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-K356-KR-22
Time Frame:	June - December 2022

LOCALITY

State(s):	Louisiana
General Locality:	Approaches to Calcasieu

2022

CHIEF OF PARTY
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Chief of Party: Jonathan L. Dasler, PE, PLS, CH
Year: 2022
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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 the survey vessel 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, two data acquisition stations, and two 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*	2022-05-27
	Method	A squat confirmation test for the S/V Blake was performed in the Gulfport Ship Channel on May 24, 2022, (DN144) with mobilization efforts beginning on May 27, 2022 (DN147). After completing the transit to the project area, system calibrations and a start-of-project patch test were performed near the Calcasieu Ship Channel on June 2, 2022, (DN153) and June 3, 2022 (DN154). Results from the squat test were consistent with results from the prior test, which was performed on June 15, 2020, in support of NOAA project OPR-J315-KR-21. 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. While the S/V Blake was dry docked at Diamond B Marine Services, Inc. in New Iberia, LA, on May 22, 2018, DEA performed side pole surveys as well as checks to the inertial 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.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Teledyne RESON T50 Series

The multibeam echosounder (MBES) was deployed in a single-head configuration using a retractable moon pool with center strut mount on the S/V Blake.

The Teledyne RESON T50 Series multibeam sonar is a 190 to 420 kHz system. For this survey, it was operated at 350 kHz in a single-head configuration with a 140-degree swath and 512 equiangular beams. The sonar 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	08964120064	5015068	2714149
		Frequency	350	350	350
		Calibration	N/A	N/A	N/A
		Accuracy Check	N/A	N/A	N/A

Figure 2: S/V Blake Retractable Moon Pool and Center-Pole Mount

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 4205 Series

The EdgeTech 4205-HF side scan sonar (SSS) system is an 115 lb, 1.40-meter long towed 540/850 kHz system (Figure 3). It was operated at 540 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><i>Manufacturer</i></td><td colspan="2">EdgeTech</td></tr>
<tr><td><i>Model</i></td><td colspan="2">4205 Series</td></tr>
<tr><td><i>Inventory</i></td><td><i>S/V Blake</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Topside Unit and Rack Mount</td><td>Towfish</td></tr>
<tr><td><i>Model Number</i></td><td>701-DL</td><td>4205</td></tr>
<tr><td><i>Serial Number</i></td><td>61361</td><td>60765</td></tr>
<tr><td><i>Frequency</i></td><td>N/A</td><td>540kHz</td></tr>
<tr><td><i>Calibration</i></td><td>N/A</td><td>N/A</td></tr>
<tr><td><i>Accuracy Check</i></td><td>N/A</td><td>N/A</td></tr>
</table>
</td></tr>
</table>

Figure 3: EdgeTech 4205 Side Scan Sonar

A.2.3.2 EdgeTech 4200 Series

The EdgeTech 4200 side scan sonar (SSS) system is an 80 lb, 1.26-meter long towed 230/540 kHz system (Figure 4). It was operated at 540 kHz and a 50-,75-, and 100-meter range scale for this project in a high-speed mode for adequate along-track ping rate.

Manufacturer	EdgeTech			
Model	4200 Series			
Inventory	*S/V Blake*	*Component*	Topside Unit and Rack Mount	Towfish
		Model Number	701-DL	4200
		Serial Number	61361	42627
		Frequency	N/A	540kHz
		Calibration	N/A	N/A
		Accuracy Check	N/A	N/A

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

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.

Manufacturer	Applanix/Trimble					
Model	POS MV 320 V5					
Inventory	*S/V Blake*	*Component*	Topside Unit	IMU	Antenna	Antenna
		Model Number	POS MV 320 V5	LN200	Trimble GA830	Trimble GA830
		Serial Number	7342	898	16954	7235
		Calibration	N/A	N/A	N/A	N/A

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

Additional GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

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

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

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 Used Before DN255	Water Column Sound Speed Profiler Used After DN255
		Model Number	Micro SVP&T	Micro SVP&T
		Serial Number	Housing:8703 SV:200790 P:304610 T:400211 After DN201: Housing:8704 SV:200790 P:300021 T:400211	Housing:009148 SV&T:221065 P:308291
		Calibration	2022-03-11	2022-05-10

A.6.2 CTD Profilers

A.6.2.1 AML Oceanographic Smart X

The AML Oceanographic Smart X was the sound speed profiler utilized when the primary system was inoperable on the S/V Blake. 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:201322 P:300021 T:404529 After DN201: Housing:20142 SV:201322 P:304610 T:404529
	Calibration	2022-03-11

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.

<table>
<tr><td><i>Manufacturer</i></td><td colspan="3">AML Oceanographic</td></tr>
<tr><td><i>Model</i></td><td colspan="3">Micro SV Xchange</td></tr>
<tr><td rowspan="4"><i>Inventory</i></td><td rowspan="4"><i>S/V Blake</i></td><td><i>Component</i></td><td>Sound Speed Sensor at sonar head</td></tr>
<tr><td><i>Model Number</i></td><td>Micro SV</td></tr>
<tr><td><i>Serial Number</i></td><td>Housing:12748 SV:205498</td></tr>
<tr><td><i>Calibration</i></td><td>2022-03-11</td></tr>
</table>

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	2022.1.22.1	Acquisition
HYPACK, Inc.	HYPACK Survey	2022.1.22.1	Acquisition
HYPACK, Inc.	HYPACK SSS Package	2022.1.22.1, After DN266: 2022.3.1.0	Acquisition
HYPACK, Inc.	HYSWEEP	2022.1.22.1	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	11.4.8, After DN192: 11.4.13	Processing
CARIS	HIPS	11.4.16 beta	Processing (GSF export only)
CARIS	BASE Editor	5.5.23	Processing
ESRI	ArcMap	10.6	Processing
Chesapeake Technology, Inc.	SonarWiz	7.09.05 (64-bit)	Processing
QPS	FMGT	7.10.1	Processing
Applanix	POSPac MMS	8.7 SP2	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	22.1	Processing
NOAA OCS/JHC	QC Tools	3.8.2	Processing
NOAA OCS/JHC	Compare Grids	22.1	Processing
NOAA OCS/JHC	POSPac AutoQC	22.1	Processing
Beyond Compare	Beyond Compare	4.4.1	Processing
AML Oceanographic	SeaCast	4.40	Acquisition

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 WILDCO Shipek Grab Sampler

The WILDCO Shipek Grab 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.

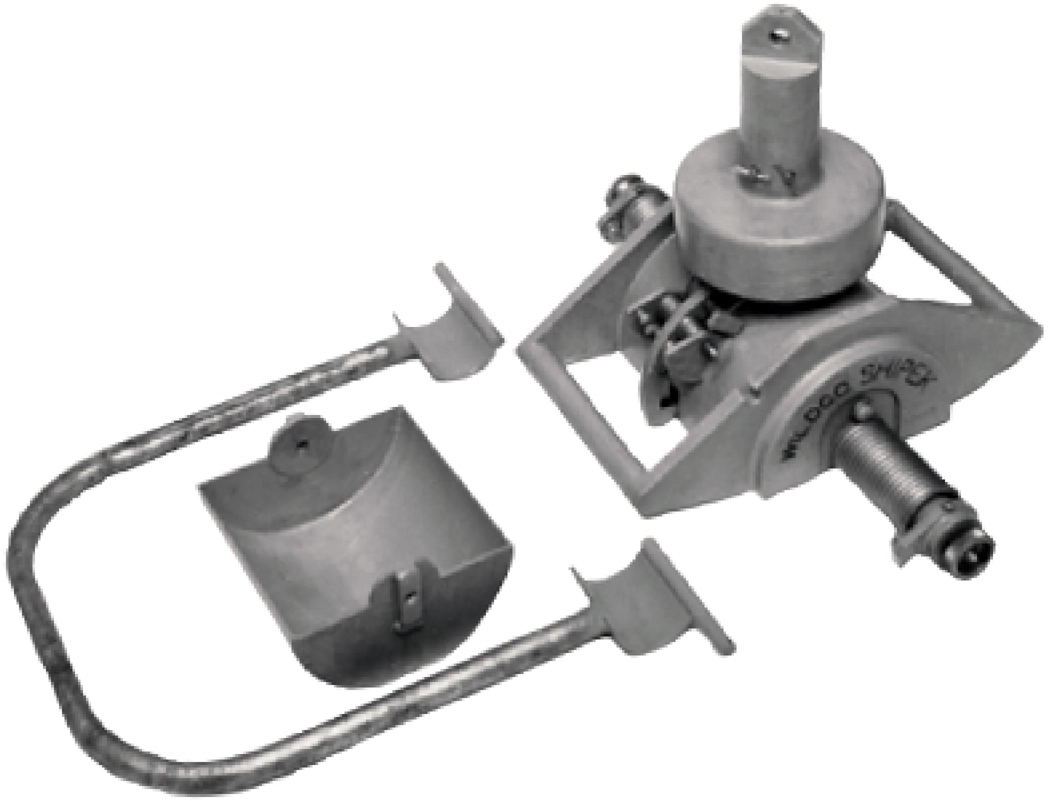

Figure 6: Shipek Grab Sampler

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. 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 the S/V Blake were calculated from vessel offset surveys, and dynamic draft values were calculated using post-processed GNSS observations. 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.

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

Vessel	S/V Blake			
Echosounder	Teledyne RESON T50			
Date	2022-05-27			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	-0.827 meters	0.030 meters
		y	0.052 meters	0.030 meters
		z	3.123 meters	0.030 meters
	Nav to Transducer	*x*	-1.380 meters	0.030 meters
		y	-4.646 meters	0.030 meters
		z	9.616 meters	0.030 meters
	Transducer Roll	*Roll*	0.000 degrees	

B.1.2 Layback

HYPACK was configured to compute side scan towfish position during acquisition. When towing the side scan from the stern, cable-out, tow point offsets, height above waterline, catenary factor, number of cable segments, and towfish depth were used by HYPACK to compute the side scan position. When towing from the bow, HYPACK was set up to use a fixed layback when computing the side scan position. Bow and stern tow points are denoted on the vessel offset drawing included in Appendix III - Vessel Offset Reports. This appendix also includes a detailed discussion on layback computation methodology.

B.1.2.1 Layback Correctors

Vessel	S/V Blake Bow Tow		
Echosounder	EdgeTech 4200/4205		
Frequency	540.0 kHz		
Date			
Layback	*Towpoint*	*x*	19.000 meters
		y	0.000 meters
		z	-1.000 meters
	Layback Error	0.030 meters	

Vessel	S/V Blake Stern Tow		
Echosounder	EdgeTech 4200/4205		
Frequency	540.0 kHz		
Date			
Layback	*Towpoint*	*x*	-9.200 meters
		y	0.000 meters
		z	-1.200 meters
	Layback Error	0.030 meters	

B.2 Static and Dynamic Draft

B.2.1 Static Draft

All surveys were collected and processed using ERS methods. The S/V Blake was built with draft dampening sight 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 approximately every week and averaged to compute vessel draft and corresponding water line correction.

Due to the application of ERS methods for this survey, static draft observations had no impact on the vertical accuracy of the survey and were only used for the water level gauge comparisons 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 Ross ball attached to the end of a wire cable and chain, marked at 2 meters, was used to bar check the multibeam sonar on the S/V Blake. The marks were checked periodically with a measuring tape. The bar check device was lowered to a recorded depth below the water surface to 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 sonar. 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 not used in the processing of this ERS survey, a settlement and squat test was performed on May 24, 2022 (DN144). This test confirmed values from previous settlement and squat tests.

A squat confirmation test was performed prior to survey operations using a post-processed GNSS technique compatible with the NOAA POSPAC AutoQC Tool. During the test, a transect was run in Mississippi Sound in the vicinity of Gulfport, MS, at increasing speeds (from zero to approximately 12 knots) in opposite directions. After post-processing the navigation and inertial data acquired during the test, the NOAA tool was used to analyze the resulting Smoothed Best Estimate of Trajectory (SBET) and produce a dynamic draft table. This test confirmed values from previous settlement and squat tests for the S/V Blake.

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 5 to 8 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 vessel to monitor the stability of the multibeam sonar’s strut mount. 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

<table>
<tr><td><i>Vessel</i></td><td>S/V Blake</td></tr>
<tr><td><i>Echosounder</i></td><td>Teledyne RESON T50</td></tr>
<tr><td><i>Date</i></td><td>2022-06-03</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
<table>
<tr><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td><i>Pitch</i></td><td>-1.630 degrees</td><td>0.080 degrees</td></tr>
<tr><td><i>Roll</i></td><td>-0.230 degrees</td><td>0.080 degrees</td></tr>
<tr><td><i>Yaw</i></td><td>-0.310 degrees</td><td>0.039 degrees</td></tr>
<tr><td><i>Pitch Time Correction</i></td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td><i>Roll Time Correction</i></td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td><i>Yaw Time Correction</i></td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.000 seconds</td><td>0.005 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

MBES acquisition within H13644, H13645, H13646, and H13647 was performed to achieve 100% bathymetric bottom coverage using Object Detection Option A and Complete Coverage Option A requirements.

In survey areas H13648, H13649, H13650, H13677, and H13678, MBES was acquired concurrently with side scan sonar to achieve Complete Coverage Option B requirements as specified in the 2022 Hydrographic Survey Specifications and Deliverables (HSSD). Complete coverage multibeam was also used to disprove features and fill some side scan holidays within these survey areas.

A graphic depicting the coverage techniques for the survey area, which meet the coverage requirements defined in the OPR-K356-KR-22 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 the navigation system 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.

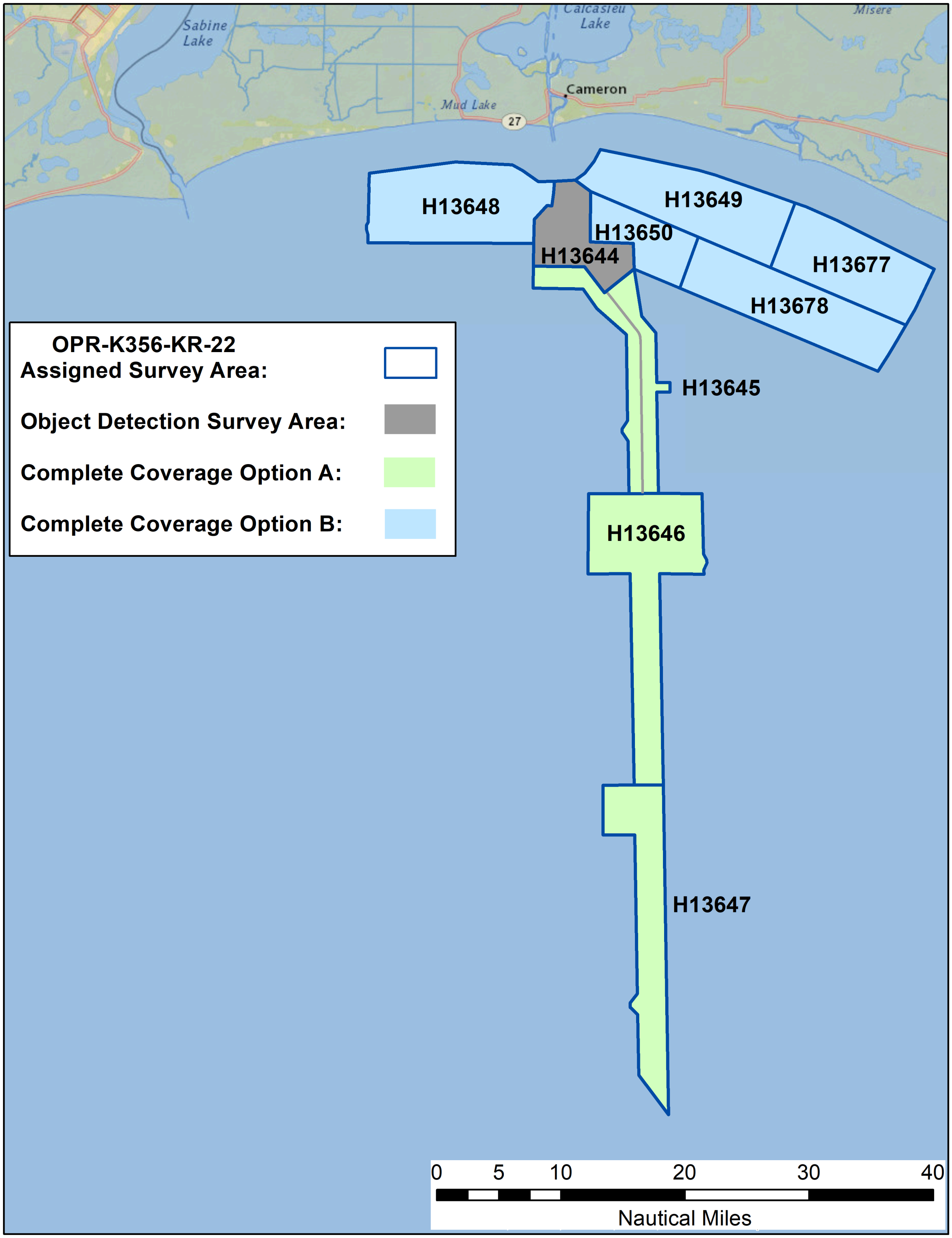

Figure 7: OPR-K356-KR-22 Coverage Types

Data Processing Methods and Procedures

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.

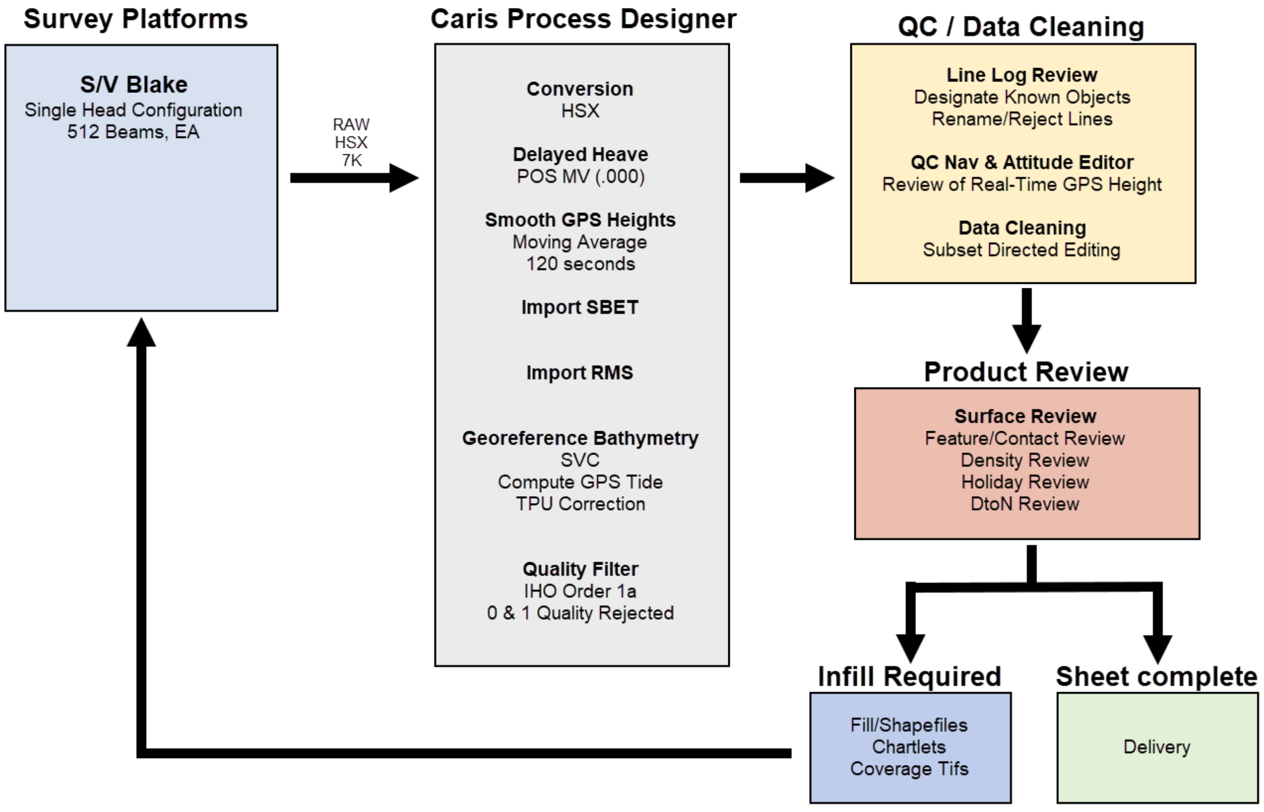

Figure 8: Flowchart of MBES Data Processing Pipeline

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 Combined Uncertainty and Bathymetry Estimator (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 2022 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 using the RESON 7058 normalized backscatter strength datagram. 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

Normalized multibeam backscatter data was processed in QPS FMGT to meet newly published backscatter requirements set in the 2022 HSSD. For all survey areas, multibeam backscatter mosaics were generated using the frequency-based resolution requirements equating to an output resolution of 2 meters. Any deviations from the processing workflow shown in Figure 9 are addressed in the individual Descriptive Reports for each survey.

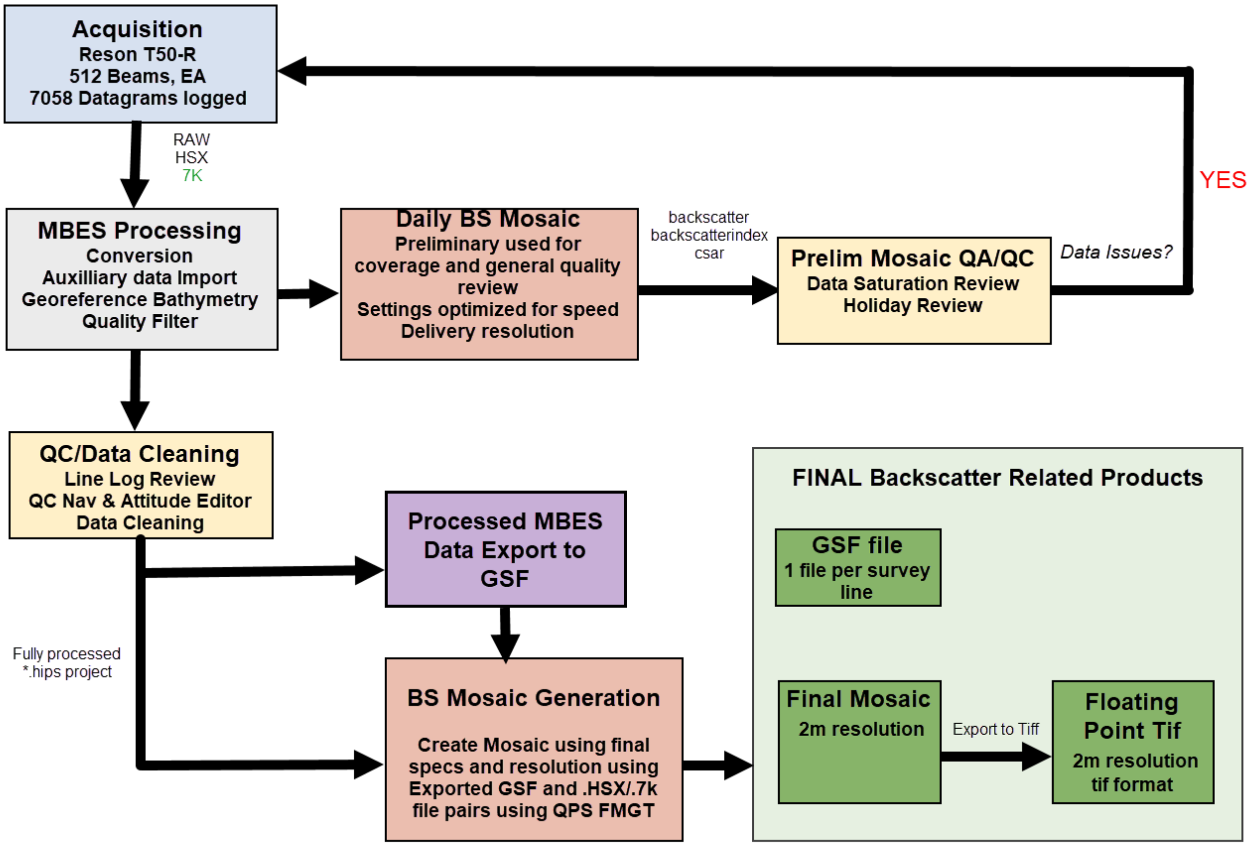

Figure 9: Flowchart of Backscatter Data Processing Pipeline

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

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

SSS imagery was acquired with an EdgeTech 4205-HF (540/850 kHz) dual-frequency side scan sonar. This sonar was operated at 540 kHz in high-speed mode using 50-, 75-, and 100-meter range scales, and at survey speeds and ping rates that enable the sonar to detect 1-meter targets in the along-track direction. SSS imagery was also acquired with an EdgeTech 4200 (230/540 kHz) dual-frequency side scan sonar after October 8, 2022 (DN281). This sonar was operated at 540 kHz in high-speed mode using 50-, 75-, and 100-meter range scales. For both sonars, the 50-meter range scale was used during mainscheme acquisition. The 75-meter and 100-meter range scales were occasionally used to extend coverage as a safety mitigation measure when operating near some offshore platforms.

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 either the bow or the stern of the vessel, depending on water depth. For the bow and stern tow configurations, the horizontal and vertical offsets of the tow point relative to the vessel reference point and waterline were entered into HYPACK hardware settings within the Towfish.dll driver setup and used in conjunction with cable-out, number of cable segments, catenary factor, and towfish depth to compute raw towfish positions. 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 factory, number of cable segments, and towfish depth was used to compute layback for stern tow. For bow tow, a fixed cable-out was used, and layback computed using the tow point offset, number of cable segments, and catenary factor with the “Shallow Fish” setting selected within the Towfish.dll setup. The vessel tow points are 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 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 EdgeTech 4205-HF series sonar has a ping rate of 30 Hz at the 50-meter range, 20 Hz at the 75-meter range, and 15 Hz at the 100-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 9 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. Operations were suspended when weather or sea conditions degraded side scan sonar imagery.

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 external USB 3.0 hard drives.

Following acquisition, the HSX files were imported into CTI SonarWiz. The side scan bottom track was then reviewed and losses of bottom or incorrect bottom track areas were re-digitized, and gain adjustments were applied. Towfish depth, tow point offset, and cable-out were used to compute layback and applied for computing towfish position. Side scan data was automatically clipped in SonarWiz based on the NOAA Altitude vs. Range scale specifications. The processed lines then underwent two independent reviews to identify significant contacts. Navigation and offset parameters were reviewed along with available MBES data to verify accurate towfish positioning. 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 shoaler than 20 meters, any contacts greater than or equal to 75 centimeters were investigated, along with contacts with questionable or incomplete shadows and other conspicuous features. 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 10 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) at 1-meter resolution and converted to floating point format in ArcMap for final delivery.

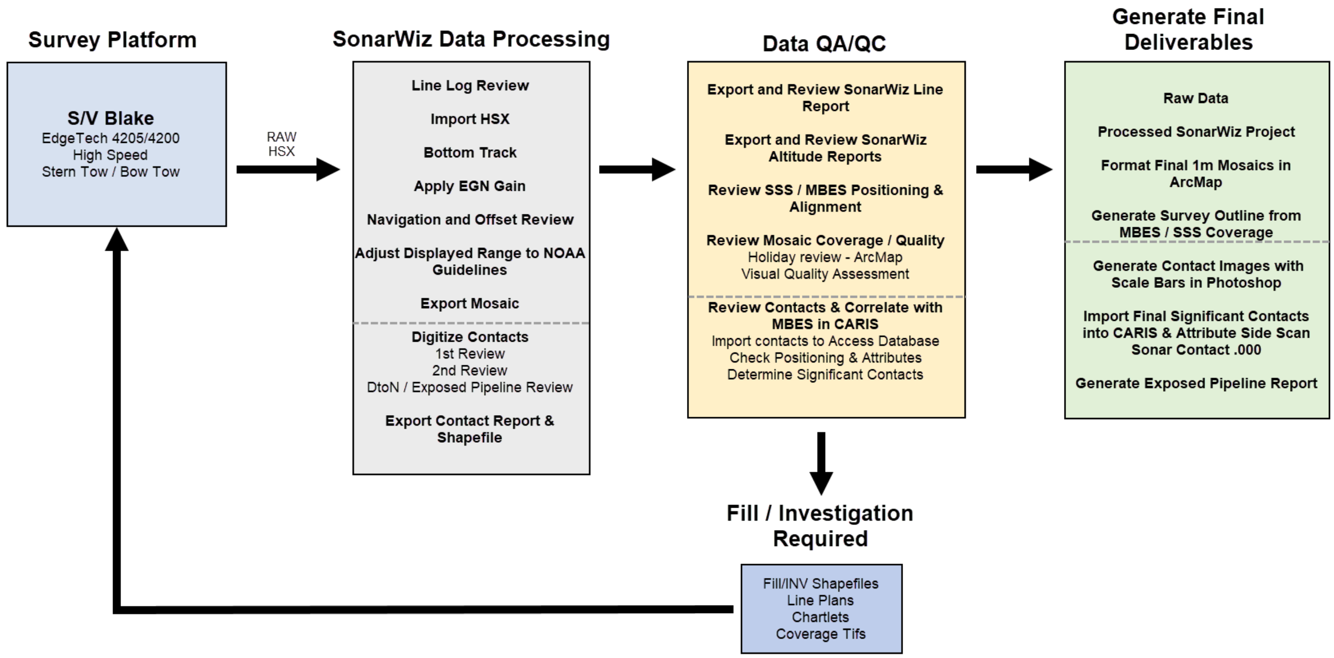

Figure 10: Flowchart of SSS Data Processing Pipeline

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

Data Acquisition Methods and Procedures

The Intuicom RTK Bridge-X installed on the S/V Blake 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 the

POS MV system. In case of signal loss, the POS MV system was 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.

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 a surface that represents the difference between the ellipsoid and chart datum for a given geographic area. The 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.

The separation model used to correct project survey depths to MLLW chart datum was derived from the National Geodetic Survey (NGS) VDatum model and provided by NOAA HSD Operation Branch with the Project Instructions.

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 all survey areas. 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.

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.

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.

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 adequate data to properly correct the multibeam data during data processing. Casts were taken at approximately 20-minute intervals. The location of casts along the survey tracklines were varied for adequate spatial coverage. At the time of collection, each cast was reviewed and compared to previous casts using the ODIM MVP Controller software. If significant cast-to-cast variability was observed, the time between casts was decreased.

Data Processing Methods and Procedures

Sound speed profiles were applied to each line using the "nearest in distance within time" 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 an AML Oceanographic Micro SV Xchange sensor. 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 bulls eye 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. Post-processed navigation, GPS height, heading and vessel motion uncertainties stored in POSPAC "smrmsg" files were loaded into HIPS with the Import Auxiliary Data function. These uncertainty values were specified in the HIPS Georeference Bathymetry dialog and applied when TPU was computed. A vertical uncertainty for the NOAA-provided separation model was also applied during this process using the GPS Sounding Datum field.

In rare instances, TPU was computed using vertical uncertainty from the static GPS Height Source stored in the vessel file when the post-processed GPS heights required smoothing to remove height anomalies. This technique was used to remove invalid GPS height uncertainty from the TPU process and resulting uncertainty surfaces.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

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

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
S/V Blake	In addition to published uncertainty values applied in the HVF, real-time sonar uncertainty sources were incorporated into the depth estimates of these data. 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. 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 on the submerged portion of the baring feature.

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 2022 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 or baring infrastructure and/or to obtain a wider variety of sediment types based on side scan and backscatter data.

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. Bottom samples have been included in the Final Feature File using the S-57 object acronym SBDARE.

C.9 Other Data

Data Acquisition Methods and Procedures

DEA performed several project control checks during survey operations. This included an evaluation of the NOAA-provided separation models and checks to water levels at the NOAA tide station Calcasieu Pass, LA, (8768094) using ERS measurements. Through these checks, DEA discovered an error in the VDatum based separation model, which was reported to NOAA Operations Branch staff. On July 18, 2022, NOAA issued a revised NAD83 to MLLW model, which resolved the error. The revised model was used to correct all sounding data to MLLW for the project and is documented in each of the survey’s Descriptive Reports.

During the project control checks, DEA reviewed the MLLW and Mean High Water (MHW) VDatum-derived separation models, as provided by NOAA Operations Branch with the Project Instructions. DEA observed that the NAD83(2011) to tidal datum separation values reported by VDatum at the locations of the NOAA tide stations at Calcasieu Pass, LA, did not match the datums published by the NOAA Center for Operational Oceanographic Products and Services (CO-OPS). The project's separation files, which were generated using VDatum, also included the observed error. Figure 11 depicts the inconsistencies between the NAD83(2011) to Mean Lower Low Water (MLLW) separation values derived from the two methods. The CO-OPS-based separation depicted in the graphic uses a geoid height computed using GEOID18.

This discrepancy was also observed in a series of vessel tide floats performed by the S/V Blake while berthed at the Stone Oil Dock, which is in the vicinity of the NOAA Calcasieu Pass tide gauge. During the vessel float, the S/V Blake remained stationary and logged data for approximately 30 minutes. GPS tides were computed relative to the vessel water line using ERS methods and original SEP model. The resulting MLLW GPS tides were then compared to water levels from the adjacent NOAA CO-OPS tide gauge. This comparison confirmed the error in the NOAA-provided SEP model.

After reporting this issue to NOAA, a revised model was issued along with an explanation for the initial error. Copies of relevant emails are included in the Project Correspondence.

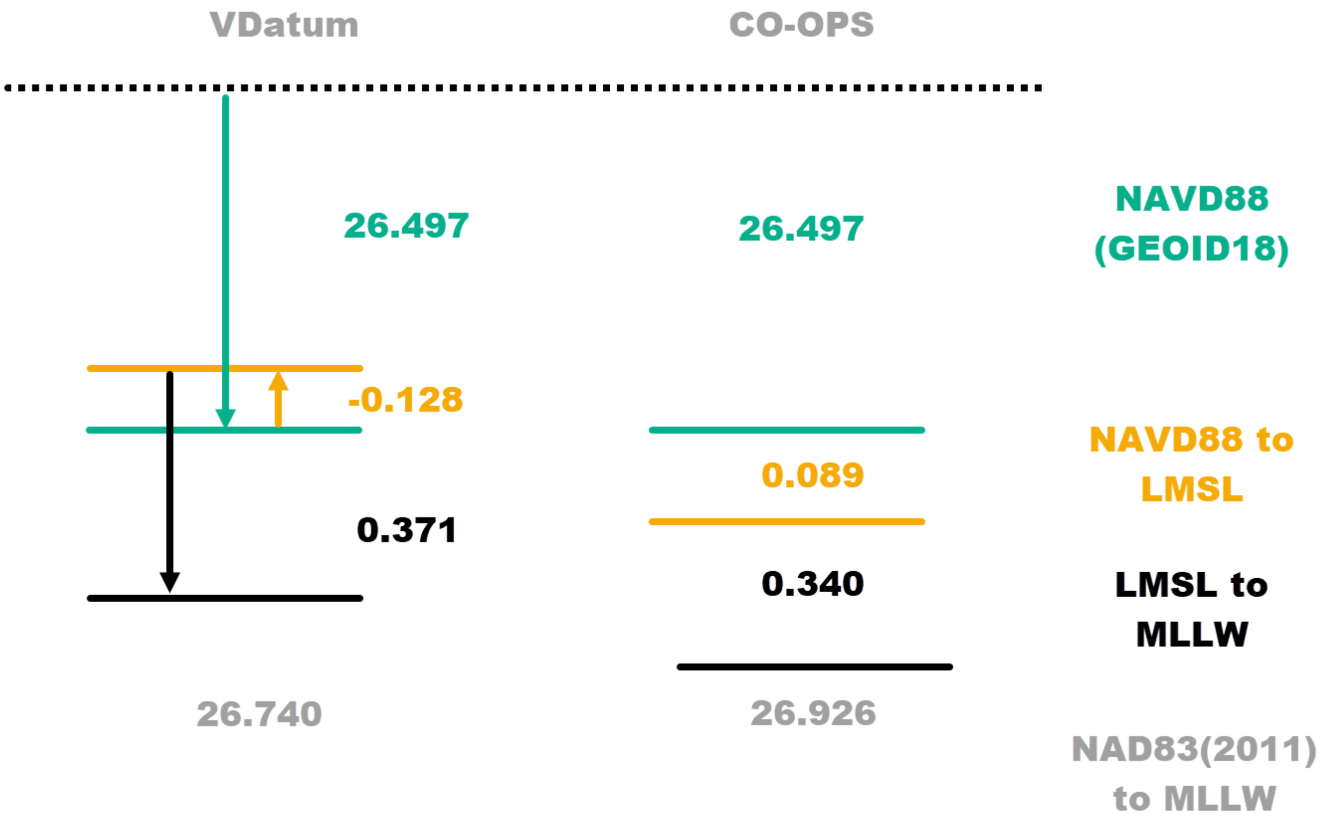

Figure 11: SEP Model Error

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 Tools output 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 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 baring platforms 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 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

Junction comparisons were performed for current and prior surveys in accordance with the HSSD and OPR-K356-KR-22 Project Instructions. Junction surveys were compared to the current survey using Pydro Compare Grids tool and detailed inspection using subset editor. All junction survey comparisons are detailed in the individual DRs for each assigned survey.

D.1.5.3 Platform to Platform

N/A

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 to check 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 SonarWiz, Microsoft Access Contact databases, and 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-K356-KR-22 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-K356-KR-22 Statement of Work (June 1, 2022) and Hydrographic Survey Project Instructions (August 11, 2022).

Approver Name	Approver Title	Date	Signature
Jonathan L. Dasler, PE, PLS, CH	NSPS-THSOA Certified Hydrographer, Chief of Party	11/18/2022	Digitally signed by Jonathan L. Dasler, PE, PLS, CH
Jason Creech, CH	NSPS-THSOA Certified Hydrographer, Project Manager	11/18/2022	Digitally signed by Jason Creech
James Guilford	IHO Cat-A Hydrographer, Lead Hydrographer	11/18/2022	Digitally signed by James Guilford
Jason Dorfman	Lead Hydrographer	11/18/2022	Digitally signed by Jason Dorfman
Sam Werner	Data Processing Manager	11/18/2022	Digitally signed by Sam Werner

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