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

Data Acquisition & Processing Report

Type of Survey:	Basic Hydrographic Survey
Project Number:	OPR-E351-KR-22
Time Frame:	February - March 2024

LOCALITY

State(s):	Maryland Virginia
General Locality:	Southwest Chesapeake Bay

2023

CHIEF OF PARTY
David Neff, C.H.

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eTrac
Chief of Party: David Neff, C.H.
Year: 2023
Version: 3.0
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A. System Equipment and Software

A.1 Survey Vessels

A.1.1 R/V Endeavor

Vessel Name	R/V Endeavor	
Hull Number	USIAR34CATL011	
Description	eTrac provided R/V Endeavor for hydrographic survey operation on OPR-E351-KR-22. R/V Endeavor was primarily focused on the 80m Line Spacing / 50m SSS Range scope of the project, excluding the vessel from extremely shallow water work. R/V Endeavor is a 44' catamaran built by Armstrong Marine. R/V Endeavor is owned and operated by eTrac and has the following specifications:	
Dimensions	*LOA*	44 ft.
	Beam	14 ft.
	Max Draft	2.5 ft.
Most Recent Full Offset Verification	*Date*	2023-02-01
	Method	Precise measurments with a hand held metal tape and a long carpenters level were used to confirm and adjust previously measured offsets duing the mobilization of OPR-E351-KR-22. The measured data were used to establish vessel equipment offsets for all components of the hydrographic system mobilized on R/V Endeavor. All measurments were perfomred a minimum of 3 times to reduce uncretainty.

Figure 1: R/V Endeavor

A.1.2 R/V Voxel

Vessel Name	R/V Voxel	
Hull Number	IAR40CATE808	
Description	eTrac provided R/V Voxel for hydrographic survey operation on OPR-E351-KR-22. R/V Voxel was primarily focused on the 80m Line Spacing / 50m SSS Range scope of the project, excluding the vessel from extremely shallow water work. R/V Voxel is a 46' aluminum catamaran. The catamaran hull is semi-SWATH (Small-Waterplane-Area Twin Hull). R/V Voxel is owned and operated by eTrac and has the following specifications:	
Dimensions	*LOA*	46 ft.
	Beam	12.5 ft.
	Max Draft	2 ft.

Most Recent Full Offset Verification	*Date*	2023-02-01
	Method	Precise measurments with a hand held metal tape and a long carpenters level were used to confirm and adjust previously measured offsets duing the mobilization of OPR-E351-KR-22. The measured data were used to establish vessel equipment offsets for all components of the hydrographic system mobilized on R/V Voxel. All measurments were perfomred a minimum of 3 times to reduce uncretainty.

Figure 2: R/V Voxel

A.1.3 R/V Taku

Vessel Name	R/V Taku
Hull Number	IAR28CATI607
Description	eTrac provided R/V Taku for hydrographic survey operation on OPR-E351-KR-22. R/V Taku was primarily focused on the 50m Line Spacing / 30m SSS and 40m Line Spacing / 25m SSS Range scope of the project. R/V Taku is a 35' aluminum catamaran built by Armstrong Marine. R/V Taku is owned and operated by eTrac and has the following specifications:
Dimensions	*LOA*: 35 ft. *Beam*: 10.5 ft. *Max Draft*: 2 ft.
Most Recent Full Offset Verification	*Date*: 2023-02-14 *Method*: Precise measurments with a hand held metal tape and a long carpenters level were used to confirm and adjust previously measured offsets duing the mobilization of OPR-E351-KR-22. The measured data were used to establish vessel equipment offsets for all components of the hydrographic system mobilized on R/V Taku. All measurments were perfomred a minimum of 3 times to reduce uncretainty.

Figure 3: R/V Taku

A.1.4 R/V 505

Vessel Name	R/V 505	
Hull Number	1AR25CATE707	
Description	eTrac provided R/V 505 for hydrographic survey operation on OPR-E351-KR-22. R/V 505 was primarily focused on the 50m Line Spacing / 30m SSS and 40m Line Spacing / 25m SSS Range scope of the project. R/V 505 is a 33' aluminum catamaran built by Armstrong Marine. R/V 505 is owned and operated by eTrac and has the following specifications:	
Dimensions	*LOA*	33 ft.
	Beam	9.5 ft.
	Max Draft	2 ft.

Most Recent Full Offset Verification	*Date*	2023-03-12
	Method	Precise measurments with a hand held metal tape and a long carpenters level were used to confirm and adjust previously measured offsets duing the mobilization of OPR-E351-KR-22. The measured data were used to establish vessel equipment offsets for all components of the hydrographic system mobilized on R/V 505. All measurments were perfomred a minimum of 3 times to reduce uncretainty.

Figure 4: R/V 505

A.1.5 R/V Pulse

<table>
<tr><td>Vessel Name</td><td colspan="2">R/V Pulse</td></tr>
<tr><td>Hull Number</td><td colspan="2">KQK24A01E404</td></tr>
<tr><td>Description</td><td colspan="2">eTrac provided R/V Pulse for hydrographic survey operation on OPR-E351-KR-22. R/V Pulse was primarily focused on the 50m Line Spacing / 30m SSS and 40m Line Spacing / 25m SSS Range scope of the project.
R/V Pulse is a 24' aluminum Monohull. R/V Pulse is owned and operated by eTrac and has the following specifications:</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>24 ft.</td></tr>
<tr><td>Beam</td><td>8.5 ft.</td></tr>
<tr><td>Max Draft</td><td>2 ft.</td></tr>
<tr><td rowspan="2">Most Recent Full Offset Verification</td><td>Date</td><td>2023-02-03</td></tr>
<tr><td>Method</td><td>Precise measurments with a hand held metal tape and a long carpenters level were used to confirm and adjust previously measured offsets duing the mobilization of OPR-E351-KR-22. The measured data were used to establish vessel equipment offsets for all components of the hydrographic system mobilized on R/V Pulse. All measurments were perfomred a minimum of 3 times to reduce uncretainty.</td></tr>
</table>

Figure 5: R/V Pulse

A.1.6 R/V Spectrum

<table>
<tr><td>Vessel Name</td><td colspan="2">R/V Spectrum</td></tr>
<tr><td>Hull Number</td><td colspan="2">LSB22051B012</td></tr>
<tr><td>Description</td><td colspan="2">eTrac provided R/V Spectrum for hydrographic survey operation on OPR-E351-KR-22. R/V Spectrum was primarily focused on the 50m Line Spacing / 30m SSS and 40m Line Spacing / 25m SSS Range scope of the project.
R/V Spectrum is a 22' aluminum Lee Shore vessel. R/V Spectrum is owned and operated by eTrac and has the following specifications:</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>22 ft.</td></tr>
<tr><td>Beam</td><td>9 ft.</td></tr>
<tr><td>Max Draft</td><td>2 ft.</td></tr>
</table>

Most Recent Full Offset Verification	*Date*	2023-02-03
	Method	Precise measurments with a hand held metal tape and a long carpenters level were used to confirm and adjust previously measured offsets duing the mobilization of OPR-E351-KR-22. The measured data were used to establish vessel equipment offsets for all components of the hydrographic system mobilized on R/V Spectrum. All measurments were perfomred a minimum of 3 times to reduce uncretainty.

Figure 6: R/V Spectrum

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 R2Sonic 2024

R/V Endeavor, R/V Voxel, R/V Taku, and R/V Spectrum were each equipped with a R2Sonic 2024 MBES. R/V 505 and R/V Pulse were equipped with a R2Sonic 2024 MBES for a duration of the project. The single head 2024 utilizes 256 discretely formed beams over a selectable sector up to 160° per sonar. At 400 kHz the 2024 focuses an across-track and along-track beam-with of 0.5° and 1° respectively. The 2024 operates at a maximum ping rate of 60 Hz and is designed to comply with IHO standards for depth measurement to a maximum range of 400 meters.

Manufacturer	R2Sonic				
Model	2024				
Inventory	*R/V Endeavor*	*Component*	Deck Unit	Sonic Receiver	Sonic Projector
	R/V Endeavor	*Model Number*	Sonar Interface Module	2024	2024
	R/V Endeavor	*Serial Number*	104685	101794	806829
	R/V Endeavor	*Frequency*	N/A	400	400
	R/V Endeavor	*Calibration*	2023-02-03	2023-02-03	2023-02-03
	R/V Endeavor	*Accuracy Check*	2023-02-03	2023-02-03	2023-02-03
	R/V Voxel	*Component*	Deck Unit	Sonic Receiver	Sonic Projector
	R/V Voxel	*Model Number*	Snoar Interface Module	2024	2024
	R/V Voxel	*Serial Number*	103334	101568	800028
	R/V Voxel	*Frequency*	N/A	400	400
	R/V Voxel	*Calibration*	2023-02-15	2023-02-15	2023-02-15
	R/V Voxel	*Accuracy Check*	2023-02-15	2023-02-15	2023-02-15
	R/V Taku	*Component*	Deck Unit	Sonic Receiver	Sonic Projector
	R/V Taku	*Model Number*	Sonar Interface Module	2024	2024
	R/V Taku	*Serial Number*	104086	101639	807033
	R/V Taku	*Frequency*	N/A	400	400
	R/V Taku	*Calibration*	2023-02-14	2023-02-14	2023-02-14
	R/V Taku	*Accuracy Check*	2023-02-14	2023-02-14	2023-02-14
	R/V 505	*Component*	Deck Unit	Sonic Receiver	Sonic Projector
	R/V 505	*Model Number*	Sonar Interfce Module	2024	2024
	R/V 505	*Serial Number*	104267	101004	800013
	R/V 505	*Frequency*	N/S	400	400
	R/V 505	*Calibration*	2023-03-13	2023-03-13	2023-03-13
	R/V 505	*Accuracy Check*	2023-03-13	2023-03-13	2023-03-13
	R/V Spectrum	*Component*	Deck Unit	Sonic Receiver	Sonic Projector
	R/V Spectrum	*Model Number*	Sonar Interface Module	2024	2024
	R/V Spectrum	*Serial Number*	103409	101583	806764
	R/V Spectrum	*Frequency*	N/A	400	400
	R/V Spectrum	*Calibration*	2023-02-03	2023-02-03	2023-02-03
	R/V Spectrum	*Accuracy Check*	2023-02-03	2023-02-03	2023-02-03
	R/V Pulse	*Component*	Deck Unit	Sonic Reveiver	Sonic Projector
	R/V Pulse	*Model Number*	Sonar Interface Module	2024	2024
	R/V Pulse	*Serial Number*	104740	101639	807033
	R/V Pulse	*Frequency*	N/A	400	400
	R/V Pulse	*Calibration*	2023-05-10	2023-05-10	2023-05-10

Figure 7: R2Sonic 2024 MBES

A.2.1.2 R2Sonic 2022

R/V Pulse and R/V 505 were equipped with a R2Sonic 2022 MBES for a duration of the project. The single head 2022 utilizes 256 discretely formed beams over a selectable sector up to 160° per sonar. At 400 kHz the 2024 focuses an across-track and along-track beam-with of 1° and 1° respectively. The 2022 operates at a maximum ping rate of 60 Hz and is designed to comply with IHO standards for depth measurement to a maximum range of 400 meters.

Manufacturer	R2Sonic				
Model	2022				
Inventory	*R/V Pulse*	*Component*	Deck Unit	Sonic Receiver	Sonic Projector
		Model Number	Sonar Interface Module	2022	2022
		Serial Number	104740	101958	807666
		Frequency	N/A	400	400
		Calibration	2023-02-05	2023-02-05	2023-02-05
		Accuracy Check	2023-02-05	2023-02-05	2023-02-05
	R/V 505	*Component*	Deck Unit	Sonic Receiver	Sonic Projector
		Model Number	Sonic Interface Module	2022	2022
		Serial Number	104267	100729	806970
		Frequency	N/A	400	400
		Calibration	2023-03-24	2023-03-24	2023-03-24
		Accuracy Check	2023-03-24	2023-03-24	2023-03-24

Figure 8: R2Sonic 2022 MBES

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

R/V Endeavor was equipped with an EdgeTech 4200 MP Side Scan Sonar (SSS) for the entirety of the project. The 4200 MP SSS utilizes dual, simultaneous frequencies operating at 300/900 kHz. The 4200 SSS can be towed at a maximum of 9.6 knots while still meeting NOAA and IHO-44S specifications of 3 pings on a 1-meter cubed target at 100 meters.
The 4200 MP SSS has a horizontal beam width of 0.28° at 300 kHz, a vertical beam width of 50°, and an across track resolution of 3 cm at 300 kHz.

<table>
<tr><td>Manufacturer</td><td colspan="4">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="4">4200</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">R/V Endeavor</td><td>Component</td><td>Topside</td><td>Towsfish</td></tr>
<tr><td>Model Number</td><td>4200</td><td>4200</td></tr>
<tr><td>Serial Number</td><td>34553</td><td>52770</td></tr>
<tr><td>Frequency</td><td>N/S</td><td>300/900</td></tr>
<tr><td>Calibration</td><td>2023-02-04</td><td>2023-02-04</td></tr>
<tr><td>Accuracy Check</td><td>2023-02-04</td><td>2023-02-04</td></tr>
</table>

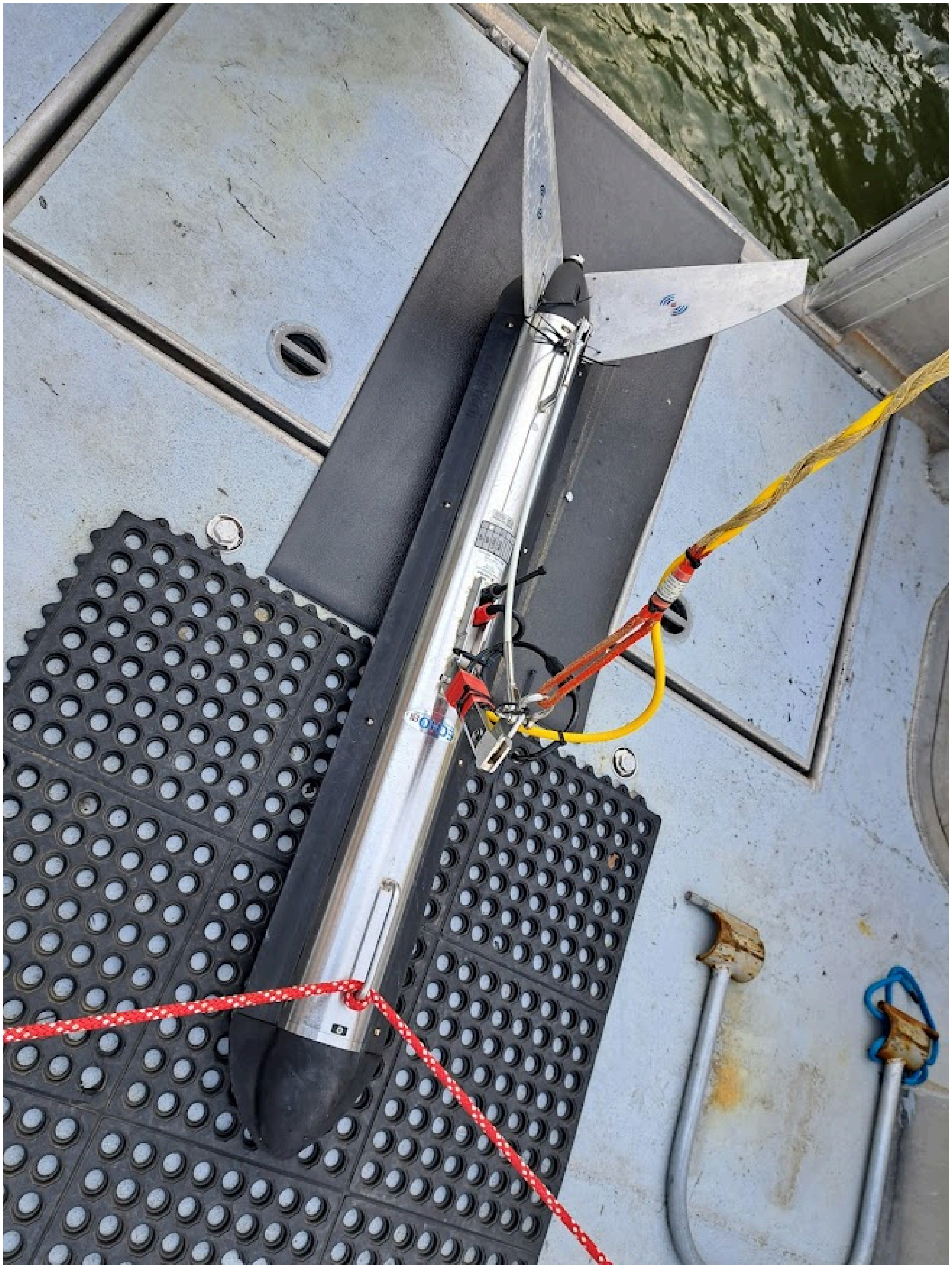

Figure 9: EdgeTech 4200 SSS

A.2.3.2 EdgeTech 4125

R/V Voxel, R/V Taku, R/V 505, R/V Pulse, and R/V Spectrum were each equipped with an EdgeTech 4125 Side Scan Sonar (SSS) for the entirety of the project. The 4125 SSS utilizes dual, simultaneous frequencies operating at 400/900 kHz. The 4125 SSS can be towed at a maximum of 4.8 knots while still meeting NOAA and IHO-44S specifications of 3 pings on a 1-meter cubed target at 100 meters.
The 4125 MP SSS has a horizontal beam width of 0.46° at 400 kHz, a vertical beam width of 50°, and an across track resolution of 2.3 cm at 400 kHz.

Manufacturer	EdgeTech			
Model	4125			
Inventory	*R/V Voxel*	*Component*	Topside	Towfish
		Model Number	4125	4125
		Serial Number	55430	58143
		Frequency	N/A	400/900
		Calibration	2023-02-15	2023-02-15
		Accuracy Check	2023-02-15	2023-02-15
	R/V Taku	*Component*	Topside	Towfish
		Model Number	4125	4125
		Serial Number	59915	59891
		Frequency	N/A	400/900
		Calibration	2023-02-14	2023-02-14
		Accuracy Check	2023-02-14	2023-02-14
	R/V 505	*Component*	Topside	Towfish
		Model Number	4125	4125
		Serial Number	59915	59891
		Frequency	N/A	400/900
		Calibration	2023-03-13	2023-03-13
		Accuracy Check	2023-03-13	2023-03-13
	R/V Pulse	*Component*	Topside	Towfish
		Model Number	4125	4125
		Serial Number	58074	58725
		Frequency	N/A	400/900
		Calibration	2023-02-05	2023-02-05
		Accuracy Check	2023-02-05	2023-02-05
	R/V Spectrum	*Component*	Topside	Towfish
		Model Number	4125	4125
		Serial Number	61434	61613
		Frequency	N/A	400/900
		Calibration	2023-02-04	2023-02-04
		Accuracy Check	2023-02-04	2023-02-04

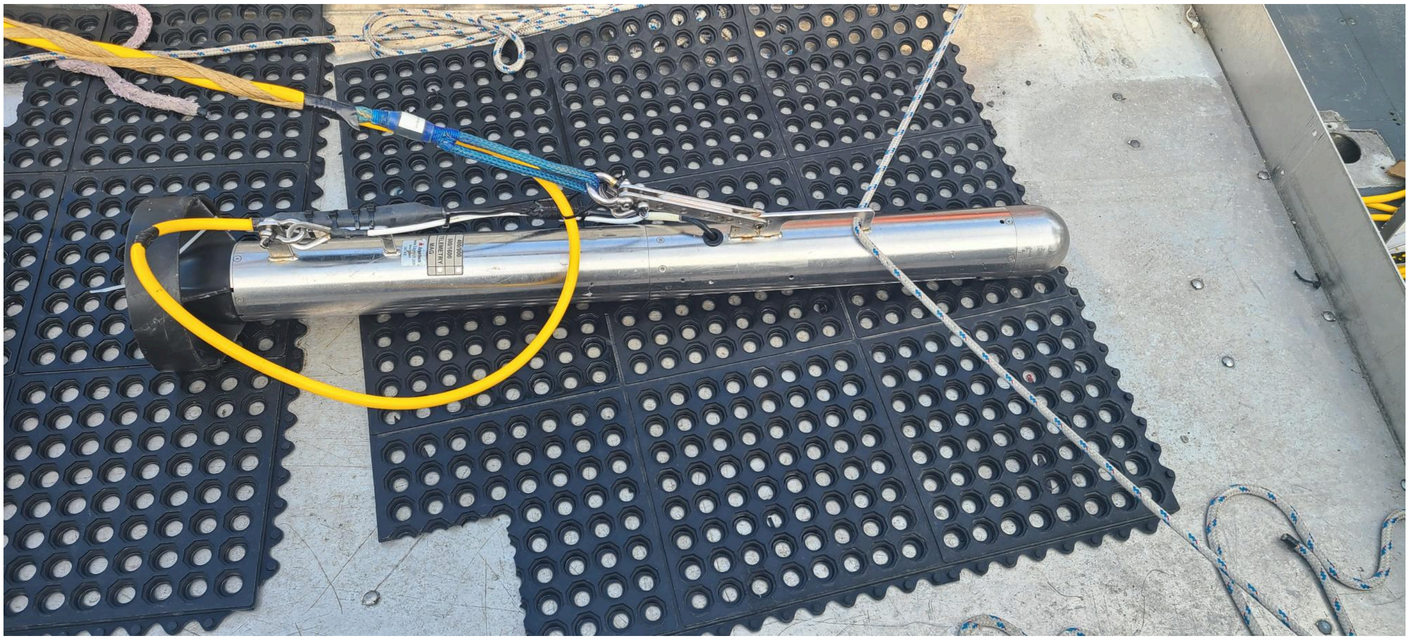

Figure 10: EdgeTech 4125 SSS

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 POS MV Oceanmaster

R/V Voxel, R/V Taku, and R/V 505 were mobilized with an Applanix POS MV Ocean Master, also known as a POSMV 320. The POS MV Oceanmaster was used to acquire position, attitude, and heading throughout the entire project. The POS MV Oceanmaster integrates a dual GPS antenna baseline and an inertial motion unit. Position, attitude, and heading data were broadcast to QPS QINSy acquisition software over Ethernet/ UDP at 50Hz for the vessels.

Manufacturer	Applanix			
Model	POS MV Oceanmaster			
Inventory	*R/V Voxel*	*Component*	Deck Unit	IMU
		Model Number	MV-320	IMU 65
		Serial Number	7163	5554
		Calibration	2023-02-14	2023-02-14
	R/V Taku	*Component*	Deck Unit	IMU
		Model Number	MV-320	IMU 36
		Serial Number	7035	2870
		Calibration	2023-02-14	2023-02-14
	R/V 505	*Component*	Deck Unit	IMU
		Model Number	MV - 320	IMU 65
		Serial Number	11293	2904
		Calibration	2023-03-12	2023-03-12

Figure 11: POS MV Oceanmaster

Figure 12: Oceanmaster IMU

A.5.1.2 Applanix POS MV Wavemaster

R/V Pulse and R/V Spectrum were mobilized with an Applanix POS MV Wavemaster, also known as a POSMV 220. The POS MV Wavemaster was used to acquire position, attitude, and heading throughout the entire project. The POS MV Wavemaster integrates a dual GPS antenna baseline and an inertial motion unit. Position, attitude, and heading data were broadcast to QPS QINSy acquisition software over Ethernet/UDP at 50Hz for the vessels. R/V Spectrum was mobilized with a different Applanix POS MV Wavemaster Deck Unit on 3/20/23 due to a networking issue.

<table>
<tr><td>Manufacturer</td><td colspan="5">Applanix</td></tr>
<tr><td>Model</td><td colspan="5">POS MV Wavemaster</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">R/V Pulse</td><td>Component</td><td>Deck Unit</td><td colspan="2">IMU</td></tr>
<tr><td>Model Number</td><td>MV - 220</td><td colspan="2">IMU 37</td></tr>
<tr><td>Serial Number</td><td>6113</td><td colspan="2">2947</td></tr>
<tr><td>Calibration</td><td>2023-02-05</td><td colspan="2">2023-02-05</td></tr>
<tr><td rowspan="4">R/V Spectrum</td><td>Component</td><td>Deck Unit</td><td>IMU</td><td>Deck Unit</td></tr>
<tr><td>Model Number</td><td>MV - 220</td><td>IMU 37</td><td>MV - 220</td></tr>
<tr><td>Serial Number</td><td>5316</td><td>2213</td><td>6368</td></tr>
<tr><td>Calibration</td><td>2023-02-04</td><td>2023-02-04</td><td>2023-03-20</td></tr>
</table>

Figure 13: POS MV Wavemaster

Figure 14: Wavemaster IMU

A.5.1.3 R2Sonic Integrated Inertial Navigation System (I2NS)

R/V Endeavor was mobilized with a R2Sonic Integrated Inertial Navigation System (I2NS). The I2NS is a combined Applanix Wavemaster, also known as a POSMV 220, and a R2Sonic topside unit. The POSMV portion of the I2NS was used to acquire position, attitude, and heading through the entire survey. The POS MV Wavemaster integrates a dual GPS antenna baseline and an inertial motion unit. Position, attitude, and heading data were broadcast to QPS QINSy acquisition software over Ethernet/UDP at 50Hz for the vessel.

<table>
<tr><td>Manufacturer</td><td colspan="2">R2Sonic</td></tr>
<tr><td>Model</td><td colspan="2">Integrated Inertial Navigation System (I2NS)</td></tr>
<tr><td>Inventory</td><td>R/V Endeavor</td><td>
<table>
<tr><td>Component</td><td>Deck Unit</td><td>IMU</td></tr>
<tr><td>Model Number</td><td>I2NS Sonar Interface Module (SIM)</td><td>I2NS IMU</td></tr>
<tr><td>Serial Number</td><td>104685</td><td>501107</td></tr>
<tr><td>Calibration</td><td>2023-02-01</td><td>2023-02-01</td></tr>
</table>
</td></tr>
</table>

Figure 15: I2NS SIM

Figure 16: I2NS IMU (pole mounted)

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

A.5.5.1 Fugro Marinestar Global Correction System

R/V Endeavor, R/V Voxel, R/V Taku, R/V 505, R/V Pulse, and R/V Spectrum received GNSS satellite corrections over the POSMV G2+ or POSMV G4+ carrier signal from the Marinestar Global Correction System maintained by Fugro.

The Marinestar system is a global realitime GNSS broadcast system that delivers corrections from a network of base stations around the world via geo-stationary satellites.

Manufacturer	Fugro		
Model	Marinestar Global Correction System		
Inventory	*R/V Endeavor*	*Component*	Marinestar Glbal Correction System
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V Voxel	*Component*	Marinestar Glbal Correction System
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V Taku	*Component*	Marinestar Glbal Correction System Marinestar Glbal Correction System
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V 505	*Component*	Marinestar Glbal Correction System
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V Pulse	*Component*	Marinestar Glbal Correction System
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V Spectrum	*Component*	Marinestar Glbal Correction System
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

No moving vessel profilers were utilized for data acquisition.

A.6.2 CTD Profilers

No CTD profilers were utilized for data acquisition.

A.6.3 Sound Speed Sensors

A.6.3.1 AML Micro•X

The R2Sonic 2024 and 2022 utilized an AML Micro•X located at the sonar head for surface sound speed measurement. The AML Micro•X is a time of flight SV sensor and is powered through the R2Sonic topside or powered directly from a 12 volt power source via RS232 serial cable connection. Sound speed measurements (measured in meters per second) are output through the same serial connection at 1Hz.

R/V 505, and R/V Spectrum were equipped with an AML Micro•X.

The Sound Velocity Sensors (SV•Xchange) were replaced on 3/18/2023 to meet HSSD specification of sensor calibration within 1 year of survey.

<table>
<tr><td>Manufacturer</td><td colspan="5">AML</td></tr>
<tr><td>Model</td><td colspan="5">Micro•X</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">R/V 505</td><td>Component</td><td>Surface Sound Speed</td><td>Sound Velocity Sensor</td><td>Sound Velocity Sensor</td></tr>
<tr><td>Model Number</td><td>Micro•X</td><td>SV•Xchange</td><td>SV•Xchange</td></tr>
<tr><td>Serial Number</td><td>12749</td><td>209734</td><td>203087</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2022-03-19</td><td>2023-03-15</td></tr>
<tr><td rowspan="4">R/V Spectrum</td><td>Component</td><td>Surface Sound Speed</td><td>Sound Velocity Sensor</td><td>Sound Velocity Sensor</td></tr>
<tr><td>Model Number</td><td>Micro•X</td><td>SV•Xchange</td><td>SV•Xchange</td></tr>
<tr><td>Serial Number</td><td>11963</td><td>205182</td><td>204994</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2022-03-19</td><td>2023-03-15</td></tr>
</table>

Figure 17: AML Micro•X installed on a R2Sonic 2024

A.6.3.2 AML 1 RT

The R2Sonic 2024 and 2022 utilized an AML 1 RT located at the sonar head for surface sound speed measurement. The AML 1 RT is a time of flight SV sensor and is powered through the R2Sonic topside or powered directly from a 12 volt power source via RS232 serial cable connection. Sound speed measurements (measured in meters per second) are output through the same serial connection at 1Hz.

R/V Endeavor, R/V Voxel, R/V Taku and R/V Pulse were equipped with an AML 1 RT.

Manufacturer	AML			
Model	1 RT			
Inventory	*R/V Endeavor*	*Component*	Surface Sound Speed	Sound Velocity Sensor
		Model Number	1 RT	SVx2
		Serial Number	A10243	210731
		Calibration	N/A	2022-05-19
	R/V Voxel	*Component*	Surface Sound Speed	Sound Velocity Sensor
		Model Number	1 RT	SVx2
		Serial Number	A10293	210610
		Calibration	N/A	2022-04-28
	R/V Taku	*Component*	Surface Sound Speed	Sound Velocity Sensor
		Model Number	1 RT	SVx2
		Serial Number	A10831	210879
		Calibration	N/A	2022-08-03
	R/V Pulse	*Component*	Surface Sound Speed	Sound Velocity Sensor
		Model Number	1 RT	SVx2
		Serial Number	A10288	210815
		Calibration	N/A	2022-08-04

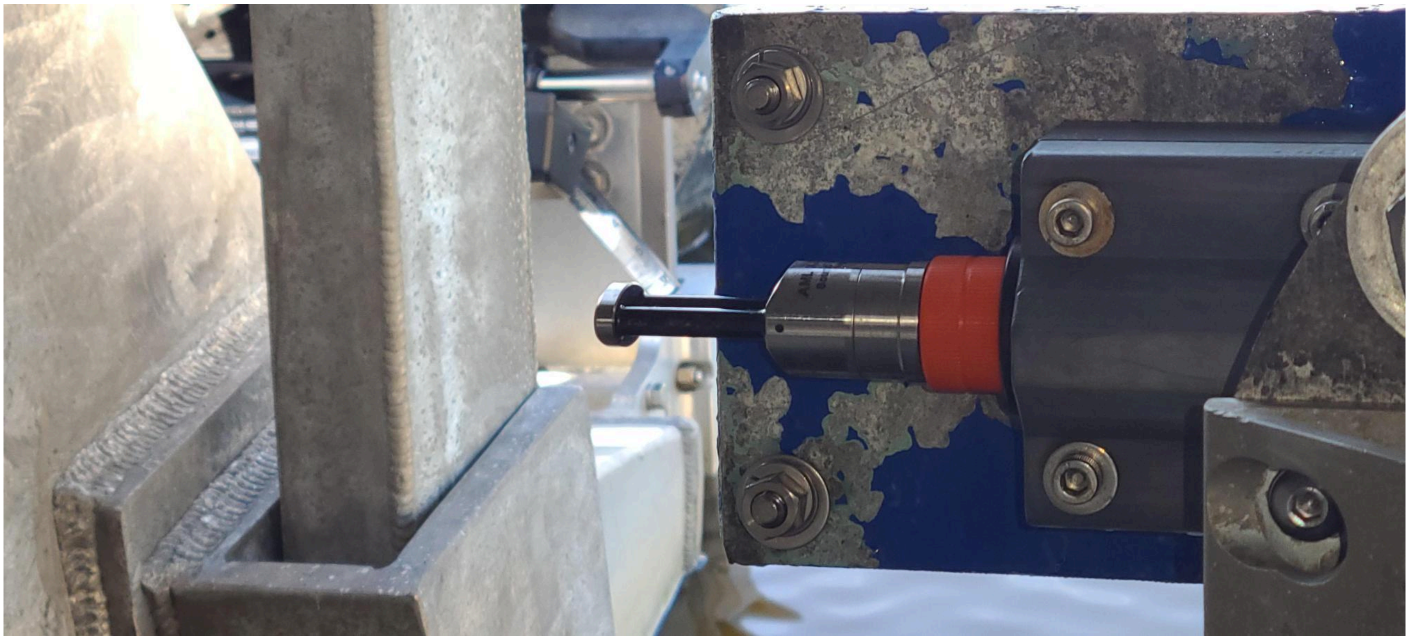

Figure 18: AML 1-RT installed on a R2Sonic 2024

A.6.3.3 AML Base•X2

The AML Base•X2 sound speed profiler is a high accuracy time of flight sound speed sensor capable of measuring sound speed in depths up to 400 meters. The Base•X2 is capable of transferring data via RS-232 serial cable. AML Sailfish software is run on the acquisition computer to facilitate the data transfer and profile formatting.

R/V Taku, R/V 505, and R/V Spectrum were equipped with an AML Base•X2.

The Sound Velocity Sensors (SV•Xchange) and Pressure Sensors (P•Xchange) on R/V 505 and R/V Spectrum were replaced on 3/18/2023 to meet HSSD specification of sensor calibration within 1 year of survey.

Manufacturer	AML
Model	Base•X2
Inventory	

R/V Taku

Component	Sound Speed Profiler	Sound Velocity Sensor	Pressure Sensor
Model Number	Base•X2	SV•Xchange	P•Xchange
Serial Number	25902	209289	305099
Calibration	N/A	2022-10-25	2022-10-26

R/V 505

Component	Sound Speed Profiler	Sound Velocity Sensor	Pressure Sensor	Sound Velocity Sensor	Pressure Sensor
Model Number	Base•X2	SV•Xchange	P•Xchange	SV•Xchange	P•Xchange
Serial Number	26216	208950	304978	205988	304556
Calibration	N/A	2022-03-19	2022-03-18	2023-03-15	2023-03-15

R/V Spectrum

Component	Sound Speed Profiler	Sound Velocity Sensor	Pressure Sensor	Sound Velocity Sensor	Pressure Sensor
Model Number	Base•X2	SV•Xchange	P•Xchange	SV•Xchange	P•Xchange
Serial Number	25114	206164	306837	207573	304978
Calibration	N/A	2022-04-07	2022-03-18	2023-03-15	2023-03-15

Figure 19: AML Base•X2

A.6.3.4 AML 3 LGR

The AML-3 LGR sound speed profiler is a high accuracy time of flight sound speed sensor capable of measuring sound speed in depths up to 400 meters. The LGR 3 is capable of transferring data via RS-232 serial cable. AML Sailfish software is run on the acquisition computer to facilitate the data transfer and profile formatting.

R/V Endeavor, R/V Voxel, and R/V Pulse were equipped with an AML3 LGR.

<table>
<tr><td>Manufacturer</td><td colspan="5">AML</td></tr>
<tr><td>Model</td><td colspan="5">3 LGR</td></tr>
<tr><td rowspan="12">Inventory</td><td rowspan="4">R/V Endeavor</td><td>Component</td><td>Sounds Speed Profiler</td><td>Sound Velocity Sensor</td><td>Pressure Sensor</td></tr>
<tr><td>Model Number</td><td>3 LGR</td><td>SVx2</td><td>Px2</td></tr>
<tr><td>Serial Number</td><td>A30024</td><td>210692</td><td>308069</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2022-05-05</td><td>2022-07-06</td></tr>
<tr><td rowspan="4">R/V Voxel</td><td>Component</td><td>Sound Speed Profiler</td><td>Sound Velocity Sensor</td><td>Pressure Sensor</td></tr>
<tr><td>Model Number</td><td>3 LGR</td><td>SVx2</td><td>Px2</td></tr>
<tr><td>Serial Number</td><td>30565</td><td>210603</td><td>308039</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2022-04-26</td><td>2022-07-06</td></tr>
<tr><td rowspan="4">R/V Pulse</td><td>Component</td><td>Sound Speed Profiler</td><td>Sound Velocity Sensor</td><td>Pressure Sensor</td></tr>
<tr><td>Model Number</td><td>3 LGR</td><td>SVx2</td><td>Px2</td></tr>
<tr><td>Serial Number</td><td>30451</td><td>210820</td><td>308164</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2022-08-04</td><td>2022-07-20</td></tr>
</table>

Figure 20: AML-3 LGR

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*
QPS	QINSy	9.5.3	Acquisition
R2Sonic, LLC	Sonic Control	2000	Acquisition
R2Sonic, LLC	R2Sonic Fimrware (SIM)	4/3/2017	Acquisition
R2Sonic, LLC	R2Sonic Fimrware (Head)	3/28/2019	Acquisition
AML Oceanographic	Sailfish	1.4.4	Acquisition
AML Oceanographic	SeaCast	4.3.1	Acquisition
EdgeTech	Discover	42.0.1.109	Acquisition
Applanix	MV-POSView	10.2	Acquisition
Applanix	POSMV 320 Firmware	10.30	Acquisition
Applanix	POSMV 320 Firmware	9.83	Acquisition
Applanix	POSMV 320 Firmware	8.63	Acquisition
Applanix	POSMV 220 Firmware	8.15	Acquisition
Applanix	POSMV 220 Firmware	10.21	Acquisition
Microsoft	Office 365		Acquisition and Processing
QPS	Qimera	2.5.0	Processing
QPS	FMGT	7.10.2	Processing
Chesapeake	SonarWiz	7.10.2	Processing
ESRI	ArcGIS Pro	3.1	Processing
Applanix	POSPac MMS	8.8	Processing
eTrac	AmiTrac - DensityTrac	10.0.0.21	Processing
eTrac	DiffTrac	10.0.0.9	Processing
eTrac	JunctionTrac	10.0.0.9	Processing
Blue Marble Geographics	Glabal Mapper	24.0	Processing
NOAA	Pydro Explorer	22.1	Processing
CARIS	HIPS and SIPS	10.2.2	Processing
ESRI	ArcGIS Pro	3.1	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Wildco Shipek Grab

The Shipek Grab is a spring loaded self-closing stainless steel grab sampler designed for sampling unconsolidated sediments from soft ooze to hard pack sand. The Shipek Grab Sampler, can be lowered by a davit or A-Frame. The Shipek Grab Sampler was mobilized on R/V Endeavor for bottom sample collection in deeper areas on OPR-E351-KR-22.

Figure 21: Shipek Grab

A.8.1.2 Wildco Ponar Grab

The Ponar Grab is a spring loaded center pivot stainless steel grab sampler designed for sampling unconsolidated sediments from soft ooze to hard pack sand. When the Ponar Grab makes contact with the bottom, the tapered cutting edges of the scoops penetrate with little sample disturbance. Removable screens on the top of each scoop allow for water to flow through as the grab is retrieved. The Ponar Grab Sampler, can be lowered by hand, or by a davit or A-Frame. The Ponar Grab Sampler was mobilized on R/V Spectrum for bottom sample collection is shallower areas on OPR-E351-KR-22.

Figure 22: Ponar Grab

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

Prior to MBES survey operations, offsets on all vessels were determined from previous offset measurements performed at varying times and were verified using a metal hand tape.

For R/V Endeavor, a reference point was established at a center-point on the aft deck. Offsets from the reference point to the I2NS POSMV were measured multiple times and verified using a metal hand tape.. These offsets were entered into POSMV - POSView for use during data acquisition. Offsets from the reference point to the acoustic center of the R2Sonic 2024 sonar were determined, measured, and confirmed using a metal hand tape. These offsets were entered into Qinsy for use during data acquisition

For R/V Voxel, R/V Taku, and R/V 505, offsets from the Applanix Oceanmaster POSMV 320 reference point to the acoustic center of the R2Sonic 2024 or R2Sonic 2022 sonar were measured multiple times and verified using a metal hand tape. These offsets were entered into Qinsy for use during data acquisition.

For R/V Pulse and R/V Spectrum, a reference point was established at a center-point on the aft deck. Offsets from the reference point to the Applanix Wavemaster POSMV 220 were measured multiple times and verified using a metal hand tape. These offsets were entered into POSMV - POSView for use during data acquisition. Offsets from the reference point to the acoustic center of the R2Sonic 2024 or R2Sonic 2022 sonar were measured multiple times and verified using a metal hand tape. These offsets were entered into Qinsy for use during data acquisition.

A QPS Vessel Template Database file (DB) was created for each vessel. The vessel files contain sensor offsets and biases, static and dynamic draft corrections, and uncertainty values to aid in Total Propagated Uncertainty (TPU) calculations.

On R/V Voxel, R/V Taku, and R/V 505 the POSMV 320 was configured to output position and motion data at the IMU. On R/V Endeavor the I2NS POSMV was configured to output position and motion data at the reference point. On R/V Pulse and R/V Spectrum POSMV 220 was configured to output position and motion data at the reference point.

B.1.1.1 Vessel Offset Correctors

Vessel	R/V Endeavor			
Echosounder	R2Sonic 2024			
Date	2/3/2023		Measurement	Uncertainty
Offsets	Reference to MRU	X (BOW +)	1.84 m	0.02 m
		Y (STBD +)	2.256 m	0.02 m
		Z (DOWN +)	1.1356 m	0.02 m
	Reference to Transducer	X (BOW +)	1.565 m	0.02 m
		Y (STBD +)	2.256 m	0.02 m
		Z (DOWN +)	1.658 m	0.02 m
	Referecne to Nav	X (BOW +)	2.911 m	0.02 m
		Y (STBD +)	-1.076 m	0.02 m
		Z (DOWN +)	-2.966 m	0.02 m

Vessel	R/V 505			
Echosounder	R2Sonic 2022 / R2Sonic 2024			
Date	3/13/2023		Measurement	Uncertainty
Offsets	Reference to MRU	X (BOW +)	1.84 m	0.02 m
		Y (STBD +)	2.256 m	0.02 m
		Z (DOWN +)	1.1356 m	0.02 m
	Reference to Transducer	X (BOW +)	1.565 m	0.02 m
		Y (STBD +)	2.256 m	0.02 m
		Z (DOWN +)	1.658 m	0.02 m
	Referecne to Nav	X (BOW +)	2.911 m	0.02 m
		Y (STBD +)	-1.076 m	0.02 m
		Z (DOWN +)	-2.966 m	0.02 m

Vessel	R/V Voxel			
Echosounder	R2Sonic 2024			
Date	2/15/2023		Measurement	Uncertainty
Offsets	Reference to MRU	X (BOW +)	0.004 m	0.02 m
		Y (STBD +)	0.001 m	0.02 m
		Z (DOWN +)	0.066 m	0.02 m
	Reference to Transducer	X (BOW +)	-0.056 m	0.02 m
		Y (STBD +)	0 m	0.02 m
		Z (DOWN +)	-0.404 m	0.02 m
	Referecne to Nav	X (BOW +)	4.026 m	0.02 m
		Y (STBD +)	-1.503 m	0.02 m
		Z (DOWN +)	-3.228 m	0.02 m

Vessel	R/V Pulse			
Echosounder	R2Sonic 2022			
Date	2/5/2023		Measurement	Uncertainty
Offsets	Reference to MRU	X (BOW +)	0.680 m	0.02 m
		Y (STBD +)	-0.502 m	0.02 m
		Z (DOWN +)	0.022 m	0.02 m
	Reference to Transducer	X (BOW +)	-0.588m	0.02 m
		Y (STBD +)	1.718 m	0.02 m
		Z (DOWN +)	1.234 m	0.02 m
	Referecne to Nav	X (BOW +)	0.076 m	0.02 m
		Y (STBD +)	0 m	0.02 m
		Z (DOWN +)	-2.420 m	0.02 m

Vessel	R/V Taku			
Echosounder	R2Sonic 2024			
Date	2/14/2023		Measurement	Uncertainty
Offsets	Reference to MRU	X (BOW +)	0.005 m	0.02 m
		Y (STBD +)	-0.006 m	0.02 m
		Z (DOWN +)	0.089 m	0.02 m
	Reference to Transducer	X (BOW +)	-4.249 m	0.02 m
		Y (STBD +)	-0.098 m	0.02 m
		Z (DOWN +)	1.214 m	0.02 m
	Referecne to Nav	X (BOW +)	-0.005 m	0.02 m
		Y (STBD +)	-1.103 m	0.02 m
		Z (DOWN +)	-2.959 m	0.02 m

Vessel	R/V Spectrum			
Echosounder	R2Sonic 2024			
Date	2/3/2023		Measurement	Uncertainty
Offsets	Reference to MRU	X (BOW +)	1.012 m	0.02 m
		Y (STBD +)	0.628 m	0.02 m
		Z (DOWN +)	-0.102 m	0.02 m
	Reference to Transducer	X (BOW +)	0.182m	0.02 m
		Y (STBD +)	1.756 m	0.02 m
		Z (DOWN +)	0.812 m	0.02 m
	Referecne to Nav	X (BOW +)	0.884 m	0.02 m
		Y (STBD +)	-0.933m	0.02 m
		Z (DOWN +)	-2.213 m	0.02 m

Figure 23: Vessel Offset Correctors

B.1.1.1 Vessel Offset Correctors

Vessel offset correctors were not applied.

B.1.2 Layback

Prior to sidescan sonar (SSS) survey operations, the offset from the vessel reference point to the towpoint sheave on each vessel was measured multiple times and verified using a metal hand tape. These offsets as well as a catenary coefficient were entered into the Qinsy layback driver utility in order to calculate an accurate towfish layback.

Additionally, a series of calibration/confidence lines were performed in order to verify layback calculations. Reciprocal SSS lines were run adjacent to a seafloor object. The object was targeted in each separate line and the distance between the 2 targets was measured. The targets showed adequate positional agreement, within 1-3m.

B.1.2.1 Layback Correctors

<table>
<tr><td>Vessel</td><td>R/V Endeavor</td></tr>
<tr><td>Echosounder</td><td>EdgeTech 4200 Dual simulataneous frequencies 300/900</td></tr>
<tr><td>Frequency</td><td>300.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-03</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-5.069 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>2.438 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
<tr><td>Frequency</td><td>900.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-03</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-5.069 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>2.438 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
</table>

<table>
<tr><td>Vessel</td><td>R/V Voxel</td></tr>
<tr><td>Echosounder</td><td>EdgeTech 4125 Dual simulataneous frequencies 400/900</td></tr>
<tr><td>Frequency</td><td>400.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-15</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-2.440 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>3.450 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
<tr><td>Frequency</td><td>900.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-15</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-2.440 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>3.450 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
</table>

<table>
<tr><td>Vessel</td><td>R/V Taku</td></tr>
<tr><td>Echosounder</td><td>EdgeTech 4125 Dual simulataneous frequencies 400/900</td></tr>
<tr><td>Frequency</td><td>400.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-14</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-4.816 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>2.172 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
<tr><td>Frequency</td><td>900.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-14</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-4.816 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>2.172 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
</table>

<table>
<tr><td>Vessel</td><td>R/V 505</td></tr>
<tr><td>Echosounder</td><td>EdgeTech 4125 Dual simulataneous frequencies 400/900</td></tr>
<tr><td>Frequency</td><td>400.0 kHz</td></tr>
<tr><td>Date</td><td>2023-03-13</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-3.967 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>1.957 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
<tr><td>Frequency</td><td>900.0 kHz</td></tr>
<tr><td>Date</td><td>2023-03-13</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-3.967 meters</td></tr><tr><td>y</td><td>0.000 meters</td></tr><tr><td>z</td><td>1.957 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
</table>

<table>
<tr><td>Vessel</td><td>R/V Pulse</td></tr>
<tr><td>Echosounder</td><td>EdgeTech 4125 Dual simulataneous frequencies 400/900</td></tr>
<tr><td>Frequency</td><td>400.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-05</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-2.000 meters</td></tr><tr><td>y</td><td>-0.700 meters</td></tr><tr><td>z</td><td>1.372 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
<tr><td>Frequency</td><td>900.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-05</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-2.000 meters</td></tr><tr><td>y</td><td>-0.700 meters</td></tr><tr><td>z</td><td>1.372 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
</table>

<table>
<tr><td>Vessel</td><td>R/V Spectrum</td></tr>
<tr><td>Echosounder</td><td>EdgeTech 4125 Dual simulataneous frequencies 400/900</td></tr>
<tr><td>Frequency</td><td>400.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-03</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-1.899 meters</td></tr><tr><td>y</td><td>-0.664 meters</td></tr><tr><td>z</td><td>1.676 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
<tr><td>Frequency</td><td>900.0 kHz</td></tr>
<tr><td>Date</td><td>2023-02-03</td></tr>
<tr><td>Layback</td><td><table><tr><td>Towpoint</td><td><table><tr><td>x</td><td>-1.899 meters</td></tr><tr><td>y</td><td>-0.664 meters</td></tr><tr><td>z</td><td>1.676 meters</td></tr></table></td></tr><tr><td>Layback Error</td><td>3.000 meters</td></tr></table></td></tr>
</table>

B.2 Static and Dynamic Draft

B.2.1 Static Draft

This project utilized an ERS workflow therefor static draft was not utilized in final sounding computations.

B.2.1.1 Static Draft Correctors

Static draft correctors were not applied.

B.2.2 Dynamic Draft

This project utilized an ERS workflow, therefore dynamic draft was not utilized in final sounding computations.

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 performed on each vessel prior to commencing data collection. A multibeam patch test is performed in order to measure the mounting/alignment biases between the MBES sensor and the the inertial motion unit (IMU). In addition to mounting/alignment biases, a patch test is also performed to determine latency between MBES and position sensor data.

Latency patch tests were performed by running reciprocal survey lines at varying speeds over a prominent geological feature or object.
Roll patch tests were performed by running reciprocal survey lines at equal speeds over a flat bottom.
Patch patch tests were performed by running reciprocal survey lines at equal speed over a prominent geological feature or object.
Yaw patch tests were performed by running parallel survey lines at equal speeds over a prominent geological feature of object.

For all vessels, each pair of specific patch survey lines were analyzed in Qimera Patch Test Tool.

Patch test data were analyzed independently by multiple hydrographers for crosscheck and also to determine accurate uncertainty values for mounting/alignment biases.

B.3.1.1 System Alignment Correctors

<table>
<tr><td>Vessel</td><td colspan="3">R/V Endeavor</td></tr>
<tr><td>Echosounder</td><td colspan="3">R2Soninc 2024</td></tr>
<tr><td>Date</td><td colspan="3">2023-02-03</td></tr>
<tr><td rowspan="10">Patch Test Values</td><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>0.369 degrees</td><td>0.049 degrees</td></tr>
<tr><td>Roll</td><td>-0.384 degrees</td><td>0.015 degrees</td></tr>
<tr><td>Yaw</td><td>1.915 degrees</td><td>0.128 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Date</td><td colspan="3">2023-03-29</td></tr>
<tr><td rowspan="10">Patch Test Values</td><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>0.606 degrees</td><td>0.091 degrees</td></tr>
<tr><td>Roll</td><td>-0.405 degrees</td><td>0.030 degrees</td></tr>
<tr><td>Yaw</td><td>2.011 degrees</td><td>0.125 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
</table>

Vessel	R/V Voxel
Echosounder	R2Sonic 2024
Date	2023-02-15

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	1.105 degrees	0.154 degrees
Roll	-0.434 degrees	0.019 degrees
Yaw	-2.569 degrees	0.195 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-03-17

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	0.963 degrees	0.217 degrees
Roll	-0.397 degrees	0.019 degrees
Yaw	-2.705 degrees	0.130 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Vessel	R/V Taku
Echosounder	R2Sonic 2024
Date	2023-02-14

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	0.604 degrees	0.137 degrees
Roll	-1.454 degrees	0.041 degrees
Yaw	0.238 degrees	0.118 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-02-23	
Patch Test Values	*Corrector*	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	0.269 degrees	0.246 degrees
Roll	-1.438 degrees	0.067 degrees
Yaw	0.201 degrees	0.170 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-03-05	
Patch Test Values	*Corrector*	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	0.667 degrees	0.030 degrees
Roll	-1.350 degrees	0.025 degrees
Yaw	0.504 degrees	0.124 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-03-24	
Patch Test Values	*Corrector*	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	0.384 degrees	0.042 degrees
Roll	-1.464 degrees	0.032 degrees
Yaw	0.400 degrees	0.036 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-03-29
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	0.268 degrees	0.056 degrees
Roll	-1.270 degrees	0.013 degrees
Yaw	0.348 degrees	0.088 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-04-02
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	0.356 degrees	0.077 degrees
Roll	-1.363 degrees	0.021 degrees
Yaw	0.240 degrees	0.097 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Vessel	R/V 505
Echosounder	R2Sonic 2024
Date	2023-03-13
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	1.096 degrees	0.164 degrees
Roll	0.165 degrees	0.037 degrees
Yaw	2.135 degrees	0.093 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

<table>
<tr><td>Vessel</td><td>R/V 505</td></tr>
<tr><td>Echosounder</td><td>R2Sonic 2022</td></tr>
<tr><td>Date</td><td>2023-03-25</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>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>1.201 degrees</td><td>0.081 degrees</td></tr>
<tr><td>Roll</td><td>0.114 degrees</td><td>0.025 degrees</td></tr>
<tr><td>Yaw</td><td>2.776 degrees</td><td>0.082 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
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<tr><td>Date</td><td>2023-04-03</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>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>1.174 degrees</td><td>0.066 degrees</td></tr>
<tr><td>Roll</td><td>0.131 degrees</td><td>0.035 degrees</td></tr>
<tr><td>Yaw</td><td>1.745 degrees</td><td>0.181 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
</table></td></tr>
<tr><td>Date</td><td>2023-04-11</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>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>1.414 degrees</td><td>0.186 degrees</td></tr>
<tr><td>Roll</td><td>0.153 degrees</td><td>0.034 degrees</td></tr>
<tr><td>Yaw</td><td>2.955 degrees</td><td>0.122 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
</table></td></tr>
</table>

Date	2023-04-20		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	1.920 degrees	0.306 degrees
	Roll	0.019 degrees	0.028 degrees
	Yaw	2.800 degrees	0.203 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-04-24		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	5.340 degrees	0.332 degrees
	Roll	-0.041 degrees	0.032 degrees
	Yaw	2.465 degrees	0.091 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-04-24		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	3.275 degrees	0.194 degrees
	Roll	0.055 degrees	0.025 degrees
	Yaw	3.028 degrees	0.420 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-04-29

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	1.990 degrees	0.125 degrees
Roll	0.030 degrees	0.019 degrees
Yaw	2.917 degrees	0.132 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-02

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	4.040 degrees	0.094 degrees
Roll	0.018 degrees	0.006 degrees
Yaw	2.278 degrees	0.314 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-10

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	3.698 degrees	0.193 degrees
Roll	0.080 degrees	0.068 degrees
Yaw	2.985 degrees	0.029 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-11
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	4.112 degrees	0.187 degrees
Roll	0.045 degrees	0.018 degrees
Yaw	2.582 degrees	0.284 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-19
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	2.343 degrees	0.359 degrees
Roll	0.054 degrees	0.041 degrees
Yaw	2.806 degrees	0.099 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-02
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	2.065 degrees	0.355 degrees
Roll	0.081 degrees	0.008 degrees
Yaw	2.856 degrees	0.096 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Vessel	R/V Pulse		
Echosounder	R2Sonic 2022		
Date	2023-02-05		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.448 degrees	0.233 degrees
	Roll	0.886 degrees	0.049 degrees
	Yaw	-0.694 degrees	0.097 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-02-11		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.455 degrees	0.257 degrees
	Roll	0.602 degrees	0.023 degrees
	Yaw	-0.712 degrees	0.122 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-02-23		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.191 degrees	0.197 degrees
	Roll	0.149 degrees	0.027 degrees
	Yaw	-0.652 degrees	0.100 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-03-09		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.972 degrees	0.154 degrees
	Roll	0.416 degrees	0.024 degrees
	Yaw	-0.670 degrees	0.271 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-03-22		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.831 degrees	0.069 degrees
	Roll	0.990 degrees	0.007 degrees
	Yaw	-0.631 degrees	0.051 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-03-30		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.139 degrees	0.204 degrees
	Roll	1.319 degrees	0.034 degrees
	Yaw	-0.544 degrees	0.255 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-04-07
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-1.197 degrees	0.135 degrees
Roll	1.137 degrees	0.024 degrees
Yaw	-0.770 degrees	0.183 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-04-09
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-1.056 degrees	0.157 degrees
Roll	1.210 degrees	0.050 degrees
Yaw	-0.692 degrees	0.251 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-04-10
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-0.901 degrees	0.168 degrees
Roll	1.284 degrees	0.065 degrees
Yaw	-0.990 degrees	0.122 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-04-24

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-0.687 degrees	0.107 degrees
Roll	0.982 degrees	0.024 degrees
Yaw	-0.464 degrees	0.242 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-03

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-1.011 degrees	0.044 degrees
Roll	0.996 degrees	0.018 degrees
Yaw	-0.640 degrees	0.106 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-04

Patch Test Values

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-0.570 degrees	0.135 degrees
Roll	1.354 degrees	0.018 degrees
Yaw	-0.688 degrees	0.160 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Vessel	R/V Pulse		
Echosounder	R2Sonic 2024		
Date	2023-05-10		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.171 degrees	0.018 degrees
	Roll	0.161 degrees	0.017 degrees
	Yaw	-1.286 degrees	0.068 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-05-11		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.715 degrees	0.148 degrees
	Roll	0.089 degrees	0.017 degrees
	Yaw	-0.674 degrees	0.194 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-05-11		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.528 degrees	0.085 degrees
	Roll	0.360 degrees	0.009 degrees
	Yaw	-1.188 degrees	0.195 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-12	
Patch Test Values	*Corrector*	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-1.801 degrees	0.102 degrees
Roll	0.331 degrees	0.053 degrees
Yaw	-1.845 degrees	0.125 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-15	
Patch Test Values	*Corrector*	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-0.897 degrees	0.122 degrees
Roll	0.260 degrees	0.035 degrees
Yaw	-0.987 degrees	0.098 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-15	
Patch Test Values	*Corrector*	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.000 seconds
Navigation Time Correction	0.000 seconds	0.000 seconds
Pitch	-0.762 degrees	0.164 degrees
Roll	0.290 degrees	0.025 degrees
Yaw	-1.420 degrees	0.172 degrees
Pitch Time Correction	0.000 seconds	0.000 seconds
Roll Time Correction	0.000 seconds	0.000 seconds
Yaw Time Correction	0.000 seconds	0.000 seconds
Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-16		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.292 degrees	0.128 degrees
	Roll	0.255 degrees	0.029 degrees
	Yaw	-1.238 degrees	0.079 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-05-19		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.067 degrees	0.085 degrees
	Roll	0.230 degrees	0.077 degrees
	Yaw	-1.076 degrees	0.269 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-05-28		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.289 degrees	0.155 degrees
	Roll	1.399 degrees	0.031 degrees
	Yaw	-1.120 degrees	0.269 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

<table>
<tr><td>Date</td><td>2023-05-30</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>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>-1.259 degrees</td><td>0.198 degrees</td></tr>
<tr><td>Roll</td><td>0.572 degrees</td><td>0.015 degrees</td></tr>
<tr><td>Yaw</td><td>-2.008 degrees</td><td>0.299 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
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</td></tr>
</table>

<table>
<tr><td>Vessel</td><td>R/V Spectrum</td></tr>
<tr><td>Echosounder</td><td>R2Sonic 2024</td></tr>
<tr><td>Date</td><td>2023-02-03</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>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>-2.087 degrees</td><td>0.123 degrees</td></tr>
<tr><td>Roll</td><td>-0.451 degrees</td><td>0.011 degrees</td></tr>
<tr><td>Yaw</td><td>-0.580 degrees</td><td>0.058 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
</table>
</td></tr>
<tr><td>Date</td><td>2023-02-09</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>0.000 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Pitch</td><td>-1.524 degrees</td><td>0.158 degrees</td></tr>
<tr><td>Roll</td><td>-0.223 degrees</td><td>0.036 degrees</td></tr>
<tr><td>Yaw</td><td>-0.484 degrees</td><td>0.225 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.000 seconds</td></tr>
</table>
</td></tr>
</table>

Date	2023-03-30		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.034 degrees	0.156 degrees
	Roll	-0.559 degrees	0.081 degrees
	Yaw	-0.117 degrees	0.170 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-04-02		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.629 degrees	0.046 degrees
	Roll	-0.632 degrees	0.011 degrees
	Yaw	-0.046 degrees	0.099 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-04-18		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.691 degrees	0.074 degrees
	Roll	-0.553 degrees	0.041 degrees
	Yaw	-0.533 degrees	0.120 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-04-22		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.625 degrees	0.067 degrees
	Roll	-0.582 degrees	0.119 degrees
	Yaw	-0.291 degrees	0.080 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-04-29		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.523 degrees	0.067 degrees
	Roll	-0.652 degrees	0.013 degrees
	Yaw	-0.463 degrees	0.245 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds
Date	2023-05-08		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-0.776 degrees	0.258 degrees
	Roll	-0.530 degrees	0.013 degrees
	Yaw	-0.206 degrees	0.161 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

Date	2023-05-29		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.000 seconds
	Navigation Time Correction	0.000 seconds	0.000 seconds
	Pitch	-1.769 degrees	0.212 degrees
	Roll	-0.587 degrees	0.024 degrees
	Yaw	0.212 degrees	0.074 degrees
	Pitch Time Correction	0.000 seconds	0.000 seconds
	Roll Time Correction	0.000 seconds	0.000 seconds
	Yaw Time Correction	0.000 seconds	0.000 seconds
	Heave Time Correction	0.000 seconds	0.000 seconds

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Data acquisition and processing throughout the entire project was overseen by the Chief of Party. Field acquisition was performed under the direct, on site, supervision of a Lead Hydrographer and a Senior Hydrographer, both with over 5 years of experience conducting hydrographic survey operations.

Line spacing for Complete Coverage Option B survey operations was based upon charted depths as well as coverage requirements set forth in the Project Instructions and the HSSD 2022.

For the R2Sonic, incremental adjustments to the range, gain, and pulse width were made during the survey and were dependent on water depth and seabed composition (bottom type). The main adjustment made by the hydrographer was the adjustment of swath width based on environmental conditions and sea state.

Every effort was made to tune the sonars to provide the highest quality of both bathymetric and backscatter data, with bathymetry being the primary focus. The R2Sonic 2024 and 2022 MBES systems were monitored realtime during all MBES acquisition efforts. Raw MBES information, including intensity, surface sound velocity, time synchronization, and ping rate, were displayed and monitored in the R2Sonic Sonic Controller Interface during acquisition.

Prior to survey operations, offsets on all vessels were determined from the vessel verification surveys using a metal hand tape. For R/V Taku, R/V Voxel, and R/V 505, offsets from the IMU reference points to the acoustic center of the sonar were determined, measured, and confirmed using a metal hand tape. These offsets were entered into QINSy for use during data acquisition. For R/V Endeavor, R/V Pulse, and R/V Spectrum offsets from the IMU to the established vessel reference point were determined, measured, and confirmed using a metal hand tape. These offsets were entered in POSMV - PosView. Offsets from the reference point to the acoustic center of the sonar were determined, measured, and confirmed using a metal hand tape. These offsets were entered into QINSy for use during data acquisition.

The R2Sonic's roll stabilization and precise timing were achieved through a combination of outputs from the I2NS POSMV or Applanix POSMV. The 1PPS pulse from the I2NS POSMV or Applanix POSMV is sent via BNC cable to the PPS input of the R2Sonic SIM. Additionally, a NMEA ZDA message at 1Hz is transferred from a I2NS POSMV or Applanix POSMV serial port to the R2Sonic SIM via standard DB9 serial cable. For roll stabilization, the TSS1 binary motion string is transferred from the I2NS POSMV or Applanix POSMV to the R2Sonic SIM via DB9 Serial connection at 200Hz.

All vessels acquired sound velocity casts independently using their assigned sound velocity probe.

In addition to performing the confidence checks on each vessel, a vessel-to-vessel comparison was performed as an added quality assurance measure.

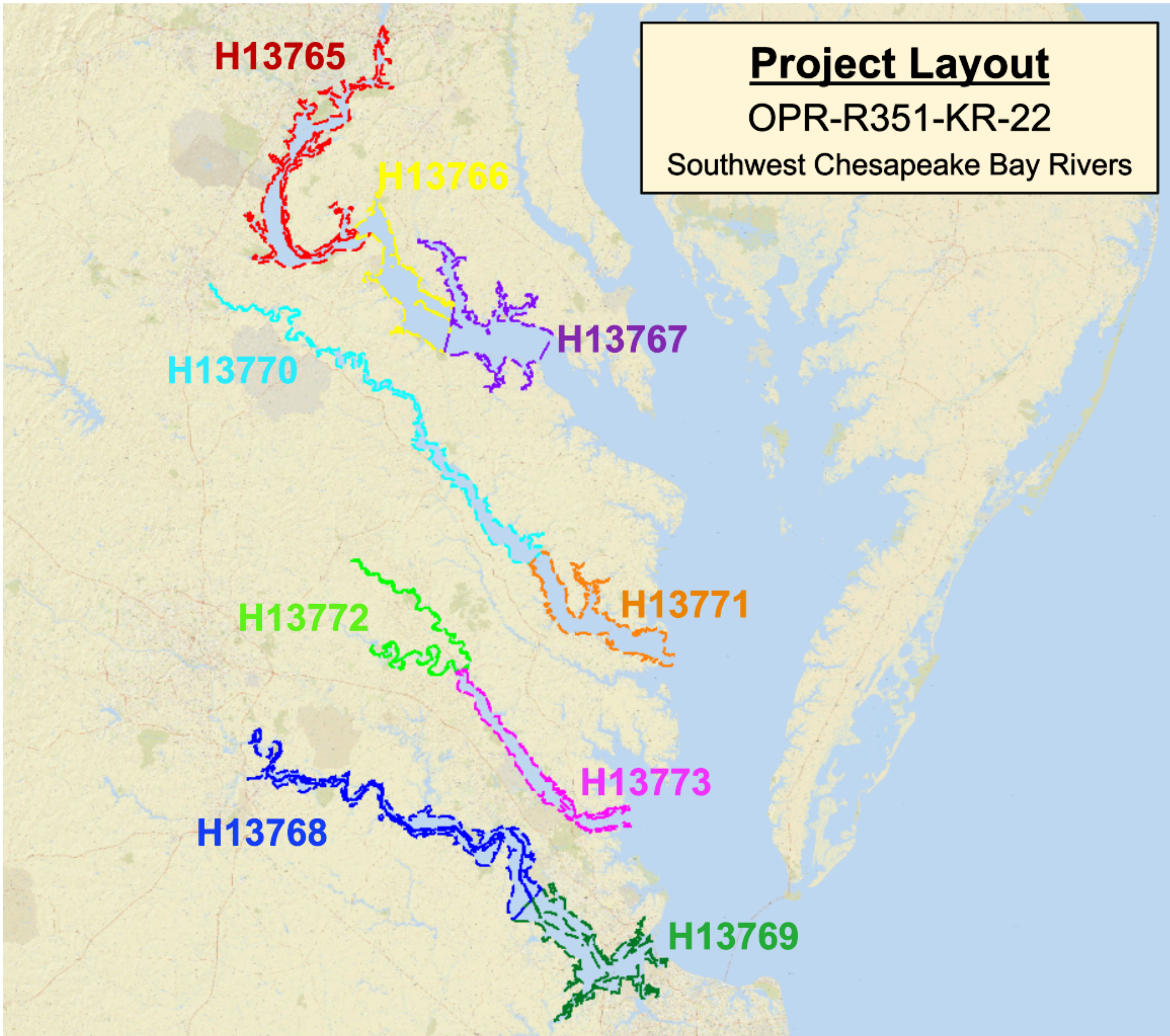

Figure 24: OPR-E351-KR-22 Project Layout

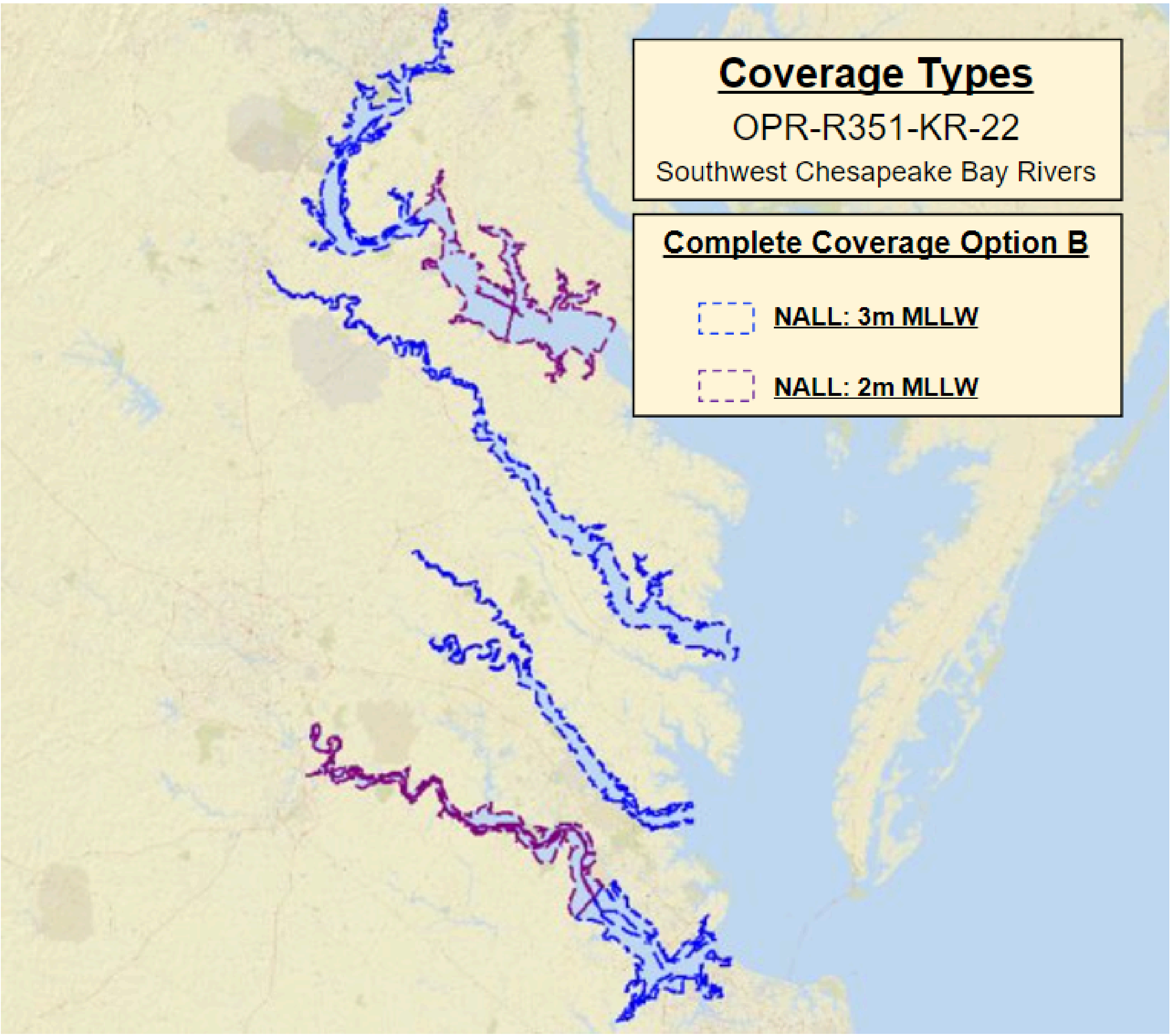

Figure 25: OPR-E351-KR-22 Coverage Types

Data Processing Methods and Procedures

Qimera was exclusively utilized for MBES processing throughout the entire project. Processing steps and procedures are detailed below in the image below.

The first part (PART 1 in the image below) of the processing pipeline consists of a series of standard Qimera processing procedures, which are completed using the Qimera process tool bar and auto processing prompts. In order to ensure each process has been completed, processes are reviewed in the output window.

The second part (PART 2 in the image below) of the Qimera processing pipeline consists of detailed review and cleaning of data, as well as project specific tasks such as investigating features or preparing DTON reports for submittal.

The third part (PART 3 in the image below) of the Qimera processing pipeline is performed once data collection has been completed for an entire H-Cell sheet. CUBE surfaces are "finalized" by choosing the option to override the CUBE hypothesis with any designated soundings. This finalized surface then represents the least depth of features and soundings worthy of a designated sounding.

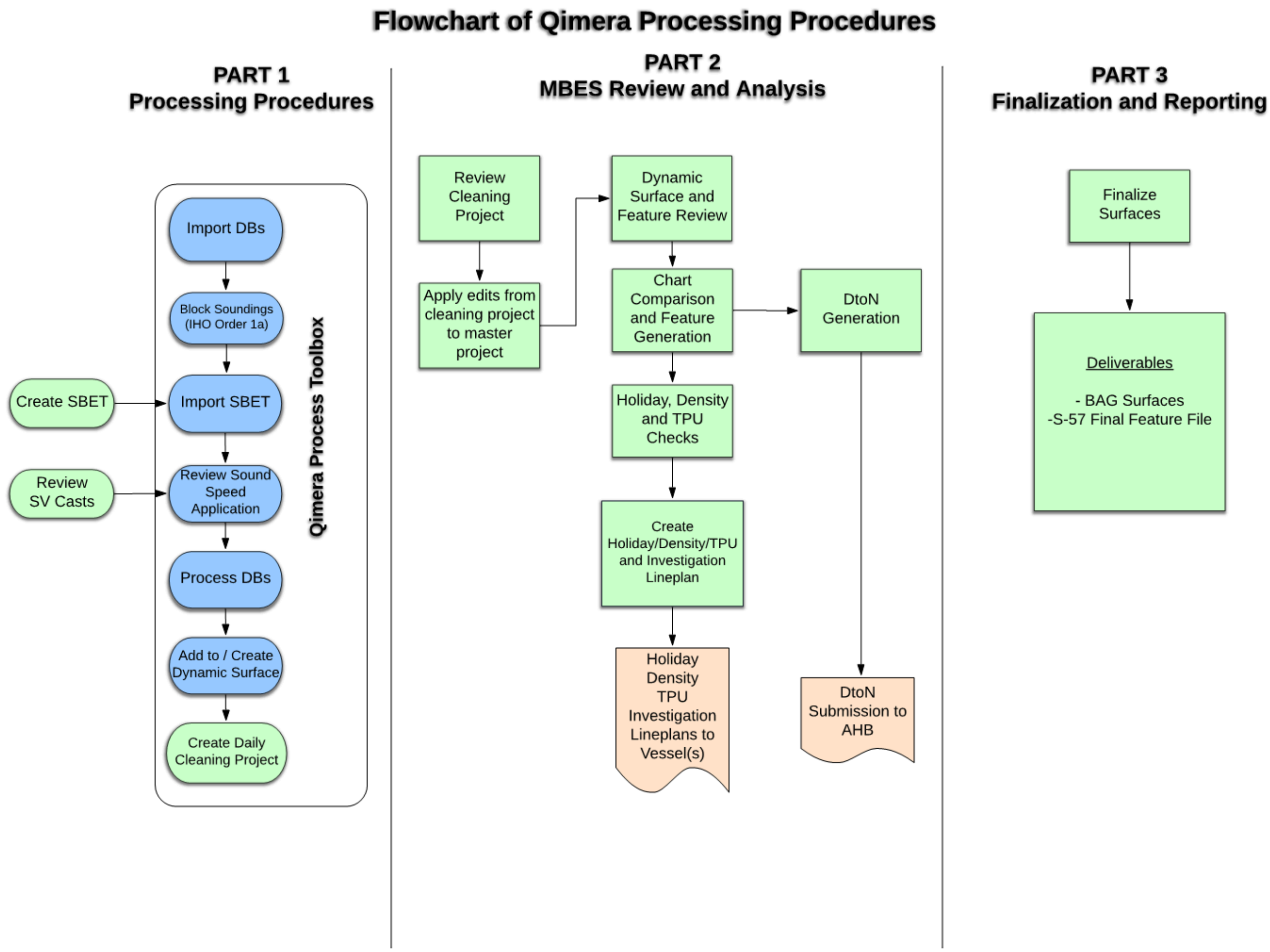

Figure 26: Qimera Processing Procedures

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

All CUBE surfaces were created in Qimera. Sheet wide parent surfaces were created in each resolution that were relevant to surveyed depth.

An additional assigned task for this project was to include interpolated grids in Mean Lower Low Water (MLLW) and North American Vertical Datum of 1988 (NAVD88) datum. To accomplish this task, MLLW XYZ data was exported from Qimera and loaded into Hypack. Using Hypack TIN, data was interpolated with a TIN Max Leg large enough to interpolate all desired gaps. The MLLW interpolated grid was then exported from Hypack and brought into AutoCAD Civil 3D and clipped to the outer and inner project boundaries of each H-cell sheet. In order to reference soundings to NAVD88 Datum, a separation model was provided by NOAA and was applied to the gridded MLLW data in QGIS.

C.1.4.2 Depth Derivation

Once data cleaning and a detailed review has been completed, finalized surfaces are created by using the "limit vertical bounds" option in the "Create Dynamic Surface" tool in Qimera. This option creates a final surface with a depth threshold. The resolution and depth ranges for each finalized surface follows the specifications in the HSSD 2022. The finalized CUBE surfaces are exported as BAG files for deliverables.

C.1.4.3 Surface Computation Algorithm

The NOAA parameters per surface resolution were imported into Qimera. These parameters were used for all surface generations throughout the duration of processing efforts.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

Snippets were collected simultaneously with MBES data collection to meet Complete Coverage Option B requirements as specified in the HSSD 2022.
Although bathymetry was the primary focus, saturation and beam intensity were monitored and adjustments were made to tune of the sonars to provide the highest quality of backscatter.

Data Processing Methods and Procedures

FMGeocoder Toolbox (FMGT) is a program designed to process, view, and analyze backscatter data. FMGT was utilized in the processing workflow as the exclusive snippets/backscatter processing software. Snippets data from raw Qinsy DB files were exported from Qimera as GSF's and were imported into FMGT and processed into backscatter mosaics daily to confirm backscatter complete coverage. After MBES data was fully processed and cleaned in Qimera, GSF files were re-exported and brought into FMGT. In FMGT the GSF files were processed into backscatter mosaics grouped by acoustic frequency and survey system. The mosaics were then compared and normalized relatively using custom histograms, and then blended and merged together into a single mosaic in ArcGIS Pro.

Processing steps and procedures are detailed below in the image below.

The first part (PART 1) of the processing pipeline consists of a series of standard FMGT processing procedures, which are completed using the FMGT import toolbar and auto processing tools. In order to ensure each process has been completed, processes are reviewed in the output window.

The second part (PART 2) of the FMGT processing pipeline consists of detailed review of coverage.

The third part (PART 3) of the FMGT processing pipeline is performed once data collection has been completed for an entire H-Cell sheet. Data is grouped into separate FMGT projects by acoustic frequency and survey system meeting HSSD specification. A mosaic is exported from each project in floating point GeoTIFF format.

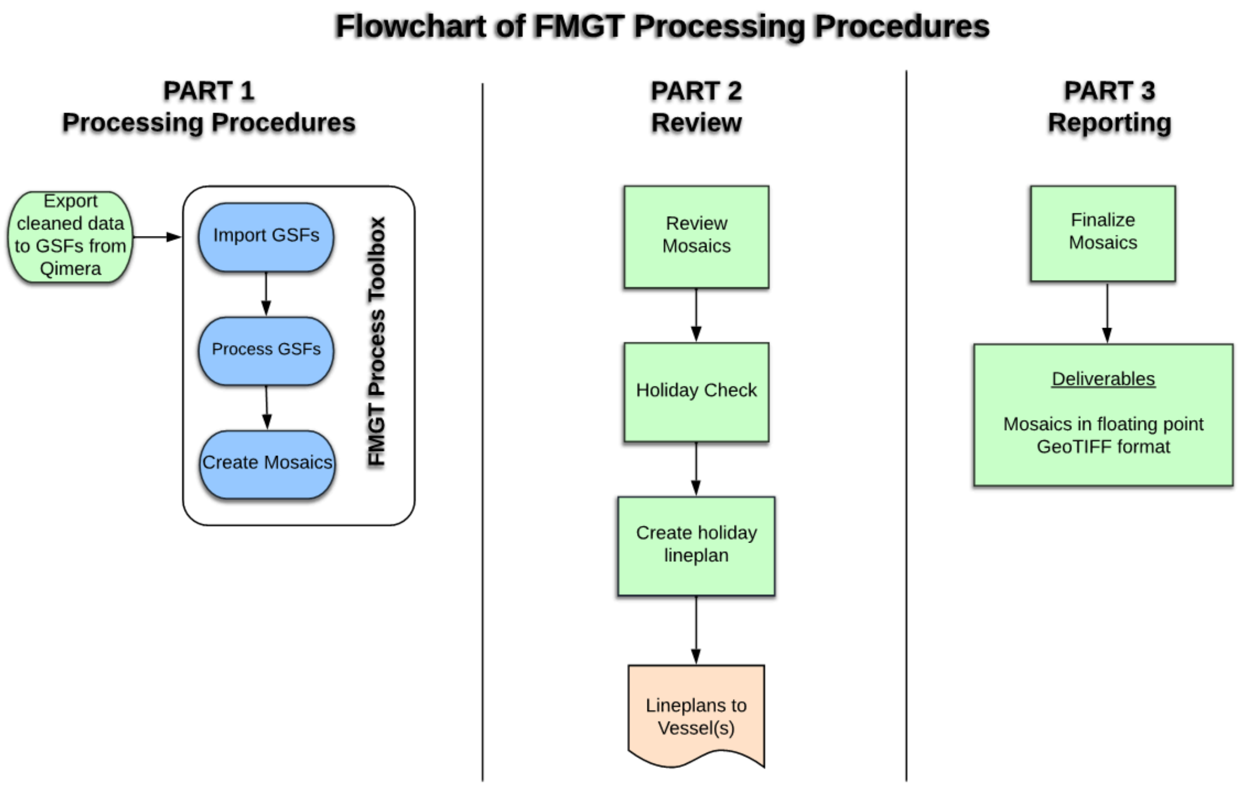

Figure 27: FMGT Processing Procedures

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

Line spacing for Complete Coverage Option B survey operations was based upon charted depths as well as coverage requirements set forth in the Project Instructions and the HSSD 2022.

For the Edgetech 4200 and Edgetech 4125 the hydrographer monitored the towfish range, height, heading, pitch, roll, location and cable out. Height adjustments were made to provide the highest quality of coverage throughout the survey.

Prior to survey operations, offsets on all vessels were determined from the vessel verification surveys using a metal hand tape. These offsets as well as a catenary coefficient were entered into the Qinsy layback driver utility in order to calculate an accurate towfish layback. Every effort was made in the field to ensure that the sidescan towfish navigation and layback were horizontally corrected, and the altitude of the towish met HSSD requirements. eTrac monitored the raw Discover SSS intensity in Qinsy during acquisition and QC'ed the coverage and general quality of the sidescan mosaics in the field daily using SonarWiz.

Data Processing Methods and Procedures

SonarWiz and ArcGIS Pro were utilized for SSS processing throughout the entire project. Processing steps and procedures are detailed in the image below.

The first part (PART 1) of the processing pipeline consists of a series of standard SonarWiz processing procedures, which are completed using the SonarWiz post-process toolbar. In order to ensure each process has been completed to all vessel data, daily 1m sidescan mosaics were created and reviewed in the output window.

The second part (PART 2) of the processing pipeline consists of detailed review of the data, which informed the field of where to resurvey or fill in holidays, as well as scanning each sidescan line for significant contacts. These contacts were exported from SonarWiz as shapefiles and correlated with the multibeam coverage. The shapefiles were then imported into the Arc Maritime Feature Database and exported in S57 format.

The third part (PART 3) of the processing pipeline is performed once data collection has been completed for an entire H-Cell sheet. The mosaics from each vessel were exported from SonarWiz as Greyscale GeoImages and then imported into ArcGIS Pro. In ArcGIS Pro, the sidescan mosaics were blended and merged together using the Mosaic to New Raster tool. Continuing in ArcGIS Pro, the merged mosaic was then converted to a 32 bit Floating Point Raster with a NoData value of -9999 using the Raster to Float tool. The Floating Point Raster was then re-exported in ArcGIS Pro using the Export Raster Tool. Data is grouped by HSSD guidelines and mosaics are finalized and exported in Floating Point GeoTIFF format.

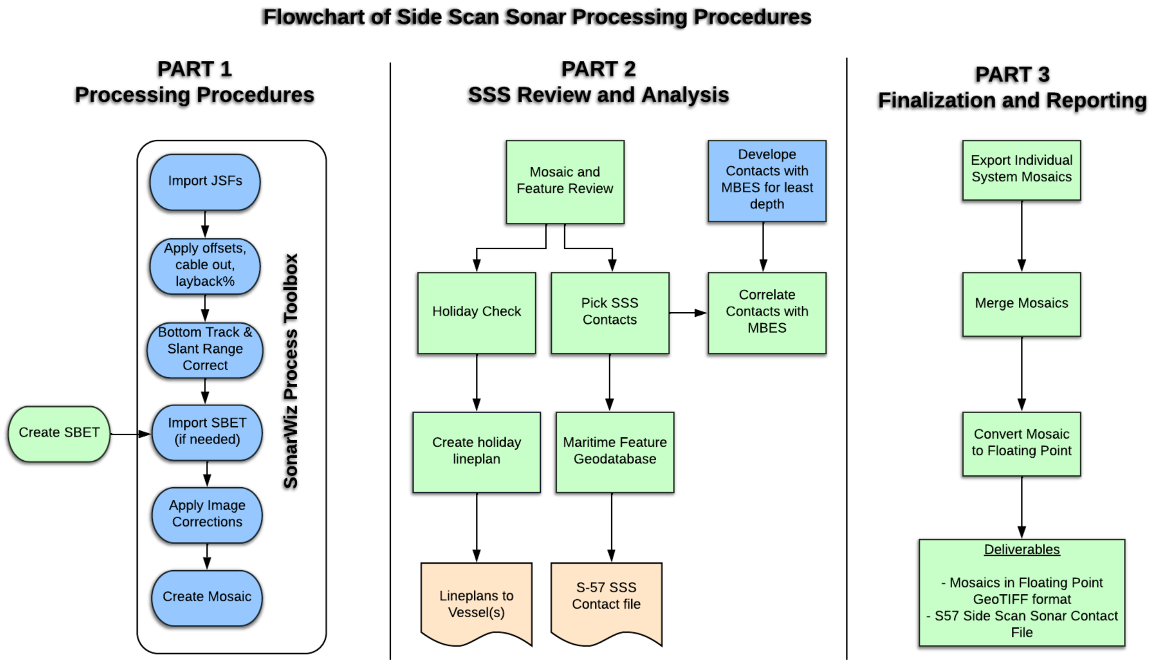

Figure 28: Side Scan Sonar Processing Procedures

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

DGPS data was not acquired.

C.3.1.3 Other Horizontal Control Equipment

Data Acquisition Methods and Procedures

During acquisition, all vessels received GNSS satellite corrections over the POS MV G2+ or G4+ carrier signal from the Marinestar Global Correction System maintained by Fugro. Marinestar is a global real-time GNSS broadcast system that delivers corrections from a network of base stations around the world via geo-stationary satellites. Corrections were monitored during data acquisition to ensure no dropouts occurred throughout the survey. Accuracies in the 10 - 15 cm range were observed through the project.

Data Processing Methods and Procedures

Applanix POSPac MMS was utilized for all survey data to post-process real-time positioning data utilizing Trimble's PP-RTX implementation of Trimble CenterPoint RTX. The Trimble CenterPoint RTX correction service is delivered via internet connection and integrated into Applanix PosPac MMS 8, to aid in post processed trajectories. Improved accuracies in the 4 – 6cm range were observed in the PP-RTX results. A Smoothed Best Estimate of Trajectory (SBET) was output from POSPac MMS and applied to survey data in QPS Qimera in order to reduce the THU of the data and achieve a higher accuracy.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

In accordance with the Project Instructions, OPR-E351-KR-22 was an Ellipsoidally Referenced (ERS) survey. Data were vertically referenced to the ITRF-2014 ellipsoid using Marinestar G2+ or G4+ Space Based corrections. A time dependent, 7 parameter transformation from ITRF-2014 to NAD83_2011 was performed in QPS Qinsy. A vertical separation model was provided by NOAA to transform the ellipsoidally referenced data from NAD83_2011 to MLLW. The transformation and the separation model were applied in QPS Qinsy on the vessels in realtime to achieve MLLW in the field. Achieving MLLW in the field was extremely efficient for field operations, as the NALL was easily identified in real-time.

Data Processing Methods and Procedures

The separation model automatically carried over into QPS Qimera through the DB files during processing. The separation model provided by NOAA is noted to have an uncertainty of 6 cm throughout the project area.

An additional assigned task for this project was to include interpolated grids in North American Vertical Datum of 1988 (NAVD88) datum. In order to reference soundings to NAVD88 Datum, a separation model was provided by NOAA and was applied to the gridded MLLW data in QGIS.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.3.2.3 Other Vertical Control Equipment

Data Acquisition Methods and Procedures

During acquisition, all vessels received GNSS satellite corrections over the POS MV G2+ or G4+ carrier signal from the Marinestar Global Correction System maintained by Fugro. Marinestar is a global real-time GNSS broadcast system that delivers corrections from a network of base stations around the world via geo-stationary satellites. Corrections were monitored during data acquisition to ensure no dropouts occurred throughout the survey. Accuracies in the 10 - 15 cm range were observed through the project.

Data Processing Methods and Procedures

Applanix POSPac MMS was utilized for all survey data to post-process real-time positioning data utilizing Trimble’s PP-RTX implementation of Trimble CenterPoint RTX. The Trimble CenterPoint RTX correction service is delivered via internet connection and integrated into Applanix PosPac MMS 8, to aid in post processed trajectories. Improved accuracies in the 4 – 6cm range were observed in the PP-RTX results. A Smoothed Best Estimate of Trajectory (SBET) was output from POSPac MMS and applied to survey data in QPS Qimera in order to reduce the TVU of the data and achieve a higher accuracy.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

During acquisition, trajectory data was logged by the Applanix Oceanmaster, Applanix Wavemaster, or the R2Sonic I2NS on each vessel. All vessels received GNSS satellite corrections over the POS MV G2+ or G4+ carrier signal from the Marinestar Global Correction System maintained by Fugro. Marinestar is a global real-time GNSS broadcast system that delivers corrections from a network of base stations around the world via geo-stationary satellites. Corrections were monitored during data acquisition to ensure no dropouts occurred throughout the survey. Accuracies in the 10 - 15 cm range were observed through the project.

Data Processing Methods and Procedures

Applanix PosPac MMS was utilized for all survey data to post-process realtime positioning data utilizing Trimble's PP-RTX implementation of Trimble CenterPoint RTX. The Trimble CenterPoint RTX correction service is delivered via internet connection and integrated into Applanix PosPac MMS 8, to aid in post processed trajectories. A Smoothed Best Estimate of Trajectory (SBET) is provided by PosPac MMS and applied to survey data in Qimera. Improved accuracies in the 4 – 6cm range were observed in the PP-RTX results.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

All sound speed sensors used on the project were calibrated within 1 year of survey commencement per the HSSD 2022. Manufacturer certified calibration sheets can be referenced in Appendices of this document.

All sound speed measurements were collected in accordance with specifications set forth in the HSSD 2022.

Sound speed profiles were collected using AML Base•X2 and AML 3-LGR profiling units. Sound Velocity Profilers were lowered by hand on all vessels. SV profiles were taken immediately prior to daily survey operations, as well as approximately every 2 hours during survey operations. In addition to planning SV casts around a 2 hour time interval, positional variance was considered when suspending survey operations to perform an SV cast.

During a cast, profiler data was collected and stored internally in the profiler. When the profiler was retrieved it was connected to the acquisition computer via serial cable.
The profiler data was then loaded in AML Seacast or Sailfish software and saved as a CSV on the MBES acquisition computer. Then, the CSV was imported to QPS QINSy acquisition software for use online and was stored in each .DB file. Once imported into the QPS QINSy software, the cast data was exported into the .SVP format for use in office processing at a later data if needed. Application of .SVP files to vessel data was not required in post processing because the applied SVP is stored in the .DB file.

Data Processing Methods and Procedures

Sound speed profiles collected in the field were applied to the MBES data. On each vessel, raw Qinsy .DB files store sound speed profile data real-time for each separate line of data. In Qimera, sound speed data is imported simultaneously with each respective raw DB file. The sound speed data was analyzed for spurious data points and cleaned if necessary. The sound speed strategy in Qimera was primarily set to Real Time Scheduling or "Nearest in Distance within Time" with a time set of 240 minutes. This sound speed strategy allowed for an intelligent sound speed dataset to be applied to full or partial .DB files based on time and space in order to achieve the best looking dataset. If the primary sound speed strategy was showing refraction in an area, the processor had the ability to set the sound speed strategy to "Real Time Scheduling" to individual .DB files to apply the sound cast that was used during acquisition.

Surface sound speed was collected at the R2Sonic transducer face, and sent via serial connection directly to the R2Sonic topside in order to facilitate beam steering.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

The R2sonic 2022 MBES and R2sonic 2024 MBES utilize an AML Micro•X or AML 1 RT located at the sonar head for surface sound speed measurement. The AML Micro•X and AML 1 RT are both time of flight SV
sensors and are powered through the R2Sonic topside. Sound speed measurements (measured in meters per second) are output through the same serial connection at 1Hz.

Surface sound speed measured by the AML Micro•X or AML 1 RT, located at the sonar head, was compared in realtime against the corresponding SV from the most current cast entered into QINSy. An alarm was set to notify the operator if the difference between the two SV readings exceeded 2m/s. If the difference was ever in consistent excess of 2m/s and persisted longer than a designated time threshold, survey operations were suspended and a new sound velocity cast was performed.

Surface sound speed was measured at 1Hz during all MBES operations using the AML Micro•X or AML 1 RT. The AML Micro•X and AML 1 RT is installed using the AML or R2Sonic provided mounting bracket and installed just above the face of the MBES receiver. Sound speed was transmitted at 1Hz to the R2Sonic topside SIM box and subsequently transmitted with the MBES data to QPS QINSy, where it was permanently logged in the raw .DB files. As mentioned above, surface sound speed was additionally utilized during online operations as a QC comparison to sound speed profile data.

Data Processing Methods and Procedures

Surface sound speed was not post-processed and all values remain as realtime.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

Values were determined from manufacturer's specified/suggested values and/or calibration methodology/ accuracy. CUBE surfaces were created in Qimera using the NOAA CUBE parameters based on surface resolution which determines uncertainty of each grid node. Uncertainty was checked in NOAA QC Tools.

Further discussion of uncertainty assessment is located in section D.1.4.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		R/V Endeavor	R/V Voxel	R/V Taku	R/V 505	R/V Pulse	R/V Spectrum
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees	0.02 degrees	0.02 degrees	0.02 degrees	0.02 degrees
	Heave	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters
	Roll	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees
	Pitch	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees
Navigation Sensor		0.10 meters	0.10 meters	0.10 meters	0.10 meters	0.10 meters	0.10 meters

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
All Vessels	The smrmsg file, containing the real time uncertainty, was applied to its relevant database files during the sbet application process within Qimera.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

Features were acquired using multiple techniques, including SSS, MBES, and visual observation.

Assigned features and new features were investigated and developed in accordance with HSSD and guidance from the COR. All contacts identified in SSS with computed target heights greater than or equal to 1m were developed with MBES. If a SSS contact met the requirements to be included in the the Final Feature File (FFF) the feature was developed following HSSD complete coverage MBES specifications. Additional MBES coverage was acquired when necessary to adequately determine the least depth of assigned and new features.

Above water features that were not developed with MBES or SSS were documented through the JotForm online survey manager on each vessel from visual observations. Hydrographers recorded feature attributes and descriptions as well as a GPS-tagged photo of each feature.

Assigned shoreline features that required an elevation were acquired using a Laser Technology TruPulse 200L Laser Range Finder. The TruPulse 200L is a handheld laser that measures, slope distance and inclination angle, and calculates horizontal distance, vertical distance, height and 2D vertical missing line values. In order to accurately calculate heights, positioning data was recorded in POSMV - PosView. The height of the shoreline features were calculated from waterline to the top of feature using the TruPulse 200L. A waterline node in QPS Qinsy was monitored and recorded at the time of each Range Finder record.

Data Processing Methods and Procedures

All assigned features and all new features were added to a single .000 S-57 file for each H-Cell Sheet.

Least depths of features and shoal sounding of navigationally significant shoals were "feature flagged" in Qimera. These flags act as designated soundings and a custom cube hypothesis is set on each one to be represented in the final surface. Features that met the feature size requirements were imported in the S-57 Final Feature File (FFF) and attributed accordingly. Each feature in the FFF was given a unique identifier in the "userid" field for the .000 S57 file.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Bottom Sample locations were assigned in the CSF. The Ponar Grab was lowered to the sea floor by hand or from a davit or A-frame to collect bottom samples for OPR-R320-KR-22. The Shipek Grab was lowered by A frame to collect bottom samples for OPR-R320-KR-22.
Below is an image of the Shipek Grab in use during bottom sample collection on R/V Endeavor.

Figure 29: Shipek Grab in use for Bottom Sample Collection on R/V Endeavor

Data Processing Methods and Procedures

All bottom samples were collected in areas designated by NOAA and results can be found in the Final Feature File of each H-cell sheet. Bottoms samples were categorized using qualitative descriptives following specifications in the HSSD 2022.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

Within Qimera, the standard deviation and cube uncertainty layers were used to detect vertical discrepancies or spurious noise.

D.1.2 Designated Sounding Selection

Within 3D editor of Qimera, soundings and the CUBE surface were visible to analyze if the CUBE surface was incorporating natural or man-made features adequately. The determination if a sounding should become a designated sounding follows the specifications set fourth in the HSSD 2022.

D.1.3 Holiday Identification

The CUBE surface was exported as a BAG file and loaded into QC Tools within NOAA's Pydro software. Within QC Tools, the BAG was processed through the "detect holidays" tool. QC Tools produces a shapefile of the detected holidays, which then can be loaded into Qimera for analysis. All retrievable holidays were added to a survey line plan to be collected by the vessels. Any non-retrievable holidays or coverage gaps were analyzed and noted in the DR.

D.1.4 Uncertainty Assessment

In Qimera versions beginning in 2.5.1 and beyond, the user has the ability to export the Dynamic Surface to a Bathymetric Attributed Grid (BAG) with TVU represented in the uncertainty layer.
The CUBE surface was exported as a BAG file and loaded in QC Tools within NOAA's Pydro software. Within QC Tools, the BAG was processed through the "Grid QA" tool. QC Tools produces a graph of the uncertainty statistics, which then states whether the data is within uncertainty specifications. TVU was also reviewed using the Colormap Range in the Qimera TVU surface layer.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

A beam-to-beam statistical analysis was performed using the Cross Check tool in Qimera. A 1 meter Combined Uncertainty and Bathymetric Estimator (CUBE) weighted dynamic surface of each sheet was created incorporating only the mainscheme lines and excluded crosslines. The Cross Check tool was used to perform the beam-by-beam comparison of the crossline data to the mainscheme surface. Comparisons showed excellent agreement, well above 95% of the allowable TVU. Note: These surfaces were created for QC only and are not submitted as a surface deliverable.

D.1.5.2 Junctions

Depth differences between junctioning surveys were evaluated using the JunctionTrac program, developed in-house by eTrac Inc. For every junction, each CUBE weighted dynamic surface's nodes were exported to an ASCII CSV file where the fields were (Easting, Northing, Depth) for each node. A 1 meter or 4 meter difference surface between the junctioning datasets was also created and exported to an ASCII CSV file where the fields were (Easting, Northing, Diff) for each node. The three ASCII CSV files were then loaded into the JunctionTrac program and junction statistics were computed. A file was also created in this process to locate any nodes from the difference surface that exceed the allowable TVU, which was imported into Qimera and any identified points from JunctionTrac were analyzed. Note: the difference surfaces were created for comparison efforts only and are not submitted as surface deliverables.

D.1.5.3 Platform to Platform

A performance test between the vessels and the systems on each vessel was preformed as an additional quality assurance measure. The confidence check between all vessels can be found in Appendix V.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Side Scan Sonar (SSS) coverage was assessed in accordance with HSSD 2022.

While the data were being processed and reviewed for contacts, the surfaces were inspected for data artifacts, areas of noise, and data gaps in ArcGIS Pro for a overall review. If the features on the riverbed could not be interpreted due to poor data quality, than the areas were sent back to the Field Team for resurvey. The water column gap at Nadir of the sidescan lines were slant range corrected using Bottom Tracking in SonarWiz and were also covered by the concurrent MBES coverage. A final data gap analysis was conducted using the completed MBES surface and the SSS mosaics to ensure all holidays within the NALL line were covered by sonar data. Surfaces were inspected for gaps in SonarWiz while data were being processed and reviewed for contacts, as well as in Global Mapper and ArcGIS Pro for a overall review. MBES grids were loaded over SSS mosaics to ensure all SSS nadir gaps were covered by MBES.

SSS lines were evaluated and reviewed to meet required specifications for overlap, speed, and altitude. SSS lines were also reviewed for gain corrections, biological interference, motion artifacts, and other interference. In any areas where coverage failed to meet specification or did not allow for contact selection, additional lines of SSS or complete coverage MBES were run.

Confidence checks of the SSS were conducted daily for each channel.

D.2.2 Contact Selection Methodology

SSS contacts were selected in accordance with HSSD 2022.

Contacts were selected and reviewed by multiple hydrographers in SonarWiz. ArcGIS Pro was used to manage, review, and finalize the SSS contacts.

The height of each contact was calculated using the slant rang corrections in the Contact Manager in SonarWiz. Each contact has a User Class that determined if the contact was significant or insignificant, and new or assigned. A second User Class provides information on the type of feature; such as obstruction, fishing gear, cable or line, mound, or pile. A full resolution GeoTIFF of each significant contact was also captured and cataloged for the deliverable. Any questionable contacts were sent to the data manager for review. All contacts were reviewed twice before exporting a single shapefile (.shp) of the daily contacts for each vessel.

The daily contact shapefiles were imported into a Maritime Feature Geodatabase in ArcGIS Pro. The Side Scan Data Manager completed any further reviews of features to determine their height from the seafloor and ensured that a GeoTIFF was captured of each significant contact. GeoTIFFs and coordinates of New or Assigned features that met the HSSD requirements were sent to the Multibeam Data Manager to plan the final feature investigations or disprovals.

Once the field data collection concluded and the entire SSS dataset of the H-Cell sheet had been analyzed, the Final Contact Database was exported to a S-57 .000 file using the ArcGIS Pri Maritime Toolbox: Geodatabase to S-57 tool.

E. Approval Sheet

As Chief of Party, field operations for this hydrographic survey were conducted under my direct supervision, with frequent personal checks of progress and adequacy. I have reviewed the attached survey data and reports.

The survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys Specifications and Deliverables, Field Procedures Manual, Letter Instructions, and all HSD Technical Directives. These data are adequate to supersede charted data in their common areas. This survey is complete and no additional work is required with the exception of deficiencies noted in the Descriptive Report.

Approver Name	Approver Title	Date	Signature
David Neff	Chief of Party	10/18/2023	David Neff Digitally signed by David Neff DN: C=US, E=david@etracinc.com, O=eTrac Inc., CN=David Neff Date: 2023.10.18 13:54:12-07'00'

List of Appendices:

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