyne Odom Echotrac CV200 single beam echo sounder has a low band frequency of 3.5kHz-50kHz and a high band frequency of 100kHz-1MHz allowing for survey to depths of up to 4000 meters. The hydrographers operated the Echotrac CV200 at 128kHz with the entire system interfaced and logged through Hypack 2018 acquisition software. The single beam data was logged as a .raw and .bin file through Hypack 2018, with only the .raw files processed in Caris Hips and Sips 10.4 processing software.

The system is comprised of a topside unit and a hull-mounted transducer.

For the Odom Echotrac installation, calibration, and verification refer to the appendices.

<table>
<tr><td>Manufacturer</td><td colspan="4">Teledyne Odom</td></tr>
<tr><td>Model</td><td colspan="4">Echotrac CV200</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">2903</td><td>Component</td><td>Processing Unit</td><td>Transducer</td></tr>
<tr><td>Model Number</td><td>CV200</td><td>CV200</td></tr>
<tr><td>Serial Number</td><td>002917</td><td>UNKNOWN</td></tr>
<tr><td>Frequency</td><td>3.5kHz-1MHz</td><td>3.5kHz-1MHz</td></tr>
<tr><td>Calibration</td><td>2019-06-03</td><td>2019-06-03</td></tr>
<tr><td>Accuracy Check</td><td>2019-06-05</td><td>2019-06-05</td></tr>
</table>

Figure 10: Installation of transducer for Odom Echotrack CV200 on the hull of 2903.

A.2.3 Side Scan Sonars

A.2.3.1 Klein Marine Systems, Inc. 5000v1

The Klein 5000v1 Side Scan Sonar (SSS) system is a beam-forming acoustic imagery device. The 5000v1 was configured from the manufacturer to operate as a Klein 5000v2 by utilizing 5000v2 internal parts. The integrated system includes a Klein 5000v1 towfish, a Transceiver/Processing Unit (TPU), and a computer for user interface. Stern-towed units also include a tow cable telemetry assembly. The towfish operates at a frequency of 455kHz and a vertical beam angle of 40°, and can resolve up to 5 discrete received beams per transducer stave. The Klein 5000v1 is deployed in a stern-towed configuration on S222.

The Klein 5000v1 has pre-set range scales of 50, 75, 100, and 150 meters; custom range scales can be set up to 250 meters. The range scale is determined by the depth of the water and the type of survey conducted for best results as determined by the HSSD 2019, the hydrographer sets the range scale before surveying. During acquisition the hydrographer controls the depth of the fish from the acquisition station, keeping the 5000v1 at an altitude between 8%-20% of the range scale.

All Klein systems were upgraded with new TPUs in 2017.

<table>
<tr><td>Manufacturer</td><td colspan="4">Klein Marine Systems, Inc.</td></tr>
<tr><td>Model</td><td colspan="4">5000v1</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">S222</td><td>Component</td><td>Processing Unit</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>5000</td><td>5000v1</td></tr>
<tr><td>Serial Number</td><td>008</td><td>280</td></tr>
<tr><td>Frequency</td><td>455kHz</td><td>455kHz</td></tr>
<tr><td>Calibration</td><td>2019-11-10</td><td>2019-11-10</td></tr>
<tr><td>Accuracy Check</td><td>2019-11-10</td><td>2019-11-10</td></tr>
</table>

A.2.3.2 Klein Marine Systems, Inc. 5000 MKII-B

The Klein System 5000 MKII-B is a high performance, 5 beam dynamically focused, economical system designed specifically for port and harbor security applications and is also ideally suited for small object detection in open boat operations. Performance of the Klein System 5000 MKII-B is comparable to the specifications and performance of the Klein System 5000 technology. The towfish is fitted to the HSL's in a hull-mounted configuration. The MKII-B is restricted to the depth of the draft of the HSL.

The Klien 5000 MKII-B has a set range scale of 50 meters, 75 meters, 100 meters, and 150 meters.

<table>
<tr><td>Manufacturer</td><td colspan="4">Klein Marine Systems, Inc.</td></tr>
<tr><td>Model</td><td colspan="4">5000 MKII-B</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">2903</td><td>Component</td><td>Processing Unit</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>5000 MKII-B</td><td>5000 MKII-B</td></tr>
<tr><td>Serial Number</td><td>009</td><td>319</td></tr>
<tr><td>Frequency</td><td>455kHz</td><td>455kHz</td></tr>
<tr><td>Calibration</td><td>2019-07-24</td><td>2019-07-24</td></tr>
<tr><td>Accuracy Check</td><td>2019-07-24</td><td>2019-07-24</td></tr>
</table>

Figure 11: Klein 5000 MKII-B installed on the launch.

A.2.3.3 EdgeTech 4200

The EdgeTech 4200 system is comprised of a topside system and a stainless steel towfish. The towfish is a dual frequency 300/600 kHz capable of simultaneous acquisition in both frequencies. The towfish is fitted to the HSL in a hull-mounted configuration. The 4200 is restricted to the depth of the draft of the HSL.

The EdgeTech 4200 uses Multi-Pulse (MP) technology to enable survey speeds up to 10 knots while maintaining 100% bottom coverage. When operated in simultaneous dual frequency acquisition mode, speed must be reduced since the frequencies alternate between 300 and 600 kHz.

Manufacturer	EdgeTech			
Model	4200			
Inventory	*2903*	*Component*	TPU	Towfish
		Model Number	4200	4200
		Serial Number	50423	40423
		Frequency	300kHz-600kHz	300kHz-600kHz
		Calibration	2019-07-02	2019-07-02
		Accuracy Check	2019-07-02	2019-07-02
	2904	*Component*	TPU	Towfish
		Model Number	4200	4200
		Serial Number	50426	50508
		Frequency	300kHz-600kHz	300kHz-600kHz
		Calibration	2019-07-03	2019-07-03
		Accuracy Check	2019-07-03	2019-07-03

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

No lead lines were utilized for data acquisition.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix Corporation POS MV 320 Version 5

The Applanix POS MV 320 Version 5 (Position and Orientation System for Marine Vessels, hereafter 'POS MV v5') is a GNSS Inertial Navigation System that provides high frequency and highly accurate vessel trajectory (both navigation/position and attitude/orientation) data. The system incorporates data from an Inertial Motion Unit (IMU) and dual multi-constellation GNSS receivers. Advanced proprietary Kalman

Filtering techniques are used to provide a blended navigation and trajectory solution in real-time that is both highly accurate and reliable. The POS MV v5 also computes vessel heave (both instantaneous and ‘delayed’ heave values). The POS MV v5 system is integrated with all platform acquisition systems. Data from the POS MV v5 is applied to echosounder data in real-time and logged for post-processing/archiving.

The POS/ MV generates attitude data in three axes (roll, pitch, and heading) to an accuracy of 0.02° or better. Real-time heave measurements supplied by the POS/MV maintain an accuracy of 5% of the measured vertical displacement or 05 cm (whichever is greater) for vertical motions less than 20 seconds in period. The standard practice on THOMAS JEFFERSON is to configure the Heave Bandwidth filter with a damping coefficient of 0.707. The standard practice is to apply a high pass filter that is determined by the longest swell period encountered on the survey grounds. The POS MV v5 is also calculates a ‘delayed heave’ (Applanix labels this ‘TrueHeave’) value. The Applanix delayed heave algorithm uses a delayed filtering technique to eliminate many of the artifacts present in real time heave data. Applanix delayed heave measurements maintain an accuracy of 2% of the measured vertical displacement or 2 cm (whichever is greater) for vertical motions less than 20 seconds in period. Delayed heave measurements are logged and applied to MBES data in post processing.

A graphical user interface provides visual representations and summary statistics of data quality in real-time. Performance parameters are monitored by acquisition hydrographers in real-time and checked against HSSD requirements.

Position and trajectory data from the POS MV v5 system is applied in both real-time and post-processed applications. Navigation and attitude data are applied to all echosounder data in real-time. Raw data from the POS MV v5 can also be post-processed after acquisition to achieve trajectory solutions that are more accurate than those achieved in real-time by using forward/backward processing methods. Post-processing is conducted using the Applanix POSPac MMS software suite. Post-processing methodology is described elsewhere in this document.

Position and Attitude data are recorded daily in 10 minute file increments to a computer at 100Hz through an Ethernet connection, on a dedicated POS MV acquisition computer with no other applications running.

Manufacturer	Applanix Corporation			
Model	POS MV 320 Version 5			
Inventory	*S222*	*Component*	IMU	PCS
		Model Number	LN200 (IMU2)	V5
		Serial Number	1047	6497
		Calibration	2019-10-17	2019-10-17
	2903	*Component*	IMU	PCS
		Model Number	LN200 (IMU2)	V5
		Serial Number	131	3245
		Calibration	2019-07-15	2019-07-15
	2904	*Component*	IMU	PCS
		Model Number	LN200 (IMU2)	V5
		Serial Number	293	8959
		Calibration	2019-09-26	2019-09-26

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

A.5.3.1 Septentrio AsteRx-U Marine

The AsteRx-U MARINE multi-constellation dual receiver has a horizontal positional accuracy of ±0.02m RMS and a vertical accuracy of ±0.04m. AsteRx-U Marine positioning system on DriX is utilizing Fugro Marinestar RTK correction service in real time.

Manufacturer	Septentrio		
Model	AsteRx-U Marine		
Inventory	*DriX*	*Component*	GNSS Receiver
		Model Number	AsteRx4
		Serial Number	3025773
		Calibration	2019-10-04

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

A.5.5.1 iXblue PHINS

The PHINS C7 is a fiber-optic gyroscope that uses optical waves propagating in a fiber-optic coil to accurately measure a rotation rate. The C7 generates attitude data in three axes (roll, pitch, and heading) to an accuracy of 0.01°.

Manufacturer	iXblue		
Model	PHINS		
Inventory	*DriX*	*Component*	IMU
		Model Number	C7
		Serial Number	2317
		Calibration	2019-10-04

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

A.6.1.1 AML Oceanographic MVP100 Moving Vessel Profiler (MVP)

S222 is equipped with a Rolls-Royce Group Brooke Ocean MVP100 Moving Vessel Profiler (MVP) that is now owned by AML Oceanographic. The MVP system consists of a sensor towfish, a conductor/tow cable, a computer controlled high speed hydraulic winch, and a cable metering system. A Conductivity-Temperature-Depth (CTD) or direct-read sound speed sensor is housed in the sensor towfish and interfaced with the ship acquisition system via the conductor/tow cable. The MVP system provides a means of collecting full water-column data while S222 remains underway. The MVP system on S222 has 320m of cable and can be used to take water-column profiles of approximately 150m in depth at speeds of approximately 10 kts.

Manufacturer	AML Oceanographic		
Model	MVP100 Moving Vessel Profiler (MVP)		
Inventory	*S222*	*Component*	MVP System
		Model Number	MVP 100
		Serial Number	N/A
		Calibration	2019-03-08

Figure 12: MVP winch and towfish during towfish deployment

A.6.2 CTD Profilers

A.6.2.1 AML Oceanographic AML MVP-X

The AML MVP-X is a multi-parameter sensor designed specifically for use with the AML Moving Vessel Profiler (MVP) models. The MVP-X is highly configurable and is compatible with all AML Xchange (tm) oceanographic sensors. The MVP-X configuration used on S222 includes conductivity, temperature and pressure sensors: the conductivity sensors provide a sensor range of 0-90 mS/cm, a resolution of 0.001 mS/cm, with an accuracy of plus/minus 0.01 mS/cm; the temperature sensors provide a sensor range of -5 to +45 Deg C, a resolution of 0.001 Deg C, with an accuracy of plus/minus 0.005 Deg C; the pressure sensors provide a sensor range of 0 to 1000 dBar, a resolution of 0.02% of measurement, with an accuracy of 0.05% of measurement. The main instrument housings on the MVP-X units are rated for operation at pressures up to 6000 dBar.

Manufacturer	AML Oceanographic	
Model	AML MVP-X	
Inventory	*Component*	Probe
	Model Number	AML MVP-X
	Serial Number	9001
	Calibration	2019-03-08

A.6.2.2 Sea-bird Electronics SBE 19plus

The Sea-Bird Electronics SBE 19plus SeaCAT profiler measures conductivity, temperature, and depth (CTD) in marine and/or freshwater environments. The SBE 19plus is rated for use at depths of up to 600 meters and is capable of sampling at a rate of 4 measurements per second. CTD values are used to calculate the speed of sound through the water column.

Sea-Bird Electronics SBE 19plus Conductivity, Temperature, and Depth (CTD) Profilers are used on S222, 2903, and 2904 to collect vertical sound speed profiles. The speed of sound is calculated from temperature, salinity, and pressure measurements. Temperature is measured directly. Salinity is calculated from measured electrical conductivity. Depth is calculated via strain gauge pressure sensor. The system is configured for a sampling rate of 0.5 seconds. CTD equipment is deployed manually aboard TJ launches. The CTD is deployed over the side of the vessel. The CTD is first soaked for 2 minutes before letting the device free fall to the bottom and then recovered at a rate roughly equal to 1 meter per second.

Manufacturer	Sea-bird Electronics	
Model	SBE 19plus	
Inventory	*Component*	CTD
	Model Number	19plus
	Serial Number	19P33589-4487
	Calibration	2019-02-24
	Component	CTD
	Model Number	19plus
	Serial Number	19P36399-4630
	Calibration	2018-05-09

A.6.3 Sound Speed Sensors

A.6.3.1 Teledyne Reson Reson SV-71

The Reson SVP-70 and SVP-71 are direct-read sound speed measurement devices. The SVP devices obtain sound speed measurements by directly measuring the travel time of sound pulses along a set 125 mm transmission path. The SVP systems are capable of reading sound speeds from 1350 to 1800 m/s with a resolution of 0.01 m/s (±0.15m/s) at a sampling rate of 20 Hz.

Reson SV-71 sensors collect the speed of sound at the face of the Kongsberg EM2040 transducers on 2903 and 2904. The sensors are bolted to the mounting sleds near the face of the transducer on each launch. The speed of sound is measured directly using a direct path echosounding sensor. The SV-71 is integrated with the Kongsberg EM2040.

Manufacturer	Teledyne Reson		
Model	Reson SV-71		
Inventory	*2903*	*Component*	Probe
		Model Number	SVP-71
		Serial Number	1213045
		Calibration	2018-08-30
	2904	*Component*	Probe
		Model Number	SVP-71
		Serial Number	1213050
		Calibration	2018-09-02

A.6.3.2 Valeport Limited MODUS SVS Thruhull

The sound speed sensor used in the system is a direct-read 'time of flight' sound speed sensor. The Modus models used aboard S222 use a 100mm measurement path and include temperature sensors. The sound speed sensor can measure sound in fresh water or marine environments with a measurement range of 1400-1600 m/s, at a resolution of 0.001 m/s, with an accuracy of ± 0.03 m/s. The thru-hull port where the sound speed sensor is deployed is located adjacent and aft of the transducer fairing.

Manufacturer	Valeport Limited		
Model	MODUS SVS Thruhull		
Inventory	*S222*	*Component*	Probe
		Model Number	065101
		Serial Number	33711
		Calibration	2019-02-27

Figure 13: Valeport SVS Thruhull installation on S222

A.6.3.3 Valeport Limited miniSVS

The miniSVS Sound Velocity Sensor is a direct-read 'time of flight' sound speed sensor. The sound speed sensor can measure sound in fresh water or marine environments with a measurement range of 1375 - 1900 m/s, at a resolution of 0.001 m/s, with an accuracy of ± 0.02 m/s.

Manufacturer	Valeport Limited		
Model	miniSVS		
Inventory	*DriX*	*Component*	Probe
		Model Number	miniSVS
		Serial Number	72086
		Calibration	2019-09-16

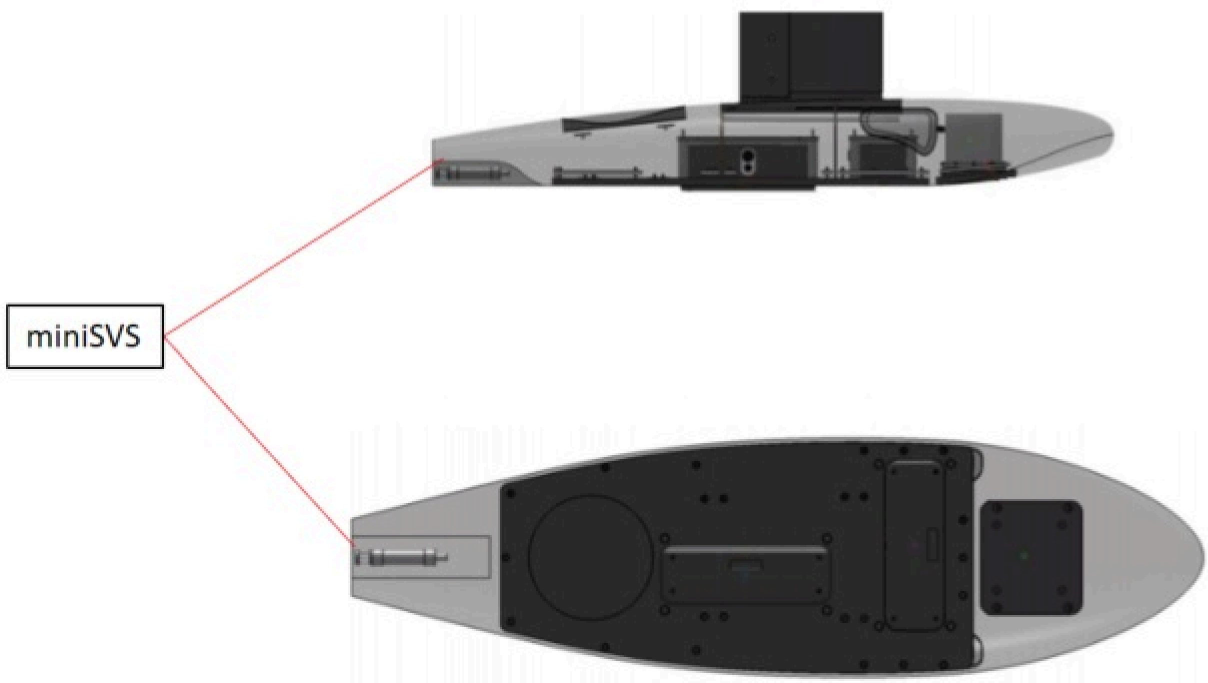

Figure 14: Valeport miniSVS installation in DriX gondola

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
Caris	HIPS	10.4	Processing
Caris	BASE Editor	5.3	Processing
NOAA	Pydro (ie: Charlene, QC tools 3, XmlDR, SHAM, transmission letter, Sound Speed Manager)	19.4	Processing
HYPACK - A Xylem Brand	HYPACK	2018	Acquisition
Applanix Corporation	POSPac MMS	8.4	Processing
Applanix Corporation	POSView	10.0	Acquisition
ESRI, Inc.	ArcGIS	10.6.1	Processing
QPS, Inc	FMGT	7.9.2	Processing
Kongsberg	Seafloor Information System (SIS)	4.3.2	Acquisition
Edgetech	Discover 4200-MP	37.0.1.111	Acquisition
Klein Marine Systems, Inc	SonarPro	14.1	Acquisition
Novatel Waypoint	GrafNav	8.70	Processing
iXblue	APPS	2.0.3	Processing
QPS, Inc	FMGT	7.8.10	Processing
QPS, Inc	Qimera	1.7.6	Acquisition
QPS, Inc	Qinsy	8.18.4	Acquisition
Teledyne Odom	eChart	1.4.0	Aquisition
NOAA	Pydro Explorer	19.4(r10747)	Post processing data integrity and quality management
NOAA	Sounds Speed Manager	2019.2.5	Aquisition and processing
NOAA	QC Tools	3.1.6	Post processing data integrity and quality management
NOAA	Flier Finder	8	Post processing data integrity and quality management
NOAA	Grid QA	5	Post processing data integrity and quality management
NOAA	Holiday Finder	4	Post processing data integrity and quality management
NOAA	Gridded Surface Comparison	19.4(r10747)	Post processing data integrity and quality management

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco Model #1728

The Ponar Wildco is a winch-deployed bottom sampler used aboard S222. The sampler is a Ponar type grab sampler of a design commonly used to sample a wide variety of sediment types. The sampler design uses self-tripping center hinged jaws and a spring loaded trigger pin that releases when the sampler makes impact with the bottom. The sampler's jaws are closed by the scissor action of the lever arms when the sampler is retrieved. The sampling area is 6" x 6".

Figure 15: Ponar Wildco bottom sampler

A.8.1.2 Kahlisco Mud Snapper 214WA100 (AKA 'The Nibbler')

The Kahlisco Mud Snapper is a hand held bottom sampler used to take bottom samples from 2903 and 2904. The Mud Snapper is a foot-trip model clam shell style bottom sampler. This sampler is designed to collect unconsolidated sediments up to the size of small pebbles. The sampler is fabricated from sturdy bronze and stainless steel materials for trouble-free service in a marine environment. The unit consists of a long threaded post surrounded by a strong compression spring that presses against the jaws at one end and an adjustable screw cap at the upper end. By turning this threaded cap the spring-compression is adjusted, changing the strength at which the jaws close. A shackle is attached through a hole on the top of the post and a line attached. Due to the small size of this sampler, it may be deployed either by using a heavy-duty fishing pole or a handline.

Figure 16: Kahlisco Mud Snapper bottom sampler

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

All offsets for S222 are derived from full surveys performed by Kongsberg USA-contracted personnel and have been verified by Hydrographic Systems and Technology Branch (HSTB) personnel. Offset values are known in the vessel reference frame, the IMU reference frame, and Kongsberg reference frame. Offset values for the Kongsberg MBES systems are entered into SIS and the ship's Caris HIPS Hydrographic Vessel File (HVF), with the exception of the orthogonal offsets between the primary GNSS sensor antenna and the Applanix IMU. The offset between the primary GNSS antenna and the IMU is applied to the POS MV. The POS MV provides navigation and attitude data in the IMU reference frame at the IMU reference point. All other offsets are applied to data during the SVP or Merge processing steps in CARIS HIPS.

All offsets for 2903 and 2904 are derived from full vessel surveys performed by personnel from the National Geodetic Survey (NGS). Offset values are known in the vessel reference frame, the IMU reference frame, and Kongsberg reference frame. Offset values for the Kongsberg MBES systems are entered into POS/MV, with the exception of the orthogonal offsets between the transducer and receiver. These values are entered into SIS and the HSL's Caris HVF. The offset between the primary GNSS antenna and the IMU is applied within the POS/MV. The reference point for the HSL's is the Kongsberg EM2040 transducer face. The POS/MV provides navigation and attitude data in the Kongsberg reference frame at the transducer face reference point. All other offsets are applied to data during the SVP or Merge processing steps in CARIS HIPS.

All offsets for the DriX are derived from a full vessel survey performed by iXblue personnel. Offset values are known in the vessel reference frame, the IMU reference frame, and Kongsberg reference frame. Offset values for the Kongsberg MBES systems are entered into SIS and the ship's Caris HVF, with the exception of the orthogonal offsets between the primary GNSS sensor antenna and the iXblue IMU. The offset between the primary GNSS antenna and the IMU is applied within AsteRx-U Marine software. The reference point for the DriX is the IMU. The AsteRx-U Marine provides navigation in the IMU reference frame at the IMU reference point. All other offsets are applied to data during the SVP or Merge processing steps in CARIS HIPS.

Offsets are applied to side scan sonar data during the Compute Towfish Navigation step.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the Appendices to this report. HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere and include all of the requested values for the DAPR necessary to reproduce an HVF.

For a detailed look at the applied lever arms and mounting angles, refer to the appendices.

B.1.1.1 Vessel Offset Correctors

Vessel	2903			
Echosounder	Kongsberg EM2040			
Date	2019-11-12			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.205 meters	0.020 meters
		y	0.152 meters	0.020 meters
		z	0.536 meters	0.020 meters
		x2	-0.100 meters	0.020 meters
		y2	0.052 meters	0.020 meters
		z2	0.520 meters	0.020 meters
	Nav to Transducer	*x*	0.922 meters	0.020 meters
		y	0.896 meters	0.020 meters
		z	4.185 meters	0.020 meters
		x2	0.617 meters	0.020 meters
		y2	0.796 meters	0.020 meters
		z2	4.169 meters	0.020 meters
	Transducer Roll	*Roll*	-0.965 degrees	

Vessel	2903			
Echosounder	Kongsberg EM2040			
Date	2019-09-26			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.177 meters	0.020 meters
		y	0.141 meters	0.020 meters
		z	0.577 meters	0.020 meters
		x2	-0.128 meters	0.020 meters
		y2	0.041 meters	0.020 meters
		z2	0.561 meters	0.020 meters
	Nav to Transducer	*x*	0.922 meters	0.020 meters
		y	0.896 meters	0.020 meters
		z	4.185 meters	0.020 meters
		x2	0.617 meters	0.020 meters
		y2	0.796 meters	0.020 meters
		z2	4.169 meters	0.020 meters
	Transducer Roll	*Roll*	-0.021 degrees	

Vessel	2904			
Echosounder	Kongsberg EM2040			
Date	2019-07-08			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.165 meters	0.020 meters
		y	0.143 meters	0.020 meters
		z	0.579 meters	0.020 meters
		x2	-0.115 meters	0.020 meters
		y2	0.057 meters	0.020 meters
		z2	0.522 meters	0.020 meters
	Nav to Transducer	*x*	0.923 meters	0.020 meters
		y	0.889 meters	0.020 meters
		z	4.193 meters	0.020 meters
		x2	0.618 meters	0.020 meters
		y2	0.789 meters	0.020 meters
		z2	4.177 meters	0.020 meters
	Transducer Roll	*Roll*	-0.050 degrees	

Vessel	2904			
Echosounder	Kongsberg EM2040			
Date	2019-12-05			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	0.165 meters	0.020 meters
		y	0.144 meters	0.020 meters
		z	0.579 meters	0.020 meters
		x2	-0.140 meters	0.020 meters
		y2	0.044 meters	0.020 meters
		z2	0.563 meters	0.020 meters
	Nav to Transducer	*x*	0.923 meters	0.020 meters
		y	0.889 meters	0.020 meters
		z	4.193 meters	0.020 meters
		x2	0.618 meters	0.020 meters
		y2	0.789 meters	0.020 meters
		z2	4.177 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

Vessel	2904			
Echosounder	Kongsberg EM2040			
Date	2019-12-18			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	0.165 meters	0.020 meters
		y	0.144 meters	0.020 meters
		z	0.579 meters	0.020 meters
		x2	-0.140 meters	0.020 meters
		y2	0.044 meters	0.020 meters
		z2	0.563 meters	0.020 meters
	Nav to Transducer	*x*	0.923 meters	0.020 meters
		y	0.889 meters	0.020 meters
		z	4.193 meters	0.020 meters
		x2	0.618 meters	0.020 meters
		y2	0.789 meters	0.020 meters
		z2	4.177 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

Vessel	DriX			
Echosounder	Kongsberg EM2040			
Date	2019-09-01			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	-0.038 meters	0.002 meters
		y	-0.660 meters	0.002 meters
		z	0.150 meters	0.002 meters
		x2	0.034 meters	0.002 meters
		y2	-0.260 meters	0.002 meters
		z2	0.134 meters	0.002 meters
	Nav to Transducer	*x*	-0.010 meters	0.002 meters
		y	0.030 meters	0.002 meters
		z	4.380 meters	0.002 meters
		x2	0.062 meters	0.002 meters
		y2	0.430 meters	0.002 meters
		z2	4.364 meters	0.002 meters
	Transducer Roll	*Roll*	0.090 degrees	
		Roll2	0.090 degrees	

B.1.2 Layback

Towfish positioning is provided to CARIS HIPS using cable-out values registered by the Totco cable counter and recorded in the SonarPro SDF files. SonarPro uses Payout and Towfish Depth to compute towfish positions. The towfish position is calculated from the position of the tow point using the cable-out value received by SonarPro from the cable payout meter, the towfish pressure depth (sent via a serial interface from the Klein 5000 TPU to the SonarPro software), and the Course Made Good (CMG) of the vessel. This method assumes that the cable is in a straight line. Therefore, no catenary algorithm is applied at the time of acquisition, but in processing, CARIS SIPS applies a 0.9 coefficient to account for the catenary.

Layback error is calculated by running a side scan certification test. This test consists of running parallel to a known feature at varying ranges from nadir to ensonify the target in the near-field (approximately 15% of range scale in use), mid-field (approximately 50 % of range scale in use), and far-field (approximately 85% of the range scale in use). The test requires that each side of the sonar ensonify the feature at each of these areas in the swath. Then the test is repeated in a direction that is orthogonal to the original set of lines such that the feature is ensonified a total of 12 times. A successful test will detect the feature in at least 10 of the 12 passes. For hull-mounted systems, the selected contact positions must be within 5m; for towed systems, the contact positions must be within 10m. Layback error is the amount of correction that must be applied to minimize the distance between contact positions.

B.1.2.1 Layback Correctors

<table>
<tr><td>Vessel</td><td colspan="3">S222</td></tr>
<tr><td>Echosounder</td><td colspan="3">Klein 5000v1</td></tr>
<tr><td>Frequency</td><td colspan="3">455 kHz</td></tr>
<tr><td>Date</td><td colspan="3">2019-11-10</td></tr>
<tr><td rowspan="4">Layback</td><td rowspan="3">Towpoint</td><td>x</td><td>6.370 meters</td></tr>
<tr><td>y</td><td>-42.550 meters</td></tr>
<tr><td>z</td><td>-4.800 meters</td></tr>
<tr><td>Layback Error</td><td colspan="2">-1.250 meters</td></tr>
</table>

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Static draft is measured on the S222 using a Sutron Bubbler system. The orifice was surveyed into the IMU reference frame and a waterline height was calculated. A common waterline for the ship when fully loaded with fuel and ballasted normally is approximately 35cm below the reference point of the ship, but the waterline may change by as much as +/- 30cm over the course of a field season.

The static draft is not applied to soundings for ERS surveys.

The waterline for S222 is measured at least weekly. When feasible, waterline measurements are taken before and after fueling or ballasting of the ship. The values are kept in a static draft log and periodically updated in the HVF. Once applied in the HVF, all affected lines have SVP re-applied and are then merged so that the updated waterline measurements will be applied.

The waterline for HSL platforms is measured using physical measurements from the waterline of the vessel to physical known benchmarks.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.2.1.1 Static Draft Correctors

Vessel		S222	2903	2904	DriX
Date		2019-10-25	2019-07-16	2019-07-16	2019-10-04
Loading		0.1 meters	0.03 meters	0.03 meters	0.1 meters
Static Draft	*Measurement*	0.402 meters	-0.615 meters	-0.618 meters	1.9 meters
	Uncertainty	0.03 meters	0.03 meters	0.03 meters	0.02 meters

B.2.2 Dynamic Draft

Dynamic draft for all platforms was measured using the Post Processed Kinematic GPS method outlined in section 1.4.2.1.2.1 of NOAA's FPM. To reduce the effect of any potential current, reciprocal lines were run at each RPM step in order to get an average speed over ground for each RPM. This average speed was used to estimate the vessel's speed through the water. Dynamic draft and vessel offsets corrector values are stored in the Hydrographic Vessel Files (HVF).

In ERS surveys (those that use recorded GPS heights corrected via a VDatum SEP model to achieve tidal datum) the dynamic draft correction is not applied to the soundings.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF can be found in the HVF Values section in the DAPR appendices. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.2.2.1 Dynamic Draft Correctors

Vessel	S222		2903		2904	
Date	2019-10-15		2019-06-01		2019-07-07	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*	*Speed (m/s)*	*Draft (m)*	*Speed (m/s)*	*Draft (m)*
	0.00	0.00	0.00	0.00	0.00	0.00
	0.50	0.00	0.50	-0.01	0.50	-0.17
	1.00	0.02	1.00	-0.00	1.00	-0.13
	1.50	0.06	1.50	0.01	1.50	0.00
	2.00	0.09	2.00	0.03	2.00	0.02
	2.50	0.11	2.50	0.05	2.50	0.04
	3.00	0.13	3.00	0.06	3.00	0.05
	3.50	0.16	3.50	0.07	3.50	0.06
	4.00	0.20	4.00	0.06	4.00	0.06
	4.50	0.29	4.50	0.04	4.50	0.04
	5.00	0.46	5.00	0.01	5.00	0.01
			5.50	-0.05	5.50	-0.23
			6.00	-0.13	6.50	-0.12
					7.00	-0.17
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*	*Vessel Speed (m/s)*	*Delta Draft (m)*	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.50	0.04	0.50	0.02	0.50	0.03

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

THOMAS JEFFERSON conducts MBES calibration tests during annual HSRR activities for each individual multibeam system on the ship and her launches.

The procedure used is outlined in Section 1.5.5.1 of the Field Procedures Manual dated April 2014. The method used to determine timing bias was running the same line at different speeds. Pitch and yaw bias was determined using a target on the seafloor. Finally, roll bias was determined using the standard flat bottom method. Offset values for all platforms were derived using Caris' patch testing tools during annual HSRR activities.

Patch test values for S222, 2903, and 2904 are applied within POS MV software at acquisition. DriX patch test values are applied during the SVP correction step in post-processing.

A patch test was conducted incorrectly on 5/23/2109 for 2904. Data collected on 5/23/2019 was collected with incorrect settings applied within POS MV. As a result, a 0.302 roll offset artifact was observed in four days of data from Project OPR-E350-TJ-19. The correct offset value of 0.302 was applied to the data collected with the incorrect patch test values via SVP2 within the Caris HVF for 2904 for those four days, and corrected in post-processing while correcting for sound speed. Additional roll offsets were observed in the data for Project OPR-E350-TJ-19 after a correct patch test was conducted. A 0.07° roll offset was applied to 2904 data acquired from 5/23/2019 to 6/1/2019, and a roll offset of 0.11 ° was applied to 2904 data acquired from 6/1/2019 to 7/15/2019. These additional roll offsets were applied via SVP2 within the Caris HVF for 2904, and corrected in post-processing while correcting for sound speed. These additional roll values were added to the POS MV offsets and subsequently set to zero within the HVF for data acquired after 7/15/2019.

Additional roll offset artifacts were observed in 2903 data from Project OPR-D304-TJ-10. A 0.10° roll offset was applied to data acquired on 10/24/2019. The additional roll offset was applied via SVP2 within the Caris HVF for 2903, and corrected in post-processing while correcting for sound speed.

A vertical difference of 50cm was observed in the SBES (Single Beam Echo Sounder) data from 2903 when compared with the reference surface from 2904’s EM2040 MBES (Multibeam Echo Sounder) data. After further investigation, the offset was attributed to the Draft and Index value within the ODOM controller software eChart. The ODOM manual states that the bar check procedure is used to correct for sound speed in case a sound speed probe is not used. Sound speed was then corrected for during post-processing, resulting in double correction for sound speed. Within the Caris HVF, the reciprocal value of the Draft and Index value was used in order to back out the values from the raw data. The value set under SVP1 within the HVF is -0.49.

DriX patch test and values were provided by iXblue survey personnel.

All calibration reports can be found in the appendices.

B.3.1.1 System Alignment Correctors

Vessel	S222
Echosounder	Kongsberg EM2040
Date	2019-01-01

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.001 seconds
Navigation Time Correction	0.000 seconds	0.001 seconds
Pitch	0.000 degrees	0.020 degrees
Roll	0.000 degrees	0.020 degrees
Yaw	0.000 degrees	0.020 degrees
Pitch Time Correction	0.000 seconds	0.001 seconds
Roll Time Correction	0.000 seconds	0.001 seconds
Yaw Time Correction	0.000 seconds	0.001 seconds
Heave Time Correction	0.000 seconds	0.001 seconds

Vessel	2903
Echosounder	Kongsberg EM2040
Date	2019-06-01

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.001 seconds
Navigation Time Correction	0.000 seconds	0.001 seconds
Pitch	0.000 degrees	0.020 degrees
Roll	0.000 degrees	0.020 degrees
Yaw	0.000 degrees	0.020 degrees
Pitch Time Correction	0.000 seconds	0.001 seconds
Roll Time Correction	0.000 seconds	0.001 seconds
Yaw Time Correction	0.000 seconds	0.001 seconds
Heave Time Correction	0.000 seconds	0.001 seconds

Vessel	2904		
Echosounder	Kongsberg EM2040		
Date	2019-06-01		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	0.000 degrees	0.020 degrees
	Roll	0.000 degrees	0.020 degrees
	Yaw	0.000 degrees	0.020 degrees
	Pitch Time Correction	0.000 seconds	0.001 seconds
	Roll Time Correction	0.000 seconds	0.001 seconds
	Yaw Time Correction	0.000 seconds	0.001 seconds
	Heave Time Correction	0.000 seconds	0.001 seconds

Vessel	DriX		
Echosounder	Kongsberg EM2040		
Date	2019-09-01		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.005 seconds
	Navigation Time Correction	0.000 seconds	0.005 seconds
	Pitch	0.000 degrees	0.020 degrees
	Roll	0.000 degrees	0.020 degrees
	Yaw	0.000 degrees	0.020 degrees
	Pitch Time Correction	0.000 seconds	0.050 seconds
	Roll Time Correction	0.000 seconds	0.050 seconds
	Yaw Time Correction	0.000 seconds	0.050 seconds
	Heave Time Correction	0.000 seconds	0.050 seconds

<table>
<tr><td>Vessel</td><td>2903</td></tr>
<tr><td>Echosounder</td><td>Teledyne Odom Echotrac CV200</td></tr>
<tr><td>Date</td><td>2019-06-01</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>0.001 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Pitch</td><td>0.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Roll</td><td>0.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Yaw</td><td>0.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.001 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

During the DriX project, 2903 and the DriX worked in conjunction with S222 to obtain multibeam data. The DriX operated at ranges up to 8000 meters from the ship. While surveying, the DriX was controlled by a pilot station in automatic mode, running survey lines provided by THOMAS JEFFERSON's survey team while S222 ran a set of parallel lines nearby. Following the workflow outlined below, the DriX hydrographer and the THOMAS JEFFERSON hydrographer worked together to conduct CTD casts at intervals that satisfied the needs of both vessels. Casts taken for the DriX by THOMAS JEFFERSON were provided to the DriX hydrographer via a shared drive.

All multibeam data are logged using Kongsberg Seafloor Information System (SIS) in the .all file format.

During acquisition aboard S222, 2903, and 2904 the hydrographer:

- Monitors the SIS interface for errors and data quality

- Monitors the SIS interface for indication of sound speed changes requiring a cast, and conducts casts as necessary

- Monitors the Hysweep interface in HYPACK

- Monitors the vessel speed and requests the bridge to adjust as necessary to ensure density and coverage specifications are met

During acquisition for DriX, the hydrographer:

- Monitors the SIS interface for errors and data quality

- Monitors the SIS interface for indication of sound speed changes requiring a cast, and requests casts as necessary

- Monitors the Quincy interface

- Monitors the vessel speed and adjusts as necessary to ensure density and coverage specifications are met

The DriX is an Autonomous Surface Vessel (ASV) and operated in tandem with THOMAS JEFFERSON by running survey lines to the port or starboard of the ship with the objective to stay within 500m.

Data Processing Methods and Procedures

The following workflow applies to S222, 2903, and 2904 for Applanix RTX with Kongsberg EM2040:

1) Create SBET and RMS files in POSPac MMS.
2) Convert raw .all data to Caris HDCS format
3) Load Delayed Heave
4) Import ancillary data: SBET and RMS
5) Apply sound speed correctors
6) Compute GPS Tides using the provided VDatum SEP model.
7) Merge; use GPS Tides.
8) Compute Total Propagated Uncertainty (TPU)
9) Create a Combined Uncertainty and Bathymetry Estimator (CUBE) surface
10) Data quality control and analysis

The following workflow applies to DriX for Fugro Marinestar with Kongsberg EM2040:

1) Create SBET and RMS files in GrafNav.
2) Convert raw .all data to Caris HDCS format
3) Import ancillary data: SBET and RMS
4) Apply sound speed correctors
5) Compute GPS Tides using the provided VDatum SEP model.
6) Merge; use GPS Tides.
7) Compute Total Propagated Uncertainty (TPU)
8) Create a Combined Uncertainty and Bathymetry Estimator (CUBE) surface

9) Data quality control and analysis

The following options are selected when CUBE surfaces were created:

- 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).

- Advanced Configuration – Dependent upon the surface resolution (Object detection v. complete coverage)

Preliminary data cleaning is performed daily. Typically, the reviewer only cleans out the most blatant of fliers and blowouts, leaving the final cleaning to a later date when all data is consolidated. Depth, Standard Deviation, Hypothesis Strength and Hypothesis Count models derived from the acquisition operation day surface are viewed with appropriate vertical exaggeration and a variety of sun illumination angles to highlight potential problem areas. Based on this analysis the most appropriate cleaning method is selected as follows:

- Subset Mode is the default tool selected due to its ability to quickly compare large numbers of soundings with adjacent or overlapping data for confirmation or rejection. Subset mode also excels with the assessment of possible features, disagreement between overlapping lines, and crossline comparison. Subset Mode can be used to visually enhance patterns and anomalies in CUBE surfaces.

- Swath Editor is useful for burst noise, multipath, and other "gross fliers" which are specific to a particular line or lines, and most easily removed in this mode. Additionally, when it was felt that the quality of the data was reduced due to environmental conditions such as rough seas or extreme variance in sound velocity, data were filtered on a line by line basis to a lesser swath width to ensure data quality.

Once all the data is cleaned, the CUBE surfaces are examined to ensure complete coverage and to plan additional lines or polygons to fill “holidays.”

C.1.2 Single Beam Echosounder

<u>Data Acquisition Methods and Procedures</u>

eChart software was used at acquisition to turn the sonar on and off. A bar check was performed and values saved in the eChart software with an index value of 0.21 and a draft value of 0.7m. Hypack was used to collect single beam echo sounder data in the .RAW format. See section B.3.1 System Alignment Methods and Procedures for alignment and configuration of the single beam echo sounder due to issues with the index value and draft value in the eChart software.

Data Processing Methods and Procedures

One workflow exist for VBES and is outlined below.

Applanix RTX with Teledyne Odom Echotrac CV200:

1) Create SBET and RMS files in POSPac MMS.
2) Convert raw .RAW data to Caris HDCS format
3) Load Delayed Heave
4) Import ancillary data: SBET and RMS
5) Apply sound speed correctors
6) Compute GPS Tides using the provided VDatum SEP model.
7) Merge; use GPS Tides.
8) Compute Total Propagated Uncertainty (TPU)
9) Create a Combined Uncertainty and Bathymetry Estimator (CUBE) surface
10) Data quality control and analysis

Preliminary data cleaning is performed daily. The most appropriate cleaning method is selected as follows:

- Single Beam Editor is the default tool used. Single beam Editor is useful for "gross fliers" which are specific to a particular line or lines, and most easily removed in this mode.

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

After initial processing, the bathymetric data are gridded into BASE surfaces using the Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm. This type of surface calculates a horizontal and vertical uncertainty for each sounding, derived from the combined uncertainty from each of the sensors that contributes data to the sounding (e.g water levels, tide zoning, attitude sensor error, navigation sensor horizontal position error, and sound speed profile error). Individual soundings are then propagated to grid nodes, which takes on a depth value as well as an uncertainty value based on all the soundings that contribute to the node. The influence of a sounding on a grid node is limited to 0.354 times the grid resolution. Resolution is determined by the Project Instructions and the HSSD 2019.

On a daily bases Single Resolution (SR) surfaces are created at the required resolution for holiday planning and data "cleaning" in order to efficiently maximize the operational time frame. For the final submission of the project a Variable Resolution (VR) surface is created and submitted as the deliverable product. When creating VR surfaces, the estimation method typically used is "Ranges". If significant "holidays" are observed in the CUBE surface after creation that is not observed within the data a new CUBE surface is created with the "Calder-Rice Density" estimation method with the finest resolution set at the required resolution as specified by the Project Instructions and the HSSD 2019.

VBES is grided as a SR CUBE surface at 4m resolution. VBES surfaces include the Shoal child layer.

C.1.4.2 Depth Derivation

Chart-datum depths are derived using tidal models provided to the field unit, usually in the form of a VDatum separation model that corrects for height disagreements between the acquisition datum (Ellipsoidal) and chart datums (Mean Lower Low Water). Anomalous data (fliers) may induce false gridded depth estimates and draw gridded depth nodes away from reliable soundings. Flier Finder within QC Tools is used to help identify such anomalous soundings for the hydrographer to flag the soundings from use with the submitted sounding dataset.

C.1.4.3 Surface Computation Algorithm

MBES data are gridded using the CUBE algorithm. Resolution is dictated by the Project Instructions, as well as section 5.2.2 of the HSSD 2019. The disambiguation method used is always Density and Local. The settings used for Capture Distance Scale, Horizontal Error Scale, and Capture Distance Minimum are those listed in section 4.2.1.1.1.1 of the 2014 FPM and are provided by the NOAA Office of Coast Survey (OCS) in a customized CUBE parameters file (CUBEParams_NOAA_2019.xml). After creation, Uncertainty and CUBE surfaces go through a quality control process. During this process, the Depth, Uncertainty, Standard Deviation, and Density child layers are examined for compliance with NOAA specifications. After the surfaces pass quality control, they are finalized. Uncertainty values for finalized surface come from the greater of either Uncertainty, or Standard Deviation.

The Advanced options configuration is employed when creating a VR surface. Estimation method parameters for Density-based CARIS VR Surfaces have the estimation method: "Ranges", with the range/resolution file set to NOAA_DepthRanges_CompleteCoverage_2019.txt or NOAA_DepthRanges_ObjectDetection_2019.txt depending on the coverage requirements. If significant "holidays" are observed in the CUBE surface after creation that is not observed within the data a new CUBE surface is created with the "Calder-Rice Density" estimation method with the finest resolution set at the required resolution. NOAA OCS has created and provided a customized CUBE parameters file (CUBEParams_NOAA_2019.xml) with new CUBE parameters that are required for each grid resolution. When creating CUBE surfaces, the user is provided an option to select parameters configuration based on the surface resolution required for the survey, which optimizes the performance of the CUBE algorithm. The Population parameters for CARIS VR surfaces is CUBE, with the IHO Order selected and set to "S44 Order 1a", and the CUBE configuration is "NOAA_VR" for a given surface.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

MBES backscatter data are logged via SIS and are included in the MBES files (.all format) by default.

The absorption coefficient depends upon depth, water temperature, salinity and frequency. A correct value is important with respect to the validity of the bottom backscatter data measured by the system.

The normal incidence sector, (angle from nadir in degrees), defines the angle at which the bottom backscatter can be assumed not to be affected by strong increase at normal incidence. For seabed imaging, it is important to adjust this angle to minimize angle-dependent amplitude variation. The value for this parameter is kept at 15 degrees unless otherwise documented.

The parameters set in SIS for pulse type is set to auto with FM disabled. The intensity values of the backscatter return are effected by sudden changes to the pulse length. Switching between pulse lengths mid-line is not ideal for backscatter acquisition and it is recommended not to use Auto for the pulse length when acquiring backscatter. With the operational depths that THOMAS JEFFERSON and her launches operate in the default pulse length selected by Auto is Short CW and there is no indication that there was use of a different pulse length within the project.

Data Processing Methods and Procedures

All acquired backscatter data are processed into a mosaic and delivered to Atlantic Hydrographic Branch. All processing of backscatter is done using the FMGT (7.9.2) module of the QPS Fledermaus software package in accordance with OCS standard data processing methods using standard operating procedure OCSQMS_SOP_Backscatter_Processing.pdf dated August 7, 2018.

The following is the general workflow for creating backscatter imagery:

1) A new project is created for each sheet and each vessel and each sonar frequency. Meta data within the .all files ensures that sonar-specific characteristics are captured during mosaic processing.

2)Lines are imported into FMGT. One mosaic is created per boat and frequency (200kHz, 300kHz, and 400kHz), meaning three mosaics are created, one for each frequency.

3) Create a mosaic. Crosslines are not needed in the mosaic and are deselected. Mosaic gridding resolution is set to 1m. The product is exported as a floating point GeoTIFF grid with a value for no data set to -9999.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

Side scan sonar data collected with the Klein 5000 SSS are logged using Klein SonarPro, in the .SDF format.
Data collected with the Edgetech 4200 SSS were logged in Edgetech Discover in .XTF format.
During acquisition the hydrographer:

- Monitors range, towfish height, heading, pitch, roll, latitude, longitude, speed, pressure, and temperature;

- Adjusts towfish height (for operations aboard S222)

Data Processing Methods and Procedures

1) Convert raw SSS data using Caris SIPS;
2) Scan Navigation and Attitude data, flagging erroneous data as rejected;
3) Re-compute towfish navigation. This is when tow point offsets and horizontal layback is applied to the data;
4) A primary reviewer scans each line for significant contacts;
5) A secondary reviewer makes an independent check-scan of all lines, verifying contacts and checking for missed contacts;
6) If the Project Instructions call for 200% Side Scan coverage, the scanners check correlation of contacts between 100% and 200% coverage;
7) Correlation is also used to reveal systematic errors, particularly if a contact shows up on lines collected in opposite or orthogonal directions;
8) Create individual mosaics for 100% and 200% coverage. Examine for coverage;
9) If necessary, create a holiday line plan.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

DGPS data was not acquired.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

Raw GNSS-INS observables data are logged through POSView for S222, 2903, and 2904.

Raw GNSS-INS observables data are logged through Septentrio reciever and logged as .SBF for DriX.

Data Processing Methods and Procedures

THOMAS JEFFERSON reduces all data to chart datum via Ellipsoidally Referenced Survey (ERS) workflows for all surveys.

GPS Tides:

The ‘Compute GPS Tides’ process in Caris HIPS is the primary means by which bathymetric data are reduced to chart datum. The Compute GPS Tides step references all MBES data to an ellipsoid and then applies a separation model to the ellipsoidally referenced data to achieve reduction to chart datum. The separation model is an XYZ surface that represents the difference between the ellipsoid and chart datum for the a given geographic area. The XYZ separation model used for typical NOAA workflows is delivered as a Caris CSAR file and represents the difference between the WGS84 ellipsoid and MLLW at a given location. All separation models for waters in which THOMAS JEFFERSON operates are derived from the National Geodetic Survey Vertical Datum (VDatum) program. Separation models are usually generated, approved and disseminated by the Hydrographic Survey Division Operations Branch.

GNSS positioning methods employed to meet ERS specifications include the methods described below:

Raw GNSS-INS observables data are logged through POSView can be post-processed in POSPac MMS to provide a trajectory solution that can be applied to MBES data in CARIS HIPS. Post-Processed Trimble CenterPoint real-time extended is the standard practice for S222, 2903, and 2904.

Inertially aided Fusion Post-Processed real-time extended:

During post-processing, horizontal positioning can be shifted to an Inertially aided Fusion Post-Processed real-time extended (Trimble PP-RTX) solution. The solution is created by combining GPS/GNSS satellite ephemeris and clock data with position information downloaded from a network of Continually Operating Reference Stations (CORS). The resulting position data are corrected for the effects of atmospheric interference on the GPS signal. The corrected GPS position is then combined with the vessel's inertial data using the POSPac MMS program to create a Smoothed Best Estimate of Trajectory (SBET). The resulting position can be used to apply higher quality navigation information to the processed data.

Real-time Precise Point Positioning (RT3P):

DriX uses the Fugro Marinestar satellite based corrector service to provide real-time correction to the horizontal position and ellipsoid height for all data acquisition. The corrector signal is received on the L1 channel of the primary GPS antenna and logged directly into the Septentrio file .SBF. The data are then put out in real time to the EM2040, and positional and motion data are applied to the acquired bathymetry.

Post-processed Precise Point Positioning (5P):

Raw GNSS-INS observables and Marinestar corrector data logged through Septentrio reciever can be post-processed in GrafNav to provide a trajectory solution that can be applied to MBES data in CARIS HIPS. 5P is the standard practice for DriX.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

As described in Section A.5 of this document.

Data Processing Methods and Procedures

As described in Section C.3 of this document.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

S222 uses an ML MVP-X Probe installed inside an MVP free-fall fish to acquire sound speed profiles. Profiles aboard the ship are generally acquired at 30 - 90 minute intervals. Cast frequency is increased when the comparisons show significant variability. Sampling intervals are adjusted to ensure spatial variability or if there is suspicion of sudden changes in the water-column.

The Moving Vessel Profiler (MVP) is an automated winch system that deploys a towfish containing a sound speed sensor. The fish is towed behind S222 in a ready position that is marked by messengers attached to the tow cable. The towfish is typically deployed at a ready depth that is approximately the same depth of the ship MBES transducers. Deployment depth is a function of water depth. The towfish descends at the rate of freefall when deployed. Towfish freefall is automatically stopped once a specified depth limit is met and the drag forces on the fish cause it to rise toward the surface due to the ship's forward motion. The cable slack is then pulled in by the winch to the ready towing position.

DriX was supplied with CTD casts from THOMAS JEFFERSON's MVP System in real time. Due to the IT constraints when using public and or commercial equipment not vetted by IT personnel, sound speed casts profiles were transfered between THOMAS JEFFERSON and DriX by the use of a USB flash drive. After each cast transfer the USB drive was scanned by onboard ET's for the safety and integrity of THOMAS JEFFERSON's network infrastructure. The sound speed cast was given to iXblue personnel by way of a USB drive and the iXblue personnel transfered the file to the Kongsberg system located on the DriX ASV via radio uplink.

2903 and 2904 both use Sea-Bird SBE 19plus CTDs to collect sound speed profiles. Casts are generally taken at 2-4 hour intervals. Casts are also conducted when changing survey areas or when a change of weather, tide, or current warrant. The launch crew also monitors the real time display of the Reson SVP-71 sound speed probe for significant changes in the surface sound speed.

The following procedure is followed when conducting manual CTD casts with the SBE 19plus: The instrument is lowered into the water and submerged just below the water's surface for about 1 minute to allow air to escape the salinity cell. The instrument is lowered at the rate of free fall. The instrument is lowered slowly (in some cases, much less than 1 meter/second) through the first 5-10 meters of water in order to accurately sample the sound speed for areas with lenses of fresh water or other complex sound speed variation near the surface.

Data Processing Methods and Procedures

Downloading and processing of sound speed data are performed using Sound Speed Manager v.2019.2.5, part of the HSTB-supplied Pydro Explorer v19.4(r10747) program suite. Sound speed values are calculated using the UNESCO equation (Fofonoff and Millard, 1983). Processed profiles are sent to SIS for realtime beam control. In addition, both raw and processed CTD files are archived and submitted to Atlantic Hydrographic Branch as part of the survey submission package.

All sound speed profiles for CARIS are concatenated into a vessel-wide or survey-wide files in order of ascending time and date. These concatenated file(s) are applied to all HDCS data acquired with "Nearest in distance within time (4 Hours)" selected under the "Profile selection Method".

Processed sound speed data are applied to the MBES data in Caris HIPS.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

S222 and DriX use a Valeport probe to find the speed of sound at the approximate depth of the Kongsberg transducers.

2903 and 2904 use Reson SV-71 probes to acquire sound speed at their respective transducer faces.

Sound speed values are applied in real-time to all MBES systems to provide refraction corrections to flat-faced transducers.

The accuracy of each surface sound speed device is checked against the closest CTD data point after every CTD cast.

Data Processing Methods and Procedures

Surface sound speed data are logged directly into Kongsberg raw data files. Surface sound speed data are not typically processed after the time of acquisition.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

Total Propagated Uncertainty (TPU) is calculated in Caris HIPS using the 'Compute TPU tool'.

The uncertainty values for each input into the TPU model can come from one of three sources: Real-time, Static, or Vessel. Real-time values are provided from the sensor or processing package (e.g. POSPac RMS values). Static values are those entered manually into the Compute TPU dialog (e.g. tidal zoning uncertainty and sound speed measurement uncertainties). Static values are documented in each Descriptive Report. Vessel values are taken from the HVF if no realtime or static values are available.

Uncertainty values entered into the HVF for the multibeam and positioning systems are derived from manufacturer specifications sheets for each sensor and from values set forth in section 4.2.3.8 and Appendix 4 - Caris HVF Uncertainty Values of the 2014 FPM.

Sound speed static values are derived from the guidance in the FPM, manufacturer specifications and annual calibration results.

Tide correction uncertainty values for the ERS work flow are static values specified in the Project Instructions.

Ellipsoid height uncertainty values for ellipsoid measurements derived from 5P or Trimble PP-RTX work flows are applied as real-time values from RMS files. Kongsberg systems provide uncertainty statistics that are recorded in raw MBES files.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

See included HVFs for information on vessel uncertainty values.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

A priori uncertainty was not applied.

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
S222	As discussed above.
2903	As discussed above.
2904	As discussed above.
DriX	As discussed above.

C.7 Shoreline and Feature Data

<u>Data Acquisition Methods and Procedures</u>

The following workflow is used to develop and verify features:

1) Potentially significant features are initially identified and inspected in Caris HIPS (both MBES and SSS contacts).

2) A development area polygon or point feature is exported from HIPS; a line plan is created using HIPS or ArcMap if needed.

3) Object Detection level MBES data are collected over all MBES and/or SSS contacts, VBES designated soundings, and all possible shoal areas.

Quality of data are controlled through:

1) Real time monitoring during acquisition to ensure that all features are covered by near nadir beams.

2) Inspection of the CUBE surface's Density, Standard Deviation, and Uncertainty layers.

3) All developments are examined for significance. Objects found to be significant are flagged with a designated sounding, and become part of the Final Feature File.

Data Processing Methods and Procedures

Feature verification begins during initial data processing. Both SSS and MBES data are processed following the conclusion of daily acquisition operations or at regular intervals (typically daily) for continuous ship operations. Significant contacts are identified and noted during initial processing. All significant contacts are then developed using a MBES. Significant features found in MBES data are flagged as 'designated soundings', then imported into Caris BASE Editor or HIPS. Inside BASE Editor, each significant contact is given an S-57 attribution, and the hydrographer recommends charting action. The final deliverable is a Final Feature File (FFF) in .000 format.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Hydrographic Survey Division Operations Branch typically provides the field unit with a number of recommended bottom sample sites. Proposed sample sites are encoded as S-57 SPRINGS and are provided in files distributed with the Project Instructions for the survey.

Bottom sample acquisition typically occurs after the majority of main-scheme MBES acquisition has completed. Bathymetric surfaces, backscatter surfaces and SSS intensity mosaics are examined to confirm the validity of the proposed sample sites. Sample sites may be moved or eliminated depending on field conditions. Samples are collected by launch or ship using one of the bottom samplers described in the equipment section of this report.

Imagery of the bottom type is collected in accordance with HSSD 2019 requirements.

Physical sample bottom material is discarded after field analysis is complete.

Data Processing Methods and Procedures

Samples are analyzed for sediment type and classified with S57 attribution.

The NATSUR S-57 attribute for a sample site is characterized as “unknown” in the event that no sample is obtained after three collection attempts.

S-57 attribution is conducted in Caris HIPS or BASE Editor.

Imagery and attribution is included as a feature file media attachment.

All bottom samples are processed in accordance with HSD HTD 2018-4_Bottom Sample Drop Camera Imagery.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

On a daily bases Single Resolution (SR) surfaces are created at the required resolution for holiday planning and data "cleaning" in order to efficiently maximize operational time frames. The Flier Finder v8, Holiday Finder v4, and Grid QA v5 program in QC Tools v3.1.6 that is included with Pydro Explorer v19.4(r10747) is used for data integrity and quality management. The Flier Finder v8 program is used to direct cleaning of potential 'fliers' in the bathymetric surface data. This algorithm contributes to detect fliers as early as possible in the quality control process. Its initial implementation scans gridded bathymetry and flags abrupt depth changes as per user-set criteria. After data "cleaning" with direction from Pydro based tools, all statistics layers generated by the Caris CUBE implementation are used (including uncertainty, hypothesis count, hypothesis strength, and standard deviation) to verify that the Pydro Tools did not grossly miss obvious "fliers".

D.1.2 Designated Sounding Selection

Designated soundings are selected in accordance with HSSD 2019, except where noted in DR.

D.1.3 Holiday Identification

Holidays within the CUBE surface are identified using the Holiday Finder v4 program in QC Tools v3.1.6, included in Pydro Explorer v19.4(r10747). The tool compares the CUBE surface to coverage requirements set forth by HSSD 2019. The standard tools included in ArcGIS 10.6.1 are also used for holiday identification, primarily to inspect SSS mosaics. In addition to automated tools, all surfaces are also visually inspected.

D.1.4 Uncertainty Assessment

Total Vertical Uncertainty and Total Horizontal uncertainty surface statistics of the CUBE surface is calculated using the Grid QA v5 program in QC Tools v3.1.6, included in Pydro Explorer v19.4(r10747). The tool then compares the statistics with the surface requirements set forth by HSSD 2019.

Statistics layers generated by the Caris CUBE implementation are visually inspected.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

The Crossline to Mainscheme Analysis is conducted using the Gridded Surface Comparison program, included in Pydro Explorer v19.4(r10747). CUBE surfaces of crossline data and mainscheme data are differenced, each gridded at the required resolution set forth by the Project Instructions and HSSD 2019. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values.

D.1.5.2 Junctions

The Junction Analysis is conducted using the Gridded Surface Comparison program, included in Pydro Explorer v19.4(r10747). A CUBE surface of the data, gridded at the required resolution set forth by the Project Instructions and HSSD 2019, is differenced with the .bag surface that is provided with the Project Instructions. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values. The Gridded Surface Comparison program may not be able to use older formates of surfaces that have an Elevation child layer. In these instances, a difference surface is created between the CUBE surface and the .bag surface in Caris 10.4 HIPS, and statistics are computed from the difference layer. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values.

D.1.5.3 Platform to Platform

The Platform to Platform Analysis is conducted using the Gridded Surface Comparison program, included in Pydro Explorer v19.4(r10747). CUBE surfaces of HSL data and ship data are differenced, each gridded at the required resolution set forth by the Project Instructions and HSSD 2019. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Coverage is assessed in accordance with HSSD 2019.

Automated and visual methods are used to inspect surface coverage: ArcGIS tools are used to automatically identify coverage deficiencies; surfaces are inspected against brightly colored backgrounds for visible gaps in coverage.

CUBE statistical surfaces that show gridded node density are used to visually assess surfaces for compliance with bathymetric surface node density requirements.

The Grid QA v5 program in QC Tools v3.1.6, included in Pydro Explorer v19.4(r10747) is used to statistically inspect CUBE surfaces for compliance with bathymetric surface node density requirements.

D.2.2 Contact Selection Methodology

Contacts are selected in accordance with HSSD 2019.

Visual inspection of all SSS data are conducted in CARIS SIPS by multiple scanners that include the initial processor, a check scanner, and the sheet manager for a minimum of three scans for contact detection.

E. Approval Sheet

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during these projects in accordance with the Hydrographic Surveys Specifications and Deliverables (2017 ed) and the Field Procedures Manual for Hydrographic Surveying (2014 ed).

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

Approver Name	Approver Title	Date	Signature
CDR Briana W. Hillstrom	Commanding Officer	03/03/2020	HILLSTROM.BRIANA.WELTON.1267667531 Digitally signed by HILLSTROM.BRIANA.WELTON.1267667531 Date: 2020.04.06 13:38:53 -04'00'
LT Calandria DeCastro	Field Operations Officer	03/03/2020	DECASTRO.CALANDRIA.MALVINA.1468902156 Digitally signed by DECASTRO.CALANDRIA.MALVINA.1468902156 Date: 2020.04.06 15:02:56 -04'00'
Joshua Hiteshew	Chief Hydrographic Survey Technician	03/03/2020	HITESHEW.JOSHUA.TAYLOR.1537939652 Digitally signed by HITESHEW.JOSHUA.TAYLOR.1537939652 Date: 2020.04.06 16:53:46 Z

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	OPR-D304-TJ-19_DAPR_Appendices.pdf
Sound Speed Sensor Calibration	OPR-D304-TJ-19_DAPR_Appendices.pdf
Vessel Offset	OPR-D304-TJ-19_DAPR_Appendices.pdf
Position and Attitude Sensor Calibration	OPR-D304-TJ-19_DAPR_Appendices.pdf
Echosounder Confidence Check	OPR-D304-TJ-19_DAPR_Appendices.pdf
Echosounder Acceptance Trial Results	OPR-D304-TJ-19_DAPR_Appendices.pdf

Additional Report	***File***
HVF Values	OPR-D304-TJ-19_DAPR_Appendices.pdf
HSRR Documentation	OPR-D304-TJ-19_DAPR_Appendices.pdf