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-J322-KR-22
Time Frame:	October - October 2022

LOCALITY

State(s):	Florida
General Locality:	Louisana

2022

CHIEF OF PARTY
David J. Bernstein, CH, PLS, GISP

LIBRARY & ARCHIVES

Date:

NOAA FORM 77-28
(11-72)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REGISTRY No
F00872

HYDROGRAPHIC TITLE SHEET

INSTRUCTIONS - The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the office.

FIELD No
Geodynamics LLC

State	**Florida**
General Locality	**Approaches to Tampa Bay**
Sub-Locality	**Louisiana**
Scale	**1:10,000**
Date of Survey	**10/01/22**
Instructions Dated	**Draft 9/30/22 / Official 10/24/22**
Project No.	**S-J322-KR-22**
Vessel	**RV Chinook**
Chief of Party	**David J. Bernstein, CH, PLS, GISP**
Surveyed by	**Geodynamics LLC**
Soundings by echo sounder	**Kongsberg 2040C**
Graphic record scaled by	**N/A**
Graphic record checked by	**N/A**
Automated Plot	**N/A**
Verification by	**Atlantic Hydrographic Branch**
Soundings in	**Meters at Mean Lower Low Water (MLLW)**

REMARKS:

NAD83 (2011), UTM Zone 17 North
Times are in UTC
The purpose of this contract is to provide NOAA with modern, accurate hydrographic survey data to update the nautical charts of the assigned area.

SUBCONSULTANTS: **N/A**

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

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Data Acquisition and Processing Report

Geodynamics LLC
Chief of Party: David J. Bernstein, CH, PLS, GISP
Year: 2022
Version: 1.0
Publish Date: 2022-12-12

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 R/V Chinook

<table>
<tr><td>Vessel Name</td><td colspan="2">R/V Chinook</td></tr>
<tr><td>Hull Number</td><td colspan="2">IAR28CATJ607</td></tr>
<tr><td>Description</td><td colspan="2">Geodynamics LLC supplied the R/V Chinook for hydrographic survey operations on S-J322-KR-22. The R/V Chinook is a 9.44 meter catamaran built by Armstrong Marine and conducted 12-hour day operations. The R/V Chinook has the following specifications:</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>9.44 m</td></tr>
<tr><td>Beam</td><td>3.20 m</td></tr>
<tr><td>Max Draft</td><td>0.61 m</td></tr>
<tr><td rowspan="2">Most Recent Full Static Survey</td><td>Date</td><td>2021-04-10</td></tr>
<tr><td>Performed By</td><td>Mike Ulmer, 3Space Inc</td></tr>
<tr><td rowspan="2">Most Recent Full Offset Verification</td><td>Date</td><td>2021-04-10</td></tr>
<tr><td>Method</td><td>The R/V Chinook offset survey was verified / conducted by measurement specialists of 3Space Inc and a team of Geodynamics hydrographers prior to S-J322-KR-22. Survey instrument offsets were measured using a Leica 402 Laser Trackers with Spatial Analyzer software. All measurements were performed multiple times and in varying combinations to reduce uncertainty and measurement errors.</td></tr>
</table>

Figure 1: R/V Chinook

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM2040C Dual

The R/V Chinook was equipped with a dual-head Kongsberg EM2040C Multibeam Echo Sounder System (MBES) with sonar heads pole mounted with a bracket holding the sonar heads at 35°/-35°. Onboard, two Kongsberg processing units (PU) were combined to enable dual swath mode. The dual-head EM2040C utilizes 512 discretely formed beams of a selectable sector up to 200° in equidistant operation mode. At 300 kHz, the EM2040C focuses an across-track and along-track beam width of 1° and 1° respectively. The EM2040C operates at a maximum ping rate of 50 Hz and is designed to comply with International Hydrographic Organization (IHO) standards for depth measurements to a maximum range of 450 meters.

<table>
<tr><td>Manufacturer</td><td colspan="7">Kongsberg</td></tr>
<tr><td>Model</td><td colspan="7">EM2040C Dual</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">R/V Chinook</td><td>Component</td><td>Port Sonar Head</td><td>Stbd Sonar Head</td><td>Processing Unit 1</td><td>Processing Unit 2</td><td>Hydrographic Workstation</td></tr>
<tr><td>Model Number</td><td>EM2040C</td><td>EM2040C</td><td>385406</td><td>385406</td><td>Cinoze DS-1202</td></tr>
<tr><td>Serial Number</td><td>2566</td><td>2565</td><td>20190</td><td>20193</td><td>U743019</td></tr>
<tr><td>Frequency</td><td>300 kHz</td><td>300 kHz</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2022-09-28</td><td>2022-09-28</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>2022-09-28</td><td>2022-09-28</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

Figure 2: Kongsberg EM2040C dual-head sonar on the R/V Chinook pole mount

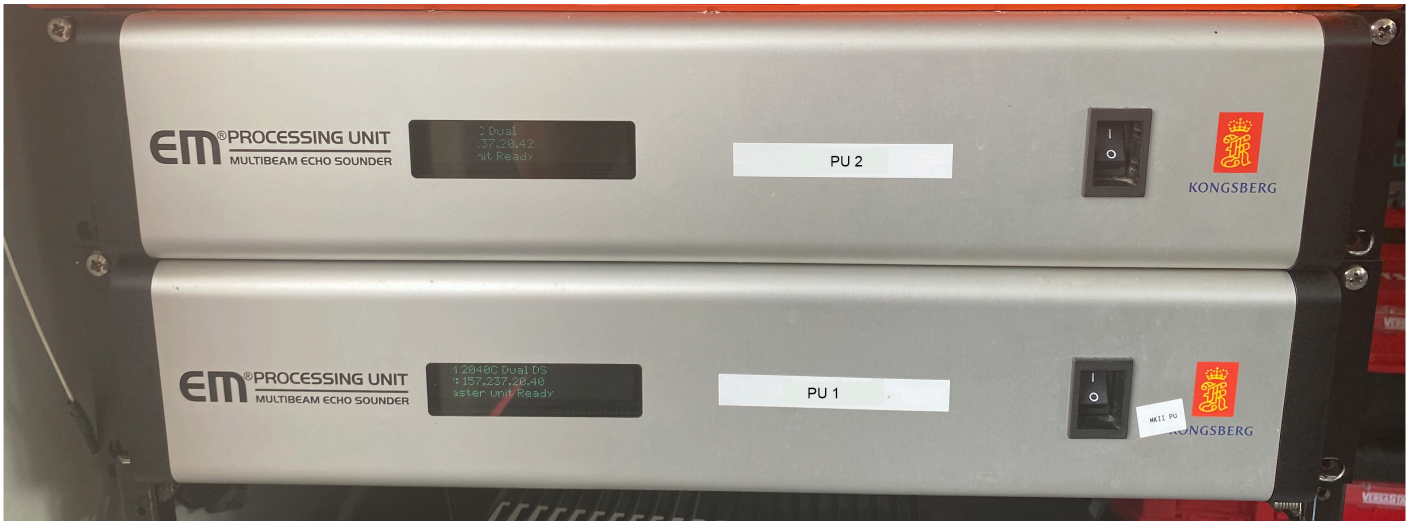

Figure 3: Kongsberg Slim Processing Units (PU) setup in dual swath configuration

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

A.2.3.1 EdgeTech 4205 Tri-Frequency Side Scan Sonar System

The EdgeTech 4205 Tri-Frequency Sonar System is comprised of a stainless steel towfish which is integrated with a topside Transceiver/Processing Unit, which interfaces with a hydrographic workstation operating the EdgeTech Discover software for realtime monitoring and control. The towfish can be configured for frequencies of 230/540/850kHz, and is capable of operating at two frequencies simultaneously.

<table>
<tr><td>Manufacturer</td><td colspan="4">EdgeTech</td></tr>
<tr><td>Model</td><td colspan="4">4205 Tri-Frequency Side Scan Sonar System</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">EdgeTech 4205</td><td>Component</td><td>EdgeTech 4205 Towfish</td><td>EdgeTech Topside Processing Unit</td></tr>
<tr><td>Model Number</td><td>21517</td><td>701-DL</td></tr>
<tr><td>Serial Number</td><td>ETN58227</td><td>57813</td></tr>
<tr><td>Frequency</td><td>230/540/850kHz</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2022-09-28</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>2022-09-28</td><td>N/A</td></tr>
</table>

Figure 4: 4205 Towfish Side View

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 V5 OceanMaster

The survey vessel deployed on S-J322-KR-22 utilized an Applanix POS MV system for positioning, attitude, and precise timing of sonar data. The POS MV is a Global Navigation Satellite System (GNSS) aided inertial navigation system that provides geo-referencing and motion compensation for hydrographic surveys. The POS MV is comprised of four main components: POS Computer System (PCS), Inertial Measurement Unit (IMU), Primary GNSS Antenna, and the Secondary GNSS Antenna.

On the R/V Chinook, positioning and heading were transmitted from the POS MV at 10 Hz and attitude was transmitted at 100 Hz to the Kongsberg sonar over RS232 serial connections. These data were also broadcast to QPS Qinsy software over Ethernet/UDP at 50 Hz for vessel navigation and realtime quality control (QC). To enable post-processing of the position and attitude data from the POSMV system, the data is recorded through ethernet logging to an internal SSD on the acquisition computer and a redundant USB logged file is also recorded on a flash drive inserted in the POSMV PCS unit itself.

The POS MV also provided precise timing for sonar data to the Kongsberg PU via BNC Pulse Per Second cable. Additionally, a NMEA ZDA message was transmitted at 1 Hz from the POS MV to QPS Qinsy and Kongsberg SIS.

The R/V Chinook utilized POS MV firmware version 10.21 and POSView software version 10.2.

During pre-survey calibrations, and when required (equipment failure/change), a POS MV calibration was performed. This calibration included a GNSS Azimuth Measurement System (GAMS) calibration and details can be found in the DAPR Appendix IV.

<table>
<tr><td>Manufacturer</td><td colspan="6">Applanix POS MV V5</td></tr>
<tr><td>Model</td><td colspan="6">OceanMaster</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">R/V Chinook</td><td>Component</td><td>PCS</td><td>Primary GNSS Antenna</td><td>Secondary GNSS Antenna</td><td>IMU</td></tr>
<tr><td>Model Number</td><td>PCS-100</td><td>540AP</td><td>540AP</td><td>IMU 65</td></tr>
<tr><td>Serial Number</td><td>11165</td><td>17980</td><td>17992</td><td>5272</td></tr>
<tr><td>Calibration</td><td>2022-09-28</td><td>2022-09-28</td><td>2022-09-28</td><td>2022-09-28</td></tr>
</table>

Figure 5: POS MV V5 OceanMaster system

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 Satellite-Based Augmentation System (SBAS)

The R/V Chinook received G2+ GNSS satellite corrections from the Marinestar worldwide correction system. SBAS settings in the POS MV were configured to receive the G2+ correction at a frequency of 1545.9375 MHz and bit rate of 1200 bits/second.

Manufacturer	Fugro		
Model	Marinestar Satellite-Based Augmentation System (SBAS)		
Inventory	*R/V Chinook*	*Component*	Marinestar SBAS
		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 Oceanographic AML Micro•X with SV•Xchange

The R/V Chinook utilized an AML Oceanographic Micro•X with SV•Xchange to provide surface sound speed to the Kongsberg PU at 1 Hz over RS232 serial connection. The sensor, installed on the sonar head mount, was powered from a 12 volt power source.

Manufacturer	AML Oceanographic			
Model	AML Micro•X with SV•Xchange			
Inventory	*R/V Chinook*	*Component*	Surface Sound Speed Instrument	SV Sensor
		Model Number	Micro•X	SV•Xchange
		Serial Number	12031	209306
		Calibration	N/A	2022-03-11

Figure 6: AML Oceanographic Micro•X with SV•Xchange

A.6.3.2 AML Oceanographic Base•X2

The AML Base•X2 is a sound speed profiling instrument integrated with time of flight sound speed sensors and pressure sensors to collect sound speed profiles. The Base•X2 transferred sound speed profile data to AML Seacast over Wireless Local Area Network (WLAN) connection and RS232 serial cable when needed. On the R/V Chinook, the Base•X2 was the primary profiling system.

<table>
<tr><td>Manufacturer</td><td colspan="5">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="5">Base•X2</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">R/V Chinook</td><td>Component</td><td>Sounds Speed Profiling Instrument</td><td>SV Sensor</td><td>Pressure Sensor</td></tr>
<tr><td>Model Number</td><td>Base•X2</td><td>SV•Xchange</td><td>P•Xchange</td></tr>
<tr><td>Serial Number</td><td>26270</td><td>200936</td><td>307376</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2022-03-11</td><td>2022-03-11</td></tr>
</table>

Figure 7: AML Oceanographic Base•X2

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	9.4.4	Acquisition
AML Oceanographic	Seacast	4.4.0	Acquisition
Applanix	POSview	10.20	Acquisition
Applanix	POSPac MMS with Trimble Centerpoint RTX	8.7	Processing
Applanix	POS MV Firmware	10.21	Acquisition
Kongsberg	Seafloor Information System (SIS)	4.3.2	Acquistion
Kongsberg	Kongsberg Firmware	1.6	Acquisition
HydrOffice	Sound Speed Manager	2022.1.1	Acquisition
Microsoft	Office 365	2022	Acquisition and Processing
CARIS	HIPS and SIPS (x64)	11.3.13	Processing
CARIS	HIPS and SIPS (x64)	11.4.4	Processing
Chesapeake Technology	SonarWiz	7.10	Acquisition
EdgeTech	4205 Discover Software	42.01.109	Acquisition
Adobe	Acrobat DC	2022.003.20282	Processing
TechSmith	Snagit	2020.1.1	Processing
QPS	Qimera	2.4.8	Processing (Patch Test)
ESRI	ArcPro	3.0.2	Processing
ESRI	ArcGIS Enterprise	10.8	Processing
ESRI	ArcGIS Online	2022	Acquisition and Processing
NOAA (HSTB)	Pydro Explorer	22.1	Acquisiton and Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

No bottom sampling equipment was utilized for data acquisition.

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

A static vessel survey was performed to determine offsets on the vessel deployed on S-J322-KR-22 prior to survey operations. Measurement Specialist, Mike Ulmer of 3Space Inc, performed the most recent static surveys the vessel, on April 10, 2021 in Key West, Florida. This static survey was performed identically in survey scheme and when possible, the static survey re-occupied a variety of previous vessel reference punch marks to ensure quality of the vessel offsets and reference frame measurements. Additionally, the 3Space Inc team are experts in Metrology and have vigorous QC procedures that were employed throughout the survey to ensure accuracy of the calculated vessel offsets. For the static survey, all sensor locations were surveyed, as well as several pre-determined punch mark locations across the vessel frame. The static surveys were conducted with a Leica 402 Laser Scanner and Spatial Analyzer software.

The R/V Chinook is configured such that position and attitude are output from the POS MV at the sonar reference point. The sonar reference point is defined as the tangent point between each sonar head in the dual-head configuration. The location and angular offsets from the tangent reference point to each sonar head, and also the waterline, are entered into SIS. Identical vessel offsets were input in the Qinsy vessel template database (.DB) file for real-time display of corrected sonar data during acquisition.

Figure 8: Static survey of R/V Chinook

B.1.1.1 Vessel Offset Correctors

Vessel offset correctors were not applied.

B.1.2 Layback

Manual layback methods were used to calculate towed distance behind the vessel by incorporating the cable out read from the 1 meter increments, and incorporated into the manual layback driver on the fly, using a catenary factor of 0.7. Given the relatively consistent depths of the survey area, a layback value of 15 m was used for most of the survey and changed only as necessary in a few deeper areas to maintain the altitudes of 6-20% of the range scale.

Layback correctors were applied in real time in QPS Qinsy and the layback corrected position of the tow fish was integrated in the Discover software. Offsets from the established vessel reference frame to the towpoint were integrated in QPS Qinsy. Reference section C.2.2. for more information on layback correctors.

B.1.2.1 Layback Correctors

Vessel	IAR28CATJ607		
Echosounder	Edgetech 4205		
Frequency	850.0 kHz		
Date	2022-09-28		
Layback	*Towpoint*	*x*	-5.060 meters
		y	0.000 meters
		z	-2.320 meters
	Layback Error	0.000 meters	

B.2 Static and Dynamic Draft

B.2.1 Static Draft

This project incorporated an Ellipsoid Referenced Survey (ERS) workflow and as a result, static draft was accounted for in the soundings by using post-processed ellipsoid-based corrections in addition to the realtime corrections. The combined correctors work to factor out the static draft, squat, and settlement of the survey vessel.

B.2.1.1 Static Draft Correctors

Static draft correctors were not applied.

B.2.2 Dynamic Draft

This project incorporated an ERS workflow and as a result, dynamic draft was accounted for in the soundings by using post-processed ellipsoid-based corrections in addition to the real-time corrections. The combined correctors work to factor out the static draft, squat, and settlement of the survey vessel.

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 the survey vessel prior to arrival of survey site to establish installation mounting biases between the attitude reference frame and the sonar reference frame. The patch tests also determined any latency bias between the sonar systems and positioning systems. Patch tests were conducted prior to the start of data acquisition and whenever a major system hardware change was made. Patch tests were conducted in accordance with section 5.2.4.1 of the March 2022 Hydrographic Survey Specifications and Deliverables (HSSD). Patch test data were assessed in QPS Qimera by multiple hydrographers to issue an uncertainty associated with the patch test biases. Patch test biases for the R/V Chinook were entered into SIS as well as the Qinsy .DB file. Additionally, these patch test biases are entered into the appropriate locations in the CARIS HVF. To ensure quality in system alignment and the integrity of the sonar data, daily roll lines were collected on the R/V Chinook since this vessel utilized a deployable over-the-side pole mount.

B.3.1.1 System Alignment Correctors

Vessel	R/V Chinook		
Echosounder	Kongsberg EM2040C Dual		
Date	2022-09-28		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	0.850 degrees	0.050 degrees
	Roll	35.558 degrees	0.050 degrees
	Yaw	0.120 degrees	0.085 degrees
	Pitch Time Correction	0.000 seconds	0.001 seconds
	Roll Time Correction	0.000 seconds	0.001 seconds
	Yaw Time Correction	0.000 seconds	0.001 seconds
	Heave Time Correction	0.000 seconds	0.001 seconds

Date	2022-09-28		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	0.950 degrees	0.050 degrees
	Roll	-35.315 degrees	0.050 degrees
	Yaw	359.110 degrees	0.085 degrees
	Pitch Time Correction	0.000 seconds	0.001 seconds
	Roll Time Correction	0.000 seconds	0.001 seconds
	Yaw Time Correction	0.000 seconds	0.001 seconds
	Heave Time Correction	0.000 seconds	0.001 seconds

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

All data planning, calibrations, acquisition, processing, quality control (QC), quality assurance (QA), and reporting were performed under the direct supervision of the Chief of Party. Field data collection and processing were done under the supervision of a highly qualified team including the Chief of Party, Lead Hydrographer, Senior Hydrographer, and Data Processing Manager. Chief of Party David Bernstein and Lead Hydrographer Nick Damm are both ACSM-NSPS-THSOA Certified Hydrographers.

Prior to the start of data acquisition, and following static vessel surveys and verification measurements, a series of calibrations and tests took place on the vessel to prepare and validate the setup and integration of all survey systems across all vessels. These procedures included navigation/GAMS calibrations, patch tests, performance checks, and a water level float test.

MBES data were acquired with concurrent Side Scan Sonar, in accordance with HSSD Section 5.2.2.4 Set Line Spacing Option A (refer to Project Instructions and Correspondence). A line plan was created to provide coverage of the centerline and quarters within the maintained channel in the survey area. MBES data were collected to provide continuous along-track coverage. Any significant shoals or obstructions identified during survey were developed to object detection standards as required by the project instructions.

R/V Chinook utilized Qinsy for navigation, monitoring of system health, data logging, real-time progress tracking, and QC assessments.

The R/V Chinook was configured with a dual-head, dual swath EM2040C system by synchronizing two Kongsberg PUs to provide approximately twice the along-track data density. The sonar system was aided by the POS MV, which provided real-time QC of position and attitude data, and logged ancillary POSPac data (.000 files) for post-processing. The Kongsberg system was controlled with SIS software and operated at 300 kHz. Additionally, the Kongsberg system had absorption coefficients adjusted for saltwater in SIS and operated in “Normal” mode with “Auto” pulse width. Multibeam bathymetry data collected with the Kongsberg EM2040C systems were stored in the .ALL file.

Throughout the survey, a series of QC measures were taken to ensure that the survey data met the specifications of the PI and HSSD. Hydrographers on the vessel collected a daily set of “roll lines” to assess any potential biases ensued from daily deployment of the over-the-side sonar mount. Vessel speed and sonar coverage were monitored and adjusted when environmental conditions negatively impacted data quality.

Data Processing Methods and Procedures

Multibeam data processing was accomplished with Charlene, CARIS HIPS, and POSPac MMS. Initial data processing consisted of data transfer, file conversion, SBET/SMRMSG generation, application of Delayed Heave and SBET/SMRMSG data, georeferenced bathymetry (application of GPS Tide and TPU calculation), and CUBE surface generation (Phase 1). To quickly ensure no shoals or navigational hazards existed, data were reviewed in both Qinsy and CARIS HIPS in real-time by the hydrographer. Immediately following acquisition, data were transferred via Charlene from portable solid-state drives (SSD) to the network attached server (NAS). Charlene is an automated file transfer and batch data processing utility within Pydro Explorer developed by the National Oceanic and Atmospheric Administration (NOAA) Hydrographic Systems and Technology Branch (HSTB). Charlene automated processing steps such that an initial surface and related QC data were generated before the next survey day. Phase 1 QC included assessing initial QC Tools results, SBET QC, surface inspection, assessment of data quality and system performance, and daily survey reporting.

Phase 2 processing began with a thorough QC of data quality using the CUBE surfaces followed by data cleaning and feature identification/designation.

Phase 3 processing included QC and finalization of features/designations and bathymetric surfaces. During this stage rigorous QC was performed to ensure completeness and adequacy of the final deliverables and associated reporting.

All processing of the multibeam data were conducted in the CARIS HIPS and SIPS version 11.3.13, however, this version of CARIS stopped properly displaying any designated soundings. The proper display and selection of designated soundings in the CARIS .hips file was able to be confirmed and re-generated in CARIS HIPS and SIPS version 11.4.4. Final surface generation was conducted using the CARIS HIPS and SIPS version 11.4.4; final surfaces were then compared to ensure that there was no difference between the surfaces generated by the two different CARIS versions.

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 bathymetric surfaces were computed from fully corrected data in CARIS HIPS using CUBE algorithms specified in the CUBEParams_NOAA_2022.xml and standards specified in section 5.2.2 of the HSSD. Parent surfaces and depth controlled finalized surfaces were provided in CSAR format for this survey.

C.1.4.2 Depth Derivation

Prior to finalizing surfaces, data were thoroughly and redundantly reviewed for completeness and adherence to specifications in the HSSD. Outer beam clipping filters and manual data cleaning were utilized to clean erroneous swath data that adversely affected the surface. Processed soundings and features were reviewed in Subset Editor using both 2D and 3D views to ensure accurate designation of critical soundings were performed. Line queries were performed to ensure all data had consistent and complete correctors applied. Finalized surfaces were computed utilizing the “Apply Designated Sounding” function such that the surface represented each designated sounding depth. Uncertainty of the finalized surface was assigned from either uncertainty or standard deviation, whichever is greater.

C.1.4.3 Surface Computation Algorithm

The 2022 NOAA CUBE Parameters were used for CUBE surface computation. Surface generation used the following settings:

Gridding Method: CUBE
Bounding Polygon Type: Buffered
IHO Order: 1a
Disambiguation Method: Density and Local
Cube Configuration: NOAA_4m

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

Multibeam backscatter data collected with the Kongsberg EM2040C system were stored in the .ALL file.

Data Processing Methods and Procedures

Backscatter mosaics were not required for this project.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

R/V Chinook deploys Side-Scan Sonar (SSS) towed astern, running through a block and sheave on the aft A-frame. The SSS was operated in dual frequency mode at 540/850kHz, with the range scale set to 75m. The towfish altitude was maintained at 6-20% of the range scale (as specified in the project instructions). The vessel speed was maintained between 2.5-3.0 meters per second, so that with the ping rate at 10Hz, the acquisition parameters in Section 6.1.2.2 of the HSSD were adhered to. The trajectory of the horizontal positioning of the towfish incorporated the vessel's heading calculated by course made good. This calculated position was sent from Qinsy to the Discover acquisition software as a NMEA-GGA string for incorporation in the recorded *.jsf files. Files were split at 500 mb for data management or at the end of a survey line.

The near-realtime waterfall display of SSS imagery was closely monitored for image quality degradation due to motion, refraction or prop wash. Although little can be done to address most refraction issues, changes to vessel speed or altitude of the towfish can and were adjusted in attempt to restore data quality when degradation was observed.

Daily confidence checks were performed to ensure proper identification and positioning of potential features, by marking targets in the acquisition software of visible, distinct features in both the port and starboard beams of the SSS. Confidence checks were recorded in the daily acquisition logs. Any targets identified during acquisition were compared to the MBES coverage to initiate further target investigation if deemed necessary. All identified SSS contacts were developed to complete coverage requirements, with the least depth determined from MBES beams within 30° of NADIR.

Data Processing Methods and Procedures

Data were recorded using Discover software, and exported to a .jsf format which was used for post processing analysis, and mosaic creation. To ensure no shoals or navigational hazards existed, data were reviewed in Discover in realtime by the hydrographer. Immediatly following acquisition, the .jsf data were transfered from the portable solid-state drives (SSD) to the network attached server (NAS). The 850 kHz frequency channels were processed using CARIS SIPS through the Charlene automation tool available through the HydrOffice. As no separate vessel position or cable out values were recorded, and towpoint offsets were zero in the vessel file (applied in realtime), CARIS read the recorded GGA position as that of the vessel, and translated that directly to the towfish, using the sensors gyro for heading. CARIS automatically bottom tracked the data, which was manually reviewed and edited by the hydrographer as necessary. A Beam Pattern file (.bbp) was generated, which averages the intensities by angle, across the data set, and was then applied when creating the SSS mosaic to produce more consistent images. The final mosaic was created at a 1m x 1m resolution, incorporating the beam pattern file, transmit and receiver gain values, and Time Varied Gain (TVG) corrections.

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

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

The R/V Chinook received G2+ GNSS satellite corrections from the Fugro Marinestar SBAS directly through the Applanix POS MV to provide real-time corrections to positioning. The Marinestar G2+ service provides corrections for GPS and GLONASS from a network of base stations around the world via geostationary satellites. Solution status was continuously monitored through the POSView controller software for dropouts or degraded accuracy.

Data Processing Methods and Procedures

For all hydrographic survey activities, POSPac data were collected through the POSView controller via Ethernet Logging and/or USB Logging. All position data were post-processed in POSPac MMS software using Trimble Centerpoint RTX solutions. The SBET was applied in CARIS HIPS to overwrite all position and attitude data and improve upon the real-time Marinestar G2+ accuracies, while minimizing Total Horizontal Uncertainty (THU).

For all processed positions and data products (other than the S-57 Final Feature File), the horizontal datum is North American Datum of 1983 (NAD83) (2011) Universal Transverse Mercator (UTM) Zone 17N, as required by the HSSD.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

All surveys utilized an ERS workflow to reduce ellipsoid derived depths to chart datum.

All survey vessels received G2+ GNSS satellite corrections from the Fugro Marinestar SBAS directly through the Applanix POS MV to provide real-time corrections to ellipsoid heights. Solution status was continuously monitored through the POSView controller software for dropouts or degraded accuracy.

As dictated in the PI, water levels were determined from ellipsoid measurements throughout this ERS and soundings were reduced to Mean Lower Low Water (MLLW) by way of a provided VDatum Separation (SEP) model. Following pre-survey calibrations, a “float test” was performed with the R/V Chinook to ensure the quality of the GNSS corrections, SEP model, and survey systems integrations. The vessel remained stationary while nearby National Ocean Service (NOS) Water Level Station 8726520 – St. Petersburg, FL and recorded the MLLW elevation of the water surface. This information was compared to the near realtime water level data collected at Station 8726520 for the same time period and showed agreement.

Data Processing Methods and Procedures

NOAA’s HSD OPS provided a VDatum SEP model package with the PI, the MLLW geoid12b SEP model within this package was utilized. All ellipsoid data were post-processed using the Applanix POSPac MMS software. Post-processed corrections were implemented with Trimble’s CenterPoint RTX service. The SBET was applied in CARIS HIPS to overwrite all position data, improve upon the real-time Marinestar G2+ accuracies to minimize Total Vertical Uncertainty (TVU), and transform the data to the desired vertical datum before SEP model application. The NAD83-MLLW_geoid12b SEP model was then utilized in CARIS HIPS to reduce the sonar data to MLLW.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

Vessel position, attitude, and trajectory data were acquired and logged with an Applanix POS MV v5. All vessels had the offsets between the Primary GNSS antenna and IMU Reference Point precisely measured and entered into the POSView controller software prior to data acquisition (see DAPR Appendix III). Additionally, vessel offsets to the tangent point of the sonar heads were entered into POSView as the Sensor 1 offset location. Prior to the start of surveys, GAMS calibrations were performed to align the Secondary GNSS antenna with the Primary GNSS antenna and IMU alignment with respect to the vessel reference frame. See DAPR Appendix IV for additional information on vessel offsets, configuration, and calibration. For the duration of the project, all survey vessels maintained subscriptions with Fugro’s Marinestar Global Correction System and received G2+ corrections. Position, attitude, and trajectory data were logged via Ethernet Logging and/or USB Logging whenever survey activities occurred. This included five minutes before and after acquisition for adequate post-processing of kalman filtered data.

Data Processing Methods and Procedures

All position and attitude data were post-processed using Applanix POSPac MMS software and Trimble CenterPoint RTX corrections to produce an SBET file with centimeter level positioning accuracy. Post-processed solutions were reviewed for position and elevation RMS accuracies and altitude consistencies prior to exporting the SBET at the MBES systems’ reference point. The SBET position data were applied to the sounding data in CARIS HIPS and further reviewed for error or inconsistencies in the post-processed data. All integrated SBETs were accompanied with a SMRMSG file for post-processed position and attitude error contributions to TPU estimates.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

All sound speed instruments utilized AML Oceanographic X•change sensors, which were calibrated within one year of survey operations. Calibration certificates can be viewed in DAPR Appendix II. On the R/V Chinook, sound speed profiles were collected using Base•X2 instruments equipped with pressure and time-of-flight sound speed sensors. Casts were routinely conducted approximately every two hours or less, and no greater than four hours, depending on conditions. Profilers were deployed and recovered by hand using a Cannon Lake-Troll Manual downrigger spooled with 300lb braided ultra-high-molecular-weight polyethylene line, recording samples at 1 Hz. Once retrieved, profile data were automatically sent to SeaCast via WLAN connection. SeaCast was setup to calculate sound velocity for saltwater, use UTC time, record in meters, split the up/down cast, and delete out of range or invalid points. Casts were reviewed and the down casts were then exported as .vel files to a folder monitored by Qinsy. The .vel files were applied automatically in Qinsy and imported into the SSM database, attributed a position from a SSM/SIS communication link, and then transmitted to SIS as an extended .ASVP file. Each vessel's daily casts were exported as an .SVP file from SSM for post-processing.

Data Processing Methods and Procedures

Sound speed profiles collected during acquisition were thoroughly reviewed for date, time, location, depth of cast, and erroneous data. Profiles were then stored in the vessel's Raw and Processed SVP folders and also a master cast file. The profiles applied to the data in SIS during the survey were maintained throughout post-processing (i.e., not re-SV corrected in HIPS).

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

For real-time beam forming and sound speed depiction of the upper water column, the vessel used a Micro•X sound speed instrument mounted at the sonar heads. The Micro•X transmitted sound speed data (m/s) through a serial RS232 connection at 1 Hz. The systems received the surface sound speed data on the operator station through SIS.

Data Processing Methods and Procedures

In both Qinsy and SIS, an alarm was set to warn the hydrographer when real-time surface sound speed and the most recent profile differed by more than 2 m/s. Real-time surface sound speed was plotted geographically in SSM on each vessel and in the PMA for additional QC and guidance of operations.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

TPU was calculated to provide an assessment of quality for the position and depth of individual soundings. Many aspects of the TPU model are based on manufacturer RMS values, while others can be more accurately modeled and minimized throughout the mobilization, acquisition, and processing phases. The

HVF contains all of the 1-sigma RMS values for the survey equipment used throughout the project for each vessel. Values for the position and attitude uncertainties are provided by Applanix, while uncertainty values with respect to sonars and frequencies are built-in to the HIPS device library. To more accurately model position uncertainties, inputs for position/navigation, and GPS height were overwritten with 1-sigma RMS values stored in the SMRMSG file associated with each SBET file. Other values stored within the HVF include lever arm distances, measurement error, and patch test uncertainties. Potential uncertainties with lever arms were minimized by performing static vessel surveys using laser tracking methods to locate sensors with respect to each other and the vessel reference frame to within millimeters. Uncertainties for the alignment of sensors were minimized by integrating SBET solutions to more accurately determine biases from the patch tests. Patch tests were evaluated by multiple hydrographers to calculate standard deviation values for Motion Reference Unit (MRU) alignment for gyro and roll/pitch biases, which were placed in the HVFs accordingly.

During acquisition, careful consideration was made to minimize artifacts and their contribution to uncertainty. Hydrographers made considerable efforts to reduce the impact of sound speed issues during acquisition. These efforts included increasing the frequency of casts, closely monitoring real-time swath “smiling” or “frowning”, utilizing alerts for surface-to-profile sound speed deviation, observing the real-time standard deviation map display, and utilizing SSM to track spatial changes in surface sound speed along with profile location. When sound velocity had drastic spatial variation, the survey approach would be constrained to areas of similar water properties to avoid large refraction issues.

TPU calculations are performed using the CARIS HIPS Compute TPU process. The Compute TPU process utilizes the a-priori uncertainty estimates, the “real-time” estimates from the SMRMSG data, information from the CARIS sonar device library, and static values set for water level and sound speed uncertainty to calculate the estimated horizontal and vertical TPU for each sounding.

Uncertainty of the SEP model used to reduce soundings from NAD83 (2011) to MLLW was provided in the PI (0.129 m at 2 sigma) and 0.13 was entered into the “Tide Zoning” field of the Compute TPU process. Uncertainty input to “Sound Speed - Measured” was derived from the field tolerance of 2 m/s deviance between surface and profile sound speed and the temporal distribution of casts (~2 hours). The "Sound Speed - Surface" value of 0.05 m/s reflects manufacturer accuracy at 2-sigma.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		R/V Chinook
Motion Sensor	*Gyro*	0.02 degrees
	Heave	5.00% 0.05 meters
	Roll	0.01 degrees
	Pitch	0.01 degrees
Navigation Sensor		0.10 meters

C.6.2.2 Real-Time Uncertainty

Real-time uncertainty was not applied.

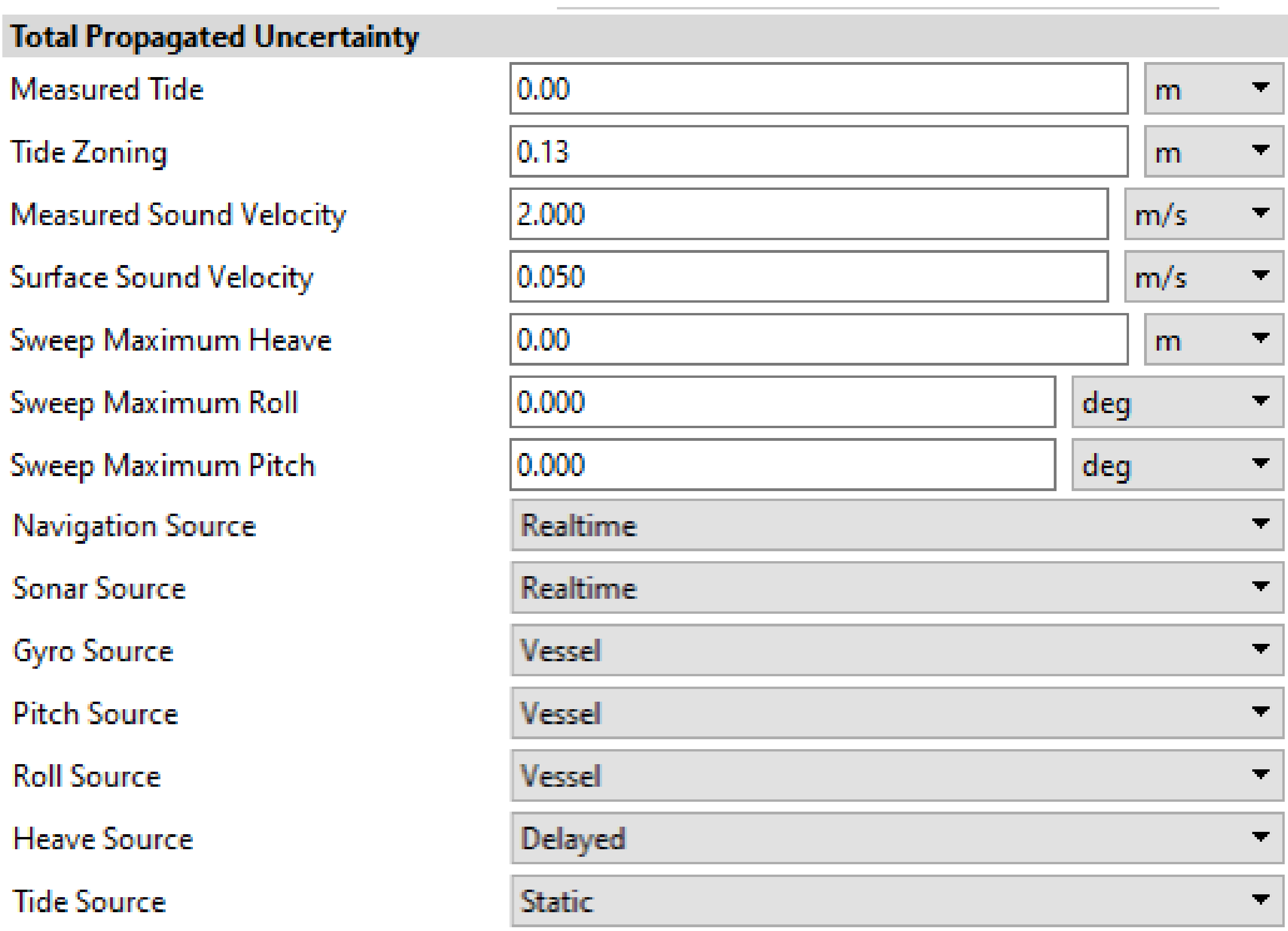

Figure 9: Uncertainty estimates parameters in the CARIS HIPS TPU Dialog within the georeference bathymetry process

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

No shoreline investigatons or shoreline data collection were required for S-J322-KR-22.

Assigned features and new features identified during multibeam data acquisition were investigated and developed in accordance with the HSSD, the PI, and guidance from the HSD Project Manager. Additional MBES coverage was acquired when necessary to adequately determine the least depth of features.

Data Processing Methods and Procedures

Feature data processing consisted of addressing all assigned features in the Composite Source File (CSF) provided with the PI package and adding all new features to a single S-57 file for each survey. All multibeam data were reviewed for features, and least depths over navigationally and/or potentially significant features were flagged as “designated soundings” in CARIS. Development of each feature was completed in accordance with the HSSD. Each feature included in the FFF was supplied a unique identifier, attributed in the Unique ID field of the FFF. Associated images in the FFF utilized the unique identifier as a filename, followed by a letter to distinguish each image.

C.8 Bottom Sample Data

Bottom sample data was not acquired.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

Direct editing of soundings were performed to clean spurious and erroneous data that adversely affected the final surface and depth determination of features. In addition to visual assessment and cleaning from the bathymetric surface, many derivative layers computed from the bathymetric surface and sounding data were used to guide data cleaning, assess quality, and illustrate adherence to the HSSD. Node standard deviation, standard deviation, uncertainty, and TVU-ness were surface layers commonly used in data cleaning and quality assessments. In addition to a visual inspection, all CUBE surfaces were analyzed using Hydro Office QC Tools Flier Finder tool to assure data does not contain fliers (anomalous data as defined by QC Tools flier finding algorithms #2-6). The tool was run with the standard presets and results were used to guide data editing.

D.1.2 Designated Sounding Selection

Designated sounding selection followed specifications in the HSSD. The CARIS HIPS Subset Editor was utilized to view soundings and the CUBE surface in 2D and 3D. Erroneous sounding data were cleaned, and a least depth was designated when necessary. Routinely and before surface finalization, the critical soundings layer in CARIS HIPS, which contains designated soundings, was regenerated for QA/QC purposes.

D.1.3 Holiday Identification

All CUBE surfaces were analyzed using Hydro Office QC Tools Holiday Finder to determine if the surface contained holidays, as described in section 5.2.2 of the HSSD. Additional examination of any survey gaps was conducted to identify any survey surface gaps greater than 3 nodes in the along track direction, as directed by the project instructions. The tool scanned the CUBE surfaces to identify any holidays and generated an S-57 file to represent the locations of holidays. Another method of holiday evaluation was to visually pan the CUBE surfaces to identify holidays. The hydrographer would often alter the surface display (color ranges, symbology, shading) to help aid in identifying coverage gaps. During survey operations, holidays and coverage gaps were compiled into a shapefile line plan and loaded into Qinsy on the vessel for recovery.

D.1.4 Uncertainty Assessment

All CUBE surfaces were analyzed using the HydrOffice QC Tools Grid QA tool to assure at least 95% of the surface grid nodes meet TVU specifications. Results of the Grid QA tool are illustrated in a graphical representation of the surface uncertainty statistics.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

The requirement to complete crosslines were waived in the PI.

D.1.5.2 Junctions

The requirement to complete junctions were waived in the PI.

D.1.5.3 Platform to Platform

Vessel to vessel confidence checks were acquired prior to survey operations to assess confidence between the survey vessel and their respective survey systems. Confidence checks were assessed in CARIS HIPS by evaluating the agreement of sounding data as well as assessing statistics derived from vessel to vessel surface differences. Results of confidence tests can be found in DAPR Appendix V.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Coverage is assessed in accordance with HSSD 2022 and the PI. Any sections of the SSS processed imagery which is of a degraded quality that would prevent the detection a object 1m x 1m x 1m object would be rejected.

Automated and visual methods are used to inspect surface coverage: ArcGIS tools are used to automatically identify coverage of deficiencies; surfaces are inspected against brightly colored background for visible gaps in coverage.

D.2.2 Contact Selection Methodology

Processed SSS lines are examined in CARIS Hips and Sips, and a log of each line review was maintained to ensure that each line of processed SSS data was examined independently by at least two trained hydrographers.

The contact heights are determined through shadow length measurement and a slant range correction. During the initial imagery review, potential contacts which show calculated contact height above the seafloor which are at least 90% of the minimum height required by the HSSD 6.1.3.3, are measured and added to the CARIS .hips file. For example: in depths of water less than or equal to 20m, contacts are picked that have computed target heights rising 0.9m above the seafloor; in depths of water greater than 20m, contacts are picked with a computed height at least 4.5% of the water depth. The implementation of contact selection criteria which is slightly broader than those defined in the 2022 HSSD, is meant to account for any human error in the measurement of shadow length from the processed SSS imagery. Any objects which had a notable sonargram signature may have also been selected at the hydrographers discretion.

All of contacts which are initially selected, receive a final evaluation by the Lead Hydrographer, and every contact which meets the selection criteria for contact selection from 6.1.3.3, is then retained in the CARIS .hips file while all others were removed. The deliverable Side Scan Sonar Contact File was created using the "SSS Contacts to Geopackage-S57" tool within HydrOffice, following the steps outlined the associated SOP. Each object in the contact file was exported as an S-57 file with the attributions listed in 6.1.3.4.

E. Approval Sheet

As Chief of Party, field operations contributing to the accomplishment of Survey F00872 were conducted under my direct supervision, with frequent personal checks of progress and adequacy. This report and accompanying data deliverable have been closely reviewed and are considered complete and adequate as per the Statement of Work (October 24, 2022).

The survey data meets or exceeds requirements as set forth in the Hydrographic Surveys Specifications and Deliverables 2022, Project Instructions (October 24, 2022), and Statement of Work (October 24,2022). These data are adequate to supersede charted data in their common areas.

This report and the accompanying data deliverable are respectfully submitted.

Approver Name	Approver Title	Date	Signature
David J. Bernstein CH, PLS, GISP	Chief of Party	12/12/2022	David J. Bernstein Digitally signed by David J. Bernstein Date: 2022.12.12 17:20:38 -05'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	I_Vessel_Wiring_Diagrams.pdf
Sound Speed Sensor Calibration	II_Sound_Speed_Sensor_Calibration_Reports.pdf
Vessel Offset	III_Vessel_Offset_Reports.pdf
Position and Attitude Sensor Calibration	IV_Position_Attitude_Sensor_Calibration_Reports_Title_Page-combined.pdf
Echosounder Confidence Check	V_Echo_Sounder_Confidence_Check_Reports.pdf
Echosounder Acceptance Trial Results	