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

Data Acquisition & Processing Report

Type of Survey:	Navigable AreaNatural Disaster Response
Project Number:	S-K378-KR-20
Time Frame:	August - September 2020

LOCALITY

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

2020

CHIEF OF PARTY
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Data Acquisition and Processing Report

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Chief of Party: Jonathan L. Dasler
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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, owned and operated by DEA (Figure 1), was the survey vessel for the project. The S/V Blake is a 92-ton USCG Subchapter T inspected vessel, Official Number 1256966, and Hull Number 213. She 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*	2020-08-29
	Method	Mobilization of the S/V Blake occurred on August 28, 2020 (DN241). System calibrations and a start of the project patch test were performed near Calcasieu on August 29, 2020 (DN242). An end of survey comparison patch test was performed on September 27, 2020 (DN271). A squat confirmation test was performed near the Calcasieu Pass on September 1, 2020 (DN245). Results from the squat test were consistent with results from the prior test, which was performed on November 14, 2014, in support of NOAA project S-K378-KR-20. The squat and settlement values were not applied to the 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.

Figure 1: S/V Blake

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Teledyne RESON T50 Series

Multi Beam Echo Sounder (MBES) deployed in a single head configuration using a retractable moonpool with center strut mount on S/V Blake.

The T50 Series multibeam sonar by Teledyne RESON is a frequency agile system capable of operating at 190 to 420 kHz, and was operated at 200 kHz in a single-head configuration for this survey. The swath angle was set at 140-degree using 512 beams in an equiangular mode. The system is capable of bathymetry, snippets/backscatter, and water column data.

Manufacturer	Teledyne RESON				
Model	T50 Series				
Inventory	*S/V Blake*	*Component*	Topside Unit	Transmit	Receive
		Model Number	T50-R	T50-R	T50-R
		Serial Number	08961618025	4816020	5015065
		Frequency	200	200	200
		Calibration	N/A	N/A	N/A
		Accuracy Check	N/A	N/A	N/A

Figure 2: Teledyne RESON T50-R on S/V Blake

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-HF

DEA's Edgetech 4200-HF Side Scanning Sonar (SSS) is an 80 lb, 1.26-meter long towed 300/600 kHz system. It was operated at 600 kHz and a 75-meter range scale for this project in a high-speed mode to ensure adequate along track ping rate. Two identical towfish were carried aboard the S/V Blake and used for this survey.

<table>
<tr><td>Manufacturer</td><td colspan="6">Edgetech</td></tr>
<tr><td>Model</td><td colspan="6">4200-HF</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">S/V Blake</td><td>Component</td><td>Topside Unit</td><td>Towfish</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>701-DL</td><td>4200-HF</td><td>4200-HF</td></tr>
<tr><td>Serial Number</td><td>35323</td><td>42627</td><td>43188</td></tr>
<tr><td>Frequency</td><td>300/600</td><td>300/600</td><td>300/600</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>

Figure 3: Edgetech 4200-HF on the back deck of S/V Blake

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

No lead lines were utilized for data acquisition.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix/Trimble POS MV 320 V5

Integrated Global Navigation Satellite System (GNSS) and inertial reference system for position, heading, heave, roll, and pitch data. This system was used for differential GNSS positioning and post processed using POSPac MMS for more precise GNSS positioning. The POS MV was configured to receive real time corrections from the Federal Aviation Administration Wide Area Augmentation System (FAA WAAS) during data acquisition.

Manufacturer	Applanix/Trimble					
Model	POS MV 320 V5					
Inventory	*S/V Blake*	*Component*	Topside Unit	IMU	Port Antenna	Starboard Antenna
		Model Number	POS MV 320 V5	LN200	Trimble GA830	Trimble GA830
		Serial Number	7342	750	7337	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

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

A.5.5.1 Measurement Technology Northwest Cable Counter

Digital output of the side scan cable length was used in conjunction with vessel towpoint offsets and digital towfish depth to compute towfish position.

Manufacturer	Measurement Technology Northwest		
Model	Cable Counter		
Inventory	*S/V Blake*	*Component*	Cable Counter
		Model Number	LCI-90
		Serial Number	0350
		Calibration	N/A

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

A.6.1.1 AML Oceanographic MVP30-350 Sound Speed Profiler

Primary sound speed profiler utilized for all sound speed casts. 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*	Sound Speed Profiler
		Model Number	Micro SVP&T
		Serial Number	Body: 810849 SV:205498 P:306797 T:404529
		Calibration	2020-04-25

A.6.2 CTD Profilers

A.6.2.1 AML Oceanographic BaseX2

Secondary sound speed profiler onboard if primary system became inoperable. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

<table>
<tr><td>Manufacturer</td><td colspan="2">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="2">BaseX2</td></tr>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>Sound Speed Profiler</td></tr>
<tr><td>Model Number</td><td>BaseX2</td></tr>
<tr><td>Serial Number</td><td>Housing: 025653 SV: 206748 P: 305746</td></tr>
<tr><td>Calibration</td><td>2020-04-26</td></tr>
</table>

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic Micro SV Xchange

Sound speed at multibeam sonar. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

<table>
<tr><td>Manufacturer</td><td colspan="3">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="3">Micro SV Xchange</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S/V Blake</td><td>Component</td><td>Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>Micro SV Xchange</td></tr>
<tr><td>Serial Number</td><td>Housing 10661 SV: 204678</td></tr>
<tr><td>Calibration</td><td>2020-04-26</td></tr>
</table>

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
HYPACK, Inc.	HYPACK	20.2.9.0	Acquisition
HYPACK, Inc.	HYPACK Survey	20.2.9.0	Acquisition
HYPACK, Inc.	HYPACK SSS Package	20.2.9.0	Acquisition
HYPACK, Inc.	Hysweep	20.2.9.0	Acquisition
Teledyne RESON	Seabat	V5.0.0.2	Acquisition
Edgetech	Discover 4200-MP	33.0.1.109	Acquisition
David Evans and Associates, Inc. Marine Services Division	Line Log	2.1	Acquisition
Applanix	MV-POSView	9.21	Acquisition
ODIM Brooke Ocean	ODIM MVP Controller	V2.450	Acquisition
NOAA OCS/JHC	Sound Speed Manager	2019.2.4	Processing
CARIS	HIPS	11.3.8	Processing
CARIS	BASE Editor	5.4	Processing
ESRI	ArcGIS and ArcMap	10.6	Processing
Chesapeake Technology, Inc. 64-bit	SonarWiz	7.06.05 (64-bit)	Processing
Applanix	POSPac MMS	8.4 SP2	Processing
Microsoft	Office Suite	2016 and 365	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	POSPacAutoQC	19.4	Processing
Beyond Compare	Beyond Compare	4.2.2	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

No bottom sampling equipment was utilized for data acquisition.

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 HIPS Vessel File (HVF).

Sensor offsets for the S/V Blake were calculated from the vessel survey and dynamic draft values were calculated through the use of post processed GPS observations. Draft (water line) was measured prior to acquisition in the most conducive sea state allowed and entered into the HVF. Draft readings were observed from draft sight tubes located in the port and starboard sponsons abeam of the multibeam sonar and vessel reference point. These corrections are listed in tabular and graphical format in Appendix III - Vessel Offset Reports.

All offsets were computed relative to the vessel reference point, a point designated and located at midship waterline and below the secondary GNSS system antenna. The vessel reference point is the origin of all offsets reported in the HVF (excluding TPU offsets) and in Appendix III – Vessel Offset Reports. The vessel center of rotation was determined by the Naval Architect that designed the Blake, and offsets from the vessel reference point to the center of rotation were input in the POS MV.

B.1.1.1 Vessel Offset Correctors

Vessel	S/V Blake			
Echosounder	Teledyne RESON T50-R (200kHz 512 Beams)			
Date	2020-08-27			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	-0.827 meters	0.030 meters
		y	0.052 meters	0.030 meters
		z	2.971 meters	0.030 meters
	Nav to Transducer	*x*	-1.380 meters	0.030 meters
		y	-4.646 meters	0.030 meters
		z	9.464 meters	0.030 meters
	Transducer Roll	*Roll*	0.000 degrees	

B.1.2 Layback

The cable out, along with the measured tow point 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.

B.1.2.1 Layback Correctors

Vessel	S/V Blake		
Echosounder	LCI-90 and HYPACK Layback Computation		
Frequency	600 kHz		
Date	2020-08-29		
Layback	*Towpoint*	*x*	-0.748 meters
		y	-8.886 meters
		z	0.900 meters
	Layback Error	NaN meters	

B.2 Static and Dynamic Draft

B.2.1 Static Draft

This survey was collected with ERS methods. Static drafts were taken prior to survey. The S/V Blake was built with draft sight tubes in each hull directly abeam of the vessel reference point 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 observations for bar checks or tide floats.

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 when conducting bar checks and obtaining an approximate waterline for the application of sound speed profiles in CARIS HIPS software.

Table B.2.1.1 below details the start of project waterline measurement. A detailed description of the static draft corrections as entered into the CARIS HVF can be found in Appendix V - Echo Sounder Confidence Check Reports of this report. The measured draft value was used to calculate draft relative to the HIPS reference point, which was entered into the “Waterline Height” field in the CARIS HVF files.

A bar check was performed to confirm that the multibeam sonar was functioning properly and static draft was accurately documented. A Ross Laboratories Inc. Model 5150 lead target ball or an aluminum plate attached to the end of a wire cable and chain, marked at 1, 2 and 3 meters, was used to bar check the multibeam on the S/V Blake. The marks were checked with a measuring tape. The bar check device was lowered to 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. A tabulated bar check comparison may be found in Appendix V - Echo Sounder Confidence Check Reports, and is consistent with other validation observations from prior surveys.

B.2.1.1 Static Draft Correctors

Vessel		S/V Blake
Date		2020-08-27
Loading		0.000 meters
Static Draft	*Measurement*	-0.085 meters
	Uncertainty	0.000 meters

B.2.2 Dynamic Draft

Though ultimately not used in the processing of this ERS survey, a settlement and squat test for the S/V Blake using post processed GNSS height observations was performed near the Calcasieu Channel on August 29, 2020. This test confirmed values from a similar test on November 14, 2014.

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

Vessel	S/V Blake	
Date	2020-08-27	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	1.69	0.02
	3.37	0.05
	3.81	0.07
	4.15	0.12
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.03	0.00

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. A patch test was performed at the beginning and end of survey to verify the adequacy of the system biases. 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 knots to 6 knots. Patch tests were run in the Calcasieu Channel. 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.

The 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 HVF SVP1 field rather than the Transducer1 field in order for the HIPS Sound Velocity correction to apply correctly. 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. Tables in this report detail the start of project values as determined on August 29, 2020. All patch values are detailed in Appendix V - Echo Sounder Confidence Check Reports and entered into the CARIS HVF.

B.3.1.1 System Alignment Correctors

<table>
<tr><td>Vessel</td><td>S/V Blake</td></tr>
<tr><td>Echosounder</td><td>Teledyne RESON T50-R (400kHz 512 Beams)</td></tr>
<tr><td>Date</td><td>2020-08-27</td></tr>
<tr><td>Patch Test Values</td><td>
<table>
<tr><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.00 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.00 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Pitch</td><td>0.00 degrees</td><td>0.08 degrees</td></tr>
<tr><td>Roll</td><td>0.00 degrees</td><td>0.08 degrees</td></tr>
<tr><td>Yaw</td><td>-2.50 degrees</td><td>0.039 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.00 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.00 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.00 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.00 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

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

Multibeam sonar data were generally acquired concurrently with towed side scan sonar data for mainscheme survey acquisition. Crossline data were collected only using multibeam sonar. Features and contacts were developed and investigated using multibeam sonar only in most cases. In some instances where side scan sonar data gaps were present, multibeam sonar was run to fill in these coverage gaps in lieu of 200% side scan sonar data. Any deviations from the following processing workflow are addressed in the individual Descriptive Report for this survey.

Multibeam data were acquired in HYPACK HYSWEEP file format (HSX). Adjustments to the sonar, including changes in range, power, and gain, were made as necessary to acquire the optimum bathymetric data quality. 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.

Data Processing Methods and Procedures

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

CARIS HIPS v 11.3.8 was used at the onset of the data processing workflow, which was initiated after rapid data were acquired. Several of the steps were repeated during the data processing due to application of revised water levels and sound speed corrections. Over the course of the project, TPU was re-computed to reflect minor revisions to vessel file. The HIPS process log for each survey line includes a full audit of all steps undertaken during processing. Any deviations from the following processing workflow are addressed in the individual Descriptive Reports for this survey.

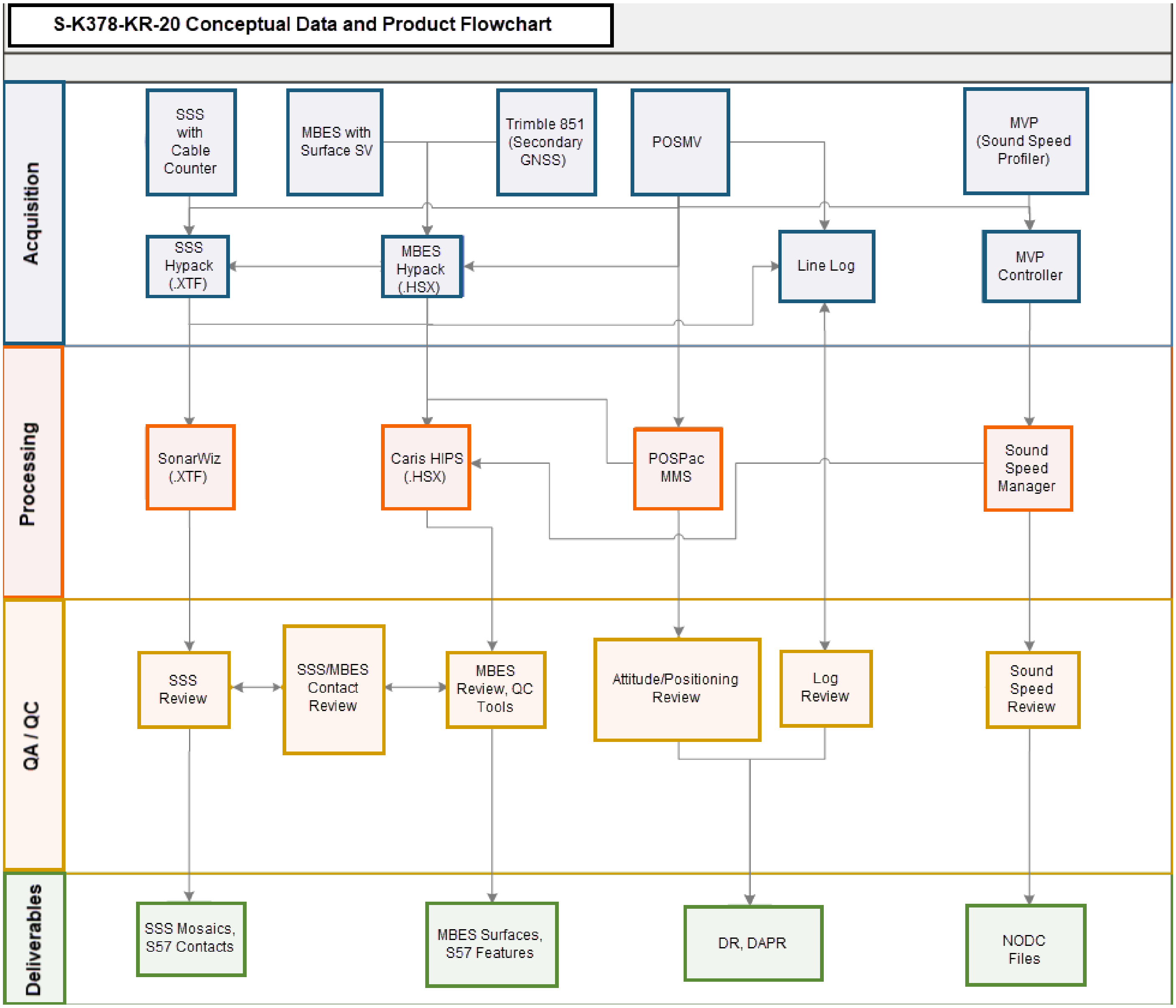

Figure 4: Flowchart of S/V Blake Data Processing Pipeline

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 HSD Operations were used to ensure that gridding parameters and surface computation algorithms 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 the survey's Descriptive Report.

C.1.4.3 Surface Computation Algorithm

Single resolution CUBE surfaces were created over the entire survey area using Object Detection Coverage grid-resolution thresholds and resolution dependent maximum propagation distances as specified in the NOS 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 multibeam data 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

Side scan sonar data were generally acquired concurrently with multibeam sonar data for mainscheme survey acquisition. Crossline data do not include side scan sonar. Features and contacts identified using side scan sonar were developed and investigated using multibeam sonar only in most cases. In some instances where side scan sonar data gaps were present, multibeam sonar was run to fill in these coverage gaps in lieu of 200% side scan sonar data. Any deviations from the following processing workflow are addressed in the individual Descriptive Report for this survey.

Side scan sonar imagery was acquired with an Edgetech 4200-HF (300/600 kHz) dual frequency side scan sonar. The sonar was operated at 600 kHz in high-speed mode using 75-meter range scale.

Side scan sonar imagery was logged as eXtended Triton Format (XTF) (8 bit, 2048 pixels/channel) in HYPACK. 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 XTF.

The side scan sonar towfish was deployed from the stern of the vessel. For the configuration, the horizontal and vertical offsets of the tow point relative to the vessel reference point was 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. The vessel tow point is denoted on the vessel offset drawings included in Appendix III - Vessel Offset Reports. This appendix also includes a discussion on layback computation methodology.

To confirm adequate target resolution at the outer limits of the selected range, side scan sonar 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, an additional HYPACK side scan sonar data acquisition computer also running Edgetech Discover. The two acquisition computers had custom HYPACK Drivers to synchronize multibeam sonar and side scan sonar data acquisition. Other software utilized on the acquisition systems included a custom event logging software, and MVP controller. Two additional computers were used on board for data processing, primarily utilizing CARIS HIPS and CTI's SonarWiz.

The side scan sonar was operated at 75-meter range scale 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 600 kHz high-speed mode.

The EdgeTech 4200 series sonar has a ping rate of 20 Hz at the 75-meter range while operating in the 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 2020 HSSD, vessel speed was monitored to allow for the acquisition of a minimum of three pings per meter. During acquisition, the side scan was towed from the stern of the S/V Blake.

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 the end of acquisition of Hurricane Laura response, acquisition and processing data from the primary QNAP were transferred to DEA's Vancouver, WA office via one external USB 3.0 hard drive.

After acquisition the XTF files were imported into Chesapeake Technologies Inc. (CTI) SonarWiz and gain adjustments were 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 contact greater than or equal to 75 centimeters was investigated. In depths greater than 20 meters, contacts with heights greater than 3.75% of water depth were investigated with multibeam sonar. This threshold was more stringent than the HSSD feature detection requirement to allow for contact height measurement error when determining contacts requiring investigation. 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 which cast little or no shadow but represented change in the seafloor elevation that may need further development to define general bathymetry. An example of a contact multibeam sonar development is shown in Figure 5.

Side scan mosaics were created using CTI SonarWiz. Georeferenced mosaics were generated in floating point GeoTIFF format at 1-meter resolution.

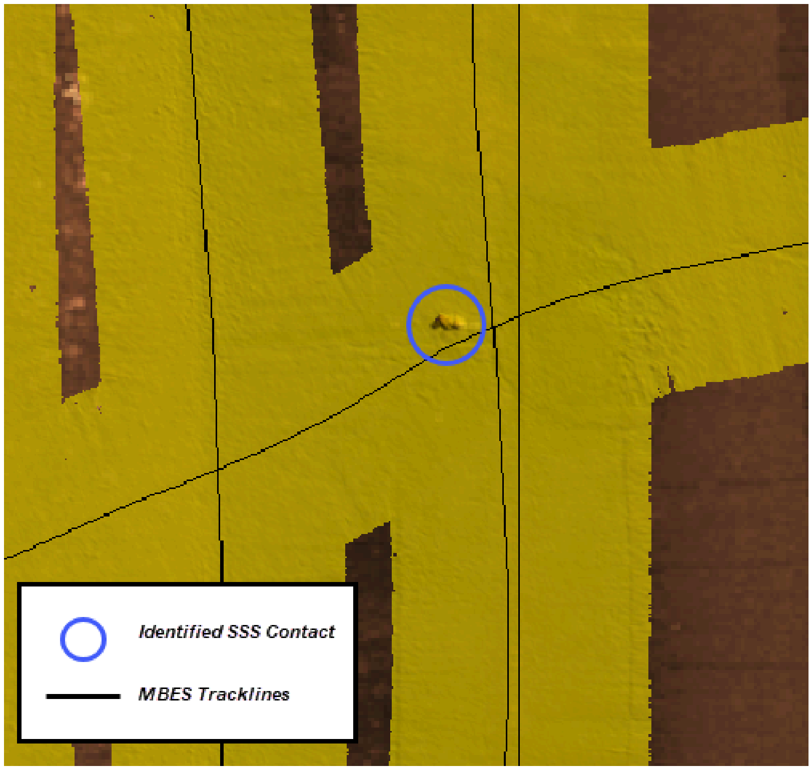

Figure 5: Example of Multibeam Development of Side Scan Contact

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

Data Acquisition Methods and Procedures

Post processing of vessel navigation (position and height) using single base processing techniques relied on data from base station Calcasieu Pass, LA (site id: CALC) operated by the Louisiana State University C4Gnet Real Time Network.

Data Processing Methods and Procedures

Base station data were downloaded and used during post processing of the vessel navigation. See section C.4 Vessel Positioning for more information.

C.3.1.2 DGPS Data

Data Acquisition Methods and Procedures

The POS MV was configured to receive WAAS corrections during data acquisition.

Data Processing Methods and Procedures

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

Data Acquisition Methods and Procedures

No water level gauge data were aquired as ERS methods were utilized for this project.

Data Processing Methods and Procedures

ERS techniques using a separation model derived from VDatum were used in sounding reduction. The separation model was provided HSD with other project files in advance of the survey. The model was created by NOAA using version 3.9 of VDatum using regional grids for and Louisiana and Texas. See section C.4 Vessel Positioning for more information.

Sounding data provided to the USACE on August 31, 2020 were reduced to chart datum with preliminary water levels from the National Water Level Observation Network (NWLON) station Calcasieu Pass, LA (8768094).

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 Inertial Motion Unit (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 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 the raw observable groups needed to post process the real-time sensor data. The POS MV logged 64-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 multibeam sonar 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 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.

Single Base (Primary method of positioning control):

Post processed Kinematic Single Base solutions were utilized to produce centimeter level accuracies through the use of carrier phase differential positioning from a single GNSS base station (Single Base).

Applanix POSPAC MMS software was used to post process the vessel navigation data using the Applanix SingleBase technique to generate an Inertially-Aided Kinematic Ambiguity Resolution (IAKAR) navigation solution for each day of survey. Limited base station data availably resulting from Hurricane Laura prevented the use of network processing methods.

During POSPAC processing the published NAD83(2011) position for the base station was used, which resulted in the creation of an Smoothed Best Estimate of Trajectory (SBET) relative to NAD83(2011), avoiding the need to transform the output SBET from ITRF2008 to NAD83(2011). The SBET included new position, height, heading and attitude measurements.

Applanix SingleBase processing relied on GNSS data from base station Calcasieu Pass, LA (site id: CALC) operated by Louisiana State’s C4Gnet Real Time Network. Data were downloaded from the C4GNet website in Receiver Independent Exchange Format RINEX format a 1 second epochs. Single base processing using base station CALC required extending the maximum baseline distance from 40 kilometers recommended by the HSSD to 50 kilometers. These distances with respect to the survey extents are depicted in Figure 6.

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

SBETs were applied in CARIS by loading both the SBET files and error data files in smrmsg format. For every SBET file generated during POSPac MMS processing there is an associated smrmsg file.

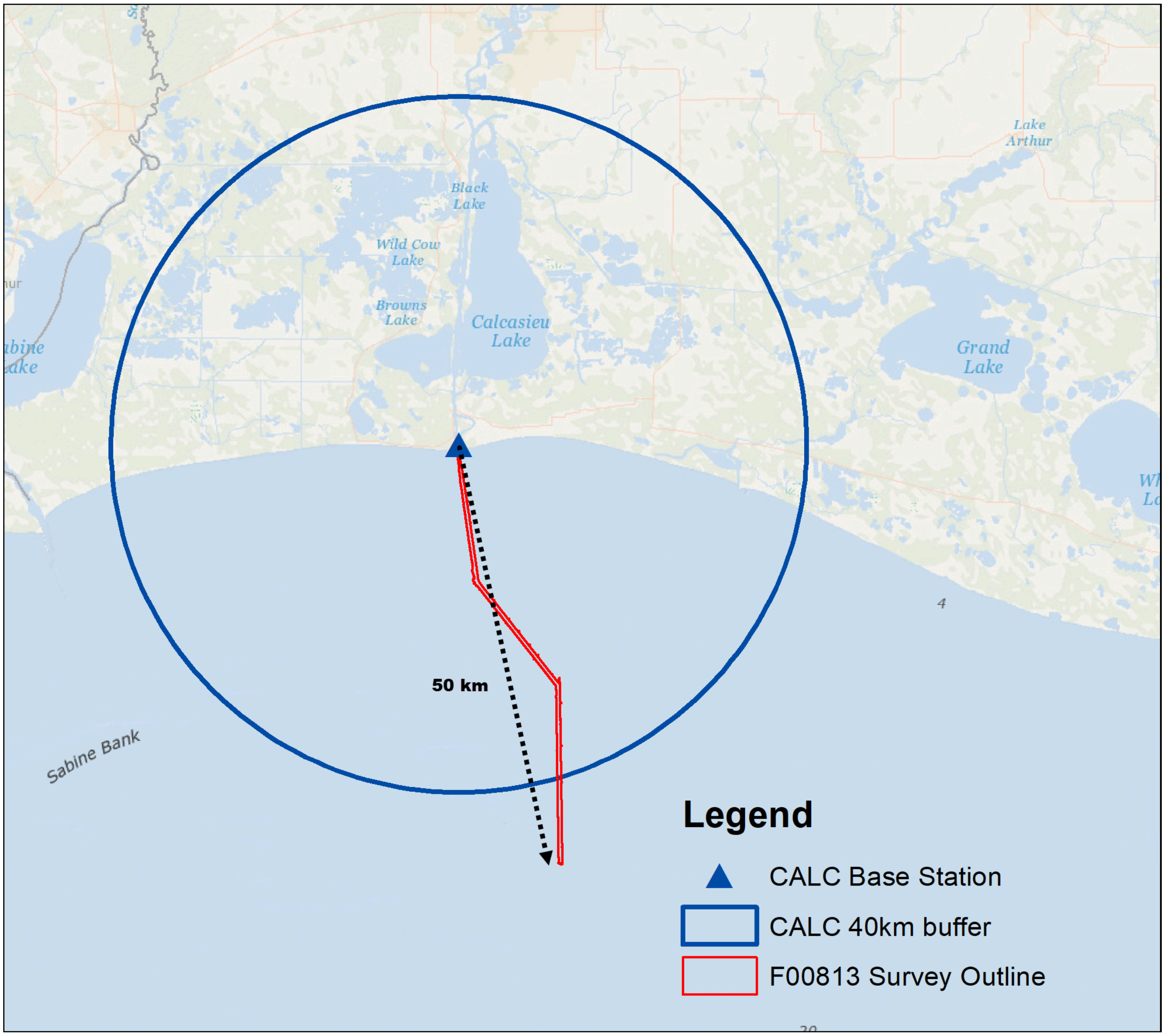

Figure 6: Base station CALC post processing maximum base line distance

C.5 Sound Speed

C.5.1 Sound Speed Profiles

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

During data acquisition, sound velocity profiles were acquired by automatic deployment to obtain an adequate number of sound velocity profiles for correction of multibeam data during data processing. Casts were taken at periodic intervals using the MVP30-350 on the S/V Blake. 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 specification. Sound speed check results are included in Separate II Sound Speed Data Summary of the Descriptive Reports.

Data Processing Methods and Procedures

Sound speed profiles were applied to each line using the nearest in distance within time (one 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 multibeam sonar 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 MVP 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 Total Propagated Uncertainty (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 phase center, vice the top hat, of the motion sensor; 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 imported into CARIS HIPS at 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
Motion Sensor	*Gyro*	0.02 degrees
	Heave	5.00% 0.05 meters
	Roll	0.02 degrees
	Pitch	0.02 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. For the vessel, real-time uncertainty values from the T50-R Multibeam Echo Sounder (MBES) sonar 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 were recorded and loaded into HIPS via the Import Auxiliary Data function. Uncertainties associated with vessel navigation, roll, pitch, and yaw were post processed using POSPac MMS, and were loaded into HIPS via the Import Auxiliary Data function. 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 side scan sonar, multibeam sonar, and visual means. Positioning of baring features was achieved using multibeam sonar 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 object catalogue version 5.7 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 features.

C.8 Bottom Sample Data

Bottom sample data was not acquired.

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.

Multibeam sonar coverage was evaluated using NOAA Pydro QC tools to check finalized surfaces for holidays.

Multibeam sonar and side scan sonar coverages were compared to ensure survey project instruction requirements were met, and that coverage from those respective systems met HSSD and PI 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 - 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. 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 datasets. Comparison statistics were also computed using the HIPS QC Report tool to evaluate a beam by beam statistical analysis, and the Pydro Compare Grids tool for a surface difference. Crossline statistics are published in the Descriptive Report for this survey.

D.1.5.2 Junctions

No junctioning surveys have been provided for this project.

D.1.5.3 Platform to Platform

Platform to platform surface difference reviews were not applicable to this project.

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 XTF 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, tow fish 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, altitude speed, etc. as required, and for subjective standards such as gain balance, biologic interference, motion artifacts, etc. Areas that failed to meet coverage that would allow for contact selection were recollected with either additional side scan sonar coverage, or in some cases filled with 100% multibeam sonar in lieu of the 200% side scan sonar requirement. Any deviations from the following processing workflow are addressed in the individual Descriptive Report for this survey.

Prominent features were used to evaluate side scan sonar positioning, and checked against multibeam sonar data sets, ensuring 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 multibeam sonar bottom depths to streamline which contacts required additional multibeam sonar 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 S-K378-KR-20 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 S-K378-KR-20 Statement of Work (August 28, 2020) and Hydrographic Survey Project Instructions (August 28, 2020).

Approver Name	Approver Title	Date	Signature
Jonathan L. Dasler, PE, PLS, CH	NSPS/THSOA Certified Hydrographer, Chief of Party	12/17/2020	Digitally signed by Jon L. Dasler Date: 2020.12.17 12:51:40 -08'00'
Jason Creech, CH	NSPS/THSOA Certified Hydrographer, Charting Manager / Project Manager	12/17/2020	Digitally signed by Jason Creech Date: 2020.12.17 12:28:23 -08'00'
Callan McGriff, EIT	IHO Cat-A Hydrographer, Lead Hydrographer	12/17/2020	Digitally signed by Callan McGriff Date: 2020.12.17 12:32:48 -08'00'
James Guilford	IHO Cat-A Hydrographer, Lead Hydrographer	12/17/2020	Digitally signed by James Guilford Date: 2020.12.17 12:43:52 -08'00'
Michael Redmayne	IHO Cat-A Hydrographer, Lead Hydrographer	12/17/2020	Digitally signed by Michael Redmayne Date: 2020.12.17 12:47:36 -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	