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-24
Time Frame:	July - January 2025

LOCALITY

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

2024

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

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Data Acquisition and Processing Report

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Year: 2024
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A. System Equipment and Software

A.1 Survey Vessels

A.1.1 Blake

<table>
<tr><td>Vessel Name</td><td>Blake</td></tr>
<tr><td>Hull Number</td><td>213</td></tr>
<tr><td>Description</td><td>The Blake (Figure 1), owned and operated by DEA, was the survey vessel utilized for the project.

The Blake is a 92-ton United States Coast Guard (USCG) Subchapter T inspected vessel, Official Number 1256966, and Hull Number 213. The 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 Blake supports a hydrographic crew of six and is supported by four ship crew for 24-hour survey operations.</td></tr>
<tr><td>Dimensions</td><td><table><tr><td>LOA</td><td>82 feet</td></tr><tr><td>Beam</td><td>27 feet</td></tr><tr><td>Max Draft</td><td>4.5 feet</td></tr></table></td></tr>
<tr><td>Most Recent Full Static Survey</td><td><table><tr><td>Date</td><td>2014-09-23</td></tr><tr><td>Performed By</td><td>DEA at Geo Shipyard in New Iberia, LA</td></tr></table></td></tr>
</table>

Most Recent Partial Offset Verification	*Date*	2024-07-03
	Method	A squat confirmation test for the Blake was performed in the Gulfport Ship Channel on July 3, 2024 (DN185) during mobilization efforts. 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 July 12, 2024 (DN194). Results from the squat test were consistent with results from the prior test, which was performed on July 2, 2022, in support of NOAA project OPR-K356-KR-22. 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 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 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. A new IMU64 was also installed in June 2024 for this project, and hand measurements were made to determine the new offsets to the IMU bullseye from new punch marks on the mounting plate.

Figure 1: Blake

A.1.2 DriX 5

<table>
<tr><td>Vessel Name</td><td>DriX 5</td></tr>
<tr><td>Hull Number</td><td>DriX 5</td></tr>
<tr><td>Description</td><td>The DriX 5 (Figure 2) is an uncrewed surface vessel (USV) that can conduct both remote-controlled and supervised autonomous operations. The DriX 5 is a 25-foot composite vessel with a 2.62-foot beam and a draft of 6 feet. The vessel is equipped with a 4-cylinder 1.5-liter diesel engine and a retractable keel that is attached to the gondola, which holds the sonar equipment. The DriX 5 requires a team of four to six hydrographers and pilots to support 24-hour survey operations.</td></tr>
<tr><td>Dimensions</td><td><table>
<tr><td>LOA</td><td>25 ft</td></tr>
<tr><td>Beam</td><td>2.62 ft</td></tr>
<tr><td>Max Draft</td><td>6 ft</td></tr>
</table></td></tr>
</table>

Most Recent Full Offset Verification	*Date*	2024-08-24
	Method	A full offset verification survey and calibration was performed on August 24, 2024, next to the Olson Centre in Durham, New Hampshire, USA. The offset survey was conducted while DriX 5 was in dry dock on cradles under static conditions with the gondola fully lowered to survey position. The survey utilized a terrestrial land survey total station from a minimum of two locations, which allowed a position uncertainty to be determined. Additionally, a start-of-project patch test was performed near the Calcasieu Ship Channel on September 18, 2024 to validate the offset survey.

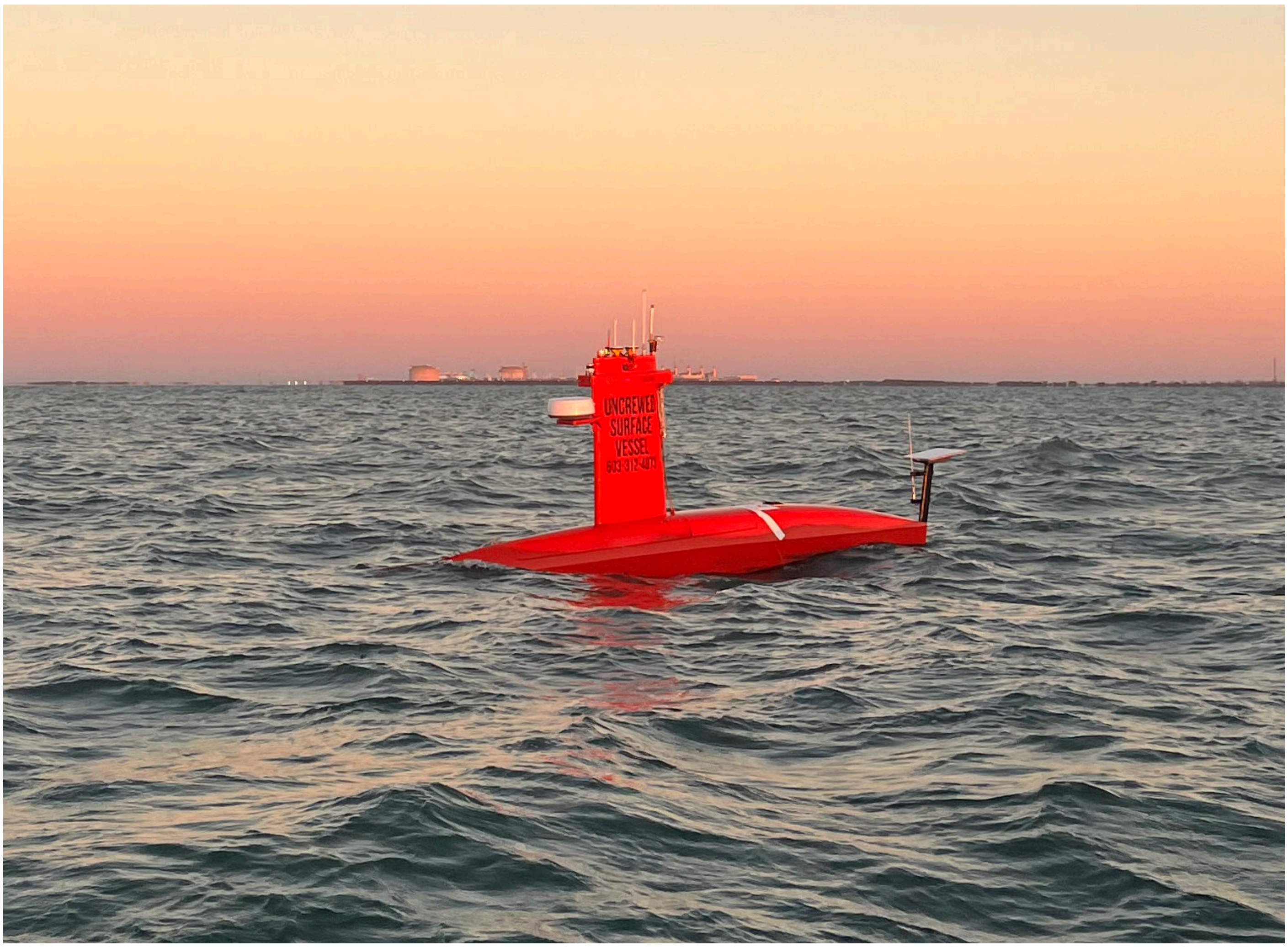

Figure 2: DriX 5

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 Blake (Figure 3).

The Teledyne RESON T50 Series multibeam sonar is a 190 to 420 kHz system. For this survey, it was operated at 400 kHz with a 140-degree swath and 512 equiangular beams. The sonar is capable of acquiring bathymetry, snippets/backscatter, side scan, and water column data.

<table>
<tr><td>Manufacturer</td><td colspan="5">Teledyne RESON</td></tr>
<tr><td>Model</td><td colspan="5">T50 Series</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">Blake</td><td>Component</td><td>Topside Unit and Rack Mount</td><td>Transmit</td><td>Receive</td></tr>
<tr><td>Model Number</td><td>T50-R</td><td>TC2181</td><td>EM7218</td></tr>
<tr><td>Serial Number</td><td>08964120064</td><td>5015068</td><td>0220037</td></tr>
<tr><td>Frequency</td><td>400</td><td>400</td><td>400</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

Figure 3: Blake Retractable Moon Pool and Center-Pole Mount

A.2.1.2 Kongsberg EM2040 MKII

The Kongsberg EM2040 MKII multibeam sonar is a 200 to 700 kHz system that was deployed on the retractable gondola of DriX 5. For this survey, it was operated at 400 kHz in a single-head configuration with a 110-degree swath and 512 equiangular beams in High Density ping mode. The sonar is capable of acquiring bathymetry, backscatter, and water column data.

<table>
<tr><td>Manufacturer</td><td colspan="4">Kongsberg</td></tr>
<tr><td>Model</td><td colspan="4">EM2040 MKII</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">DriX 5</td><td>Component</td><td>Multibeam Sonar</td></tr>
<tr><td>Model Number</td><td>EM2040 MKII</td></tr>
<tr><td>Serial Number</td><td>EM2040_PU_40295</td></tr>
<tr><td>Frequency</td><td>400</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td></tr>
</table>

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 a 115 lb, 1.40-meter long towed 540/850 kHz system (Figure 4). It was operated at 540 kHz and a 75-meter range scale for this project in High Speed, Motion Tolerant mode for adequate along-track ping rate.

<table>
<tr><td>Manufacturer</td><td colspan="4">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="4">4205 Series</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">Blake</td><td>Component</td><td>Topside Unit and Rack Mount</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>701-DL</td><td>4205</td></tr>
<tr><td>Serial Number</td><td>61361</td><td>60765</td></tr>
<tr><td>Frequency</td><td>N/A</td><td>540kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td></tr>
</table>

Figure 4: 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 5). It was operated at 540 kHz and a 75-meter range scale for this project in a High-Speed mode for adequate along-track ping rate.

<table>
<tr><td>Manufacturer</td><td colspan="2">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="2">4200 Series</td></tr>
<tr><td>Inventory</td><td>Blake</td><td>
<table>
<tr><td>Component</td><td>Topside Unit and Rack Mount</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>701-DL</td><td>4200</td></tr>
<tr><td>Serial Number</td><td>Before DN242: 61361 On and after DN242: 46213</td><td>42627</td></tr>
<tr><td>Frequency</td><td>N/A</td><td>540kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td></tr>
</table>
</td></tr>
</table>

Figure 5: EdgeTech 4200 Side Scan Sonar

A.2.3.3 Exail Sams Series 150

The Exail Sams 150 is a Synthetic Aperture Sonar (SAS) that was mounted on the gondola of the DriX 5. It was operated at 150 kHz and a 75- and 100-meter range scale for acquiring seafloor imagery on this project.

The Sams 150 data was acquired and processed to provide imagery in order to meet side scan coverage and feature detection requirements. The Sams 150 bathymetry was not evaluated for this project.

Manufacturer	Exail				
Model	Sams Series 150				
Inventory	*DriX 5*	*Component*	Topside	Transmit	Receive
		Model Number	Sams 150 PC	Sams 150	Sams 150
		Serial Number	002	007, 008	001, 001, 003, 004
		Frequency	N/A	150kHz	150kHz
		Calibration	N/A	N/A	N/A
		Accuracy Check	N/A	N/A	N/A

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 Ocean Master

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

Manufacturer	Applanix/Trimble					
Model	POS MV Ocean Master					
Inventory	*Blake*	*Component*	Topside Unit	IMU	Antenna	Antenna
		Model Number	Ocean Master	IMU64	Trimble GA830	Trimble GA830
		Serial Number	14862	7280	7234	16954
		Calibration	N/A	N/A	N/A	N/A

A.5.1.2 Exail Phins Compact C7

The Exail Phins is an Inertial Navigation System (INS) providing position, true heading, attitude, speed, depth and heave. Its high accuracy inertial measurement unit is based on Exail's Fiber-Optic Gyroscope (FOG) technology coupled with an embedded digital signal processor that runs an advanced Kalman filter.

<table>
<tr><td>Manufacturer</td><td colspan="3">Exail</td></tr>
<tr><td>Model</td><td colspan="3">Phins Compact C7</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">DriX 5</td><td>Component</td><td>INS</td></tr>
<tr><td>Model Number</td><td>Compact C7</td></tr>
<tr><td>Serial Number</td><td>2297</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
</table>

A.5.1.3 Septentrio AsteRx-U-Fg

The AsteRx-U-Fg is a GNSS receiver from Sepentrio. It provides multi-frequency, multi-constellation GNSS positioning capability.

<table>
<tr><td>Manufacturer</td><td colspan="3">Septentrio</td></tr>
<tr><td>Model</td><td colspan="3">AsteRx-U-Fg</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">DriX 5</td><td>Component</td><td>GNSS Receiver</td></tr>
<tr><td>Model Number</td><td>AsteRx-U-Fg</td></tr>
<tr><td>Serial Number</td><td>3022750</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
</table>

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 Blake. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

The back up Micro SVP & T sensor used after DN215 (August 8, 2024) was last recalibrated by the manufacturer in March of 2023, which exceeded the 12-month recalibration period in the HSSD. However, a comparison of sound speed measurements between this system and the recently calibrated primary system revealed that the readings were well within the required tolerances, indicating no need for manufacturer recalibration.

<table>
<tr><td>Manufacturer</td><td colspan="3">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="3">MVP30-350 Sound Speed Profiler</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">Blake</td><td>Component</td><td>Water Column Sound Speed Profiler</td></tr>
<tr><td>Model Number</td><td>Micro SVP&T</td></tr>
<tr><td>Serial Number</td><td>Before DN215: Housing:M12981 SV/T: 221065 P:308291 DN215-DN009: Housing:10849 SV:201322 P:304610 T:404529 After DN009: Housing:M12981 SV:213664 P:308291</td></tr>
<tr><td>Calibration</td><td>2024-04-30</td></tr>
</table>

A.6.2 CTD Profilers

A.6.2.1 Teledyne Valeport SWiFT SVP

The SWiFT SVP was the primary sound speed profiler utilized for sound speed casts on the DriX 5. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

<table>
<tr><td>Manufacturer</td><td colspan="2">Teledyne Valeport</td></tr>
<tr><td>Model</td><td colspan="2">SWiFT SVP</td></tr>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>Water Column Sound Speed Profiler</td></tr>
<tr><td>Model Number</td><td>0660047-50</td></tr>
<tr><td>Serial Number</td><td>Housing:91720 SV:184914 P:276262 T:14361</td></tr>
<tr><td>Calibration</td><td>2024-06-18</td></tr>
</table>

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic Micro-X/SV

The AML Oceanographic Micro-X/SV was the sound speed sensor at the S/V Blake's primary MBES sonar head. 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-X/SV</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">Blake</td><td>Component</td><td>Sound Speed Sensor at sonar head</td></tr>
<tr><td>Model Number</td><td>Micro SV</td></tr>
<tr><td>Serial Number</td><td>Housing:12748 SV:205498</td></tr>
<tr><td>Calibration</td><td>2024-04-26</td></tr>
</table>

A.6.3.2 Teledyne Valeport miniSVS

The Teledyne Valeport miniSVS was the sound speed sensor at the DriX 5's primary MBES sonar head. See Appendix II - Sound Speed Sensor Calibration Report(s) for calibration information.

<table>
<tr><td>Manufacturer</td><td colspan="3">Teledyne Valeport</td></tr>
<tr><td>Model</td><td colspan="3">miniSVS</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">DriX 5</td><td>Component</td><td>Sound Speed Sensor at sonar head</td></tr>
<tr><td>Model Number</td><td>miniSVS</td></tr>
<tr><td>Serial Number</td><td>67305</td></tr>
<tr><td>Calibration</td><td>2024-03-25</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	24.0.4.0	Acquisition
QPS	Qinsy	9.5	Acquisition
Teledyne RESON	SeaBat	5.0.0.2	Acquisition
Edgetech	Discover	42.0.1.109	Acquisition
Kongsberg	SIS	5.12.3	Acquisition
David Evans and Associates, Inc.	LineLog	2.1	Acquisition
Applanix	MV-POSView	11.5	Acquisition
ODIM Brooke Ocean	ODIM MVP Controller	2.45	Acquisition
AML Oceanographic	SeaCast	4.40	Acquisition
Teledyne Valeport	Ocean	1.2.3.5	Acquisition
Exail	Multilogger	3.4	Acquisition
Exail	Delph Geo	5.0.506	Acquisition and Processing
Exail	Delph INS Inertial Explorer 9.0	3.7.2	Processing
NOAA OCS/JHC	Sound Speed Manager	2021.2.3	Processing
CARIS	HIPS	11.4.29	Processing
CARIS	BASE Editor	6.1	Processing
ESRI	ArcPro	3.3.0	Processing
ESRI	ArcMap	10.8.1	Processing
Chesapeake Technology, Inc.	SonarWiz	8.00.01 (64-bit)	Processing
QPS	FMGT	7.11.1	Processing
Applanix	POSPac MMS	9.0 SP1	Processing
Microsoft	365 Apps (Word, Excel)	365	Processing
Adobe	Adobe Acrobat Pro DV (32-bit)	2023.008.20555	Processing
NOAA OCS/JHC	Pydro (XmlDR, Compare Grids, POSPAC AutoQC)	24.6	Processing
NOAA OCS/JHC	QC Tools	3.11.0	Processing
Beyond Compare	Beyond Compare	4.4.1	Processing
QGIS	QGIS	3.40.4-Bratislava	Processing

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 Blake for this project.

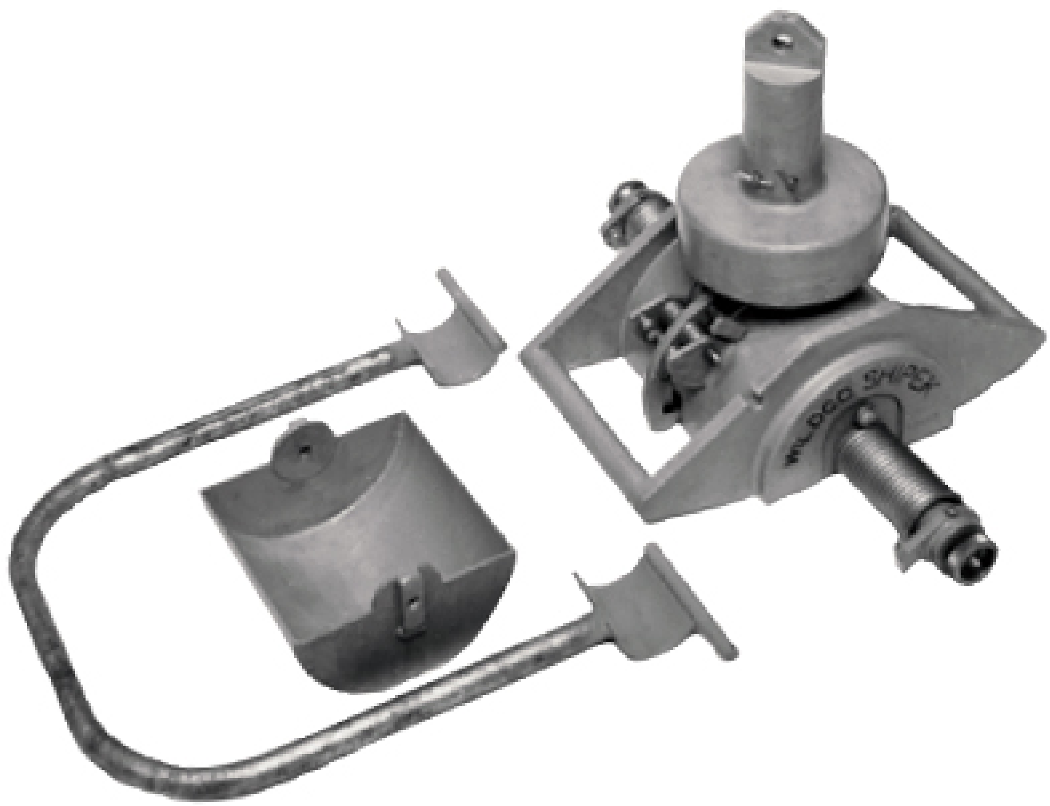

Figure 6: Shipek Grab Sampler

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

Vessel offsets and associated measurement uncertainties for the 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. A new IMU64 was also installed in June 2024 for this project, and measurements were made to determine the new offsets to the IMU bulls-eye from new punch marks on the mounting plate. Vessel offsets and uncertainties were used in the HVF.

Sensor offsets for the 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 month of survey operations from draft sight tubes located in the port and starboard sponsons abeam of the multibeam sonar and vessel reference point.

Vessel offsets and associated measurement uncertainties for the DriX 5 were calculated from a full offset survey and calibration of the motion and heading sensors onboard DriX 5, performed next to the Olson Centre in Durham, NH, on August 24, 2024. The offset survey was conducted while the DriX 5 was in dry dock on cradles, under static conditions with the gondola fully lowered to survey position. The survey utilized a terrestrial land survey total station from a minimum of two locations, which allowed a position uncertainty to be determined.

The Sams 150 system installed on the DriX 5 includes six antennas: one transmit and two receive antennas on each side of the gondola. Each transmit antenna has a single acoustic center, while each receive antenna contains 16 acoustic centers. Because these offsets are not compatible with the NOAA XML DAPR schema, they are not included in Section B.1.1.1: Vessel Offset Correctors. However, the Sams 150 offsets and survey methods are documented in Appendix III – Vessel Offset Reports.

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

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

B.1.1.1 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="4">Blake</td></tr>
<tr><td>Echosounder</td><td colspan="4">Teledyne RESON T50</td></tr>
<tr><td>Date</td><td colspan="4">2024-07-03</td></tr>
<tr><td rowspan="8">Offsets</td><td rowspan="4">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>-0.827 meters</td><td>0.030 meters</td></tr>
<tr><td>y</td><td>0.044 meters</td><td>0.030 meters</td></tr>
<tr><td>z</td><td>3.123 meters</td><td>0.030 meters</td></tr>
<tr><td rowspan="3">Nav to Transducer</td><td>x</td><td>-1.380 meters</td><td>0.030 meters</td></tr>
<tr><td>y</td><td>-4.646 meters</td><td>0.030 meters</td></tr>
<tr><td>z</td><td>9.616 meters</td><td>0.030 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.000 degrees</td><td></td></tr>
</table>

<table>
<tr><td>Vessel</td><td colspan="4">DriX 5</td></tr>
<tr><td>Echosounder</td><td colspan="4">Kongsberg EM2040 MKII</td></tr>
<tr><td>Date</td><td colspan="4">2024-08-24</td></tr>
<tr><td rowspan="14">Offsets</td><td rowspan="7">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>0.003 meters</td><td>0.012 meters</td></tr>
<tr><td>y</td><td>-0.719 meters</td><td>0.006 meters</td></tr>
<tr><td>z</td><td>0.147 meters</td><td>0.001 meters</td></tr>
<tr><td>x2</td><td>-0.004 meters</td><td>0.013 meters</td></tr>
<tr><td>y2</td><td>-0.260 meters</td><td>0.005 meters</td></tr>
<tr><td>z2</td><td>0.136 meters</td><td>0.002 meters</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>-0.029 meters</td><td>0.007 meters</td></tr>
<tr><td>y</td><td>-0.083 meters</td><td>0.004 meters</td></tr>
<tr><td>z</td><td>4.646 meters</td><td>0.001 meters</td></tr>
<tr><td>x2</td><td>-0.036 meters</td><td>0.006 meters</td></tr>
<tr><td>y2</td><td>0.376 meters</td><td>0.003 meters</td></tr>
<tr><td>z2</td><td>4.635 meters</td><td>0.002 meters</td></tr>
<tr><td>Transducer Roll</td><td>Roll</td><td>0.000 degrees</td><td></td></tr>
</table>

B.1.2 Layback

On the S/V Blake, 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. The stern tow point is denoted on the vessel offset drawing included in Appendix III - Vessel Offset Reports.

No layback computations were required for the Sams 150 on the DriX 5 as the system was mounted onto the gondola.

B.1.2.1 Layback Correctors

Vessel	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 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 month 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 on the Blake 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 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.

Data collected with the DriX 5 also utilized ERS methods; therefore static draft was not computed. Bar checks for the DriX 5 were not conducted, but platform-to-platform comparisons were made with data collected by the Blake as detailed in section D.1.5.3.

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, settlement and squat tests were conducted for both survey vessels. The test for the Blake was performed in the vicinity of Gulfport, MS on July 3, 2024 (DN193) and confirmed values from previous settlement and squat tests. A settlement and squat test was performed in the vicinity of Calcasieu Pass, south of Cameron, LA, for the DriX 5 on September 9, 2024 (DN253).

Both tests were performed using a post-processed GNSS technique compatible with the NOAA POSPAC AutoQC Tool. During testing, transects were run at increasing speeds (from zero to approximately 12 knots) in opposite directions. After post-processing the navigation and inertial data acquired during the tests, the NOAA tool was used to analyze the resulting Smoothed Best Estimate of Trajectory (SBET) and produce a dynamic draft table.

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. 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 tests were processed using post-processed positions and attitude.

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.

Multiple patch tests were performed by the DriX 5 to confirm offsets, but only the beginning of project patch was entered into the HVF.

Roll test lines were frequently acquired to monitor the stability of the multibeam sonar mount. Roll test values were processed and used to verify the validity of the Roll Corrector calculated from the patch test. These roll values were documented but not included in the HVF.

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

B.3.1.1 System Alignment Correctors

Vessel	Blake		
Echosounder	Teledyne RESON T50		
Date	2024-07-12		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.005 seconds
	Navigation Time Correction	0.000 seconds	0.005 seconds
	Pitch	-1.470 degrees	0.048 degrees
	Roll	-0.220 degrees	0.048 degrees
	Yaw	-0.500 degrees	0.020 degrees
	Pitch Time Correction	0.000 seconds	0.005 seconds
	Roll Time Correction	0.000 seconds	0.005 seconds
	Yaw Time Correction	0.000 seconds	0.005 seconds
	Heave Time Correction	0.000 seconds	0.005 seconds

<table>
<tr><td>Vessel</td><td>DriX 5</td></tr>
<tr><td>Echosounder</td><td>Kongsberg EM2040 MKII</td></tr>
<tr><td>Date</td><td>2024-08-24</td></tr>
<tr><td>Patch Test Values</td><td>
<table>
<tr><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Pitch</td><td>-0.422 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Roll</td><td>0.311 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Yaw</td><td>0.100 degrees</td><td>0.050 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
</table>
</td></tr>
</table>

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

MBES data were acquired concurrently with side scan sonar data over the entire project area to achieve Complete Coverage Option B requirements as specified in the 2022 Hydrographic Survey Specifications and Deliverables (HSSD).

The DriX 5 was operated from two Remote Operation Centers (ROCs); one located on-site in Cameron, LA, and the other located in Vancouver, WA. Occasionally, the vessel was operated from a third location in La Ciotat, France. The ROCs generally consisted of two main workstations. One workstation was primarily used for vessel piloting and navigation, while the other workstation was primarily used for survey data acquisition and monitoring. From the survey acquisition station, the operator gained remote VPN access to two survey PCs on the DriX 5 running Kongsberg SIS for MBES data acquisition, and Delph Geo for Sams 150 seafloor imagery data acquisition. Access to the Septentrio GNSS receiver, Phins INS, and Valeport SWiFT SVP probe were also achieved though web portals or from the survey PC. While navigation data, coverage, and survey equipment settings and commands controls were accessible from the survey PCs themselves, select survey data, navigation information, coverage displays, and equipment settings were accessible from the main DriX Human Machine Interface (HMI).

On the Blake, multibeam data were acquired in HYPACK HYSWEEP file format (HSX), while the DriX 5 acquired multibeam data in Kongsberg SIS file format (KMALL). 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 both HYPACK RAW format and the KMALL format, as a supplementary backup. Time series backscatter data were logged on the Blake in HYPACK 7K format, and on the DriX 5 in KMALL format.

The 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 sonars were 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 to maintain range 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.

The Reson T-50 sonar on the Blake was occasionally operated in Multi-Detect mode during some feature investigations, enabling the collection of multiple soundings per beam.

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. 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 7 are addressed in the individual Descriptive Report (DR) for each survey.

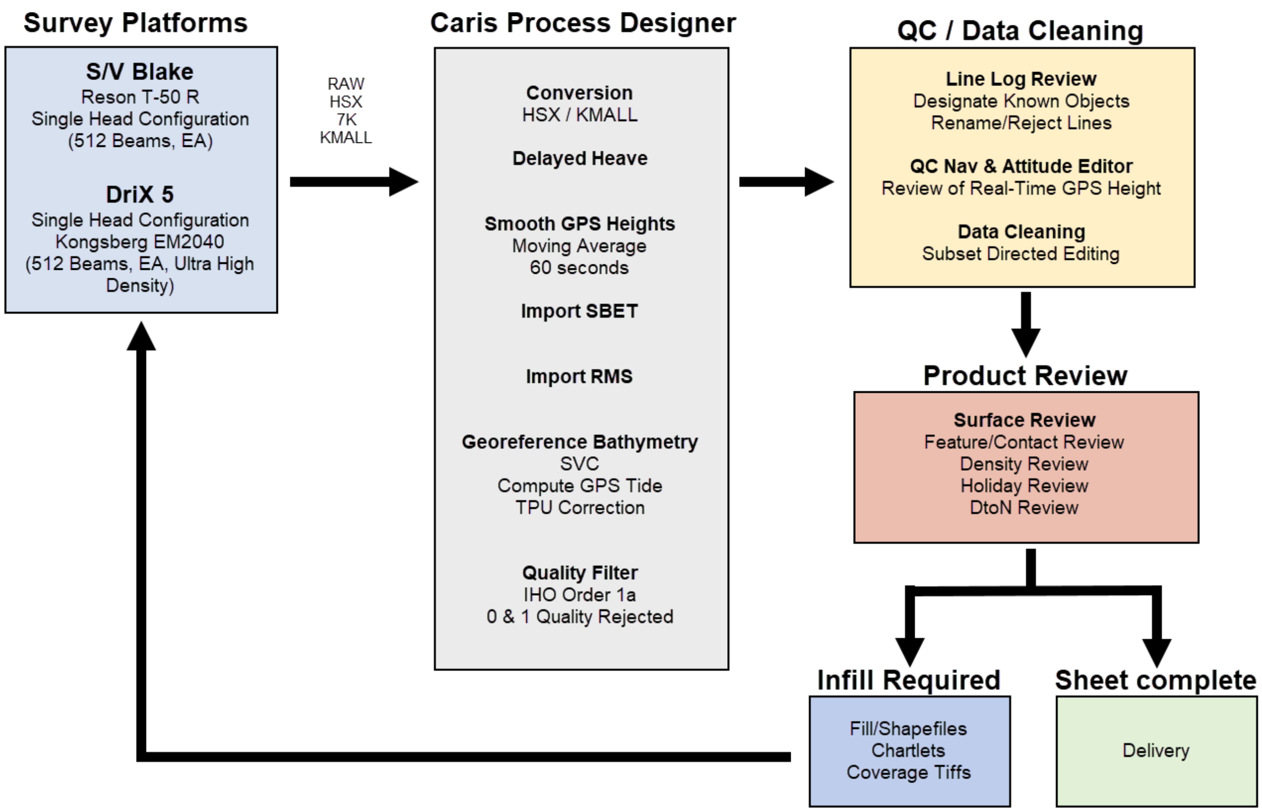

Figure 7: Flowchart of MBES Data Processing Pipeline

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 “Uncertainty” 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 from the Reson T50 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 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 2024 NOAA CUBE parameters file.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

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

For the Blake, 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.

For the DriX 5, Kongsberg SIS was used to acquire multibeam data and time-series backscatter, logged in KMALL file format.

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

Multibeam time-series backscatter data was processed in QPS FMGT to meet 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 8 are addressed in the individual DR for each survey.

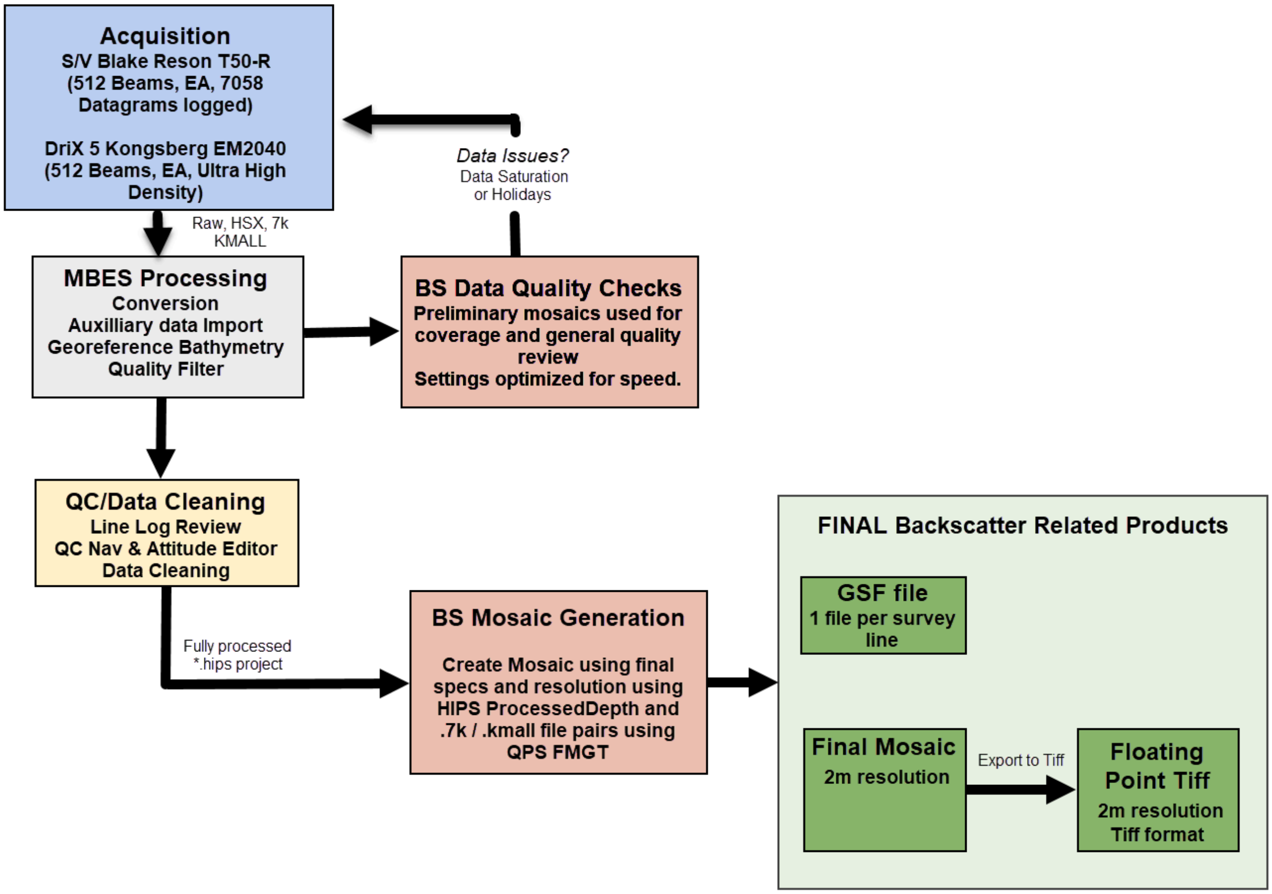

Figure 8: Flowchart of Backscatter Data Processing Pipeline

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

Side scan sonar (SSS) data were acquired concurrently with MBES data for mainscheme survey acquisition to meet acquisition requirements for Complete Coverage Option B. Side scan was generally not acquired during crosslines. Features and contacts identified using SSS were developed and investigated using MBES.

SSS imagery was acquired with either an EdgeTech 4205 or EdgeTech 4200 side scan sonar on the Blake, or an Exail Sams 150 on the DriX 5. The EdgeTech sonars were operated at 540 kHz using 75-meter range scales, and at survey speeds and ping rates that enabled the sonar to detect 1-meter targets in the along-track direction. The 4205 Motion Tolerant SSS used High Speed Motion Tolerant Mode, and the 4200 SSS used High Speed Mode. The Sams 150 sonar was operated at 150 kHz using 75- and 100-meter range scales, and at survey speeds that enabled the sonar to detect 1-meter targets in the along-track direction.

On the Blake, 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 DriX 5, imagery was logged in Delph proprietary XTF format. In addition to the imagery, vessel heading, pitch, roll, position, and altitude were also recorded to the XTF. The Sams 150 logs multiple XTF files per survey line. The system produces a single XTF file containing only the 90-degree beam data from each individual ping. This "single-ping" XTF is akin to traditional side scan sonar data and was processed separately in Chesapeake SonarWiz software as the primary data set for the survey. In addition, the system logs a series of much larger XTF files for each survey line, containing the full "multi-ping" SAS data. The full XTF package was processed in Exail's Delph Geo software to produce high-resolution inertially-corrected side scan seafloor imagery mosaics to aid contact identification in SonarWiz.

On the Blake, the side scan sonar towfish was deployed from the stern of the vessel. 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 towfish layback positions. An LCI-90 cable payout interface was used to measure cable-out. The vessel tow point is denoted on the vessel offset drawings included in Appendix III - Vessel Offset Reports.

On the DriX 5, the Sams 150 was mounted on the gondola of the vessel, removing the need for layback computations. Horizontal and vertical offsets of the transducers relative to the vessel reference point were recorded into the Sams 150 data files.

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.

On the Blake, the acquisition stations were custom-installed and integrated 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 and 4200 series sonars have a ping rate of 20 Hz at the 75-meter range while operating in High Speed Mode. This 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 of the Blake was monitored to allow for the acquisition of a minimum of three pings per meter.

The Sams 150 on the DriX 5 does not have a multi-pulse configuration and only sends one pulse into the water at a time. The ping rate is therefore limited to 10 Hz at 75-meter range and 7.5Hz at 100-meter range. The DriX 5 operated at the minimum operational vessel speed of around 6.5 knots in order to maximize the along-track ping rate. At speeds under 6.5 knots, the alternators on the vessel could not adequately charge the vessel batteries to sustain operation. At 6.5 knots, the along-track ping rate for the single-ping XTF file recorded by the system at 75-meter range, just meets the 3 pings per meter requirement specified in the HSSD. At 100-meter range, the requirement was theoretically not satisfied as the vessel would need to travel at speeds less than 5 knots. However, the true ping density of the full synthetic aperture XTF data recorded by the system at both range scales more than satisfies the survey's feature detection requirements. The ping density for a synthetic aperture sonar increases with range as a result of wave-form processing, and is also largely dependent on platform stability. For these reasons, the HSSD requirement is not totally applicable to the full synthetic aperture data set processed for this project.

The side scan sonar operator was assigned the task of analyzing the digital sonogram and, if applicable, 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 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 day. 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.

Data collected from the DriX 5 were logged locally on external hard drives inside the DriX 5, then backed up to a QNAP network storage system inside the ROC when the DriX 5 came into port for maintenance and fuel. Data were then transferred to the Vancouver, WA office via external USB 3.0 hard drives. Smaller data files were routinely transferred directly to the Vancouver office network via FTP transfers from the vessel while it was at sea.

Following acquisition, the HSX files from the Blake and the XTF files from the DriX 5 followed two similar but distinctive processing workflows (Figures 9 and 10, respectively). The traditional side scan HSX files acquired on the Blake from EdgeTech sonars were processed solely in CTI SonarWiz software. The XTF files acquired on the DriX 5 from the Sams 150 followed a dual-processing workflow, with the smaller, more manageable single-ping XTF files processed in SonarWiz, for faster turn-around and ease of use. The larger, more cumbersome full SAS XTF package was processed in Exail’s Delph Geo software to provide inertially corrected, high resolution imagery for comparison.

Prior to import, the SonarWiz NavInjectorPro utility was used to write calendar date stamps and Julian date stamps to each record in the Sams 150 single-ping XTF files, which were not encoded in the raw files by the software developer. HSX files from the Blake and the single-ping XTF files from the DriX 5 were then imported directly into SonarWiz, utilizing the towfish positions derived from HYPACK layback computations, or the towfish position on the DriX gondola. Post-processed navigation SBET files, processed in Inertial Explorer and Delph INS software, were applied to the DriX single-ping XTF data in SonarWiz using the NavInjectorPro utility. These were the same SBET files used for multibeam processing. In keeping with DEA's standard side scan data processing workflow for traditional towed side scan systems on the Blake, where positional uncertainties typically outweigh any benefit of post-processed navigation, SBETs were not applied to the Blake data. The side scan bottom track was then reviewed in SonarWiz. Losses of bottom or incorrect bottom track areas were re-digitized, and gain adjustments were applied using the Empirical Gain Normalization (EGN) setting in SonarWiz. Navigation and offset parameters were reviewed along with available MBES data to verify accurate towfish positioning.

In a parallel processing workflow, the full Sams 150 data package for each trackline was imported into Delph RoadMap, a sensor analysis module under the main Delph Geo Interpretation software suite. Post-processed SBET files were not applied in Delph Geo to simplify the processing workflow. Side scan products generated in Delph Geo were used to aid contact identification in SonarWiz and meet feature detection requirements. The bottom track was reviewed in Delph Geo and a calibrated Automatic Gain Control (AGC) file was created and applied to the data in a batch processing routine. After processing, data were mosaiced in a batch process to create 10-centimeter motion-corrected “inertial side scan” seafloor imagery mosaics for each individual trackline using the currently named “Incoherent SAS” mosaicing routine in Delph Geo. Due to speed and excessive motion on the DriX 5, true SAS processing, either "coherent" or "incoherent", was not achieved. The output is what Exail refers to as "inertial side scan". Trackline mosaics were then merged in Delph Geo to create a single daily 10-centimeter seafloor imagery mosaic and export in Tagged Image File Format (TIF) to review against the single-ping side scan data processed in SonarWiz.

The processed single-ping side scan lines and 10-centimeter inertial side scan mosaics then underwent at least two independent reviews in SonarWiz to identify significant contacts. Contacts were digitized from the SonarWiz imagery to ensure proper 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. Although Exail software developers made improvements to the SAS data processing routines throughout the project, it was often the case that objects identified in the Sams 150 data presented as a pronounced bright return, but lacked a measurable shadow, or displayed other artifacts, elongating the image from multiple returns. Though already a standard practice, extra caution was exercised when reviewing Sams 150 data for side scan contacts, and any contacts with bright returns were investigated with multibeam, regardless of the presence of a measurable shadow. Any deviations from the processing workflows shown in Figures 9 and 10 are addressed in the individual Descriptive Reports for each survey.

Due to the nature of the Sams 150 being mounted on the gondola of the DriX 5, altitude control was not possible. Thus altitudes are often outside of the required range listed in the 2022 HSSD. However, as noted in the Project Instructions, an altitude waiver was provided for this project.

Side scan mosaics were created using CTI SonarWiz for both Blake side scan and DriX 5 single-ping side scan data. Georeferenced mosaics were generated in TIF format at 1-meter resolution and converted to floating point format in ArcMap for the final primary mosaic delivery. Individual trackline mosaics in Delph Geo were merged to create a single 10-centimeter seafloor imagery mosaic for each percent coverage (100% or 200%), when a second 100% coverage was required for charted feature disprovals. Each mosaic is comprised of a large number of TIF images, and an associated .XMO file containing the mosaic tiling scheme, readable only within Delph Geo software. For ease of review, the Delph Geo mosaic tiles were merged using QGIS software and provided a single 10-centimeter seafloor imagery mosaic for each percent coverage in TIF format that can be opened in any standard GIS software, including CARIS. Due to the different processing routines of each software, different data inputs, resolutions, and attention to elective processing options such as draw order, gain settings, and vessel-turn clipping, mosaics produced in Delph Geo may appear slightly different. These differences may be seen in terms of coverage or quality when compared to their counterparts produced in SonarWiz. The 1-meter resolution single-ping side scan mosaics produced from SonarWiz are intended as the primary mosaic product and meet the HSSD and Project Instruction requirements.

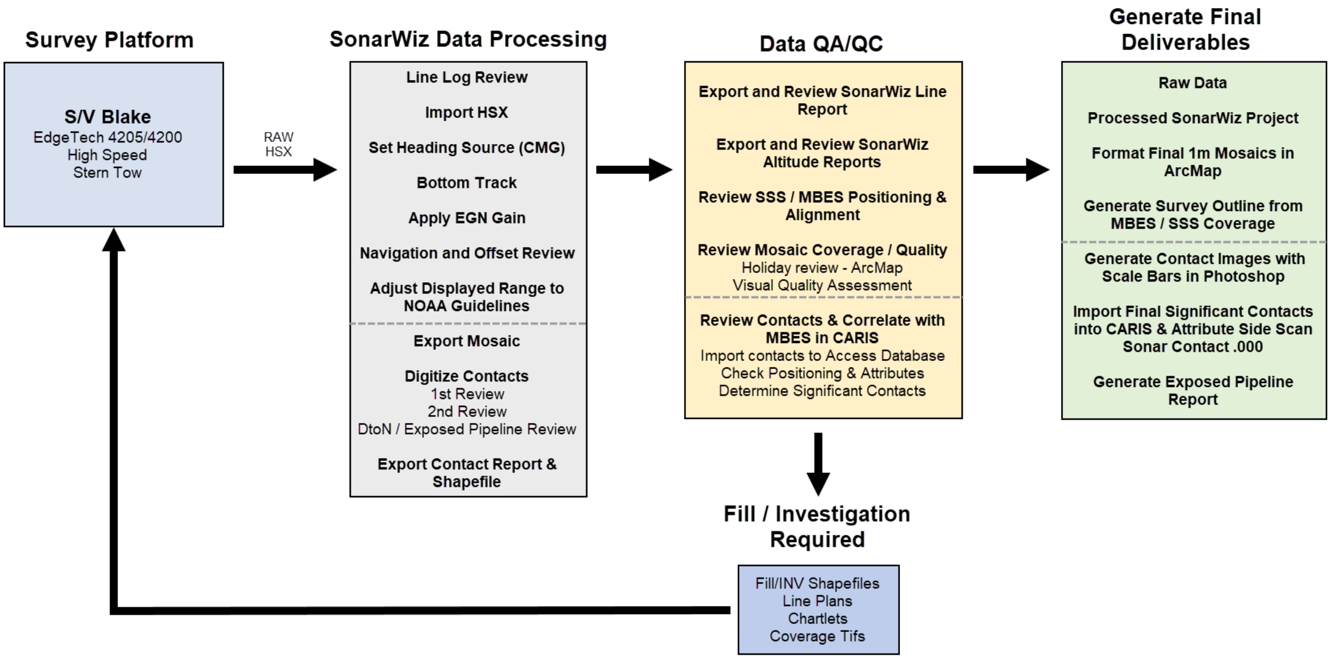

Figure 9: Flowchart of SSS Data Processing Pipeline

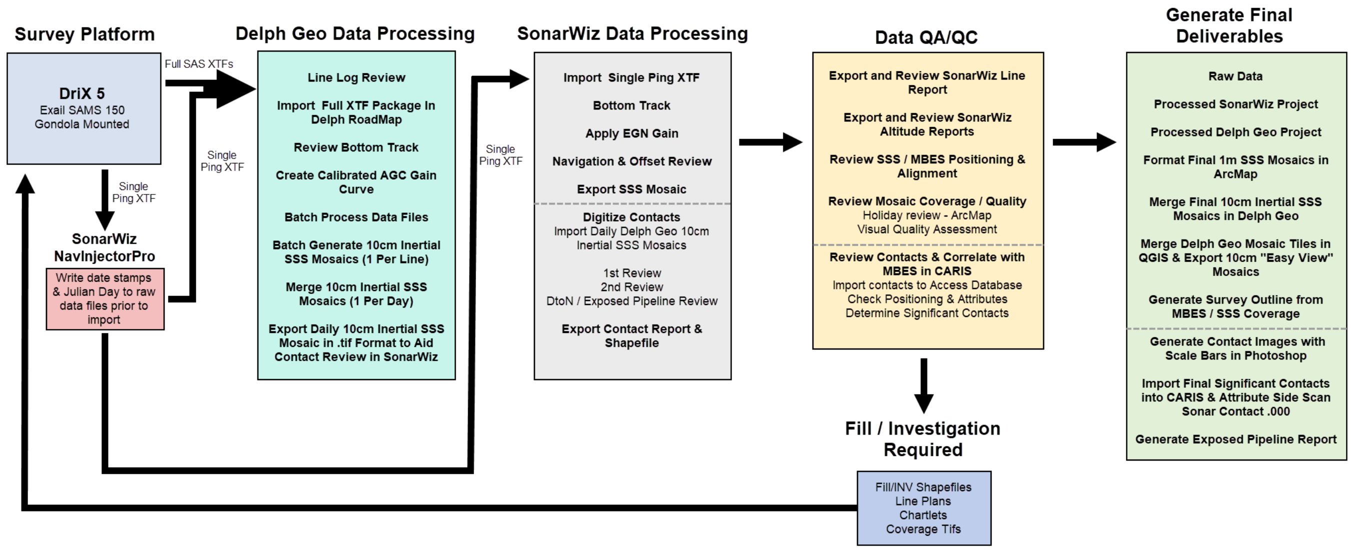

Figure 10: Flowchart of SAS Data Processing Pipeline

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

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

The POS MV system of the Blake 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 and single-ping SSS 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 Blake was outfitted with an Applanix POS MV Ocean Master 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.

The DriX 5 was outfitted with an Exail Phins Compact Series C7, which was used to measure attitude, heading, heave, and position via an integrated Septentrio GNSS receiver with one antenna. The Septentrio GNSS Receiver received real-time corrections using the Fugro Marinestar correction service.

Position, timing, heading, heave, and motion data were output to the QPS Qinsy acquisition system using the Exail Multilogger software. GNSS data was output to Novatel *.24_ files at a rate of one per hour. In relation to INS, inertial data was logged in Delph *.log format at a rate of one per hour.

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 methods:

RTX (Primary method of positioning control for Blake acquisition):

POSPac Post-Processed Real Time Extended (PP-RTX) was used to post-process POS MV data acquired in all designated Blake 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.

SBET files were applied to single-ping SSS data in SonarWiz using the NavInjectorPro utility. Corresponding uncertainty files were not applied to SSS data.

Novatel Terrastar NRT PPP Solution (Primary method of positioning control for DriX):

A post-processed inertially coupled PPP Solution using Novatel Terrastar NRT corrections and INS data from the Phins C7 was applied to all data acquired within the DriX designated survey sheets. The NRT corrections were used to provide centimeter positioning and ellipsoid heights while working offshore, outside the practical range of CORS stations.

SBET files and associated Root Mean Square (RMS) files were output from the Delph INS software and reviewed using Delph INS and NOAA AutoQC Tools.

SBETs were applied in CARIS by loading both the SBET files and corresponding uncertainty 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 40-minute intervals for the Blake, and 4-hour intervals for the DriX 5 to reduce strain on the winch. 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 on the Blake, and Qinsy for DriX 5. 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 for the Blake data, and four-hour option for DriX 5 data. 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 on the Blake, and a Teledyne Valeport miniSVS on the DriX 5. These sound speed values were applied in real-time to the MBES system to provide refraction corrections to the transducer for beam forming. Values were monitored in real-time and compared against the water column cast data. Cast interval was modified as necessary to ensure spatial and temporal sound velocity change was adequately captured throughout survey operations.

Data Processing Methods and Procedures

Surface sound speed data were used in HIPS during georeferencing as the starting point for each cast when available.

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 was available from both the Reson T-50 and Kongsberg EM2040 MKII, and was logged to the HSX or KMALL file respectively, for each sounding. This data was read into CARIS HIPS at the time of conversion. Post-processed navigation, GPS height, heading and vessel motion uncertainties stored in "smrmsg" files were loaded into HIPS with the Import Auxiliary Data function.

Dynamic and global uncertainty values, such as the ERS separation model uncertainty, provided by NOAA, were specified in the HIPS Georeference Bathymetry dialog and applied when TPU was computed.

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		Blake	DriX 5
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees
	Heave	2.00% 0.02 meters	5.00% 0.05 meters
	Roll	0.01 degrees	0.02 degrees
	Pitch	0.01 degrees	0.02 degrees
Navigation Sensor		0.10 meters	0.10 meters

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
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.
DriX 5	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 Kongsberg EM2040 sonars were logged in the KMALL 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 Delph INS. 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 or SSS positions on the submerged portion of the baring feature.

Data Processing Methods and Procedures

Designated soundings that were determined to be obstructions, 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 2024 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. The final sampling plan was created by DEA to keep 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 model and a vessel tide float at the NOAA tide station Calcasieu Pass, LA, (8768094) using ERS measurements. Through these checks, DEA discovered that the VDatum based separation model (SEP) provided with the OPR-K356-KR-24 Project Instruction was created using GEOID12B, which differed from SEP files used during prior junctioning surveys performed in 2022 and 2023. NOAA issued a revised NAD83 to MLLW SEP file on July 30, 2024, which used the most recent version of VDatum and xGEOID20.

Data Processing Methods and Procedures

After reprocessing the tide float with the revised SEP, the mean difference between the gauge and ERS tides generated with POSPac RTX was 0.09 meters, with the tide gauge values being less than the vessel-based GNSS values. The revised SEP model was used to correct all sounding data to MLLW for the project and is documented in the DR for each survey.

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 to meet 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 single-ping 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.

During the grid finalization process, “uncertainty” was selected as the uncertainty source. 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-24 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

A platform-to-platform quality control check was performed by evaluating gridded differences between overlapping data acquired by the Blake and DriX 5. MBES data were collected in the vicinity of the Lake Charles Shipping Channel during several patch tests performed during the project. Platform-to-platform differences were evaluated using the Pydro Compare Grids tool after extracting gridded coverage to exclude data within the channel and along steep slopes. The mean difference from the comparison was 1.9 centimeters (Blake deeper than DriX 5) with a standard deviation of 0.058.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

On the Blake, 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.

On the DriX 5, Delph Geo acquisition software was used to record the Sams 150 synthetic aperture side scan sonar data in XTF format. Adjustments to the pulse-width and range were made as necessary during acquisition to meet specifications and provide the best image quality possible. Any changes to sensor settings or other pertinent survey-related information were recorded in the daily acquisition log. Typical windows for monitoring raw sensor information included a waterfall display of the single-ping side scan sonar imagery, towfish/vessel motion and navigation displays, and a command control web interface for configuring the sonar chirp, pulse duration, power, and range range settings; monitoring I/O ports, signal status, and time synchronization; and for controlling transmit and disk logging status. Data were displayed on multiple LCD flat-panel monitors in each ROC location.

Coverage assessment was performed in real-time, using HYPACK on the Blake, and in post-processing using a combination of software, including SonarWiz, Delph Geo, CARIS, and ArcMap. Sonar lines were evaluated to meet both technical standards for overlap, altitude, and 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 additional SSS coverage.

Prominent features were used to evaluate SSS positioning and compared with MBES data sets to check feature 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, and the high-resolution inertial side scan imagery was evaluated for comparison in Delph Geo for the DriX 5.

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. An abundance of caution was used when evaluating contact heights calculated from shadow length when determining which contacts required additional MBES investigation, particularly when analyzing the Sams 150 data from the DriX 5. Contacts were often investigated with MBES regardless of their shadow height measurement if there were other indications the feature may be of significant height.

Management of side scan sonar contacts was accomplished by utilizing SonarWiz, Microsoft Access contact databases, 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-24 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-24 Statement of Work (July 11, 2024) and Hydrographic Survey Project Instructions (July 11, 2024).

Approver Name	Approver Title	Date	Signature
Jonathan L. Dasler, PE, PLS, CH	NSPS-THSOA Certified Hydrographer, Chief of Party	04/16/2025	Digitally signed by Jonathan L. Dasler, PE, PLS, CH Date: 2025.04.16 14:08:11 -07'00'
Jason Creech, CH	NSPS-THSOA Certified Hydrographer, Charting Manager / Project Manager	04/16/2025	Digitally signed by Jason Creech, CH Date: 2025.04.16 14:13:16 -07'00'
James Guilford, CH(A)	NSPS-THSOA Certified Hydrographer, Lead Hydrographer	04/16/2025	Digitally signed by James Guilford Date: 2025.04.16 14:14:17 -07'00'
Jason Dorfman, CH	NSPS-THSOA Certified Hydrographer, Lead Hydrographer	04/16/2025	Digitally signed by Jason Dorfman Date: 2025.04.16 14:15:17 -07'00'
Sam Werner	Data Processing Manager	04/16/2025	Digitally signed by Sam Werner Date: 2025.04.16 14:16:26 -07'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	Appendix I - Vessel Wiring Diagram_Rev1.pdf
Sound Speed Sensor Calibration	Appendix II - Sound Speed Sensor Calibration Reports_Rev1.pdf
Vessel Offset	Appendix III - Vessel Offset Reports_Rev1.pdf
Position and Attitude Sensor Calibration	Appendix IV - Position Attitude Sensor Calibration Reports _Rev1.pdf
Echosounder Confidence Check	Appendix V - Echo Sounder Confidence Check Reports_Rev1.pdf
Echosounder Acceptance Trial Results	N/A