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-J315-KR-21
Time Frame:	June - November 2021

LOCALITY

State(s):	Alabama Louisiana Mississippi
General Locality:	Approaches to Pascagoula, Northern Gulf of Mexico, Louisiana, Mississippi, and Alabama

2021

CHIEF OF PARTY
Jonathan L. Dasler, PE, PLS, CH

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Data Acquisition and Processing Report

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Chief of Party: Jonathan L. Dasler, PE, PLS, CH
Year: 2021
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A. System Equipment and Software

A.1 Survey Vessels

A.1.1 S/V Blake

Vessel Name	S/V Blake
Hull Number	213
Description	The S/V Blake (Figure 1), owned and operated by DEA, was one of the survey vessels utilized for the project. The S/V Blake is a 92-ton United States Coast Guard (USCG) Subchapter T inspected vessel, Official Number 1256966, and Hull Number 213. The S/V Blake is an 82-foot aluminum catamaran with a 27-foot beam and a draft of 4.5 feet. The vessel is equipped with wave-piercing bows, Tier-3 diesel engines, twin 55-kilowatt generators, a retractable moon pool and center-pole mount, pole mounts on either side of the vessel for dual-head multibeam deployment, stern mounted A-frame, bow-mounted knuckle-boom crane, climate-controlled equipment and server closet, one data acquisition station, and three data processing stations. The S/V Blake supports a hydrographic crew of six and is supported by four ship crew for 24-hour survey operations.
Dimensions	*LOA*: 82 feet *Beam*: 27 feet *Max Draft*: 4.5 feet
Most Recent Full Static Survey	*Date*: 2014-12-16 *Performed By*: DEA at Geo Shipyard in New Iberia, LA

Most Recent Partial Offset Verification	*Date*	2021-06-15
	Method	Mobilization for bathymetric survey of the S/V Blake occurred on June 13, 2021 (DN164). System calibrations and a start-of-project patch test were performed in Gulfport Ship Channel on June 15, 2021 (DN166). A squat confirmation test was performed in Gulfport Ship Channel on June 15, 2021 (DN166). Results from the squat test were consistent with results from the prior test, which was performed on September 1, 2020, in support of NOAA project S-K378-KR-20. The squat and settlement values were not applied to the ellipsoidally referenced survey (ERS) methods used for this project. Vessel offsets and associated measurement uncertainties for the S/V Blake were calculated from a vessel offset survey performed at Geo Shipyard in New Iberia, LA, on September 23-24, 2014. All survey points were positioned using a terrestrial land survey total station, from a minimum of two locations, which allowed a position uncertainty to be determined. Vessel offsets and uncertainties were used in the HIPS Vessel File (HVF). Changes to the hardware offsets since the initial vessel offset survey were necessary to account for new equipment installation. DEA performed the side pole surveys on May 22, 2018, at Diamond B Marine Services, Inc. in New Iberia, LA, while the S/V Blake was dry docked with checks to initial motion unit (IMU), center sonar strut and real-time kinematic (RTK) global navigation satellite system (GNSS). The survey included use of a terrestrial total station with multiple primary survey points and differential leveling from the IMU to port and starboard sonars.

Figure 1: S/V Blake

A.1.2 R/V Broughton

Vessel Name	R/V Broughton
Hull Number	EZX04815D010
Description	The R/V Broughton (Figure 2), owned and operated by DEA, was one of the survey vessels utilized for this project. The R/V Broughton is a 24-foot custom Duckworth Offshore. The vessel is equipped with twin outboard 200-horsepower engines, an integrated navigation and data acquisition system, a custom mount for the Teledyne RESON SeaBat T50-R multibeam sonar head, with a side scan sonar mounted to the starboard side of the vessel. The R/V Broughton supports a hydrographic crew of two and one vessel operator.

Dimensions	*LOA*	24 feet
	Beam	8.5 feet
	Max Draft	2.75 feet
Most Recent Full Static Survey	*Date*	2018-01-16
	Performed By	DEA at the Marine Services Division office in Vancouver, WA
Most Recent Partial Offset Verification	*Date*	2021-07-20
	Method	Mobilization of the R/V Broughton for bathymetric survey occurred on July 19, 2021 (DN200). System calibrations and a start-of-project patch test were performed in the Gulfport Ship Channel on July 20, 2021 (DN201). A squat confirmation test was performed in Gulfport Ship Channel on July 21, 2021 (DN202). The squat and settlement values were not applied to the ERS method used for this project. Vessel offsets and associated measurement uncertainties for the R/V Broughton were calculated from a vessel offset survey performed on October 21, 2010, and updated on January 16, 2018, to include offsets to the port sonar pole and addition of a laser scanner. Vessel offsets and uncertainties were used in the HVF. Changes to the hardware offsets since the initial vessel offset survey were necessary to account for new equipment installation.

Figure 2: R/V Broughton

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Teledyne RESON T50 Series

The multibeam echosounders (MBES) were deployed in a single-head configuration using a retractable moon pool with center strut mount on the S/V Blake, and single-head configuration with a custom-fabricated pole mount deployed on the starboard side of the R/V Broughton (Figure 3).

The T50 Series multibeam sonar by Teledyne RESON is a 400 kHz system, operated at 350 kHz in a single-head configuration for this survey. It was operated at a 140-degree swath angle using 512 beams per head in an equiangular mode. It is capable of acquiring bathymetry, snippets/backscatter, side scan and water column data.

Manufacturer	Teledyne RESON				
Model	T50 Series				
Inventory	*S/V Blake*	*Component*	Topside Unit and Rack Mount	Transmit	Receive
		Model Number	T50-R	TC2181	EM7218
		Serial Number	3716029	5015068	2714149
		Frequency	350	350	350
		Calibration	N/A	N/A	N/A
		Accuracy Check	N/A	N/A	N/A
	R/V Broughton	*Component*	Topside Unit and Rack Mount	Transmit	Receive
		Model Number	T50-R	TC2181	EM7218
		Serial Number	08961618025	5015057	0220037
		Frequency	350	350	350
		Calibration	N/A	N/A	N/A
		Accuracy Check	N/A	N/A	N/A

S/V Blake

R/V Broughton

Figure 3: Sonar configuration on all survey vessels

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

A.2.3.1 EdgeTech 4200 Series

The EdgeTech 4200-HF Side Scan Sonar (SSS) System is an 80 lb, 1.26-meter long towed 100/400 kHz or 300/600 kHz system (Figure 4). It was operated at 400 kHz or 600 kHz and a 50- to 75-meter range scale for this project in a high-speed mode for adequate along-track ping rate.

<table>
<tr><td>Manufacturer</td><td colspan="2">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="2">4200 Series</td></tr>
<tr><td rowspan="2">Inventory</td><td>S/V Blake</td><td>
<table>
<tr><td>Component</td><td>Topside Unit and Rack Mount</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>701-DL</td><td>4200</td></tr>
<tr><td>Serial Number</td><td>46213</td><td>42627</td></tr>
<tr><td>Frequency</td><td>600</td><td>600</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td></tr>
</table>
</td></tr>
<tr><td>R/V Broughton</td><td>
<table>
<tr><td>Component</td><td>Topside Unit and Rack Mount</td><td>Towfish</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>701-DL</td><td>4200</td><td>4200</td></tr>
<tr><td>Serial Number</td><td>35324</td><td>On and before DN220: 43188</td><td>After DN220: 35482</td></tr>
<tr><td>Frequency</td><td>600/400</td><td>600</td><td>400</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>
</td></tr>
</table>

Figure 4: EdgeTech 4200 Side Scan Sonar

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

A.4.5.1 Intuicom RTK Bridge-X

The Intuicom RTK Bridge-X (Figure 5) was used for receiving RTK corrections via Networked Transport of RTCM via Internet Protocol (NTRIP).

Manufacturer	Intuicom	
Model	RTK Bridge-X	
Inventory	*Component*	S/V Blake Intuicom
	Model Number	RTK Bridge-X
	Serial Number	X162034
	Calibration	N/A
	Component	R/V Broughton Intuicom
	Model Number	RTK Bridge-X
	Serial Number	X151065
	Calibration	N/A

Figure 5: Intuicom RTK Bridge-X

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix/Trimble POS MV 320 V5

The Applanix/Trimble Position and Orientation System for Marine Vessels (POS MV) 320 V5 was the GNSS and inertial reference system used for measuring position, heading, heave, roll, and pitch data.

<table>
<tr><td>Manufacturer</td><td colspan="6">Applanix/Trimble</td></tr>
<tr><td>Model</td><td colspan="6">POS MV 320 V5</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">S/V Blake</td><td>Component</td><td>Topside Unit</td><td>IMU</td><td>Antenna</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>POS MV 320 V5</td><td>LN200</td><td>Trimble GA830</td><td>Trimble GA830</td></tr>
<tr><td>Serial Number</td><td>7342</td><td>898</td><td>16954</td><td>7235</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td rowspan="4">R/V Broughton</td><td>Component</td><td>Topside Unit</td><td>IMU</td><td>Antenna</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>POS MV 320 V5</td><td>LN200</td><td>Aero</td><td>Aero</td></tr>
<tr><td>Serial Number</td><td>7344</td><td>1058</td><td>8568</td><td>8569</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

A.5.2 DGPS

A.5.2.1 Trimble GNSS Receivers

The Trimble GNSS positioning system provided a secondary position for real-time monitoring of position data and was utilized for quality control purposes.

<table>
<tr><td>Manufacturer</td><td colspan="3">Trimble</td></tr>
<tr><td>Model</td><td colspan="3">GNSS Receivers</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">S/V Blake</td><td>Component</td><td>Secondary GNSS Positioning System</td></tr>
<tr><td>Model Number</td><td>SPS851</td></tr>
<tr><td>Serial Number</td><td>5005K65409</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
<tr><td rowspan="4">R/V Broughton</td><td>Component</td><td>Secondary GNSS Positioning System</td></tr>
<tr><td>Model Number</td><td>SPS855</td></tr>
<tr><td>Serial Number</td><td>5506R00074</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
</table>

A.5.3 GPS

Additional GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

A.5.4.1 Laser Technology, Inc. Laser Rangefinder

The Laser Technology, Inc. TruPulse 360 Laser Rangefinder was used to measure distance and bearing to baring features relative to the position of the vessel. A final feature position was calculated in the HYPACK target editor.

<table>
<tr><td>Manufacturer</td><td colspan="3">Laser Technology, Inc.</td></tr>
<tr><td>Model</td><td colspan="3">Laser Rangefinder</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S/V Blake</td><td>Component</td><td>Laser Rangefinder</td></tr>
<tr><td>Model Number</td><td>TruPulse 360</td></tr>
<tr><td>Serial Number</td><td>028470</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
</table>

A.5.5 Other Positioning and Attitude Equipment

No additional positioning and attitude equipment was utilized for data acquisition.

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

A.6.1.1 AML Oceanographic MVP30-350 Sound Speed Profiler

The AML Oceanographic MVP30-350 was the primary sound speed profiler utilized for sound speed casts of the S/V Blake. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

Manufacturer	AML Oceanographic		
Model	MVP30-350 Sound Speed Profiler		
Inventory	*S/V Blake*	*Component*	Water Column Sound Speed Profiler
		Model Number	Micro SVP&T
		Serial Number	Housing: 8703 SV: 205498 P:306797 T:404529
		Calibration	2021-04-14

A.6.2 CTD Profilers

A.6.2.1 AML Oceanographic Smart X

The AML Oceanographic Smart X was the primary sound speed profiler utilized for sound speed casts of the R/V Broughton, and was the sound speed profiler utilized when the primary system was inoperable on the S/V Blake. The Smart X was also utilized as a comparison system for weekly checks. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

Manufacturer	AML Oceanographic	
Model	Smart X	
Inventory	*Component*	S/V Blake Water Column Sound Speed Profiler
	Model Number	Smart X
	Serial Number	Housing:20142 SV:204796 P:304616 T:404176
	Calibration	2021-05-08
	Component	R/V Broughton Water Column Sound Speed Profiler
	Model Number	Smart X
	Serial Number	Housing:20429 SV:204011 P:304610 T:404001
	Calibration	2021-06-08

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic Micro SV Xchange

The AML Oceanographic Micro SV Xchange was the sound speed sensor at the primary MBES sonar head. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

Manufacturer	AML Oceanographic		
Model	Micro SV Xchange		
Inventory	*S/V Blake*	*Component*	Sound Speed Sensor at sonar head
		Model Number	Micro SV
		Serial Number	Housing:12748 SV:206189
		Calibration	2021-06-08
	R/V Broughton	*Component*	Sound Speed Sensor at sonar head
		Model Number	Micro SV
		Serial Number	Housing:11250 SV:204871
		Calibration	2021-06-08

A.6.4 TSG Sensors

No TSG sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No other surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
HYPACK, Inc.	HYPACK	20.2.20.0	Acquisition
HYPACK, Inc.	HYPACK Survey	20.2.20.0	Acquisition
HYPACK, Inc.	HYPACK SSS Package	20.2.20.0	Acquisition
HYPACK, Inc.	HYSWEEP	20.2.9.0	Acquisition
Teledyne RESON	SeaBat	V5.0.0.2	Acquisition
David Evans and Associates, Inc. Marine Services Division	LineLog	2.1	Acquisition
Applanix	MV-POSView	9.2	Acquisition
ODIM Brooke Ocean	ODIM MVP Controller	V2.450	Acquisition
NOAA OCS/JHC	Sound Speed Manager	2021.2.3	Processing
CARIS	HIPS	11.3.8	Processing
CARIS	BASE Editor	5.4.7	Processing
ESRI	ArcGIS and ArcMap	10.6	Processing
Chesapeake Technology, Inc.	SonarWiz	7.06.06 (64-bit)	Processing
Applanix	POSPac MMS	Before DN240: 8.6 After DN240: 8.7	Processing
Applanix	LV-POSView	8.15	Processing
Microsoft	Office Suite	2016 and 365	Processing
Adobe	Adobe Acrobat Pro DV (32-bit)	21.005.20060	Processing
NOAA OCS/JHC	XmlDR	19.4	Processing
NOAA OCS/JHC	QC Tools	3.2.10	Processing
NOAA OCS/JHC	Compare Grids	19.4	Processing
NOAA OCS/JHC	POSPac AutoQC	19.4	Processing
Beyond Compare	Beyond Compare	4.2.2	Processing
AML Oceanographic	SeaCast	4.40	Acquisition

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 WILDCO Shipek Grab Bottom Sampler

The WILDCO Shipek Grab Bottom Sampler is a three-liter stainless cylinder that collects sediments quickly, cleanly, and reliably (Figure 6). The sampler was deployed from the S/V Blake for this project.

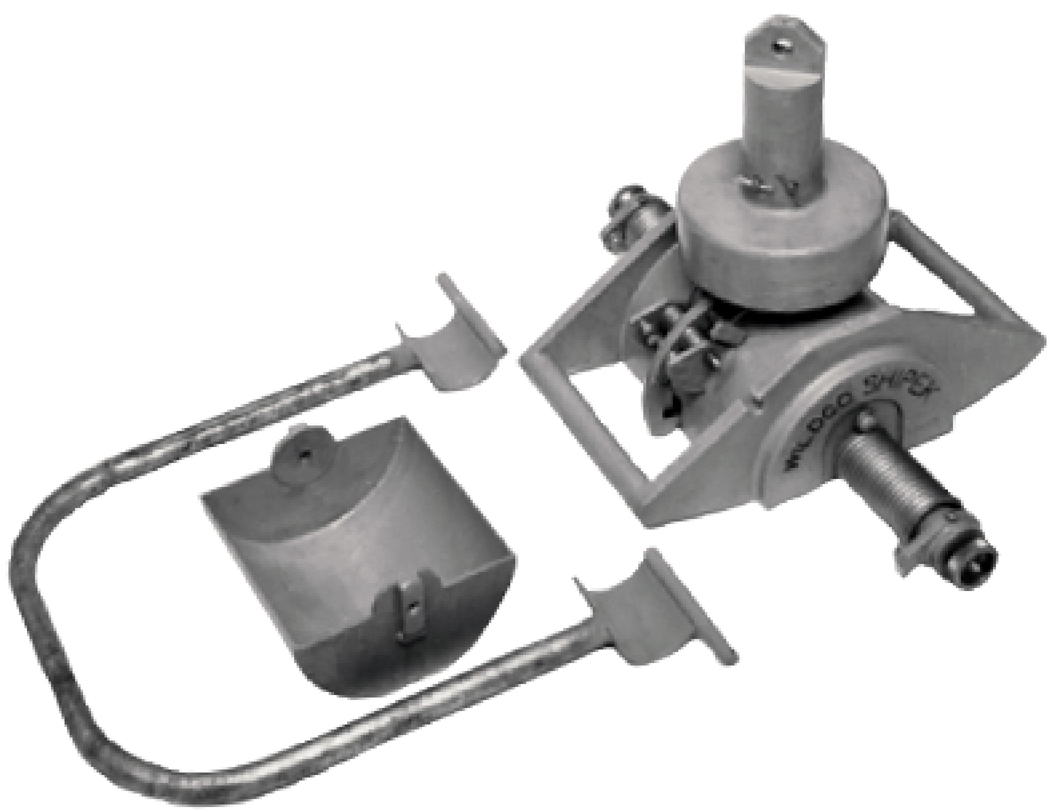

Figure 6: Shipek Grab Bottom Sampler

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

Vessel offsets and associated measurement uncertainties for the S/V Blake were calculated from a vessel offset survey performed at Geo Shipyard in New Iberia, LA, on September 23-24, 2014. Vessel offsets and associated measurement uncertainties for the R/V Broughton were calculated from a vessel offset survey performed on January 16, 2018. All survey points were positioned using a terrestrial land survey total station from a minimum of two locations, which allowed a position uncertainty to be determined. Vessel offsets and uncertainties were used in the HVF.

Sensor offsets for survey vessels were calculated from vessel offset surveys, and dynamic draft values were calculated using post-processed Global Positioning System (GPS) observations. For the S/V Blake, draft (water line) was measured and entered approximately every week of survey operations from draft sight tubes located in the port and starboard sponsons abeam of the multibeam sonar and vessel reference point. For the R/V Broughton, draft was measured and entered approximately weekly from the vessel hull.

While dynamic draft and waterline were measured and documented, they were not applied in CARIS Hydrographic Information Processing System (HIPS) during data processing. Ellipsoidally referenced heights determined by the GNSS system on each survey vessel incorporated these corrections in their instantaneous measurements.

All offsets were computed relative to the vessel reference point, which is the origin of all offsets reported in the HVF, excluding total propagated uncertainty (TPU) offsets. Vessel offset diagrams and dynamic draft tables are included in Appendix III - Vessel Offset Reports.

B.1.1.1 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="4">S/V Blake</td></tr>
<tr><td>Echosounder</td><td colspan="4">Teledyne RESON T50</td></tr>
<tr><td>Date</td><td colspan="4">2021-06-15</td></tr>
<tr><td rowspan="8">Offsets</td><td rowspan="4">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>-0.827 meters</td><td>0.030 meters</td></tr>
<tr><td>y</td><td>0.052 meters</td><td>0.030 meters</td></tr>
<tr><td>z</td><td>2.971 meters</td><td>0.030 meters</td></tr>
<tr><td rowspan="3">Nav to Transducer</td><td>x</td><td>-1.380 meters</td><td>0.030 meters</td></tr>
<tr><td>y</td><td>-4.646 meters</td><td>0.030 meters</td></tr>
<tr><td>z</td><td>9.464 meters</td><td>0.030 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.000 degrees</td><td></td></tr>
</table>

<table>
<tr><td>Vessel</td><td colspan="4">S/V Blake</td></tr>
<tr><td>Echosounder</td><td colspan="4">Teledyne RESON T50</td></tr>
<tr><td>Date</td><td colspan="4">2021-06-22</td></tr>
<tr><td rowspan="8">Offsets</td><td rowspan="4">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>-0.827 meters</td><td>0.030 meters</td></tr>
<tr><td>y</td><td>0.052 meters</td><td>0.030 meters</td></tr>
<tr><td>z</td><td>3.123 meters</td><td>0.030 meters</td></tr>
<tr><td rowspan="3">Nav to Transducer</td><td>x</td><td>-1.380 meters</td><td>0.030 meters</td></tr>
<tr><td>y</td><td>-4.646 meters</td><td>0.030 meters</td></tr>
<tr><td>z</td><td>9.616 meters</td><td>0.030 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.000 degrees</td><td></td></tr>
</table>

<table>
<tr><td>Vessel</td><td colspan="4">R/V Broughton</td></tr>
<tr><td>Echosounder</td><td colspan="4">Teledyne RESON T50</td></tr>
<tr><td>Date</td><td colspan="4">2021-07-21</td></tr>
<tr><td rowspan="8">Offsets</td><td rowspan="4">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>1.394 meters</td><td>0.005 meters</td></tr>
<tr><td>y</td><td>-0.851 meters</td><td>0.005 meters</td></tr>
<tr><td>z</td><td>0.313 meters</td><td>0.005 meters</td></tr>
<tr><td rowspan="3">Nav to Transducer</td><td>x</td><td>0.545 meters</td><td>0.005 meters</td></tr>
<tr><td>y</td><td>-0.494 meters</td><td>0.005 meters</td></tr>
<tr><td>z</td><td>3.169 meters</td><td>0.005 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.000 degrees</td><td></td></tr>
</table>

B.1.2 Layback

The cable-out, along with the measured tow point offset and height above the waterline, catenary factor, number of cable segments, and towfish depth were used by HYPACK to compute layback. The vessel tow point is denoted on the vessel offset drawings included in Appendix III – Vessel Offset Reports. This appendix also includes a detailed discussion on layback computation methodology.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

All surveys were collected with ERS methods. Static drafts were taken approximately weekly. The S/V Blake was built with draft dampening tubes in each hull, providing a means to monitor vessel static draft. Static draft readings from the port and starboard side draft sight tubes were recorded and averaged at the time of observation. The R/V Broughton had draft marks on the hull port and starboard of the vessel reference point.

Due to the application of ERS methods for this survey, static draft observations had no impact on the vertical accuracy of the survey and was only used for the water level gauge comparison and bar checks. A detailed description of the static draft corrections can be found in Appendix V - Echo Sounder Confidence Check Reports. Periodic bar checks were performed to confirm that the multibeam sonar was functioning properly and static draft was accurately documented. An aluminum plate attached to the end of a wire cable and chain, marked at 2 meters, was used to bar check the multibeam sonar on all survey platforms. The marks were checked periodically with a measuring tape. The bar check device was lowered to a recorded depth below the water surface, a point above the natural bottom, where it could be clearly ensonified. The depth of the bar was compared to the depth of the bar reported by the sonars. Observations were recorded in a comparison log. Tabulated bar check comparisons may be found in Appendix V - Echo Sounder Confidence Check Reports.

B.2.1.1 Static Draft Correctors

Static draft correctors were not applied.

B.2.2 Dynamic Draft

Though ultimately not used in the processing of this ERS survey, a settlement and squat test was performed for each survey vessel. The squat test for the S/V Blake was performed near Gulfport, MS, on June 15, 2021 (DN166). The squat test for the R/V Broughton was performed near Gulfport, MS, on July 21, 2021 (DN202). These tests confirmed values from tests conducted previously.

The settlement and squat values were obtained by computing an average of GNSS height values at different ship speeds, measured in knots and revolutions per minute (RPM). Transects were run twice at each RPM interval along opposing headings. With the vessel at rest, static GNSS height observations were recorded between each RPM interval in order to obtain a baseline GNSS height value not affected by tide changes during the test. These values were linearly interpolated to determine the baseline GNSS height at the time of the dynamic draft measurement. The difference between the GNSS height while the vessel was in motion and the interpolated static GNSS height was used to calculate the dynamic draft for each transect. An average dynamic draft corrector was then calculated from the average of the two values for each RPM interval. The average speed for each RPM interval and the average dynamic draft corrector were entered into the HIPS vessel file. Uncertainty estimates for dynamic draft were calculated by taking the average of the standard deviation for all dynamic draft calculations per transect.

B.2.2.1 Dynamic Draft Correctors

Dynamic draft correctors were not applied.

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

Multibeam patch tests were conducted to measure alignment offsets between the IMU sensor and the multibeam transducer and to determine time delays between the time-tagged sensor data. Multiple patch tests were performed throughout the project to verify the adequacy of the system biases. Patch tests were performed periodically throughout the project, including at the beginning of the project, after any system replacement, and at the end of the project. Each patch test consisted of a series of lines run in a specific pattern, which were then used in pairs to analyze roll, pitch, and heading alignment bias angles.

A precise timing latency test was performed by running a single line over a flat bottom with induced vessel motion. The line was then opened in HIPS Subset Editor (after applying tide and SVP corrections) and a small along-track slice of data was evaluated in the outer swath of the line for motion artifacts. Incremental changes to the roll time offset were made to evaluate the performance of the precise timing setup and to determine if a latency correction was needed.

Roll alignment was determined by evaluating the reciprocal lines run over a flat bottom. Pitch tests consisted of a set of reciprocal lines located on a steep slope or over a submerged feature. The yaw error was determined by running parallel lines over the same area as the pitch tests. Latency tests were run over a slope or feature in the same direction at different speeds. All lines were run at approximately 3 to 6 knots. Patch tests were run in Mississippi Sound near Gulfport, MS, and Pascagoula, MS, and at a deeper site offshore in the survey area. Selected pairs of lines were then analyzed in HIPS Subset Editor to measure the angular sensor bias values. Visual inspection of the data confirmed each adjustment.

All patch test data were processed using post-processed Applanix POSPac MMS SBET positions.

Sonar offsets and alignment angles computed during patch tests were entered into the HVF. Sonar roll and pitch values were entered in the HVF SVP1 field rather than the Transducer1 field in order for the HIPS Sound Velocity correction process to apply the values correctly. Yaw values were entered into the HVF Transducer fields as recommended by CARIS. Uncertainty estimates for the MRU alignment for gyro, pitch, and roll were calculated by taking the average of the standard deviation on multiple iterations of patch test lines. Initial calibration values from the start of the project for each survey vessel are depicted in Section B.3.1.1. All patch values are detailed in Appendix V - Echo Sounder Confidence Check Reports and entered into the CARIS HVF.

Roll test lines were frequently acquired on the vessels to monitor the stability of the multibeam sonar's pole mount(s). Roll values from these tests were included alongside the values from the standard patch test in order to account for minor variations in roll. Due to the extremely small change witnessed, the roll values were processed and documented but not included in the HVF.

B.3.1.1 System Alignment Correctors

Vessel	S/V Blake		
Echosounder	Teledyne RESON T50		
Date	2021-06-15		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.005 seconds
	Navigation Time Correction	0.000 seconds	0.005 seconds
	Pitch	-1.475 degrees	0.010 degrees
	Roll	-0.287 degrees	0.010 degrees
	Yaw	-0.667 degrees	0.020 degrees
	Pitch Time Correction	0.000 seconds	0.005 seconds
	Roll Time Correction	0.000 seconds	0.005 seconds
	Yaw Time Correction	0.000 seconds	0.005 seconds
	Heave Time Correction	0.000 seconds	0.005 seconds

<table>
<tr><td>Vessel</td><td colspan="3">R/V Broughton</td></tr>
<tr><td>Echosounder</td><td colspan="3">Teledyne RESON T50</td></tr>
<tr><td>Date</td><td colspan="3">2021-07-21</td></tr>
<tr><td rowspan="10">Patch Test Values</td><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Pitch</td><td>-1.750 degrees</td><td>0.010 degrees</td></tr>
<tr><td>Roll</td><td>-1.775 degrees</td><td>0.010 degrees</td></tr>
<tr><td>Yaw</td><td>-0.470 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
</table>

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

MBES acquisition within H13488, H13490, and portions of H13487 was performed to achieve 100% bathymetric bottom coverage using Object Detection and Complete Coverage requirements.

In survey areas H13489 and portions of H13487, MBES was acquired concurrently with side scan sonar to achieve Complete Coverage Option B requirements as specified in the 2021 Hydrographic Surveys Specifications and Deliverables (HSSD).

A graphic depicting the coverage requirements for the survey as assigned in the OPR-J315-KR-21 Project Instructions is shown in Figure 7.

In all cases, multibeam data were acquired in HYPACK HYSWEEP file format (HSX). Adjustments to the sonar, including changes in range, swath angle, power, and gain, were made as necessary to acquire the optimum bathymetric data quality and coverage. Additionally, vessel speed was adjusted in accordance with the HSSD to meet the required along-track coverage. Typical windows for monitoring raw sensor information included timing synchronization, vessel motion, number of satellites, horizontal dilution of precision, and position dilution of precision. Raw attitude and nadir depth were also recorded in HYPACK RAW format, as a supplementary backup. Time series backscatter data were logged in HYPACK 7K format.

The HYPACK acquisition station operator monitored and tuned the multibeam sonar, tracked vessel navigation, and maintained a digital acquisition log. Operators monitored primary and secondary navigation systems to verify quality position data were acquired. The multibeam sonar was operated at different range scales throughout the survey by adjusting the depth range to obtain the best coverage in varying depths of water, taking care not to overly increase range and keep the range at levels that supported density requirements based on vessel speed. Gain and power were adjusted to record a strong bottom return capable of supporting quality depth and backscatter data.

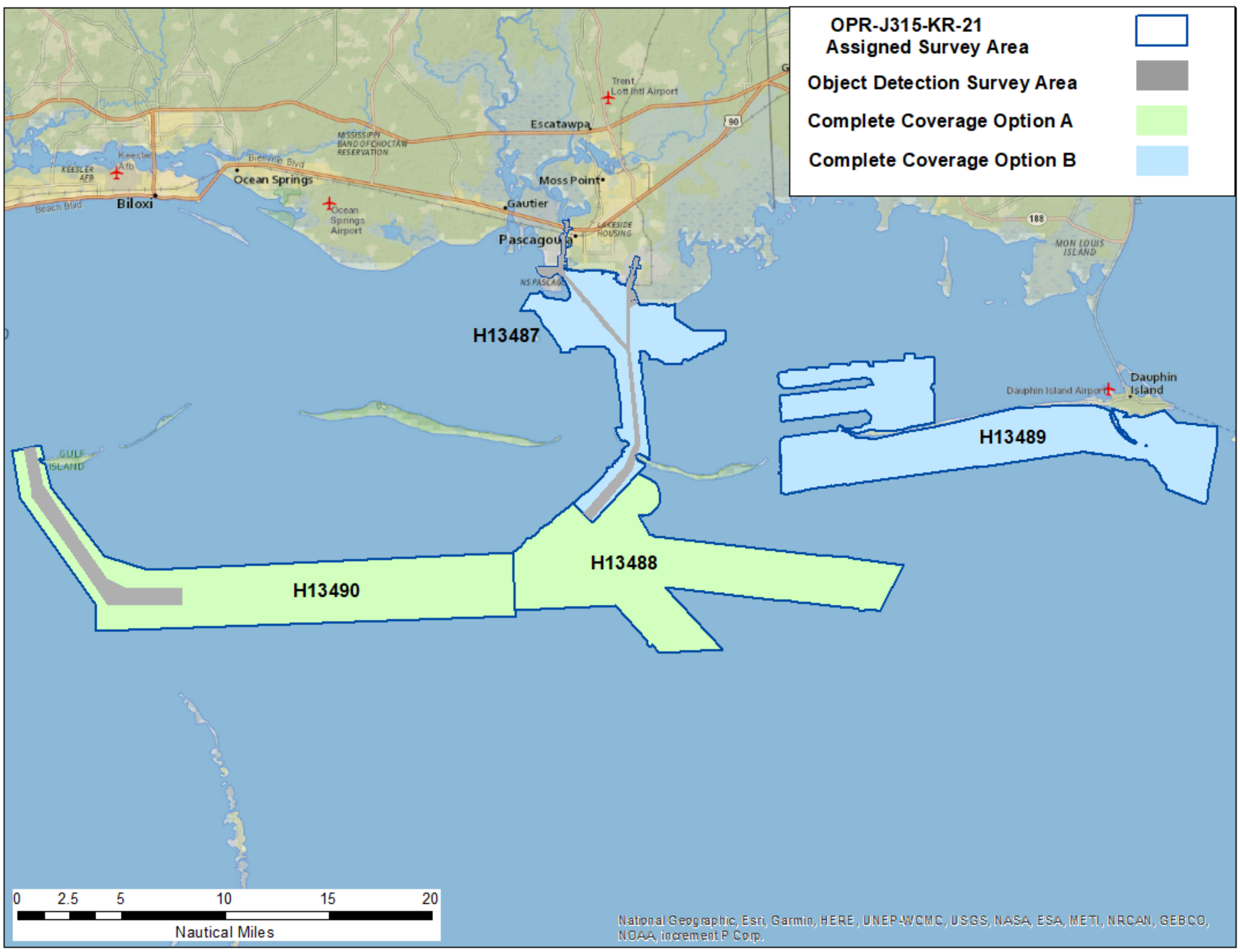

Figure 7: OPR-J315-KR-21 Coverage Requirements

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

Review of bathymetric data was conducted by reviewing multiple CARIS HIPS child layers coupled with utilizing NOAA QC Tool outputs for surface review guidance.

CARIS Process Designer was used throughout the data processing workflow to standardize the application of correctors and automate standard processing tasks. Over the course of the project, TPU was re-computed to reflect minor revisions to the HVF. The HIPS process log for each survey line includes a full audit of all steps undertaken during processing. Any deviations from the processing workflow shown in Figure 8 are addressed in the individual Descriptive Report (DR) for each survey. A surface filter was occasionally used during data cleaning in subset mode to aid in the rejection of fliers.

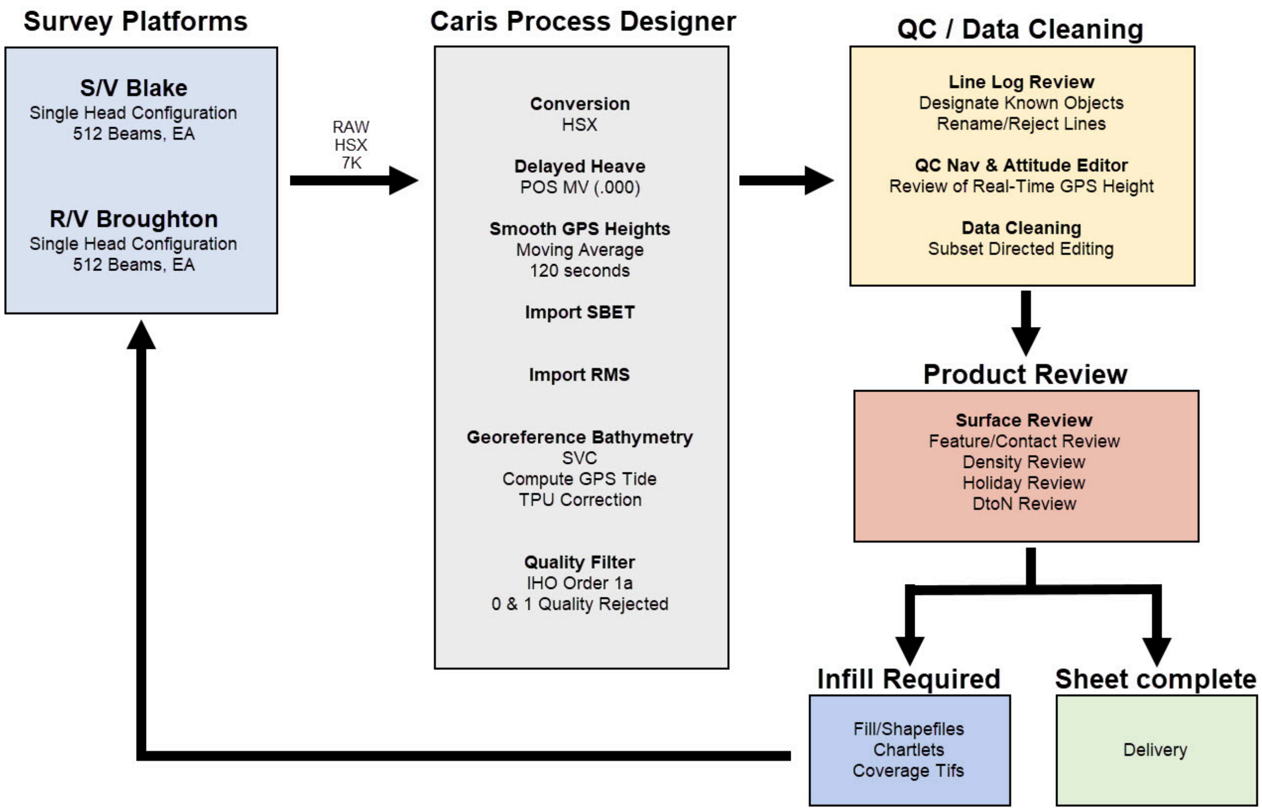

Figure 8: Flowchart of MBES Data Processing Pipeline

C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

Upon the completion of editing multibeam data in HIPS, finalized CUBE grids were generated using the "greater of the two" option for the final uncertainty value. Selected soundings and contours were generated from the surfaces and used for chart comparison purposes, but are not included with the deliverables.

C.1.4.2 Depth Derivation

CUBE parameter files provided by NOAA HSD were used for gridding parameters and surface computation algorithms to comply with the HSSD requirements.

Soundings with quality flags assigned as 0 and 1 were rejected on import. The HIPS Filter Observed Depths tool was used to reject data based on International Hydrographic Organization (IHO) Order and beam angle. All data were filtered based on IHO Order 1a limits. Angular swath filters were applied as necessary and on a survey-specific basis. Additional angular filters applied to specific days are detailed in each survey's Descriptive Report.

C.1.4.3 Surface Computation Algorithm

Single resolution CUBE surfaces were created over each survey area at either Object Detection or Complete Coverage grid-resolution thresholds and resolution-dependent maximum propagation distances as specified in the HSSD. Other gridding options selected were IHO S-44 Order 1a sounding cut-off values and the "Density and Local Disambiguation" method. All processing computers were set up to use the 2020 NOAA CUBE parameters file.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

All MBES acquisition included time series backscatter. HYPACK HYSWEEP was used to acquire multibeam data in HYSWEEP HSX file format and time-series backscatter in 7K file format.

Data Processing Methods and Procedures

Multibeam backscatter data were logged and submitted, but were not processed for this project.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

SSS data were generally acquired concurrently with MBES data for mainscheme survey acquisition in areas designated as Complete Coverage Option B. Crossline data do not include SSS. Features and contacts identified using SSS were developed and investigated using MBES only. In some instances where SSS data gaps were present, MBES was run to fill in these coverage gaps in lieu of 100% SSS data.

Side scan sonar imagery was acquired with an EdgeTech 4200-HF (100/400 kHz and 300/600 kHz) dual-frequency side scan sonar. On the S/V Blake, the sonar was operated at 600 kHz in high-speed mode using 50- and 75-meter range scale. On the R/V Broughton, the sonar was operated at 400 or 600 kHz in high-speed mode, depending on the towfish being utilized, using a 50-meter range scale.

Side scan sonar imagery was logged in HYPACK native HSX format. In addition to the imagery, vessel heading, pitch, roll, position, towfish depth and altitude, and computed towfish position from layback calculations were also recorded to the HSX.

On the S/V Blake, the side scan sonar towfish was deployed from both the bow and stern of the vessel, depending on water depth. For the bow and stern tow configuration, the horizontal and vertical offsets of the tow point relative to the vessel reference point were entered into HYPACK hardware settings. The tow point position calculated was sent to Towfish.dll in HYPACK and used with cable-out and towfish depth to compute the raw towfish position. During stern tow, an LCI-90 cable payout interface was used to measure cable-out. The cable-out, along with the measured tow point height above the waterline, catenary factor, and towfish depth, were used by HYPACK to compute layback for stern tow. For bow tow, a fixed cable-out was used. The vessel tow point is denoted on the vessel offset drawings included in Appendix III - Vessel Offset Reports.

On the R/V Broughton, the side scan sonar towfish was deployed from the port side davit on the vessel. For this tow configuration, the horizontal and vertical offsets of the tow point relative to the vessel reference point were entered into HYPACK hardware settings. The tow point position was set to use a fixed cable-out value. The cable-out, along with the measured tow point height above the waterline, catenary factor, and towfish depth, were used by HYPACK to compute layback. The vessel tow point is denoted on the vessel offset drawings included in Appendix III - Vessel Offset Reports.

To confirm adequate target resolution at the outer limits of the selected range, SSS confidence checks were conducted on a daily basis during acquisition and noted in the acquisition logs. In deteriorating acoustic conditions, confidence checks were performed more frequently to confirm detection of features at the outer range limits.

The acquisition stations were custom-installed and integrated on the S/V Blake by DEA and consisted of a HYPACK HYSWEEP multibeam acquisition and navigation computer and an additional HYPACK side scan sonar data acquisition computer also running EdgeTech Discover. The two acquisition computers had custom HYPACK Drivers to synchronize MBES and SSS data acquisition. Other software utilized on the acquisition systems included a custom event-logging software, MVP controller, and NOAA CastTime software. Two additional computers were used on board for data processing, primarily utilizing CARIS HIPS and CTI SonarWiz.

The side scan sonar on the S/V Blake was operated at a 50- and 75-meter range scale, and on the R/V Broughton at a 50-meter range scale, both at survey speeds and ping rates that enabled the sonar to detect 1-meter targets in the along track direction. All data were acquired in the 400 or 600 kHz high-speed mode.

The EdgeTech 4200-HF series sonar has a ping rate of 30 Hz at the 50-meter range and 20 Hz at the 75-meter range while operating in high-speed mode. High-speed mode makes use of the optional Multi-Pulse (MP) technology, which places two sound pulses in the water at a time rather than the traditional one pulse, and allows for tow speeds upwards of 8 knots. In accordance with the HSSD, vessel speed was monitored to allow for the acquisition of a minimum of three pings per meter.

The side scan sonar operator was assigned the task of analyzing the digital sonogram and keeping the towfish height within specification by adjusting cable-out. The operator also called out contacts and daily confidence checks, which were entered into the digital acquisition log. When weather or sea conditions degraded side scan sonar imagery, operations were suspended.

Data Processing Methods and Procedures

Data collected from the S/V Blake were logged locally on each acquisition computer and backed up to a QNAP network attached storage (NAS) device at the end of each survey line. A secondary QNAP NAS was used to perform backups of the primary QNAP. At each vessel port call, acquisition and processing data from the primary QNAP were transferred to the Vancouver, WA, office via two external USB 3.0 hard drives.

Data collected from the R/V Broughton were logged locally on the acquisition computer and backed up to a QNAP network attached storage (NAS) device in the Gulfport, MS, office at the end of each survey day. Data were then transmitted electronically to the Vancouver, WA, office daily.

Following acquisition, the HSX files were imported into CTI SonarWiz and gain adjustments applied. The side scan bottom track was then reviewed and losses of bottom or incorrect bottom track areas were re-digitized. Towfish depth, tow point offset, and cable-out were used to compute layback and applied. The processed lines then underwent two independent reviews to identify significant contacts. In most cases, side scan contacts were determined to be significant if the measured height was within the required height based on the depth area per survey sheet. In depths under 20 meters, any contacts greater than or equal to 75 centimeters were investigated. Contacts greater than these heights were investigated with MBES. Contacts were also created on objects with minimal shadow heights in areas deemed to be critical to navigation, or if they appeared to be mounds or other geologic structures that cast little or no shadow, but represented change in the seafloor elevation that may need further development to define general bathymetry. Any deviations from the processing workflow shown in Figure 9 are addressed in the individual Descriptive Reports for each survey.

Side scan mosaics were created using CTI SonarWiz. Georeferenced mosaics were generated in Tagged Image File Format (TIF) with an associated world file (TFW) at 1-meter resolution.

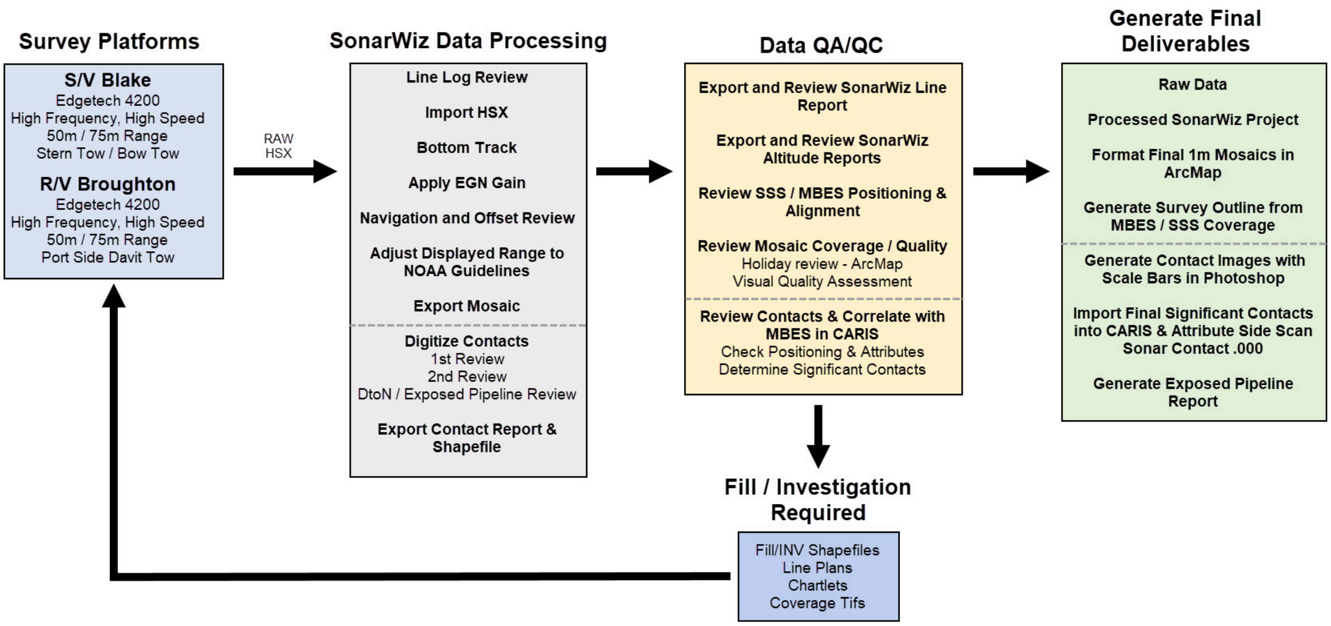

Figure 9: Flowchart of SSS Data Processing Pipeline

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

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

The Intuicom RTK Bridge-X installed on each survey vessel received RTK corrections broadcast by the Louisiana State University Center for GeoInformatics real-time network (C4GNet RTN) via Networked Transport of RTCM via Internet Protocol (NTRIP). RTK corrections were provided in real time to both the

POS MV and Trimble GNSS systems. In case of signal loss, the POS MV systems were configured to accept corrections from the Federal Aviation Administration Wide Area Augmentation System (FAA WAAS).

The real-time navigation data for MBES survey lines were later overwritten with post-processed solutions derived using Applanix POSPac MMS.

Data Processing Methods and Procedures

Differential Global Positioning System (DGPS) data were not directly processed. See Section C.4 for additional discussion on post-processed positioning.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Water level data was not acquired.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

The S/V Blake was outfitted with a POS MV 320 V5 with GNSS and inertial reference system, which was used to measure attitude, heading, heave, and position. The system was comprised of an IMU, dual GNSS antennas, and a data processor.

Positions from all systems were displayed in real-time using HYPACK and continuously compared during survey operations. A position comparison between the primary and secondary positioning system was observed and documented while the vessel was either secured in port or within the extents of the survey area. Logged position data were extracted from the HYPACK RAW file and entered into an Excel file for comparison.

Position, timing, heading, and motion data were output to the HYPACK acquisition system using the POS MV real-time Ethernet option at 50 Hz.

The POS MV provided time synchronization of sonar instruments and data acquisition computers using a combination of outputs. The RESON processors and HYPACK acquisition computers were provided a Pulse Per Second (PPS) and National Marine Electronics Association (NMEA) Global Positioning System Timing Message (ZDA) to achieve synchronization with the POS MV. All messages contained time strings that enabled the acquisition computers and sonars to synchronize to the time contained within the message. Time offsets between the instruments and computers, relative to the times contained in POS MV network packets, were typically sub-millisecond.

The POS MV was configured to log all raw observable groups needed to post-process the real-time sensor data. The POS MV logged 64- and 128-megabyte .000 files, which resulted in multiple files created per day. The TrueHeave™ data group was also logged to these files.

Data Processing Methods and Procedures

The "Compute GPS Tides" process in CARIS HIPS is the primary means by which bathymetric data is 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 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 NAD83 (2011) ellipsoid and Mean Lower Low Water (MLLW) at a given location.

All separation models were derived from the NGS VDatum model as provided by NOAA HSD Ops. Separation models are usually generated, approved and disseminated by HSD Ops.

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

Vertical control requirements were satisfied through the following method.

RTX (Primary method of positioning control):

POSPac Post-Processed Real Time Extended (PP-RTX) was used to post-process POS MV data acquired in survey areas H13488, H13489, and H13490. PP-RTX is the Trimble CenterPoint RTX positioning solution, which combines the methodology of PPP with advanced ambiguity resolution technology to produce centimeter-level accuracies without the need for local reference stations. PP-RTX is used when a regional real-time virtual network or CORS stations were unavailable and a shore-side reference station would be difficult or impossible to install due to topography, distance from shore, or land use restrictions.

POS MV data acquired in survey area H13487 were post-processing using POSPac MMS single base mode with corrections from Gautier, MS, (MSGA) or Grand Bay NERR (MSGB). These base stations are operated by the Gulf Coast Geospatial Center (GCGC) and integrated in both the GCGC and C4GNet real-time networks. Single-base processing was used for this area due to the availability of the local base stations and to improve the vertical accuracy of the post-processed navigation solutions for the survey area, which encompasses to the Port of Pascagoula and several federal channels. Figure 10 shows the H13487 survey area in relation to a 40-kilometer maximum baseline distance radius surrounding the MSGA and MSGB base stations. Published NAD83 (2011) base station coordinates used during post-processing are shown in Figure 11.

Smoothed Best Estimate of Trajectory (SBET) files and associated Root Mean Square (RMS) files were calculated using the Applanix Position and Orientation System Post-Processing Package Mobile Mapping Suite (POSPac MMS) software. All SBET/RMS files were created in POSPac MMS version 8.6 or 8.7.

SBET files were reviewed using POSPac MMS and NOAA AutoQC tools.

SBETs were applied in CARIS by loading both the SBET files and corresponding error data file in smrmsg format.

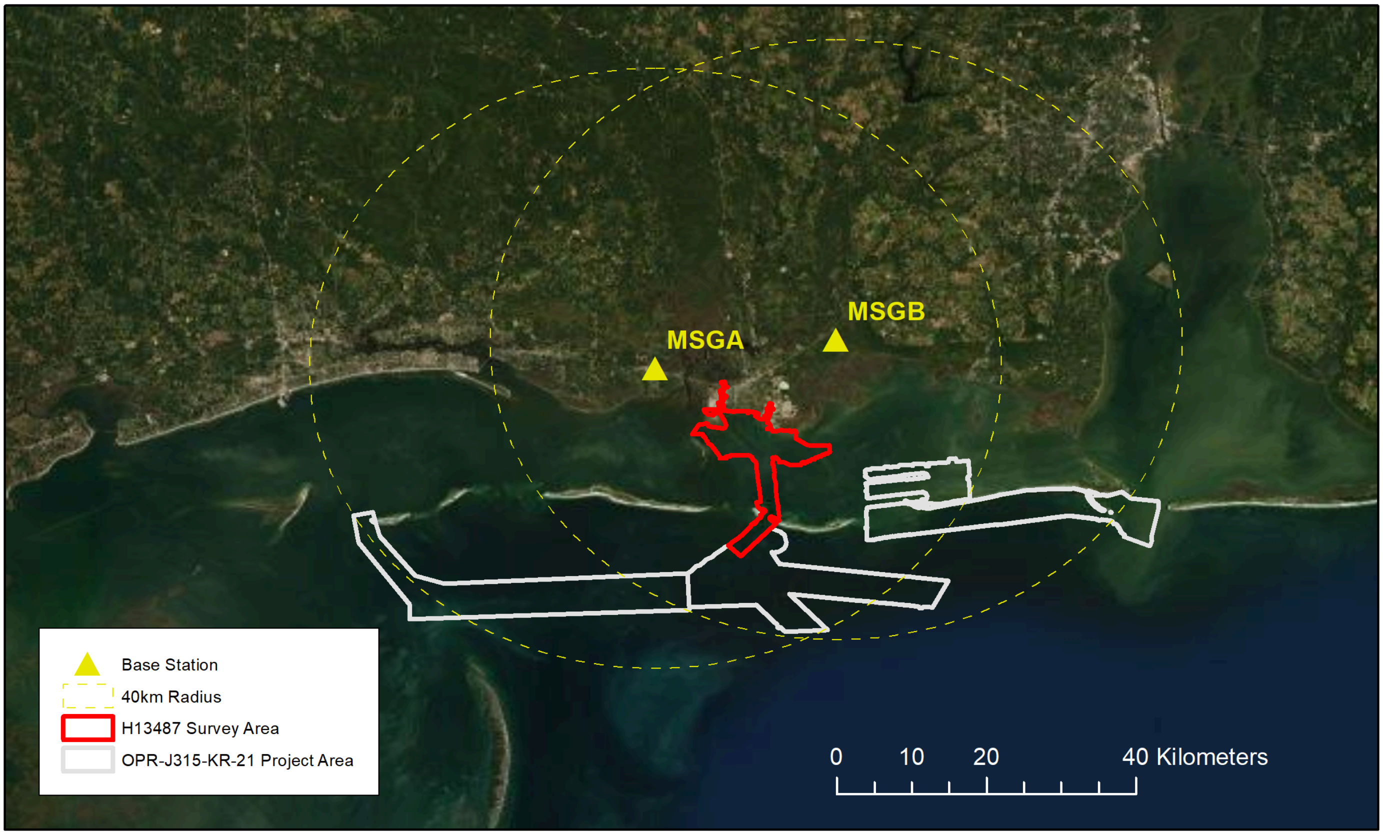

Figure 10: H13487 Survey Area and MSGA, MSGB Base Stations

Base Station ID	Latitude	Longitude	Height (Meters)	Datum	Antenna Type	Method	Height from ARP to Reference LLH
MSGA	N30°23'40.46415"	W88°38'42.48995"	-7.830	NAD83(2011)	Zepheyr Geodetic 2RoHS	ARP	0.000m
MSGB	N30°25'44.74871"	W88°25'39.98337"	-20.061	NAD83(2011)	Zepheyr Geodetic 2RoHS	ARP	0.000m

*Base Station Position Values Provided by LSU C4Gnet Real Time Network Web Portal http://c4gnet.xyz/Map/SensorMap.aspx

Figure 11: NAD83(2011) Base Station Coordinates

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

During data acquisition, sound velocity profiles were acquired by manual or automatic deployment to obtain an adequate number of sound velocity profiles to properly correct the multibeam data during data processing. Casts were taken at approximately 20-minute intervals. The location of casts along the survey track lines were varied for adequate spatial coverage. If significant cast-to-cast variability was observed, the time between casts was decreased.

Checks were completed to verify pressure sensor and sound speed instrument performance. Corrections for the speed of sound through the water column were computed for each sensor. Sound speed profiles were imported and overlaid for comparison into an Excel file. All comparisons were well within survey specifications.

Data Processing Methods and Procedures

Sound speed profiles were applied to each line using the nearest in distance within time (one- and two-hour) option in the HIPS SVP correct routine. All casts were concatenated into a HIPS SVP file for each survey day, using NOAA Sound Speed Manager. Time, position, depth, and sound speed for each profile were included in the HIPS file.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed values were measured by AML Oceanographic Micro SV Xchange sensors. These sound speed values were applied in real-time to the MBES system to provide refraction corrections to the transducer, beam forming, and by HIPS during sound velocity correction. Values were monitored in real-time and compared against the water column cast data to adequately capture sound velocity change throughout the survey operations.

Data Processing Methods and Procedures

Surface sound speed data were not independently processed.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

Best estimates for TPU values were entered into the vessel files based on current knowledge of the TPU/CUBE processing model. The manufacturers' published values were entered in the static sensor accuracy fields. Other values were either calculated or estimated.

Navigation and transducer separation distances from the motion sensor were computed relative to the IMU sensing center rather than the bullseye label on the IMU; therefore, the vessel file standard deviation offsets will not exactly match the sensor offset values.

Real-time sonar uncertainty, which was logged to the HYPACK HSX files for each sounding, was read into CARIS HIPS at the time of conversion. Real-time navigation, delayed heave, and the associated real-time uncertainties for these data were loaded into HIPS with the Import Auxiliary Data Function. These real-time uncertainty values were applied when TPU was computed.

Tide uncertainties were entered in the Compute TPU process for zoning values with the provided SEP model.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		S/V Blake	R/V Broughton
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees
	Heave	2.00% 0.02 meters	2.00% 0.02 meters
	Roll	0.01 degrees	0.01 degrees
	Pitch	0.01 degrees	0.01 degrees
Navigation Sensor		0.10 meters	0.10 meters

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
S/V Blake, R/V Broughton	In addition to published uncertainty values applied in the HVF, real-time sonar uncertainty sources were incorporated into the depth estimates of these data. For all vessels, real-time uncertainty values from the T50 Series sonars were logged in the HYPACK HSX files per sounding and read into CARIS HIPS at the time of conversion. For all survey vessels using a POS MV, real-time estimates for delayed heave, position, roll, pitch, and yaw were loaded into HIPS via the Import Auxiliary Data function. These values were overwritten with post-processed values for survey lines that were processed with POSPac MMS. These real-time and post-processed uncertainty sources were applied during TPU computation.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

Features were evaluated using a combination of methods including verification by SSS, MBES, and visual means. Positioning of baring features was achieved using MBES positions.

Data Processing Methods and Procedures

Designated soundings that were determined to be obstructions, rocks, wrecks, or other significant features were imported into the S-57 feature files and attributed. S-57 objects were created for uncharted surveyed features and newly positioned charted baring features.

All features were created using the NOAA Profile Version 2021 catalogue, which references the NOAA Extended Attributes defined in the NOS HSSD. All mandatory feature attributes have been populated. In addition, the images attribute has been used to provide multibeam and side scan screen shots of submerged features. For baring features, the images attribute has been populated with a photo from a handheld camera.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Bottom samples were acquired as specified in the Hydrographic Survey Project Instructions in accordance with the HSSD, utilizing equipment as described in the equipment section of this document. Approximate bottom sample locations were provided by NOAA in the final project reference file (PRF). The final sampling plan was modified to move planned sample locations away from submerged infrastructure and/or into areas deeper than the surveyed 3.5-meter inshore limit. Prior to sampling, the MBES and SSS data at these locations were reviewed to verify that there was no charted or surveyed oil and gas infrastructure observed in the vicinity that could be damaged by the bottom sampler.

Data Processing Methods and Procedures

Bottom samples were analyzed for sediment type and classified with S-57 attribution, with the most prevalent sediment type listed first. Photographs of the samples were taken in the field and are included in the feature attribution of each sample.

C.9 Other Data

Data Acquisition Methods and Procedures

DEA performed several checks to the project control prior to and during survey operations. This included an evaluation of the NOAA-provided separation models, GPS ties to tidal benchmarks at the NOAA tide station at Pascagoula NOAA Lab, and checks to the water levels at the tide station using ERS measurements made from a survey vessel and land based RTK observations.

VDatum Review

During the planning phase of the project, DEA reviewed the preliminary MLLW and Mean High Water (MHW) VDatum-derived separation models, as provided by NOAA Operation Branch with the draft Project Instructions. During this review, DEA observed that VDatum and the VDatum derived separation models for the project did not encompass the entire project area. Coverage did not extend inshore into the Port of Pascagoula's East and West Harbors. DEA reported this coverage gap to NOAA Operations branch, which later issued revised separation models that were extended to cover the entirety of the survey area. The revisions were to the project models only; as of November 2021, these gaps in coverage have not been addressed in VDatum (see Figure 12).

Pascagoula NOAA Lab, MS (8741533)

On February 19, 2021, DEA performed position checks on two tidal benchmarks in the vicinity of NOAA NWLON gauge Pascagoula NOAA Lab, MS (8741533) to validate the use of ERS-based water levels for the project. Positions were acquired using a Trimble SPS881 Smart GNSS antenna and TSC3 Controller using RTK corrections from the C4GNet RTN. The system used the same NTRIP mountpoint that was configured onboard each survey vessel. All positions were collected relative to NAD83(2011) with NAVD88 (Geiod12B) heights. GPS positions were compared to published OPUS solutions for benchmarks 1533 A 2005 and 1533 B 2005. For both checks, GPS orthometric heights were compared directly to published NAVD88 elevation from OPUS solutions and to MLLW elevations published by CO-OPS. For the MLLW comparison, NAVD88 elevations were converted to MLLW using the 0.201-meter adjustment published by CO-OPS. Results from these checks are presented in Figure 13

DEA also set a temporary staff gauge at the NOAA water level station, which was tied to MLLW through GPS observations. Staff readings were made every 6 minutes and compared to preliminary water level data from the NOAA gauge. Results from the staff gauge comparison are presented in Figure 14

Tide Float

A vessel float was performed on November 17, 2021, at the Pascagoula water level station to check the validity of the NOAA-provided NAD83 to MLLW separation model. During the vessel float, the R/V Broughton remained stationary and logged data for approximately 15 minutes while adjacent to the NOAA water level gauge. GPS tides were later computed from a post-processed SBET relative to the vessel water line and smoothed using a 60-second moving average. The resulting MLLW GPS tide was compared to verified water levels from the adjacent NOAA CO-OPS tide gauge.

The average difference between the two water levels was 15.7 centimeters (Figure 15) with gauge water levels consistently higher than those measured by the survey vessel. A vessel float performed by DEA at the same gauge in 2017 during project OPR-J348-KR-17 produced similar results, with gauge water levels 15 centimeters higher than those measured by a survey vessel. The 2017 float was performed south of the gauge at the edge of the published VDatum coverage. Results and recommendations from the 2017 survey were included in the OPR-J348-KR-17 Horizontal and Vertical Control Report.

It appears that the revised separation model, which was extended to encompass the Port of Pascagoula and the entirety of the survey area in 2021 including the Port of Pascagoula, uses an incorrect relationship between NAVD88 and MLLW at the location of the NOAA gauge. The separation value between NAVD88 and MLLW for the OPR-J315-KR-21 model file computed by backing out the geoid (GEOID12B) is 0.067m

(NAVD88 is 0.067 meters above MLLW). The NAVD88 to MLLW offset published by CO-OPS (used in the previously discussed staff gauge analysis) at the Pascagoula gauge is 0.201 meters. The difference between the two values is 13.4 centimeters which is consistent with the 15.9-centimeter average difference observed during the tide float analysis. A graphic depicting these relationships is shown in Figure 16.

The hydrographer recommends that these results be passed on the NOAA VDatum Team with recommendations that Pascagoula gauge datums be incorporated into future VDatum revisions.

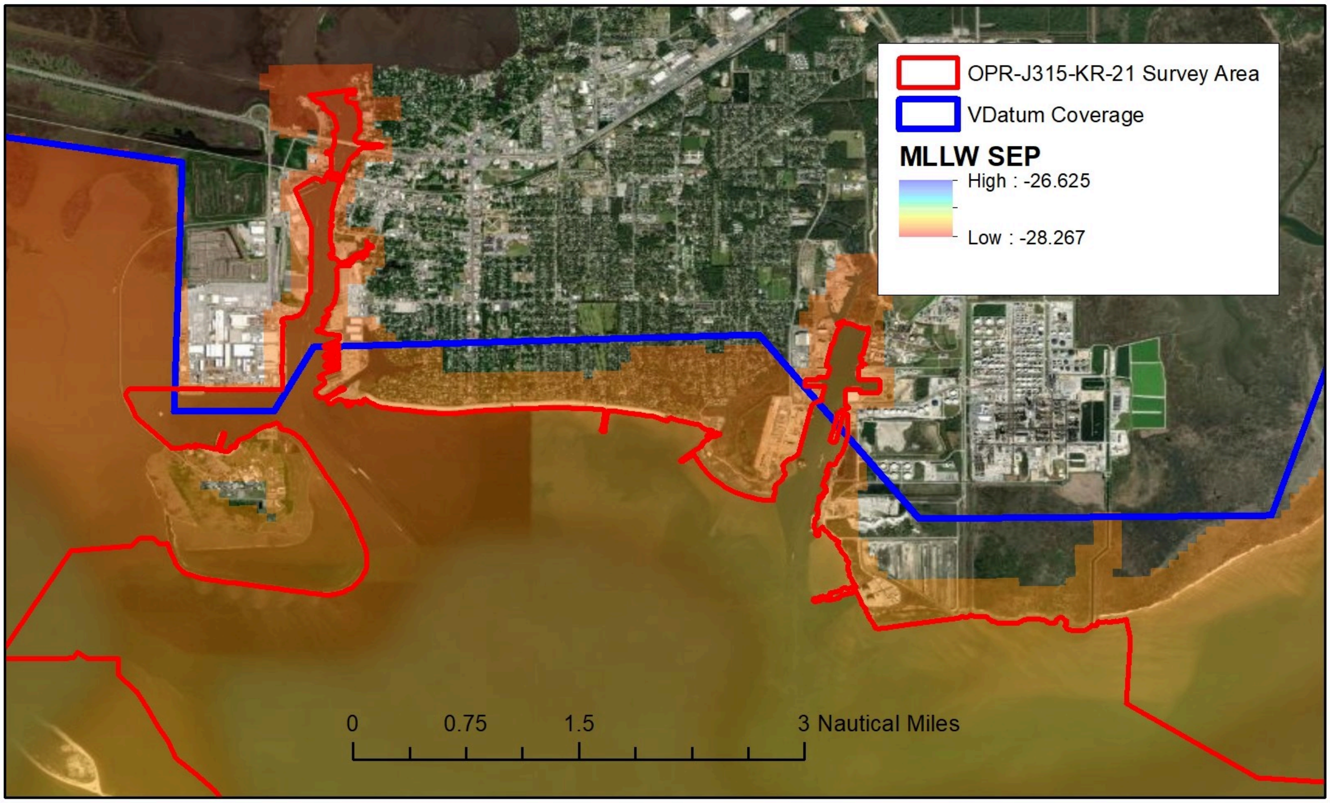

Figure 12: VDatum Coverage at the Port of Pascagoula

Pascagoula NWLON Station 8741533 Pascagouls NOAA Lab, MS
RTK GNSS Observations 2/19/2021

Hardware: Trimble 885 with TSC3 Data Collector
Correctors: LA C4G Virtual Network GNSS
Antenna Height to ARP: 1.34 meters
Horizontal: NAD83 UTM 16N Meters
Vertical: NAVD88 (GEOID18)
Observations: 180 seconds

Observations on Tidal BM 1533A						CO-OPS	
Source	Point	North (m)	East (m)	NAVD88 (m)	MLLW*	MLLW (Pub.)	Difference
OPUS	**1533A**	**3360620.495**	**349807.22**	**2.247**	2.448	2.422	0.026
RTK	1533A1	3360620.479	349807.213	2.251	2.452	2.422	0.030
Difference (m)		**0.016**	**0.007**	**-0.004**			

* CO-OPS adjustment +0.201m from NAVD88 to MLLW

Observations on Tidal BM 1533B							
Source	Point	North (m)	East (m)	NAVD88 (m)		CO-OPS	
OPUS	**1533B**	3360571.582	349813.569	**2.313**	MLLW*	MLLW (Pub.)	Difference
RTK	1533B1	3360571.571	349813.554	2.291	2.492	2.468	0.024
RTK	1533B2	3360571.578	349813.556	2.287	2.488	2.468	0.020
RTK	1533B3	3360571.579	349813.548	2.323	2.524	2.468	0.056
RTK Average		**3360571.576**	**349813.553**	**2.300**	2.501	2.468	0.033
Difference		**0.006**	**0.016**	**0.013**			

* CO-OPS adjustment +0.201m from NAVD88 to MLLW

Figure 13: GPS Position Check

Tide Staff Observations 2/19/2021

All times are Central Standard Time

Seas: 4cm wind chop

*Adjustment to Staff:-0.043m from averaged RTK Shots and converting NAVD88 to MLLW by subtracting 0.201m

Local Time	Staff (m)	Preliminary CO-OPS MLLW (m)	Staff to CO-OPS Difference	Adjusted* to MLLW	Staff MLLW* (m) to Preliminary MLLW Difference
8:48	0.19	0.133	0.057	0.147	0.014
8:54	0.20	0.137	0.063	0.157	0.02
9:00	0.21	0.139	0.071	0.167	0.028
9:06	0.21	0.15	0.06	0.167	0.017
9:12	0.22	0.154	0.066	0.177	0.023
9:18	0.22	0.161	0.059	0.177	0.016
9:24	0.22	0.154	0.066	0.177	0.023
9:30	0.22	0.153	0.067	0.177	0.024
9:36	0.215	0.155	0.06	0.172	0.017
9:42	0.225	0.161	0.064	0.182	0.021
9:48	0.23	0.168	0.062	0.187	0.019
		Average	0.063	0.172	0.020

Figure 14: Staff Gauge Comparison

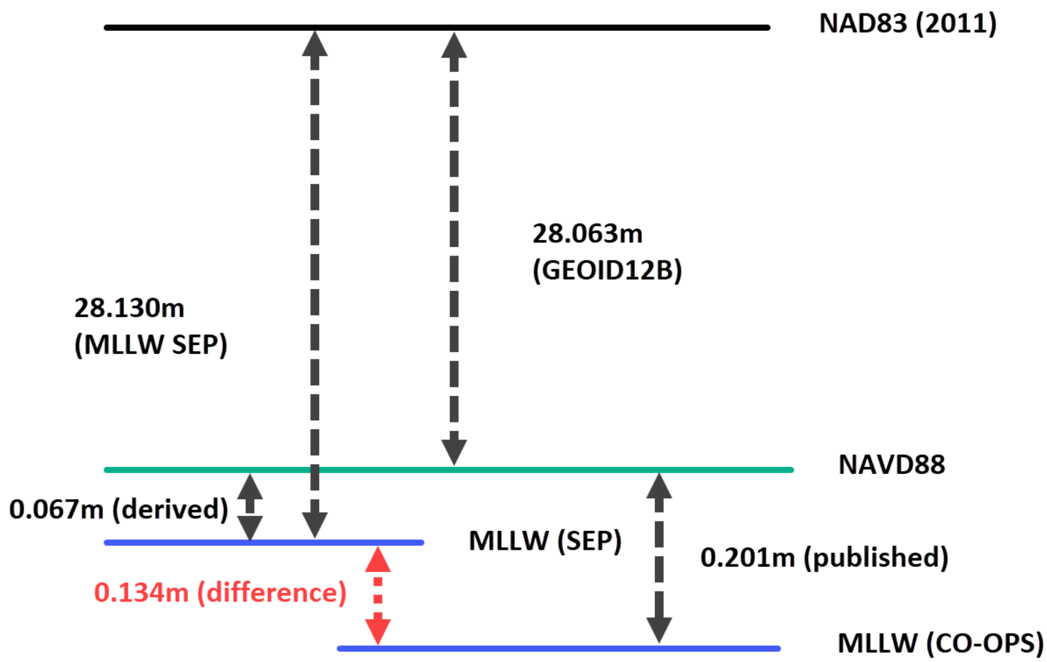

Figure 15: Datum Comparison

Time (UTC)	Gauge (m)	Vessel (m)	Difference (m)
14:36	0.313	0.181	0.132
14:42	0.316	0.147	0.169
14:48	0.319	0.149	0.170
		Mean	**0.157**

Figure 16: Vessel Tide Float

Data Processing Methods and Procedures

N/A

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

Review of bathymetric data was conducted by reviewing multiple HIPS child layers coupled with utilizing NOAA QC Tool outputs for surface review guidance.

Surfaces were reviewed for artifacts indicative of systematic errors, data fliers impacting the surface, and for consistency with the grid requirements set in the HSSD.

D.1.2 Designated Sounding Selection

Soundings rejected by quality filters, with the exception of filtered TPU, were displayed during editing, and any feature removed by a filter was manually re-accepted. Fliers making the CUBE surface shoaler than expected by more than the allowable IHO Order 1a vertical error were rejected. Designated soundings were used as necessary to force the finalized depth surface through reliable shoaler soundings. Soundings were designated per NOAA HSSD requirements. In addition, data processors reviewed sounding data and CUBE surfaces for excessive motion artifacts or systematic biases.

D.1.3 Holiday Identification

Node density was evaluated to verify that at least 95% of soundings were populated with at least five soundings per HSSD requirements. All multibeam data collected were reviewed in HIPS 3D Subset Editor with the in-house defined shoal biased reference surface active.

MBES coverage was evaluated using NOAA Pydro QC tools to check finalized surfaces for holidays. In addition, the coverage was reviewed along the Navigable Area Limit Line (NALL) to verify that coverage requirements were meet. In all instances, holidays identified during this review process were added to survey fill plans and addressed unless there were concerns for the safety of the survey vessel and crew, or ships or barges at berth prevented additional data collection. The Descriptive Report for each survey further discuss survey coverage and any outstanding holidays.

Due to the "skunk stripe" nature of Complete Coverage Option B, large MBES holidays may be flagged as a false positive depending upon the review methodology. Likewise, large underwater or baring features may prohibit full bottom coverage by MBES, either due to physical size or needing to be removed from the data set for feature management purposes.

MBES and SSS coverages were compared to check survey project instruction requirements were met, and that coverage from those respective systems met HSSD and Project Instruction requirements.

D.1.4 Uncertainty Assessment

Individual sounding uncertainty was computed using CARIS compute TPU and other associated steps. Soundings exceeding IHO thresholds were filtered out during processing.

Grid node uncertainty was chosen from the "greater of the two" from the standard deviation of the soundings contributing to the depth solution, or the "a priori" computed uncertainty estimate. Node uncertainty was evaluated to verify that nodes met uncertainty requirements per HSSD requirements. Finalized surfaces were reviewed in their respective uncertainty layers, and using NOAA Pydro QC Tools. Hydrographers inspected soundings and surfaces in subset, removing or re-accepting soundings based upon expertise and experience.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

All crosslines were manually reviewed for high internal consistency between the data sets and comparison statistics were also computed using the HIPS QC Report to evaluate a beam-by-beam statistical analysis and the Pydro Compare Grids tool for a surface difference.

D.1.5.2 Junctions

In accordance with the HSSD guidelines, a surface difference comparison was conducted and reviewed for all current and prior surveys that junction the assigned survey limits for this project. Junction surveys were compared to the current survey using Pydro Compare Grids tool and detailed inspection using subset editor. In circumstances of larger disagreement between the current survey and prior surveys, the DR from existing data was reviewed to identify if there were any discrepancies in tidal applications. All junction survey comparisons are detailed in the individual DRs for each assigned survey.

D.1.5.3 Platform to Platform

Multibeam data overlap between survey platforms was evaluated during processing at the grid level and while reviewing data during subset editing. The depth (with increased vertical exaggeration) and standard deviation child layers were reviewed to locate areas of disagreement between survey platforms. When areas with platform-to-platform disagreement were observed, they were generally caused by anomalous GNSS heights or changes in the bottom (natural and man-made) that occurred between survey passes. If applicable, disagreement between survey lines caused by these issues is further discussed in the individual survey’s Descriptive Report.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

HYPACK acquisition software was used to record side scan sonar data in HSX format. Adjustments to towfish height were made during stern tow data acquisition as necessary and logged into HYPACK to meet specifications and provide the best image quality possible. Changes to cable-out values, sensor settings, offset configurations, data quality, and contacts were recorded in the daily acquisition log. Typical windows for monitoring raw sensor information included a waterfall display for the sonar imagery, towfish motions, cable-out and layback, sonar signal voltage display, and I/O port monitor. Data were displayed on a 30-inch LCD flat-panel monitor mounted vertically at the acquisition station. The large-format display allowed for increased time to analyze online contacts.

Coverage assessment was performed in real-time using HYPACK and in post-processing using a combination of software, including SonarWiz, CARIS and ArcMap. Sonar lines were evaluated to meet both technical standards for overlap and altitude speed, as required, and for subjective standards, such as gain balance, biologic interference, and motion artifacts. Areas that failed to meet coverage that would allow for contact selection were recollected with either additional SSS coverage, or in some cases filled with 100% MBES in lieu of the 100% SSS requirement.

Prominent features were used to evaluate SSS positioning, and compared with MBES data sets, checking object detection and accuracy requirements.

D.2.2 Contact Selection Methodology

Contacts were selected in real-time and during post-processing. Sonar contacts were processed using CTI SonarWiz software.

Contacts were selected and reviewed by multiple reviewers. Contact height significance thresholds were made based upon MBES bottom depths to streamline which contacts required additional MBES development.

Management of side scan sonar contacts was accomplished by utilizing CARIS feature creation tools and Hydrographic Object Binary (HOB) files, meeting the requirements of the HSSD. The use of the HOB format allowed direct geographic display of contacts within CARIS HIPS, where contacts were correlated and compared to the chart and other survey data.

E. Approval Sheet

Field operations contributing to the accomplishment of OPR-J315-KR-21 were conducted under my direct supervision with frequent personal checks of progress and adequacy.

This report and associated data have been closely reviewed and are considered complete and adequate as per the OPR-J315-KR-21 Statement of Work (March 9, 2021) and Hydrographic Survey Project Instructions (April 27, 2021).

Approver Name	Approver Title	Date	Signature
Jonathan L. Dasler, PE, PLS, CH	NSPS-THSOA Certified Hydrographer, Chief of Party	12/07/2021	Digitally signed by Jonathan L. Dasler, PE, PLS, CH Date: 2021.12.07 13:12:46 -08'00'
Jason Creech, CH	NSPS-THSOA Certified Hydrographer, Charting Manager/ Project Manager	12/07/2021	Digitally signed by Jason Creech Date: 2021.12.07 13:19:39 -08'00'
James Guilford	IHO Cat-A Hydrographer, Lead Hydrographer	12/07/2021	Digitally signed by James Guilford Date: 2021.12.07 13:25:58 -08'00'
Michael Redmayne	IHO Cat-A Hydrographer, Lead Hydrographer	12/07/2021	Digitally signed by Michael Redmayne Date: 2021.12.07 13:31:30 -08'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	Appendix I - Vessel Wiring Diagram.pdf
Sound Speed Sensor Calibration	Appendix II - Sound Speed Sensor Calibration Reports.pdf
Vessel Offset	Appendix III - Vessel Offset Reports.pdf
Position and Attitude Sensor Calibration	Appendix IV - Position Attitude Sensor Calibration Reports.pdf
Echosounder Confidence Check	Appendix V - Echo Sounder Confidence Check Reports.pdf
Echosounder Acceptance Trial Results	N/A