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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	S-D915-BH2-23
Time Frame:	April - May 2023

LOCALITY

State(s):	Delaware Maryland
General Locality:	Elk River, MD

2023

CHIEF OF PARTY
LTJG Jane D. Saunders

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NOAA R/V *Bay Hydro II*
Chief of Party: LTJG Jane D. Saunders
Year: 2023
Version: 1.0
Publish Date: 2023-09-21

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 R/V Bay Hydro II

<table>
<tr><td>Vessel Name</td><td colspan="2">R/V Bay Hydro II</td></tr>
<tr><td>Hull Number</td><td colspan="2">S5401</td></tr>
<tr><td>Description</td><td colspan="2">R/V Bay Hydro II was used for the acquisition and post-processing of all side scan sonar (SSS), single beam echo sounder (SBES), multibeam echo sounder (MBES), sound velocity profile (SVP), and detached position (DPS) data unless otherwise noted in the Descriptive Report. Vessel configuration and offset measurements are included in the Appendix.</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>17.3 meters</td></tr>
<tr><td>Beam</td><td>6.33 meters</td></tr>
<tr><td>Max Draft</td><td>1.8 meters</td></tr>
<tr><td rowspan="2">Most Recent Full Static Survey</td><td>Date</td><td>2009-03-23</td></tr>
<tr><td>Performed By</td><td>H. Stewart Kuper Jr., NGS</td></tr>
</table>

Figure 1: R/V Bay Hydro II

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM2040C-DH

The Kongsberg EM2040C-DH system is a digital recording dual-head multibeam echo sounder which is capable of operating at 200kHz, 300kHz, 400kHz, or a Frequency Modulation (FM) Chirp. The system is comprised of two sonar heads mounted on a sliding sonar strut, a Hydrographic Work Station (HWS), and a Processor Unit (PU). The projector and receiver of each head are set up in a Mills Cross configuration, and deployed through a retractable door located on the center line of the vessel. The EM2040C-DH is operated through Seafloor Information System (SIS) software; version 4.3.2. The EM2040C-DH is used to acquire full and partial bottom bathymetric coverage throughout a survey area to determine least depths over critical items such as wrecks, obstructions, dangers-to-navigation, and general object detection. While operating in partial coverage, the EM2040C-DH collects data concurrently with the EdgeTech 4200 without acoustic interference, commonly referred to as "skunk striping". R/V BAY HYDRO II operates the EM2040C-DH at a frequency of 300kHz for normal operations, as specified in the Kongsberg operator's manual. This configuration provides an ideal mix of resolution and range for surveying within R/V BAY HYDRO II's operational area. The specifications below reflect this mode of operation.

Manufacturer	Kongsberg		
Model	EM2040C-DH		
Inventory	*S5401*	*Component*	MBES
		Model Number	EM2040C-DH
		Serial Number	N/A
		Frequency	300 kilohertz
		Calibration	2023-04-18
		Accuracy Check	2023-04-19

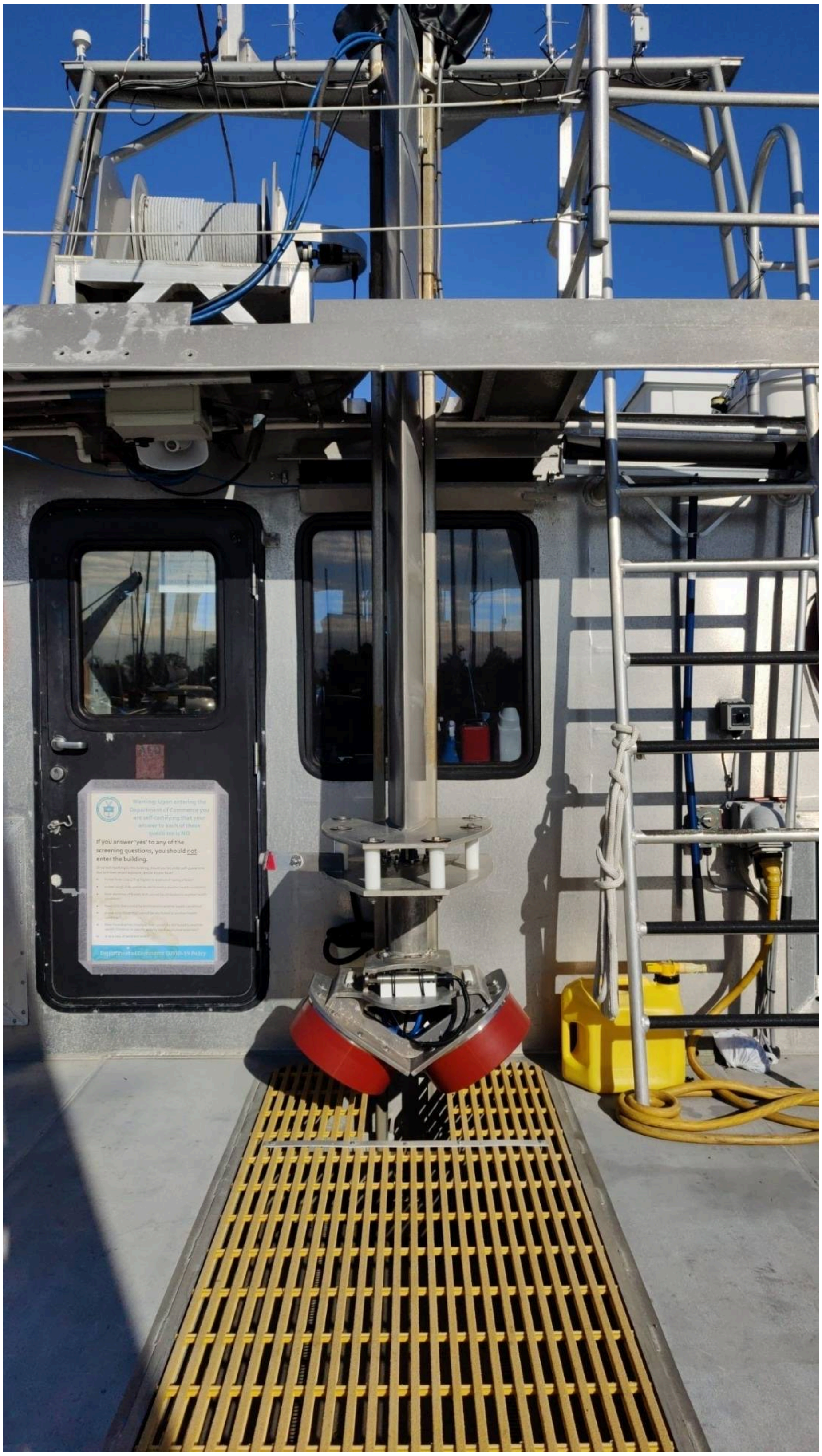

Figure 2: Kongsberg EM2040C-DH housing and sonar, in the retracted position.

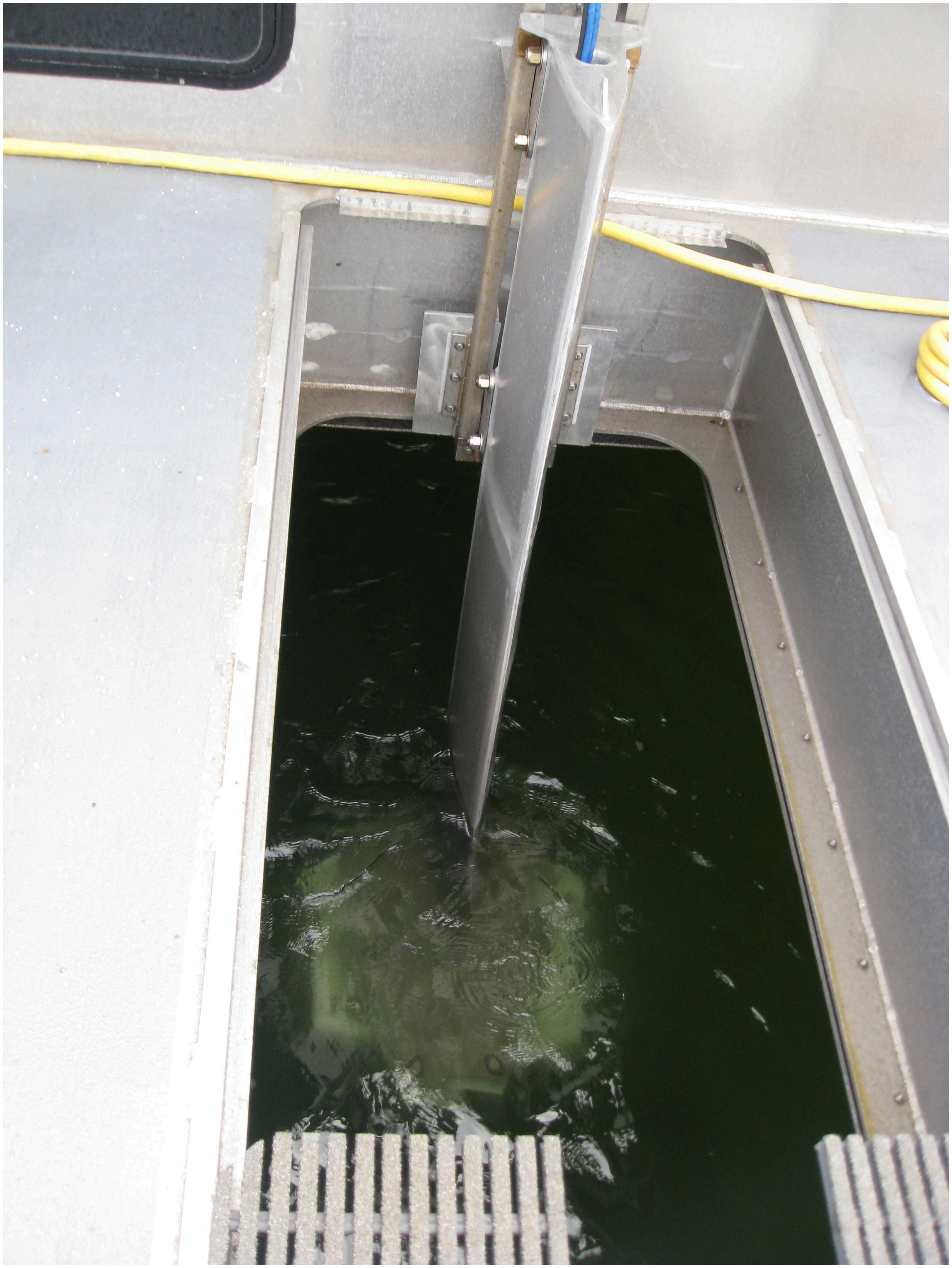

Figure 3: Kongsberg EM2040C-DH housing and sonar in the deployed position.

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

The EdgeTech High Speed/High Resolution side scan sonar system is a beam-forming acoustic imagery device, towed behind R/V BAY HYDRO II via an armored cable and a hydraulic A-frame. The EdgeTech 4200 towfish is a dual frequency system that operates at 230kHz and 540kHz with a vertical beam width of 50°. Even though the system is dual frequency and both frequencies are logged, only the high frequency data is converted and processed in CARIS. The low frequency is available to the hydrographer as a quality control tool and is archived at The National Centers For Environmental Information (NCEI) upon completion of the survey. The integrated system includes an EdgeTech 4200 lightweight towfish, a tow cable telemetry system, and a Topside Processing Unit (TPU).

Positioning of the towfish is calculated using CARIS SIPS and is derived from the amount of cable out, the towfish depth (from the towfish's pressure gage), and the vessel's Course Made Good (CMG). Towfish altitude is maintained between 8% and 20% of the range scale, in accordance with the FPM Section 2.5.3.1.2. The length of cable out is adjusted during SSS acquisition to ensure that the towfish stays in the required range to maximize sonar grazing angles. Confidence checks are performed daily in accordance with the HSSD Section 6.1.3.1. More information can be found in Section C.2.2 of this document.

The EdgeTech 4200 is capable of operation in three distinct modes; Mode 1 is single pulse/high definition, Mode 2 is multipulse/high speed, and Mode 3 is multipulse/high resolution. Each distinct mode uses the transducer arrays in a different configuration. R/V BAY HYDRO II uses Mode 3. The use of multipulse mode coupled with high resolution allows for operational speeds up to 9.6 kts, while providing quality imagery and density that meet the standards in HSSD 6.1.2.2.

In February 2022 an annual SSS calibration test was performed in accordance with FPM 1.5.7.1.2. For a full report see the Appendix.

<table>
<tr><td>Manufacturer</td><td colspan="3">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="3">4200</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">S5401</td><td>Component</td><td>SSS</td></tr>
<tr><td>Model Number</td><td>4200</td></tr>
<tr><td>Serial Number</td><td>46971</td></tr>
<tr><td>Frequency</td><td>230/500</td></tr>
<tr><td>Calibration</td><td>2022-03-09</td></tr>
<tr><td>Accuracy Check</td><td>2022-03-09</td></tr>
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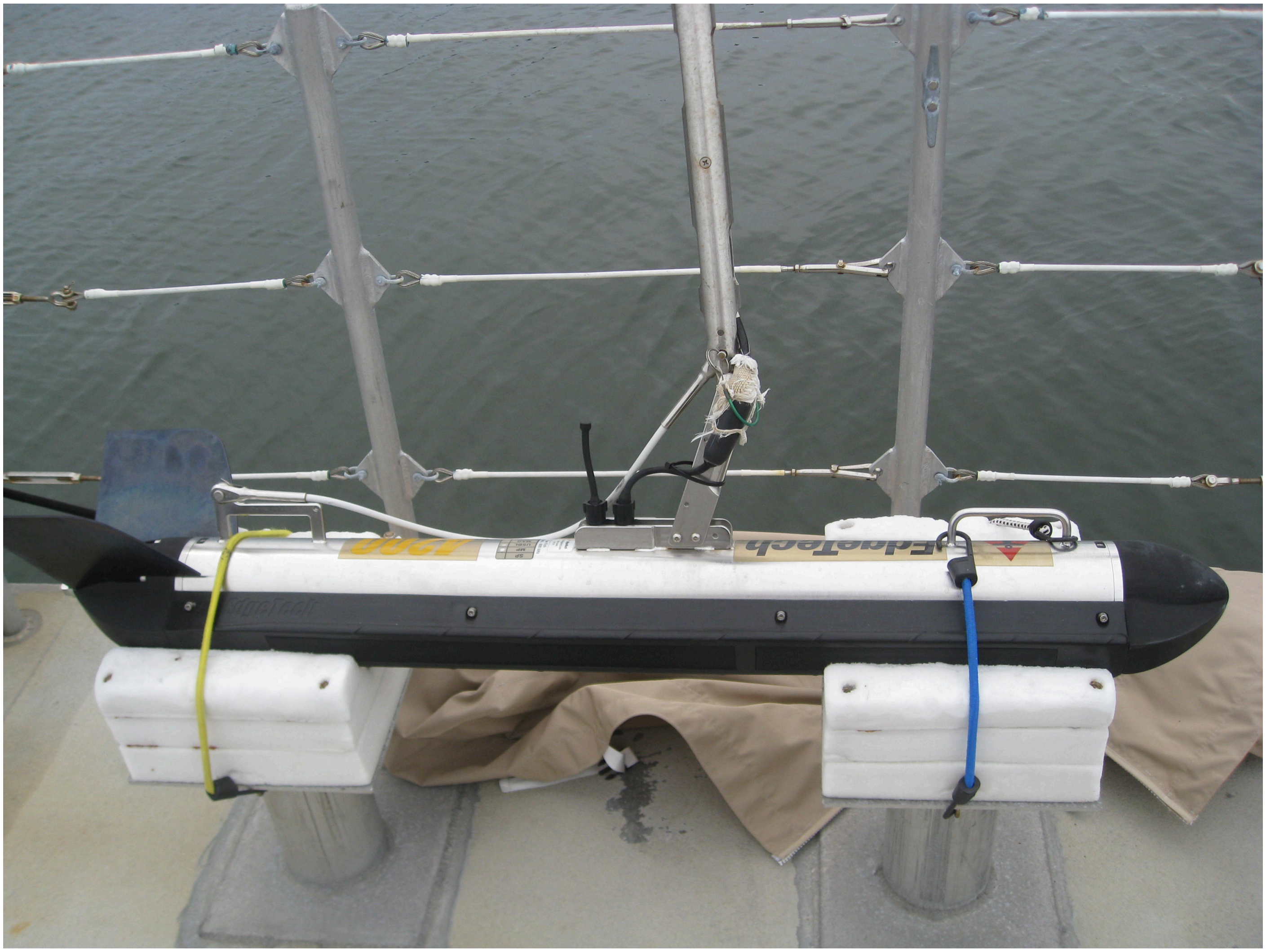

Figure 4: EdgeTech 4200 side scan sonar

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

R/V BAY HYDRO II is equipped with a non-traditional lead line fabricated from Amsteel® brand line and an eight inch tall mushroom anchor. This lead line was fabricated on 16-June-2009.

Manufacturer	N/A		
Model			
Inventory	*S5401*	*Component*	N/A
		Model Number	N/A
		Serial Number	N/A
		Calibration	2023-03-06

Figure 5: Bay Hydro II's non-traditional lead-line with orange meter incrementation.

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 (a Trimble company) POS/MV

R/V BAY HYDRO II's POS/MV is a GPS-aided inertial positioning system that provides position and orientation data to external equipment. The system is comprised of an Inertial Measurement Unit (IMU), two GNSS receivers, and a POS Computing System (PCS) unit. Roll, pitch, and heave values are measured by the IMU, while position is derived from the tightly-coupled GPS/IMU integration. The system determines vessel heading by integrating data from the GNSS antennas and heading estimates by the IMU. Port antenna (30012) is primary, starboard antenna (30013) is secondary. GAMS Calibration performed on 12-April-2023.

<table>
<tr><td>Manufacturer</td><td colspan="2">Applanix (a Trimble company)</td></tr>
<tr><td>Model</td><td colspan="2">POS/MV</td></tr>
<tr><td>Inventory</td><td>S5401</td><td>
<table>
<tr><td>Component</td><td>IMU</td><td>PCS</td><td>Antenna</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>89</td><td>v.5</td><td>GA830</td><td>GA830</td></tr>
<tr><td>Serial Number</td><td>6750</td><td>14129</td><td>30012</td><td>30013</td></tr>
<tr><td>Calibration</td><td>2023-04-12</td><td>2023-04-12</td><td>2023-04-12</td><td>2023-04-12</td></tr>
</table>
</td></tr>
</table>

Figure 6: POS/MV computing system unit (orange) rack mounted aboard R/V BAY HYDRO II.

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

Additional GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

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

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

No moving vessel profilers were utilized for data acquisition.

A.6.2 CTD Profilers

A.6.2.1 SonTek (a Xylem brand) Castaway

R/V BAY HYDRO II is equipped with a SonTek CastAway CTD profiler and uses it as the primary CTD device. Temperature and electrical conductivity (to calculate salinity) are measured directly, while depth is calculated from strain gauge pressure. Using the Chen-Millero Equations, CTD data is used to calculate sound velocity profiles. As part of the annual HSRR, the CTD profiler is sent to the manufacturer for factory calibration. A Calibration Report can be found in the Appendix.

Manufacturer	SonTek (a Xylem brand)	
Model	Castaway	
Inventory	*Component*	CTD
	Model Number	N/A
	Serial Number	CC1332002
	Calibration	2023-03-14

Figure 7: SonTek CastAway CTD.

A.6.3 Sound Speed Sensors

A.6.3.1 Valeport miniSVS

The Valeport miniSVS is a sing-around transducer that determines the sound velocity by measuring the time needed for a ping of sound to travel a known distance. This unit was used to determine the speed of sound at the head of the Kongsberg EM2040C-DH MBES on R/V BAY HYDRO II. As part of the annual HSRR, BHII's miniSVS is sent to the manufacturer for factory calibration. A Calibration Report can be found in the Appendix.

Manufacturer	Valeport		
Model	miniSVS		
Inventory	*S5401*	*Component*	miniSVS
		Model Number	N/A
		Serial Number	22882
		Calibration	2023-02-10

Figure 8: Valeport MiniSVS mounted to the MBES case.

A.6.4 TSG Sensors

No TSG sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

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

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
HYPACK, Inc	HYPACK 2022	2022+	Acquisition
Applanix	POSView	11.21	Acquisition
Applanix	POSPac MMS	11.26	Processing
Teledyne Caris	HIPS and SIPS	11.4.25	Processing
NOAA OCS HSTB	PydroExplorer	22.1	Processing
EdgeTech	Discover 4200-MP	40.0.1.119	Acquisition
Kongsberg	SIS	4.3.2	Acquisition
Teledyne Caris	BASE Editor	5.5	Processing
Hydroffice	Sound Speed Manager	2021.0.2	Processing
SonTek	CastAway	1.5	Acquisition

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Wildco Petite Ponar Grabber

The Ponar-type grab sampler is used to collect sediment for seafloor bottom type classification/verification.

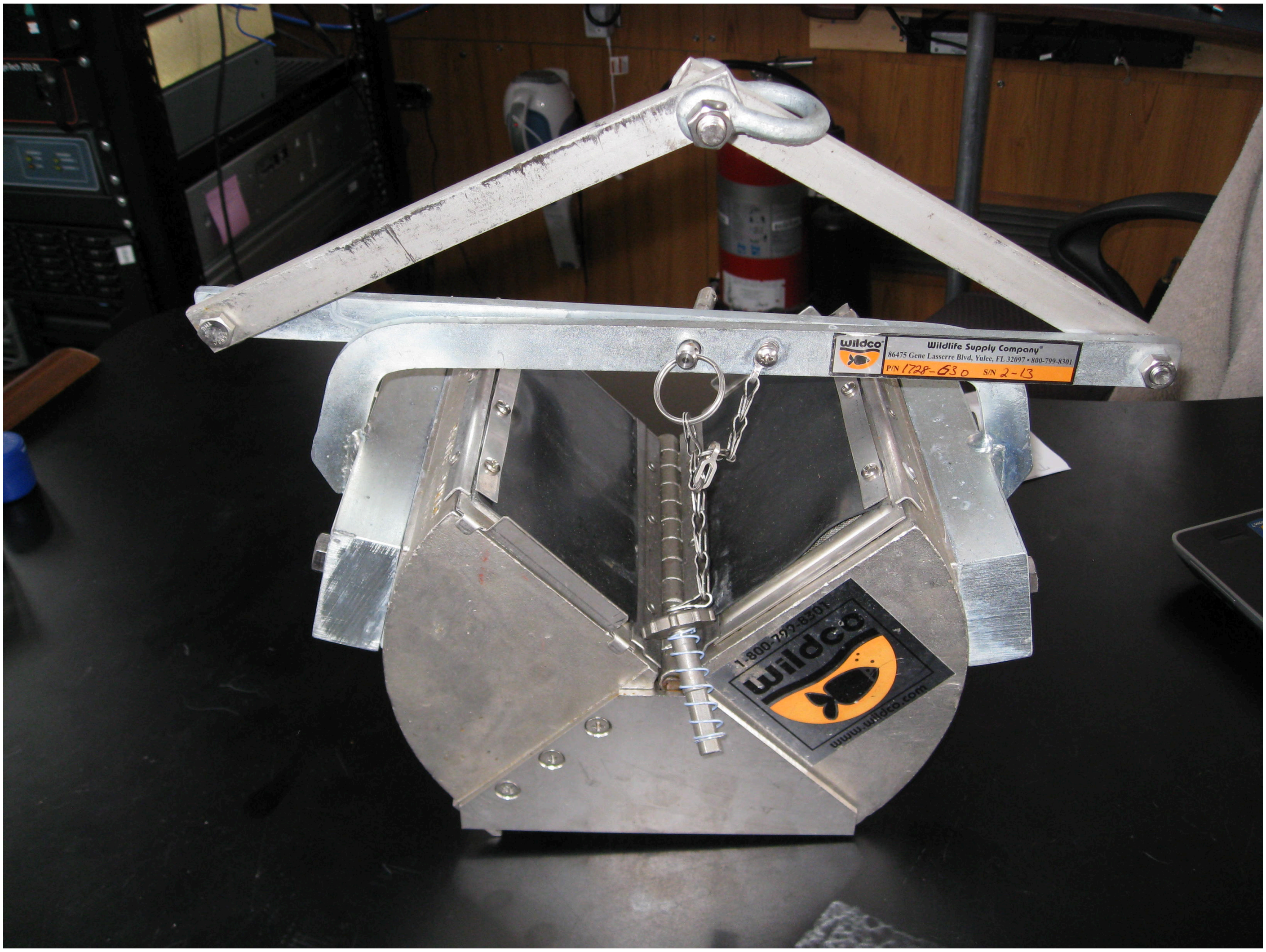

Figure 9: R/V BAY HYDRO II's Petite Ponar grab sampler.

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

A NGS survey of R/V BAY HYDRO II was performed on 23-March-2009 using optical levels. The survey established a vessel Reference Point (RP), then found X, Y, and Z distances for the GNSS antennas and multibeam sonar. On 26-February-2010 the crew surveyed in the Tow Point for the side scan sonar. On 18-March-2010 the crew surveyed in the vessel's singlebeam transducers (See Offset Report in the Appendix).

The X, Y, Z offsets of the MBES between the transducer heads and the IMU are entered into the HVF in the "SVP1" and "SVP2" sections of the HVF, as well as in the installation parameters in SIS (Figure 17).

The MRU and Nav to Transducer offsets are shown in the tables below. The Kongsberg Multibeam offsets associated with the port transducer head (x,y,z) are entered in the Caris HVF. This ensures the offsets will be applied, rather than realtime readings in calculating TPU. The Kongsberg Multibeam offsets associated with the starboard transducer head (x2,y2,z2) are entered as shown below in the Caris HVF.

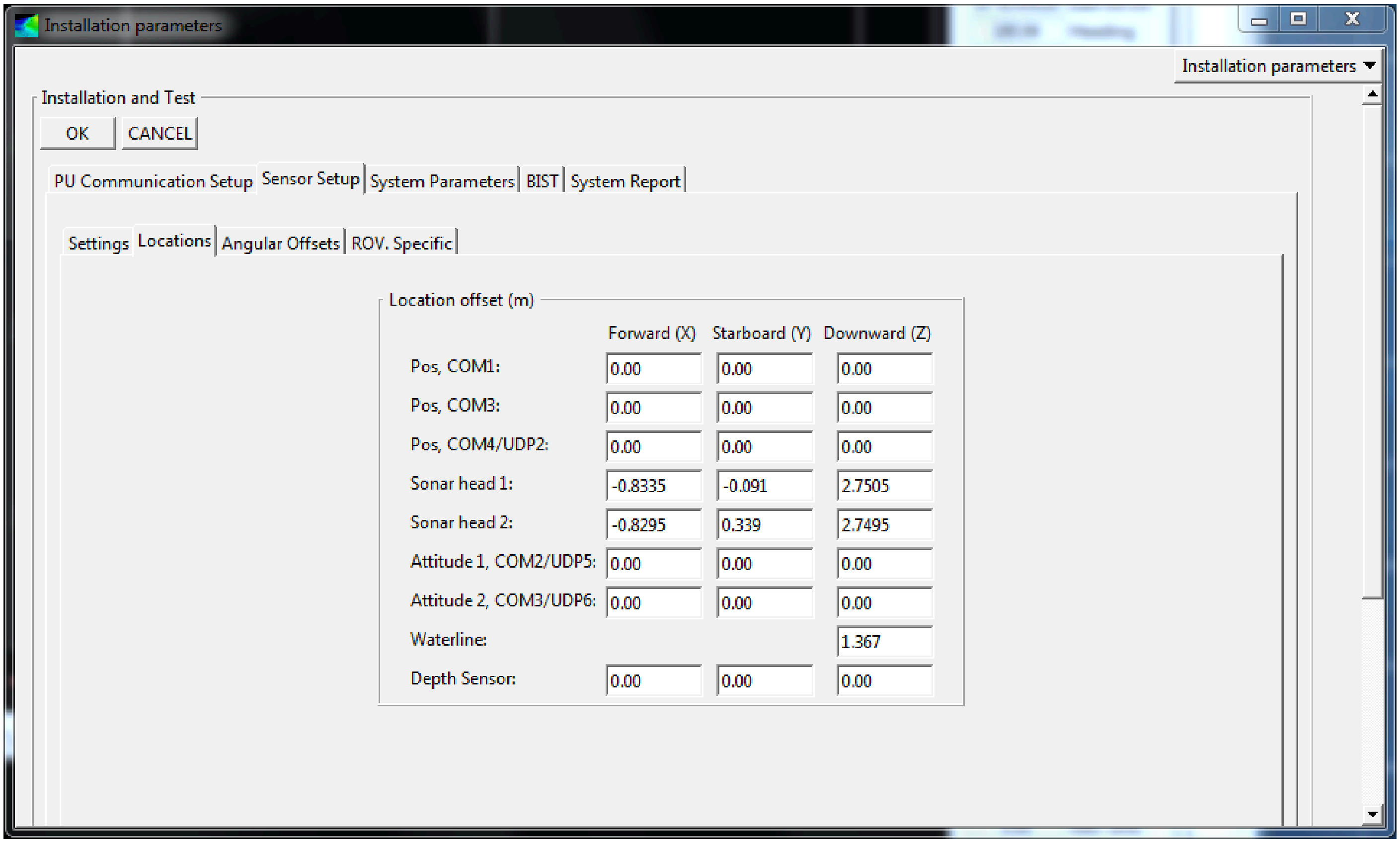

Figure 10: Offsets of Tx to Rx in SIS

B.1.1.1 Vessel Offset Correctors

Vessel	S5401			
Echosounder	Kongsberg EM2040C-DH 300 kilohertz			
Date	2022-02-15			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	-0.094 meters	0.002 meters
		y	-0.840 meters	0.002 meters
		z	2.758 meters	0.002 meters
		x2	0.336 meters	0.002 meters
		y2	-0.836 meters	0.002 meters
		z2	2.757 meters	0.002 meters
	Nav to Transducer	*x*	1.359 meters	0.002 meters
		y	-6.319 meters	0.002 meters
		z	5.665 meters	0.002 meters
		x2	1.789 meters	0.002 meters
		y2	-6.315 meters	0.002 meters
		z2	5.664 meters	0.002 meters
	Transducer Roll	*Roll*	34.470 degrees	
		Roll2	-35.676 degrees	

B.1.2 Layback

Layback on R/V BAY HYDRO II is the position of the towfish based upon the vessel tow point (sheave at the top of the A-frame). The value for layback is calculated based on the vessel speed and the amount of cable deployed. No catenary algorithm is applied.

During acquisition, the amount of side scan cable out is fed into HYPACK through the cable counter and recorded into the .hsx file. The values from the .hsx file are used to calculate the towfish position (within 10 meters) during data conversion and processing with CARIS SIPS.

B.1.2.1 Layback Correctors

Vessel	S5401		
Echosounder	EdgeTech 4200 Towfish, 701-DL Transceiver Processing Unit		
Frequency	600.0 kHz		
Date	2018-02-01		
Layback	*Towpoint*	*x*	0.145 meters
		y	-9.876 meters
		z	-2.552 meters
	Layback Error	0.000 meters	

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Static draft (i.e., the height of the waterline above/below the reference point) for R/V BAY HYDRO II is determined by an average and standard deviation of 44 measured values over the 2020 field season. The waterline is occasionally measured as a confidence check. The calculated value is entered directly into to SIS and into the HVF for use by Charlene for processing.

B.2.1.1 Static Draft Correctors

Vessel	*Date*	*Loading*	*Static Draft*	
			Measurement	*Uncertainty*
S5401	2023-04-19	0.100 meters	-1.359 meters	0.030 meters

B.2.2 Dynamic Draft

A 2021 dynamic draft measurement was conducted using the MBES method to determine the dynamic draft for the R/V BAY HYDRO II in accordance with NOAA FPM Section 1.4.2.1.2.1. A total of 26 1,100m lines were run in opposite directions for each of 13 different RPM's on the vessel's main engines. The evaluation was completed by acquiring three drift lines that ran orthogonal to the azimuth of the main lines.

The data was processed using Charlene and surfaces were made in CARIS HIPS/SIPS. A separation model was created to reference the surfaces to the ellipse. All MBES DDM data was filtered to +/- 5° of swath (10° total). This process results in a near true nadir-to-nadir analysis of depth values. Individual 1m resolution surfaces were created from the filtered data for all 19 MBES lines. Difference surfaces were generated from each DDM line compared to each of the three drift lines at 1m resolution.

In ERS surveys, those that use recorded GPS heights corrected via a VDatum SEP model to achieve tidal datum, the dynamic draft correction is not applied to the soundings.

B.2.2.1 Dynamic Draft Correctors

Vessel	S5401	
Date	2023-04-19	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
	0.50	0.00
	1.00	0.00
	1.50	0.01
	2.00	0.02
	2.50	0.02
	3.00	0.03
	3.50	0.04
	4.00	0.05
	4.50	0.06
	5.00	0.09
	5.50	0.14
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.50	0.01

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

The 2023 field season patch test was conducted as part of the HSRR (see the Appendix for full report). The patch test determined any roll, pitch, and yaw biases (X, Y, and Z axis) and the time offset between the MBES reference frame and the navigational reference frame. All patch tests are conducted in accordance with the HSSD Section 5.2.4.1. The lines are post-processed and the CARIS Calibration Utility is performed by all R/V BAY HYDRO II crew members. The results of the three trials are averaged and the result is recorded in the "IMU Frame w.r.t. Ref. Frame" inputs located in the POS Installation: Lever Arms & Mounting Angles window, after converting the values from the CARIS to the POS M/V coordinate system (See image below). The standard deviation of several calibration iterations for pitch and roll are averaged to produce the HVF associated value.

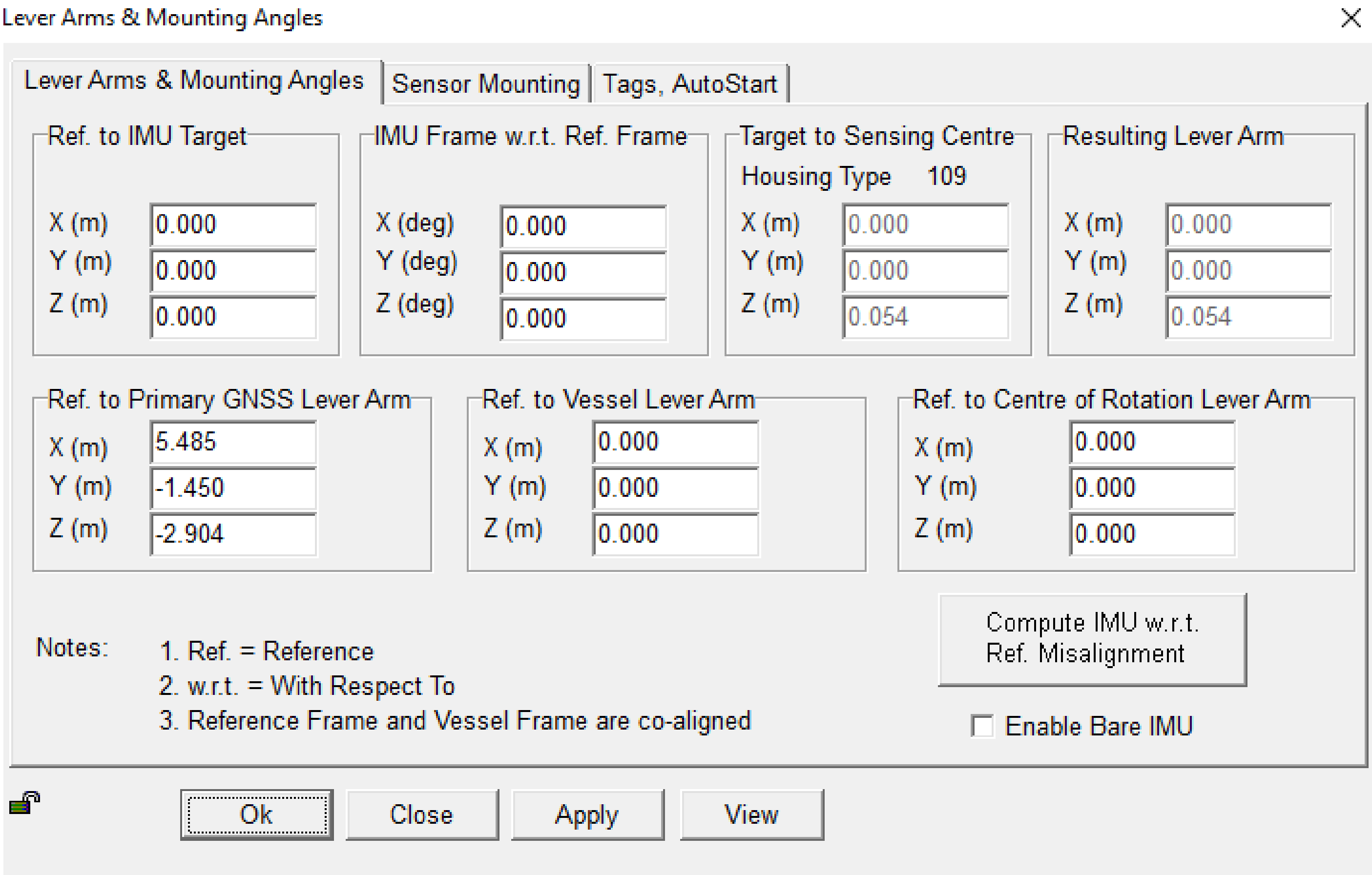

Figure 11: Lever Arms and Mounting Angles in POS.

B.3.1.1 System Alignment Correctors

Vessel	S5401		
Echosounder	Kongsberg EM2040		
Date	2023-04-19		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 hertz	0.005 seconds
	Navigation Time Correction	0.000 seconds	0.005 seconds
	Pitch	0.000 degrees	0.020 degrees
	Roll	0.000 degrees	0.020 degrees
	Yaw	0.000 degrees	0.611 degrees
	Pitch Time Correction	0.000 seconds	0.005 seconds
	Roll Time Correction	0.000 seconds	0.005 seconds
	Yaw Time Correction	0.000 seconds	0.005 seconds
	Heave Time Correction	0.000 seconds	0.005 seconds

Date	2023-04-19		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.005 seconds
	Navigation Time Correction	0.000 seconds	0.005 seconds
	Pitch	0.000 degrees	0.020 degrees
	Roll	0.000 degrees	0.020 degrees
	Yaw	0.000 degrees	0.611 degrees
	Pitch Time Correction	0.000 seconds	0.005 seconds
	Roll Time Correction	0.000 seconds	0.005 seconds
	Yaw Time Correction	0.000 seconds	0.005 seconds
	Heave Time Correction	0.000 seconds	0.005 seconds

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Kongsberg multibeam data is logged using SIS in the ".all" format. The hydrographer scans the real time SIS data for system wide errors, anomalies, and dropouts. Display windows such as Sea Bed Image, Time Series, Water Fall, and Beam Intensity aid in this task. SIS data is also fed through HYPACKS's HYSWEEP for the coxswain's display. This secondary interface acts as another real time monitoring tool. During acquisition, the hydrographer reviews the real time data and provides feedback to the coxswain in order to ensure acquired data will meet coverage requirements set forth in the Project Instructions and HSSD Section 5.2.2.

PicoMB multibeam data is logged using HYPACK and HYSWEEP in the ".HSX" and ".RAW" formats. The hydrographer scans the real time data for system wide errors, anomalies, and dropouts. Display windows such as Intensity Waterfall, Matrix Maps, and Beam Profile aid in this task. This system is controlled via remote desktop over Wifi connection. Using this Wifi interface, data is viewed real-time from the parent platform, but is collected on the ASV internal computer. During acquisition, the hydrographer reviews the real time data and provides feedback to the coxswain in order to ensure acquired data will meet coverage requirements set forth in the Project Instructions and HSSD Section 5.2.2.

Data Processing Methods and Procedures

Once data acquisition is complete, raw MBES data is converted in CARIS HIPS to provide a visual examination of the data points collected. Corrections and offsets are then applied to the MBES data to produce high resolution depth profiles of the seafloor. These conversions, corrections, and offsets are performed via the automated processing and data transfer tool, Charlene.

The process starts by converting the Kongsberg .all files using CARIS HIPS. Converted files are saved in the CARIS HDCS file format. Navigation and attitude data are are visually inspected for gross errors. Data files are corrected for delayed heave, tides, and sound velocity profiles, and then merged. After the merge, the Total Propagated Uncertainty (TPU) is computed (See Section C.6.1).

In the case of a RTK survey, standard tide files are not used, instead compute GPS tide is applied because the RTK corrections provide high resolution accuracy to an ellipsoid. This has the same outcome as applying SBETs and SBET RMS files during an ERS survey. In order to bring the data to MLLW, a separation model is applied. The separation model is provided to the field by the Project Manager.

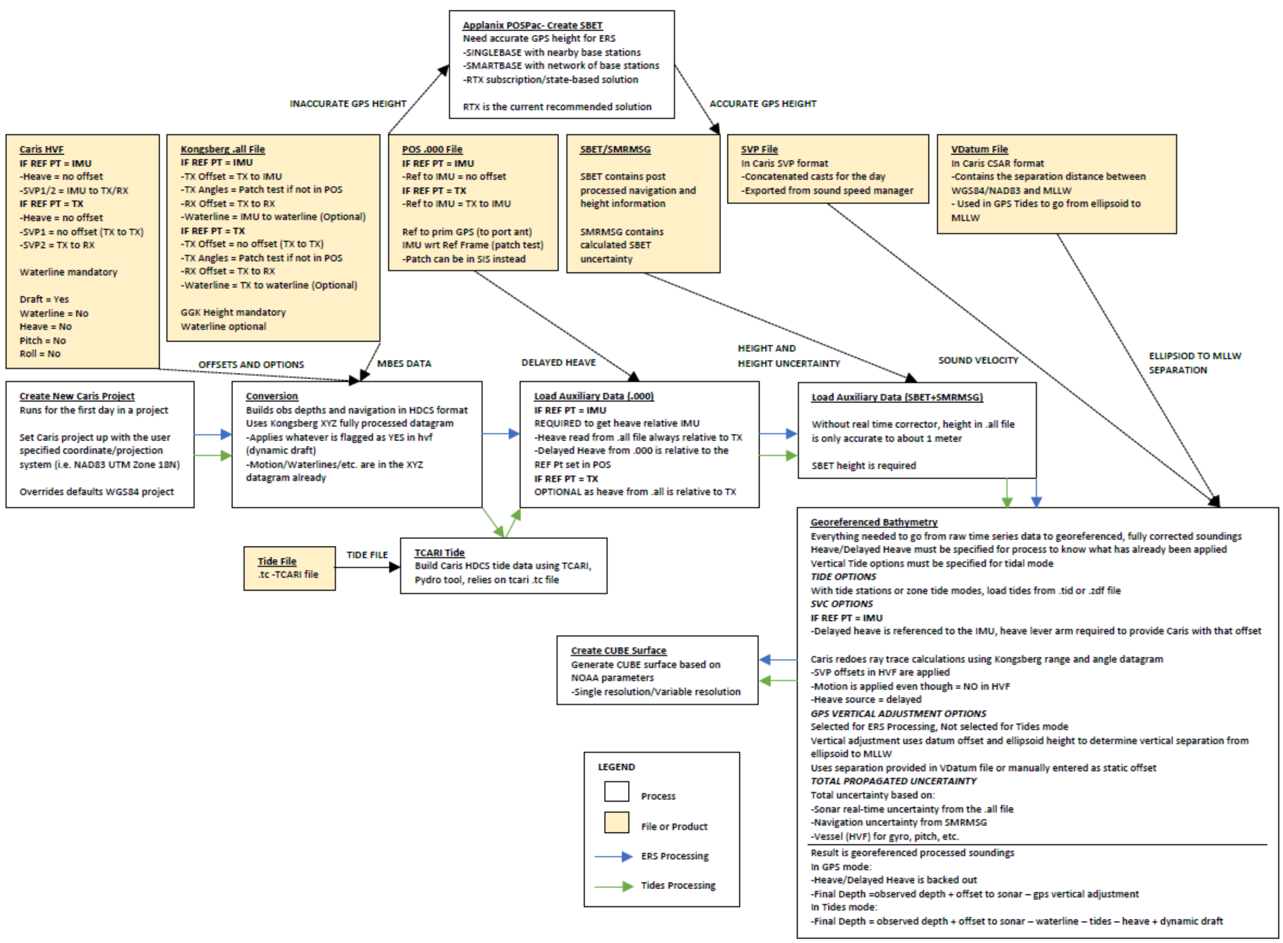

Figure 12: MBES Data Processing Workflow

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

MBES data are gridded using CARIS HIPS Combined Uncertainty and Bathymetric Estimator (CUBE) algorithm and is processed as described in FPM Section 4.2.1.1, using methods described above in Section C.1.1. The CUBE surface is also created using a grid resolution determined by coverage type and depth, as required by the Project Instructions and specified in the HSSD, Section 5.2.2. The "Depth" layer is reviewed for holidays (gaps in coverage) or erroneous soundings. Any erroneous soundings, known as fliers, are flagged as rejected and removed from the surface so the surface more accurately represents the seafloor. Any least depth on a feature that is not accurately reflected in the surface is flagged as “designated” in order to force the surface to reflect that shoaler depth in accordance with HSSD Section 5.2.1.2.3.

C.1.4.2 Depth Derivation

See above

C.1.4.3 Surface Computation Algorithm

See above

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

Backscatter data is collected during acquisition. This data is submitted to Pacific Hydrographic Branch along with the associated survey data.

Backscatter data is not collected during acquisition with the PicoMB.

Data Processing Methods and Procedures

Backscatter data were not processed.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

All side scan sonar data is logged using HYPACK, in the ".hsx" and ".RAW" formats. The hydrographer sets the range scale to maximize coverage, while providing sufficient resolution to easily identify contacts in post-processing. During acquisition, the hydrographer ensures the towfish's height off the bottom meets the HSSD specifications set forth in Section 6.1.2.3. This is accomplished by adjusting the length of cable out, increasing the speed of the vessel to increase the towfish height, or by decreasing the vessel speed to decrease the towfish height. The hydrographer monitors the towfish's health and function via realtime data displays of the towfish's position, speed, course, and altitude, making sure that they correspond with data coming from the vessel's positioning software.

All side scan sonar data is logged using HYPACK, in the ".hsx" and ".RAW" formats. The hydrographer sets the range scale to maximize coverage, while providing sufficient resolution to easily identify contacts in post-processing. During acquisition, the hydrographer ensures the range scale meets the HSSD specifications based on the depth of the water set forth in Section 6.1.2.3. This is accomplished by adjusting the range scale settings in HYPACK realtime. The hydrographer monitors the sonar's health and function via realtime data displays of the Side Scan Intensity Waterfall as well as the ASV's position, speed, course, and altitude, making sure that they correspond with data coming from the vessel's positioning software.

During acquisition of SSS data, lines are acquired so approximately 20% of the swath will overlap the swath from an adjacent line. This overlap is used to ensure continuous coverage over the survey area without creating holidays.

The hydrographic team conducts confidence checks on survey days to ensure the SSS system is functioning properly by passing by a known object; this object is typically within the survey area and is visually conspicuous at the surface. An example is using a navigation buoy and its associated buoy block on the seafloor to verify. Once the vessel passes the object, the hydrographer reviews the real time data for the object's presence in the appropriate channel and at the offset from nadir. Once the object is confirmed in the data, the confidence check is complete.

Data Processing Methods and Procedures

SSS processing work flow begins with converting Edgetech SSS .hsx file using CARIS SIPS via Charlene. The towfish navigation and gyro are examined for gross errors, and the towfish altitude is inspected and corrected as needed to accurately track the seafloor.

SSS processing work flow begins with converting Tritech SSS .hsx file using CARIS SIPS via Charlene. The towfish navigation and gyro are examined for gross errors, and the towfish altitude is inspected and corrected as needed to accurately track the seafloor.

The individual lines are stitched together to create a mosaic of the SSS data. As per the Project Instructions, the hydrographer creates mosaics for each percentage of coverage required (i.e.: one mosaic for the first set of data and a second mosaic for the second set of data of the project area). If holidays are found, a holiday line plan is created and the gaps are acquired by either SSS or MBES.

The hydrographer reviews each SSS line for contacts by visually inspecting the imagery record for contacts on the seafloor with a shadow height that meets or exceeds the specifications for a significant contact as stated in HSSD 6.1.3.2. The hydrographer has the ability to adjust the color histogram, zoom in and out on the image record, and switch between the processed and unprocessed view of the imagery to make locating contacts and measuring associated shadows easier. An additional hydrographer reviews the data using the same processes, verifies contacts found by the first hydrographer, and inspects all lines to ensure no possible contacts were missed.

Once the data has been scanned by two hydrographers, all identified contacts are treated as features and fully investigated with MBES, as explained in section C.7.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

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

For WAAS surveys, the POS/MV is optionally configured to receive correctors from the Wide Area Augmentation System (WAAS). The WAAS is a Satellite Based Augmentation System (SBAS) for North America, developed by the Federal Aviation Administration and the Department of Transportation as an aid to air navigation. Usable by any WAAS-enabled GPS receiver, WAAS corrects for GPS signal errors caused by ionospheric disturbances, timing and satellite orbit errors, and it provides vital integrity information regarding the health of each GPS satellite.

WAAS consists of multiple widely-spaced Wide Area Reference Stations (WRS) sites that monitor GPS satellite data. The WRS locations are precisely surveyed so that any errors in the received GPS signals can be detected. Two master stations, located on either coast, collect data from the reference stations via a terrestrial communications network and create a GPS correction message. This correction accounts for GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere. The corrected differential message is then broadcast through geostationary satellites with a fixed position over the equator. The information is compatible with the basic GPS signal structure, which means any WAAS-enabled GPS receiver can read the signal.

The WAAS specification requires it to provide a position accuracy of 7.6 meters (25 ft) or better (for both horizontal and vertical measurements), at least 95% of the time. Actual performance measurements of the system at specific locations have shown it typically provides better than 1.0 meter horizontally and 1.5 meters vertically throughout most of the contiguous United States and large parts of Canada and Alaska. In more remote regions of Alaska, values range between 2 and 6 meters horizontally.

Data Processing Methods and Procedures

Position accuracy and quality were monitored using the POSView Controller software to ensure positioning accuracy requirements in the HSSD Section 3.2 were met.

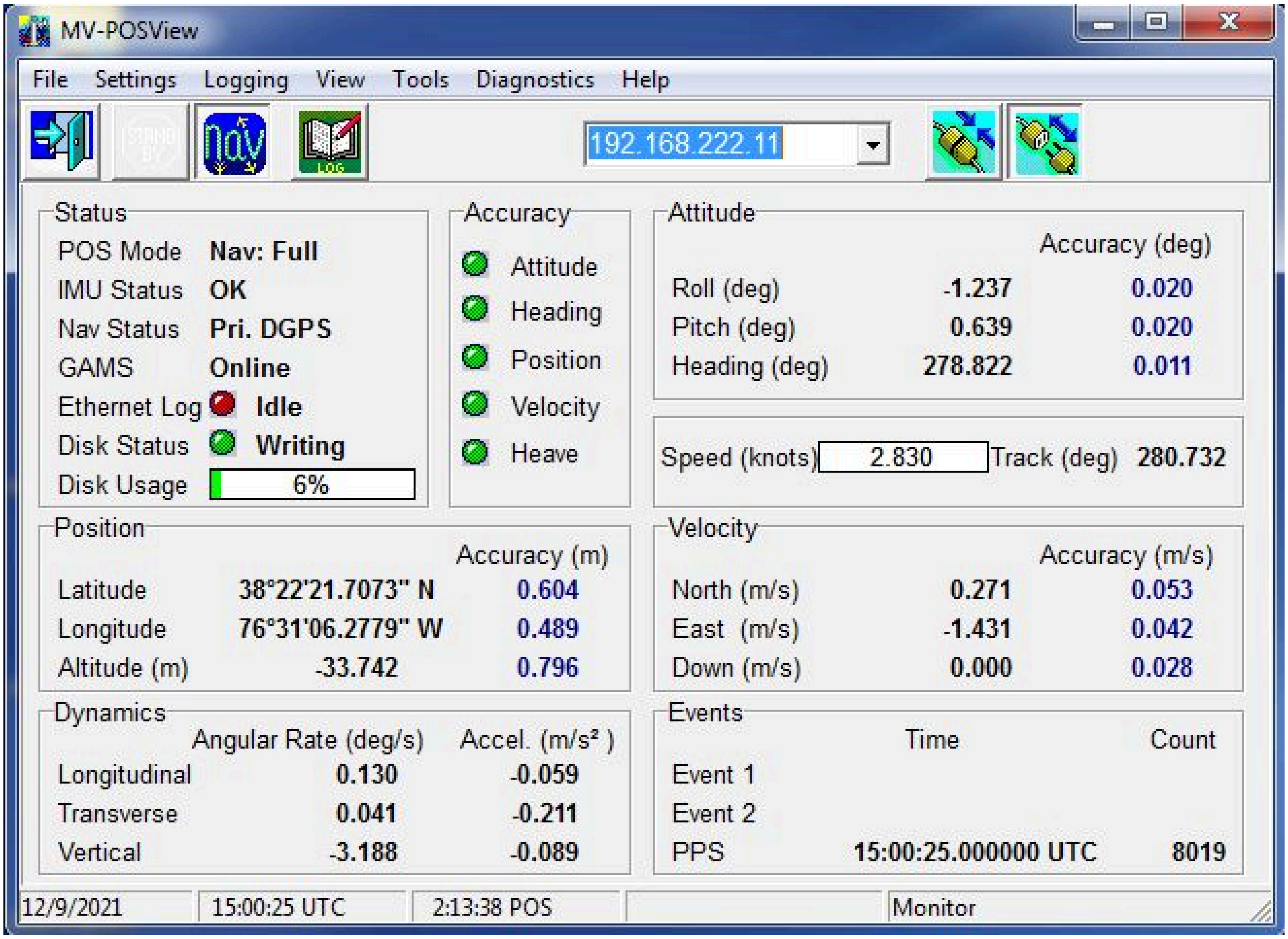

Figure 13: Real Time POS M/V monitoring interface.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

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

R/V BAY HYDRO II performs Ellipsoidally Referenced Surveys (ERS) or VDatum surveys.

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

The raw POSPac file is processed using reference stations (usually CORS Stations) and a Smooth Best Estimate of Trajectory (SBET) is produced via Charlene and POSPac MMS. This SBET is used in CARIS via "Input Auxiliary Data" to calculate the GPS tide, and then merged to generate a surface at the ellipsoid. The separation model provided by the Project Manager is applied to the data to reduce it to the local MLLW datum.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

POS/MV positioning and attitude data are logged and the ZDA (day, month, year, and local time zone offset), GGK (time, position, and fix), and attitude packets are applied in real time to the raw sonar data.

Data Processing Methods and Procedures

The POS/MV file is recorded during acquisition and saved to the network RAW drive. The POS/MV file is loaded, applied to, and merged with the raw sonar data in CARIS via Charlene, using the "Import Auxiliary Data" utility as part of the standard processing flow.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

The CastAway CTD is the primary instrument to acquire sound velocity profiles, unless otherwise stated in the Descriptive Report. CARIS HIPS then utilizes the concatenated sound velocity data as a corrector. Casts are acquired every 2-4 hours during MBES acquisition. Profiles are collected more frequently when current and weather conditions warrant or when SIS indicates a new cast is needed.

Data Processing Methods and Procedures

All SVP casts are processed using HydrOffice's Sound Speed Manager and exported into SIS to be used in real time beam pattern formation. In CARIS, the "Nearest in Distance Within Time of Four Hours" option is used when correcting the data for sound speed unless otherwise noted in the DR.

All SVP casts are processed using HydrOffice's Sound Speed Manager. In CARIS, the "Nearest in Distance Within Time of Four Hours" option is used when correcting the data for sound speed unless otherwise noted in the DR.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed data is directly measured by the Valeport miniSVS for use by the MBES during acquisition.

Data Processing Methods and Procedures

The Kongsberg EM2040 uses the sound velocity profile from the CTD profile for its beam forming equation and only depends on the surface sound speed as a comparison tool to ensure accuracy. This accuracy check is performed by comparing the continuous reading from the surface sound speed profiler to the CTD reading at the same depth. If the two measurements fall outside the range of 0 m/s to 2 m/s, then SIS indicates that a new cast is needed. All surface sound speed is internal to Kongsberg and stored in the .ALL file.

The PicoMBES-120SF uses the surface sound speed for its beam forming equation and only depends on the CTD sound speed profile for post-processing only. An accuracy check is performed by comparing the continuous reading from the surface sound speed profiler to a CTD reading at the same depth.The hydrographer monitors the surface sound speed readings and frequently preforms casts to ensure proper representation of the water column sound speed profile. All surface sound speed is internal to the PicoMBES and stored in the .HSX file.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

TPU is computed using CARIS HIPS. Compute TPU and the CUBE surface Uncertainty child layer is reviewed to ensure all depth measurement uncertainties meet the uncertainty standard in HSSD Section 5.1.3. Uncertainty standards are also confirmed using Pydro QC Tools.

In the CARIS TPU calculation, real time uncertainty values are used, where possible. Real time calculated uncertainties found in the .all file are used for position, sonar, heading, pitch, and roll. The vertical real time uncertainty is from the SBET's RMS file and the tidal uncertainty is derived from the ERS Separation Model.

When real time uncertainty data is not available, the uncertainty values recorded in the HVF are used. These uncertainties come directly from the manufacturers and are typically found in the systems operators manual's specification section.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		S5401
Motion Sensor	*Gyro*	0.02 degrees
	Heave	5.00% 0.05 meters
	Roll	0.02 degrees
	Pitch	0.02 degrees
Navigation Sensor		1.00 meters

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
S5401	The Kongsberg .ALL file contains many realtime uncertainty calculations, however, when processing in Caris, the a priori uncertainty values are used.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

All potentially significant features are divided into three categories. The first, features that are not safe for R/V BAY HYDRO II to approach, are given a cursory visual inspection. If they are visible above the water line, a detached position is calculated. An azimuth and range (via compass and laser range finder, respectively) are measured along with a known vessel position, and photographed from a safe distance. This allows the feature's position to be calculated with a high degree of accuracy without placing the vessel or crew in danger. The features are imported into the Final Feature File (FFF) and S-57 attributed. For unsafe features, the feature is not addressed and referenced as such in the Descriptive Report.

The second category of features are those safe for R/V BAY HYDRO II to investigate. For features in this category, a file is created in CARIS HIPS and SIPS identifying the position of the feature and the area around the feature that is to be ensonified by MBES, called a shape file. This shape file is exported into HYPACK and used by the coxswain during data collection. The MBES development lines are created over the suspected feature in a way that is safest for the vessel and crew, ensonify all sides of the feature, and ensonify the feature with both the port and starboard channels of the MBES. The features are created in CARIS HIPS and SIPS, are S-57 attributed and added to the FFF.

The third category is shoreline features. In the event that shoreline verification is required, or a significant/ assigned feature is only accessible by shore, the Trimble GeoXH is used and a high resolution photograph of the object is taken. This hand held unit is held as high on the object as possible, for a minimum of ten minutes to achieve a positional accuracy of one meter. The data collected with the Trimble is post-processed using the Trimble Pathfinder Office software package, exported to BDB, S-57 attributed, and added to the FFF.

Data Processing Methods and Procedures

See previous section.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Bottom samples are collected at the designated sites by the Project Instructions. Samples are obtained with a Ponar type grab sampler (See Section A.8).

Data Processing Methods and Procedures

All samples are photo logged and classified using the classification system in Chart 1, Section "J", Nature of the Seabed.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

The surface's child layers are reviewed to ensure the surface meets NOAA standards as set forth in the HSSD, and is free from systematic errors. The Hypothesis Count and Hypothesis Strength child layers are reviewed to ensure that fliers are not causing confusion in determining the actual sea floor. The Density layer is reviewed to determine that all the data has the appropriate density as set by the HSSD Section 5.2.2.2. The Standard Deviation layer is reviewed to ensure that all the data lies within the 95% confidence level. The depth layer is reviewed for erroneous soundings. Any erroneous soundings, known as fliers, are flagged as rejected and removed from the surface so the surface more accurately represents the seafloor.

D.1.2 Designated Sounding Selection

Any least depth on a feature that is not accurately reflected in the surface is flagged as “designated” in order to force the surface to reflect that shoaler depth in accordance with HSSD Section 5.2.1.2.3.

D.1.3 Holiday Identification

The depth layer of each resolution grid is reviewed visually for gross holidays (gaps in coverage) by the hydrographer and then run through QC Tools "Holiday Finder" for a more thorough identification of holidays. All holidays are identified and data is later acquired to resolve the gap in data coverage to the best of the hydrographer's ability. In the unusual event that holidays are identified after the survey team has departed the survey area and are unable to return, holidays are digitized in a .HOB file and submitted with the data to the Branch.

D.1.4 Uncertainty Assessment

The uncertainty layer is viewed to ensure that the data has not exceeded specifications as set by the HSSD Section 5.2.3. Pydro's QC Tools are used to further investigate and produce statistics and graphs to whether or not the data meets uncertainty requirements.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Crosslines are collected, processed, and compared in accordance with Section 5.2.4.3 of the HSSD. A CUBE surface is created at the appropriate resolution for the survey area using only mainscheme lines and a second surface is created using only crosslines. Using the two surfaces, a difference surface (mainscheme - crosslines = difference surface) is generated. Statistics are calculated to show the mean difference between the depths derived from the mainscheme and crosslines and reported in the DR. The difference surface is also compared to the IHO allowable total vertical uncertainty (TVU) standards and reported in the DR.

D.1.5.2 Junctions

Junction surveys are performed in accordance with HSSD Section 7.2.2. The process is the same as the crossline to mainscheme review (see paragraph above). The two data set surfaces are differenced using the CARIS Differencing algorithm and difference surface statistics are generated. When the difference surface are in good agreement between the two data sets, the process is complete. If the data sets are found to be in poor agreement, the data will be reviewed to determine if a vessel bias has been introduced into the HVF, a processing error has occurred, or a significant weather event has change in the sea floor. Analyses are documented in the DR.

D.1.5.3 Platform to Platform

In the event R/V BAY HYDRO II is assigned a survey with another vessel, data is consistently reviewed for differences and troubleshooting is performed, as necessary.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

See Section C.2.

D.2.2 Contact Selection Methodology

See Section C.2.

E. Approval Sheet

As Chief of Party, I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

The entire survey is adequate to supersede previous data.

Approver Name	Approver Title	Date	Signature
LTJG Jane D Saunders	Chief of Party	08/03/2023	

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	BHII_2022_System_Configuration.pdf
Sound Speed Sensor Calibration	2023_Castaway_Calibration.pdf 2023_MiniSVS_Calibration.pdf
Vessel Offset	NGS2009.pdf BHII_2010_HSRR_TowPoint_Measurement_Report.pdf 2023_BHII_ERDDM_Report.pdf
Position and Attitude Sensor Calibration	2023 GAMS Calibration.pdf
Echosounder Confidence Check	2023_BHII_Submission Package.zip 2023_BHII_S5401_EM2040C_DH_2023-109_50cm_RefSurface.bag
Echosounder Acceptance Trial Results	N/A