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National Ocean Service

Data Acquisition & Processing Report

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Project Number:	OPR-F324-FH-23
Time Frame:	May - October 2022

LOCALITY

State(s):	North Carolina
General Locality:	Wilmington, North Carolina

2023

CHIEF OF PARTY
Commander William Winner, NOAA

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Date:

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Data Acquisition and Processing Report

NOAA Ship *Ferdinand R. Hassler*
Chief of Party: Commander William Winner, NOAA
Year: 2023
Version: 1.0
Publish Date: 2023-10-21

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 NOAA Ship FERDINAND R. HASSLER

Vessel Name	NOAA Ship FERDINAND R. HASSLER	
Hull Number	S250	
Description	FERDINAND R. HASSLER is a Small Waterplane Area, Twin-Hull (SWATH) coastal mapping vessel.	
Dimensions	*LOA*	37.7 meters
	Beam	18.5 meters
	Max Draft	3.85 meters
Most Recent Full Static Survey	*Date*	2019-03-18
	Performed By	IMTEC
Most Recent Partial Static Survey	*Date*	2012-06-12
	Performed By	Kevin Jordan, NGS
Most Recent Partial Offset Verification	*Date*	2013-04-07
	Method	Optical level run while ship was out of drydock. A level loop was run from the POS antenna to each sensor mounted on the ship's hull. In addition, measurements were made to both IMU base plates through the sonar cable passage. The resulting offsets from this survey were used to verify and update Z offsets between all sensors. IMTEC performed a new vessel survey of the FERDINAND R. HASSLER, with offsets relative to Granite Block during the EM 2040 install 15-18 March, 2019 and is included in the Appendix.

Figure 1: NOAA Ship FERDINAND R. HASSLER

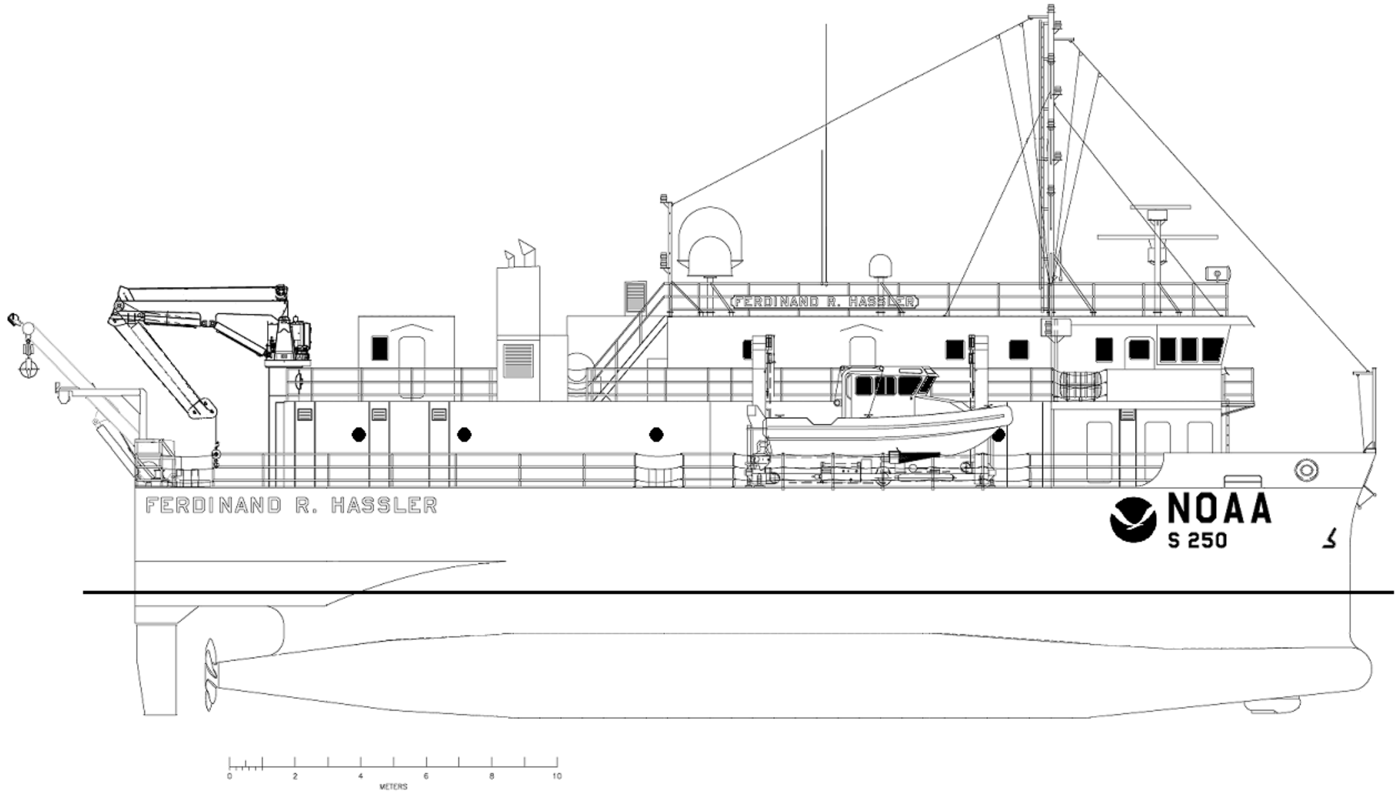


Figure 2: NOAA Ship FERDINAND R. HASSLER, starboard view

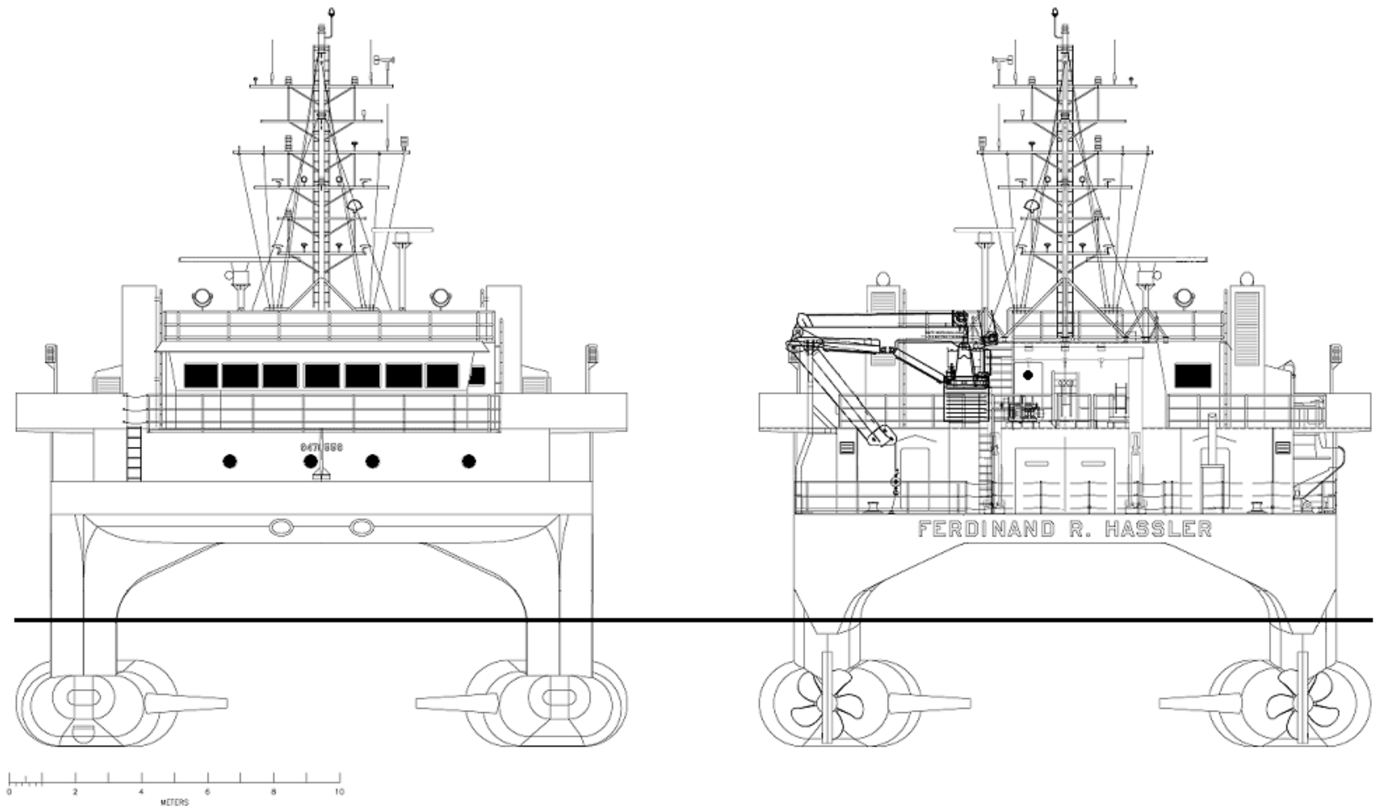


Figure 3: NOAA Ship FERDINAND R. HASSLER, bow and stern views

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM 2040

The EM 2040 Dual TX Dual RX system is comprised of two EM 2040 systems in a Master/Slave configuration, with one installed on each hull of R/V FERDINAND R. HASSLER. The systems are angled outward at an angle of 4°, and are approximately 15 meters apart.

The EM 2040 is capable of operating at low frequency (200kHz), intermediate frequency (300 kHz), and high frequency (400 kHz), with a maximum swath coverage of 150°. At the common usage frequency of 300 kHz, the beam width is 1° for both TX and RX. The system forms 256 beams, with dynamic focusing employed in the near field. The system forms 400 soundings per swath with an equidistant beam spacing. The transmit beams are divided into two sectors which transmit sequentially with each ping, using the frequencies to maximize range capability and to suppress interference from multiples of strong bottom echoes. The typical operational depth range for the EM 2040 is 0.5 to 350m.

The ship system was fully calibrated in the 400kHz mode in May 2021 in near Cape Charles, VA. In February 2023, a patch test was conducted; however the numbers were so similar to those from 2021, that the HVF was not changed. To confirm the alignment, a reference surface was produced and compared to the Ferdinand R. Hassler surface from 2022 and the NOAA Ship Thomas Jefferson surface from 2020 - both results had a favorable comparison.

Manufacturer	Kongsberg				
Model	EM 2040				
Inventory	*S250 Starboard*	*Component*	Processing Unit	Receiver	Transducer
		Model Number	n/a	EM 2040	EM 2040
		Serial Number	40156	394	297
		Frequency	n/a	200-400kHz	200-400kHz
		Calibration	2023-02-27	2021-05-08	2021-05-08
		Accuracy Check	N/A	2023-02-25	2023-02-25
	S250 Port	*Component*	Processing Unit	Receiver	Transducer
		Model Number	n/a	EM2040	EM2040
		Serial Number	40144	389	285
		Frequency	n/a	200-400kHz	200-400kHz
		Calibration	2023-02-27	2021-05-08	2021-05-08
		Accuracy Check	N/A	2023-02-25	2023-02-25

Figure 4: EM 2040 gondola installed in one hull of S250.

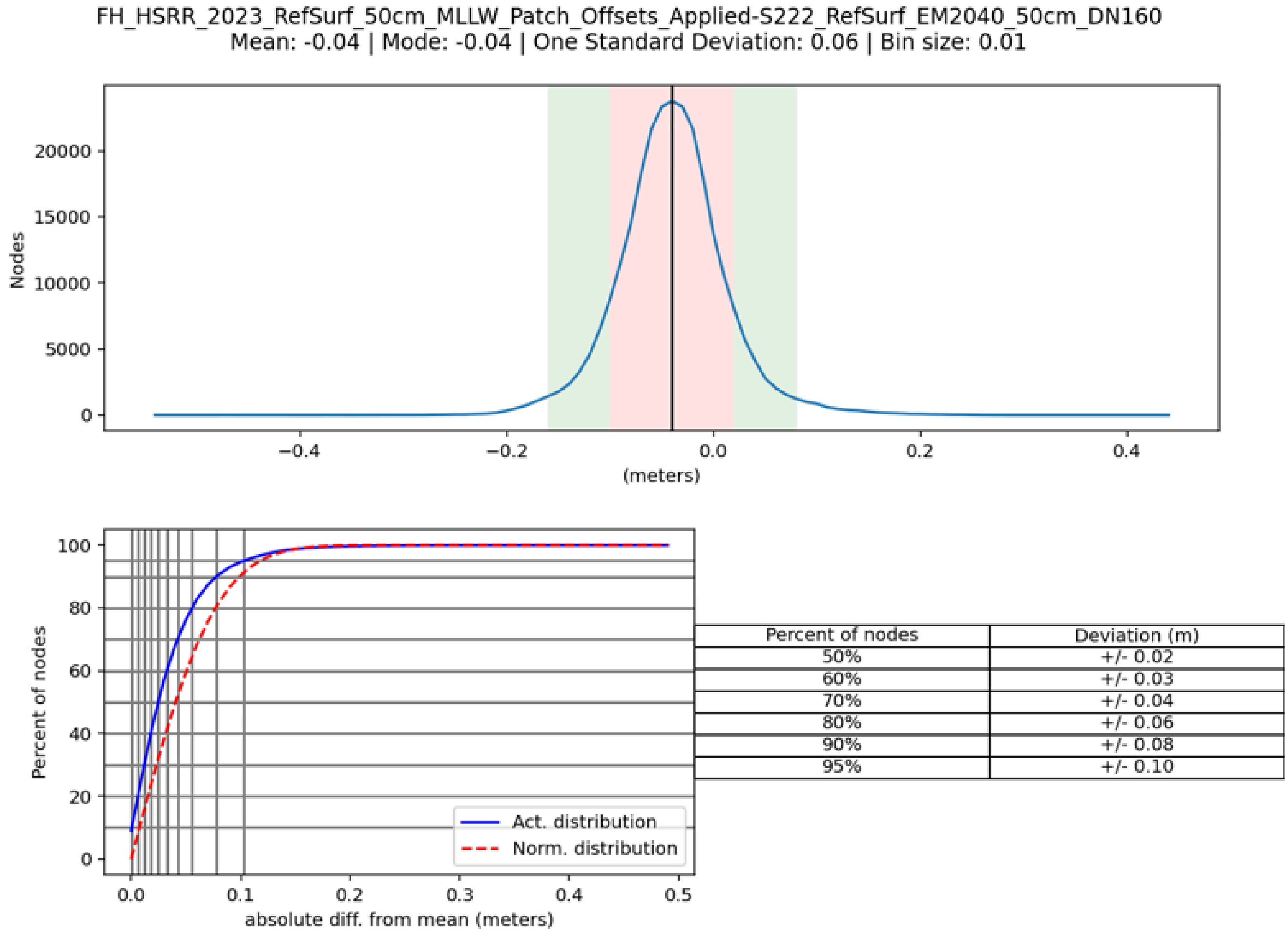


Figure 5: Reference Surface Comparison Statistics [FH2023 to TJ2020]

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

No side scan sonars were utilized for data acquisition.

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 320 V5

The POS MV V5 calculates position, heading, attitude, and vertical displacement (heave) of a vessel. It consists of a rack mounted POS Computer System (PCS), a bolt down IMU-7 Inertial Measurement Unit (IMU), and two GNSS antennas corresponding to GNSS receivers in the PCS.

The POS MV V5 is a tightly coupled GPS, inertial positioning and attitude sensing system. The Inertial Measurement Units (IMU) on the ship are located below water line close to both Kongsberg EM 2040 wet ends. The GPS antennas (Trimble GA830) are located on the O-2 level of S250. The two V5 systems were installed on July 29, 2013.

Data from both sonars reference the starboard V5 system described below while the port system is maintained as a backup.

<table>
<tr><td>Manufacturer</td><td colspan="6">Applanix</td></tr>
<tr><td>Model</td><td colspan="6">POS MV 320 V5</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">S250 Starboard</td><td>Component</td><td>PCS Starboard</td><td>IMU Starboard</td><td>Antenna</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>POS/MV 320 V5</td><td>V5- Type 36</td><td>GA830 GNSS/ MSS</td><td>GA830 GNSS/ MSS</td></tr>
<tr><td>Serial Number</td><td>5807</td><td>2672</td><td>5401</td><td>5415</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td rowspan="4">S250 Port</td><td>Component</td><td>PCS Port</td><td>IMU Port</td><td>Antenna</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>POS/MV 320 V5</td><td>V5 - Type 36</td><td>GA830 GNSS/ MSS</td><td>GA830 GNSS/ MSS</td></tr>
<tr><td>Serial Number</td><td>5807</td><td>2423</td><td>6997</td><td>7000</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

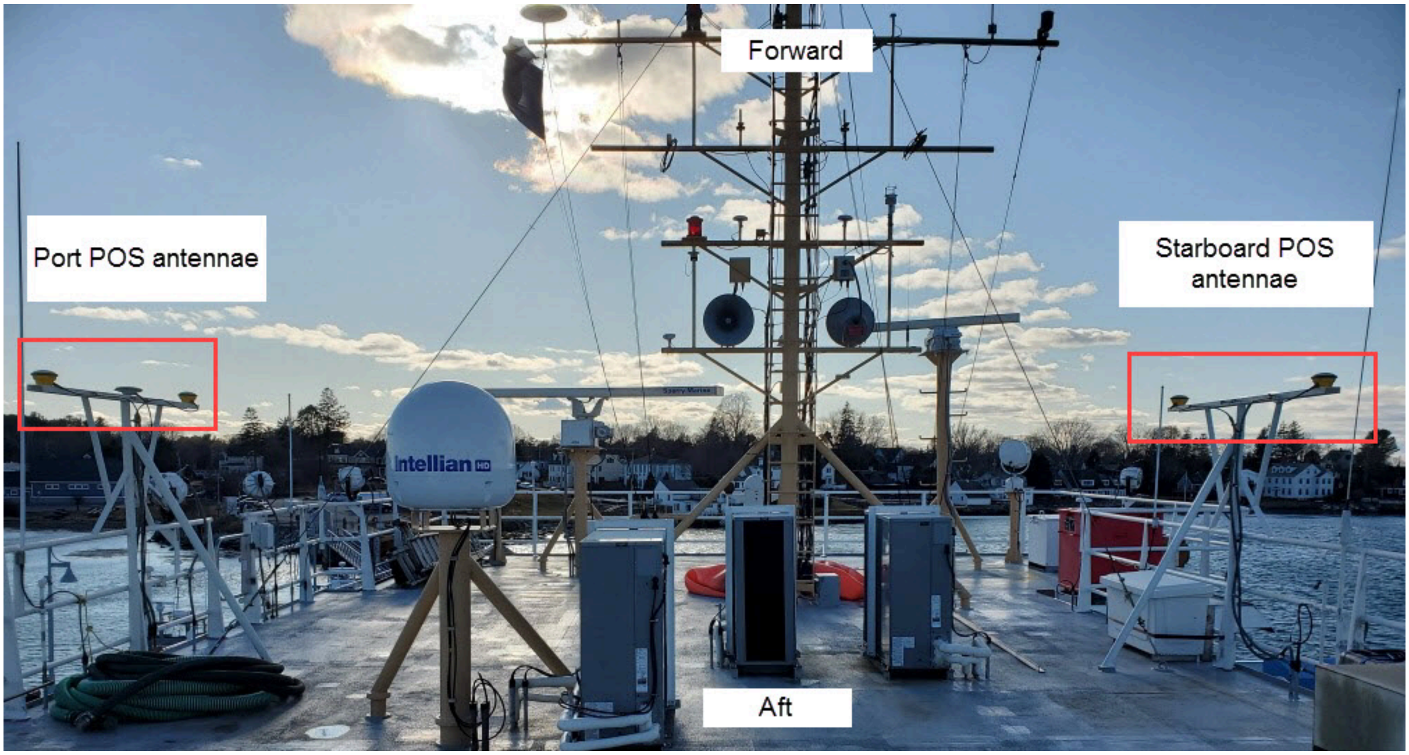


Figure 6: GNSS antennae location on the flying bridge

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

Additional GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

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

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

A.6.1.1 Rolls-Royce Brooke-Ocean MVP 200

The MVP 200 is a self-contained system capable of sampling water column profiles to depths of 200 meters from a vessel moving up to 12 kts, achieving deeper depths at slower speeds. During towed operation, the MVP 200 can be controlled by computer without the requirement for personnel on deck. The system consists of a single-sensor free-fall fish, an integrated winch and hydraulic power unit, a towing boom, and a remotely located computer controller with a user interface. The MVP towfish aboard FERDINAND R. HASSLER is equipped with an AML Oceanographic Micro-CTD sensor capable of acquiring conductivity, temperature, and depth (CTD) profiles. These profiles are used to determine the speed of sound and rate of sound absorption in the water column, primarily to correct the bathymetry data acquired with the EM 2040 MBES.

<table>
<tr><td>Manufacturer</td><td colspan="5">Rolls-Royce Brooke-Ocean</td></tr>
<tr><td>Model</td><td colspan="5">MVP 200</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S250</td><td>Component</td><td>Winch</td><td>Towfish</td><td>CTD</td></tr>
<tr><td>Model Number</td><td>N/A</td><td>MVP200 Single Sensor Free Fall Fish</td><td>Micro CTD</td></tr>
<tr><td>Serial Number</td><td>10794</td><td>11406</td><td>008615</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2022-04-25</td><td>2023-01-26</td></tr>
</table>

Figure 7: Moving Vessel Profiler on the starboard fantail of the ship

A.6.2 CTD Profilers

A.6.2.1 Sea-Bird Electronics (SBE) SeaCat 19plus

The SBE SeaCat 19plus is an internal logging conductivity, temperature, and depth measuring device. The SBE SeaCat 19plus is used during launch surveys and when the MVP is inoperable. It should be noted that there are three CTDs aboard the ship in Figure 8 but only two were calibrated, and only one (S/N 4642) used on this project

<table>
<tr><td>Manufacturer</td><td>Sea-Bird Electronics (SBE)</td></tr>
<tr><td>Model</td><td>SeaCat 19plus</td></tr>
<tr><td>Inventory</td><td>
<table>
<tr><td>Component</td><td>CTD</td><td>CTD</td></tr>
<tr><td>Model Number</td><td>SBE 19plus</td><td>SBE19plus</td></tr>
<tr><td>Serial Number</td><td>4642</td><td>4480</td></tr>
<tr><td>Calibration</td><td>2023-01-31</td><td>2023-01-25</td></tr>
</table>
</td></tr>
</table>

Figure 8: SBE SeaCat 19plus

A.6.3 Sound Speed Sensors

A.6.3.1 RESON SVP-70

The SVP-70 sound velocity probe was developed for fixed-mount installation near sonar transducer heads. The probe uses a direct path echosounding technique that instantly compensates for temperature and pressure with internal sensors, providing accurate surface sound velocity measurements for beam steering. There are two SVP-70 aboard Ferdinand R. Hassler, one per hull and collocated with the EM2040s. Both sonars utilize the data from the starboard SVP-70. The port system is maintained as a backup.

<table>
<tr><td>Manufacturer</td><td colspan="4">RESON</td></tr>
<tr><td>Model</td><td colspan="4">SVP-70</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S250</td><td>Component</td><td>Surface Sound Speed Sensor</td><td>Surface Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>SVP 70</td><td>SVP 70</td></tr>
<tr><td>Serial Number</td><td>2718066</td><td>2718067</td></tr>
<tr><td>Calibration</td><td>2022-12-28</td><td>2022-12-27</td></tr>
</table>

Figure 9: SVP-70 mounted locally at the 2040 transducer and reciever.

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*
CARIS	HIPS/SIPS	11.4.25	Processing
Applanix	POSPac MMS	8.9	Acquisition and Processing
NOAA	Pydro Explorer	22	Processing
QPS	FMGT	7.10.2	Processing
Hypack	Hypack/Hysweep	2022	Acquisition and Processing
Applanix	MVPOS View Controller	11.21	Acquisition
QPS	Qimera	2.5.1	Processing
Kongsberg	SIS	4.3.2	Acquisition
QPS	FM Midwater	7.9.4	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco 1728

The Ponar Wildco grab sampler is a clam shell design intended to trigger when contact is made with the seafloor after a freefall through the water column.

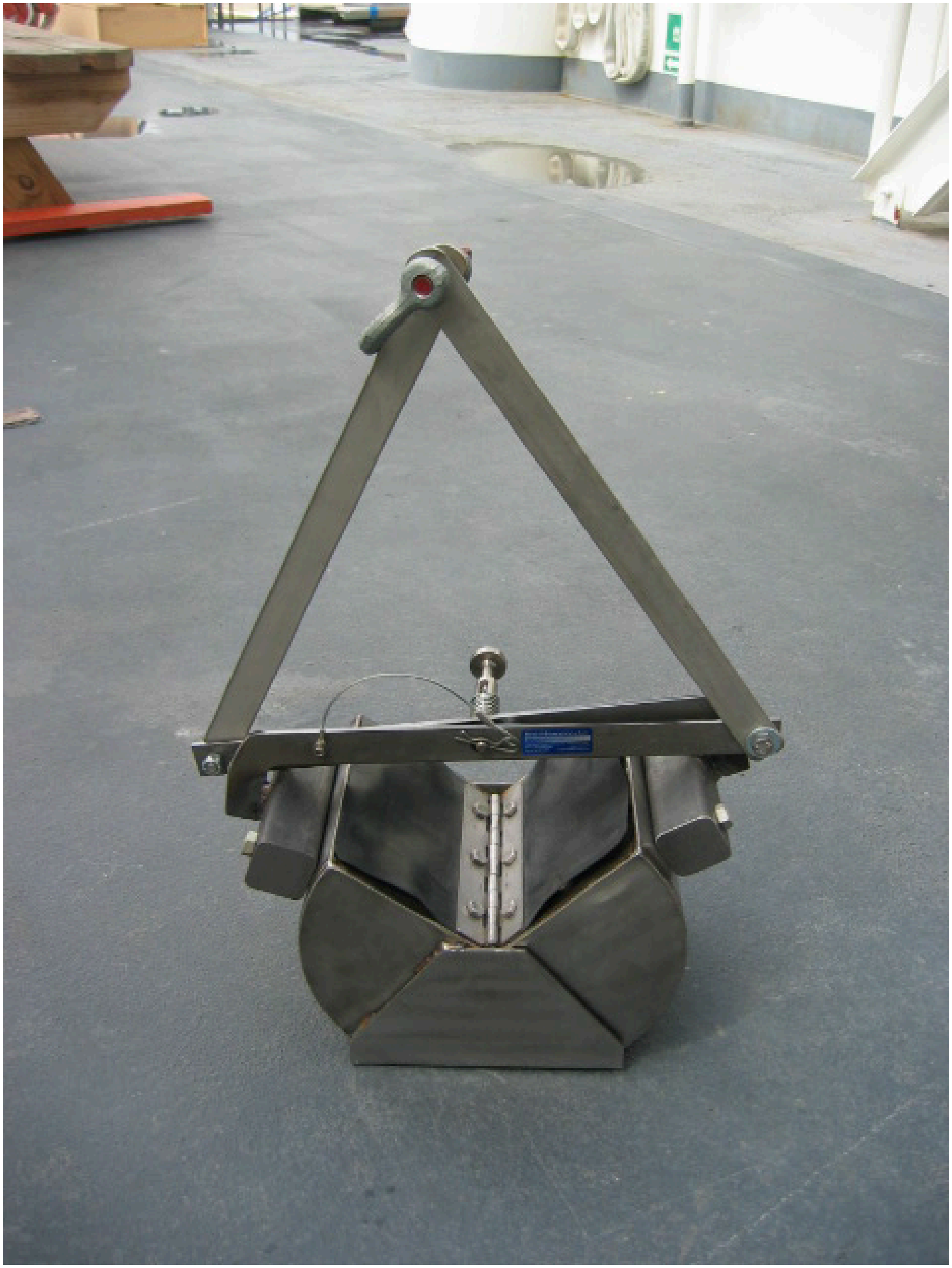


Figure 10: Ponar grab sampler.

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

Sensor offsets are measured with respect to the vessel's reference point. These offsets are derived from the full survey performed in the shipyard and measurements/verifications performed by FERDINAND R. HASSLER personnel. All offsets are tracked and updated as needed on a spreadsheet submitted with the appendices of this report.

The reference point for all positioning, atitude, and sonar systems on the Hassler is co-located at the starboard IMU.

B.1.1.1 Vessel Offset Correctors

Vessel	Hassler_2040_Dual			
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode			
Date	2019-06-08			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	-13.598 meters	0.020 meters
		y	0.495 meters	0.020 meters
		z	1.282 meters	0.020 meters
		x2	1.251 meters	N/A
		y2	0.331 meters	N/A
		z2	1.385 meters	N/A
	Nav to Transducer	*x*	-10.620 meters	0.020 meters
		y	-2.074 meters	0.020 meters
		z	14.257 meters	0.020 meters
		x2	4.229 meters	N/A
		y2	-2.238 meters	N/A
		z2	14.360 meters	N/A
	Transducer Roll	*Roll*	4.444 degrees	
		Roll2	-3.438 degrees	

B.1.2 Layback

Layback was not required as side scan sonar acquisition was not used.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

Because of her SWATH design, FERDINAND R. HASSLER is particularly susceptible to loading and trim. During typical survey operations, FERDINAND R. HASSLER burns approximately 4,000 liters of diesel per day. At a density of 0.83 kilograms/liter this is approximately 3.3 metric tons of fuel per day. At the design draft of 3.77 meters, 1.3 metric tons is required to submerge an additional 0.01 meters of the hull in salt water. The daily fuel burn would thus account for 0.03 meters of variation in the draft. The assumed design waterline of 3.8 meters and the measured offsets to the IMU were used to determine the static draft of the reference point.

Waterline measurements are taken at the draft markings at each corner of the ship from the water's surface to the main deck. These values are plugged into the S250 Waterline Calculator. This table averages the fore-aft waterline of each hull, and then averages across the ship. This yields the static draft at the center of the ship on the main deck which shares a vertical location with the granite block. Then, using the offset value for the STBD IMU w.r.t. the granite block, the waterline of the reference point is found. This method is used to confirm the design waterline as described above. These measurements are taken regularly and the ship is either ballasted, or the waterline is updated in the SIS and Caris software. Ship personnel keep this calculation up to date although ERS processing methods in CARIS no longer require this data.

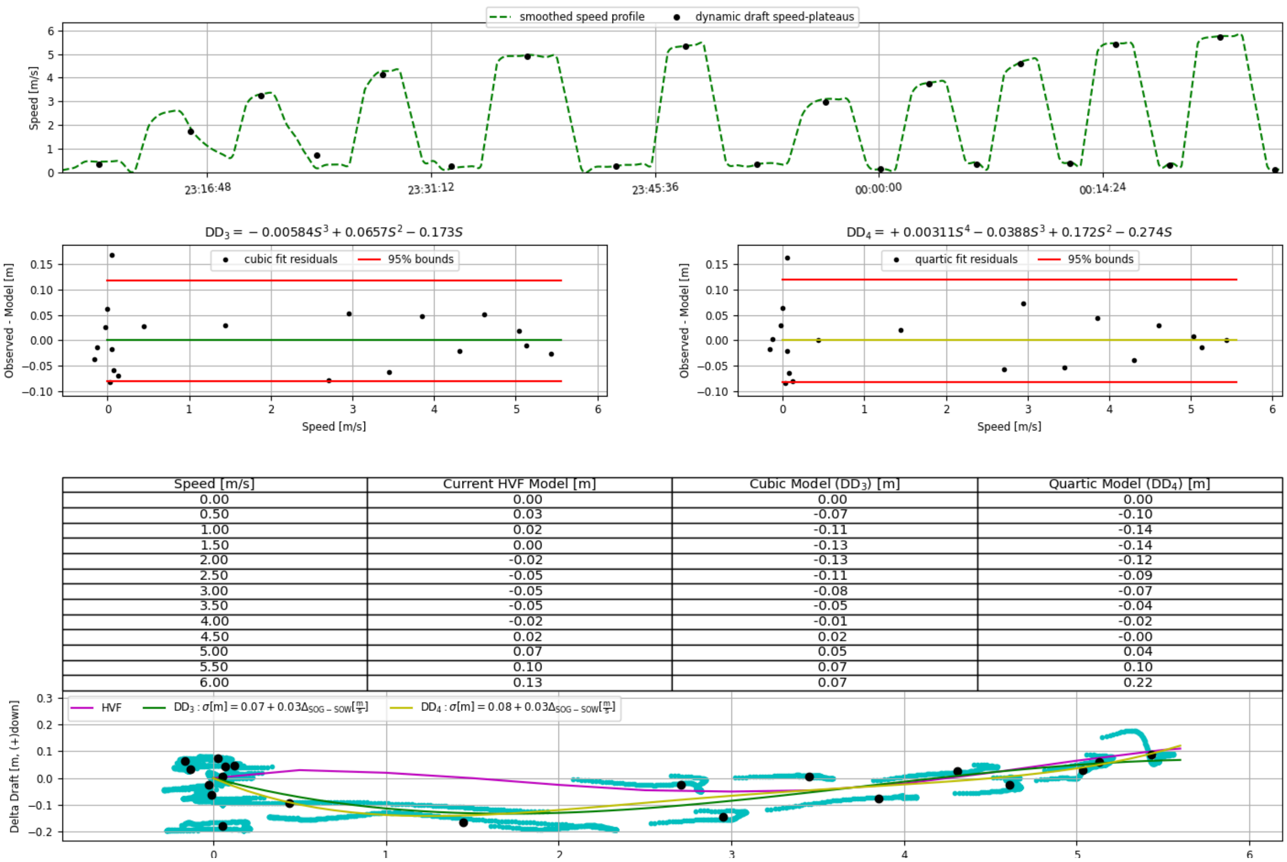
B.2.1.1 Static Draft Correctors

Vessel	*Date*	*Loading*	*Static Draft*	
			Measurement	*Uncertainty*
Hassler_2040_Dual	2019-06-08	0.050 meters	-2.383 meters	0.030 meters

B.2.2 Dynamic Draft

Dynamic draft is calculated as the dynamic height of the vessel reference point as a function of vessel speed compared to the height at rest. This correction is applied during CARIS processing. An ellipsoidally referenced dynamic draft measurement (ERDDM) was performed following the guidelines in the 2021 Field Procedures Manual (FPM) on Feb 23, 2023 (DN 055) for vessel S250.

An area was selected in Long Island Sound where a long trackline could be safely transited during the test. Data were acquired with canards at zero trim angle. During all survey operations, the canards are set to zero trim angle. Speeds from 5 to 12 knots were run in one direction. The ship was then turned to the reciprocal heading, brought to a complete stop, and then the speeds from 5 to 12 knots were run in the opposite direction. The fourth order polynomial results for the dynamic draft curves from the first run and the second run were averaged to mitigate the effects of current on the results. The fourth order polynomial results compared favorably to the results from 2022.



Speed [m/s]	Current HVF Model [m]	Cubic Model (DD_3) [m]	Quartic Model (DD_4) [m]
0.00	0.00	0.00	0.00
0.50	0.03	-0.07	-0.10
1.00	0.02	-0.11	-0.14
1.50	0.00	-0.13	-0.14
2.00	-0.02	-0.13	-0.12
2.50	-0.05	-0.11	-0.09
3.00	-0.05	-0.08	-0.07
3.50	-0.05	-0.05	-0.04
4.00	-0.02	-0.01	-0.02
4.50	0.02	0.02	-0.00
5.00	0.07	0.05	0.04
5.50	0.10	0.07	0.10
6.00	0.13	0.07	0.22

Figure 11: S250 dynamic draft results derived from ERDDM.

B.2.2.1 Dynamic Draft Correctors

Vessel	Hassler_2040_Dual	
Date	2023-02-23	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
	0.50	-0.02
	1.00	-0.04
	1.50	-0.06
	2.00	-0.08
	2.50	-0.08
	3.00	-0.06
	3.50	-0.05
	4.00	-0.02
	4.50	0.02
	5.00	0.06
	5.50	0.08
	6.00	0.10
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.50	0.03

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

A multibeam patch test was performed in the vicinity of Cape Charles, VA on February 25, 2023 (DN55). Values were determined using the QPS Qimera patch test tool using both hydrographer and automatic value evaluation. Final values used were the median of the three values found by two hydrographers and the automatic calculation found by Qimera.

B.3.1.1 System Alignment Correctors

Vessel	S250		
Echosounder	Kongsberg Simrad EM2040 Dual		
Date	2023-02-25		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.011 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	0.000 degrees	0.100 degrees
	Roll	0.000 degrees	0.100 degrees
	Yaw	0.000 degrees	0.150 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	2023-02-25		
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	0.000 degrees	0.100 degrees
	Roll	0.000 degrees	0.100 degrees
	Yaw	0.000 degrees	0.150 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

The acquisition methods employed were determined based on considerations of sonar system specifications, sea floor topography, water depth, and the capabilities of the acquisition platform. They were also dictated by the coverage method(s) specified in the Project Instructions for the survey area. All multibeam data were acquired in the .all file format within the Kongsberg SIS (Seafloor Information System) software. Data were monitored in real-time display windows in SIS 4. During acquisition, the hydrographers adjusted the parameters of the Kongsberg systems to improve data quality as necessary. The following are the parameters that were most commonly adjusted: the port and starboard beam angle, the force depth fields, ping mode, and yaw stabilization. Settings and specialized filters are found in the Runtime Parameters tear off window within SIS.

Mainscheme MBES lines were generally run parallel to depth contours with appropriate overlap to ensure the data density requirements in the 2022 Hydrographic Surveys Specifications and Deliverables (HSSD) were met. For discrete item developments, 200% coverage was acquired to ensure least-depth determination by multibeam near-nadir beams. For complete coverage surveys, the Hypack/ Hysweep realtime coverage display is used in lieu of pre-planned line files. Hysweep displays the acquired multibeam swath during acquisition and was monitored to ensure sufficient overlap and full bottom coverage.

Seafloor backscatter data were acquired for all lines during the 2023 field season, logged automatically in the .all file format.

Navigation and motion data were acquired and monitored in Applanix POSView and logged to a POS MV file with a .000 extension. Data were logged with Ethernet logging and automatically split into 128 MB files. Various position and heading accuracies, as well as satellite constellations, were monitored real-time in POSView and in Hypack/ Hysweep to ensure the quality of data collected. It was standard procedure to stop POS/MV data logging at UTC midnight each day, especially on Saturdays, the end of the UTC week. At this time the GPS seconds of the week resets.

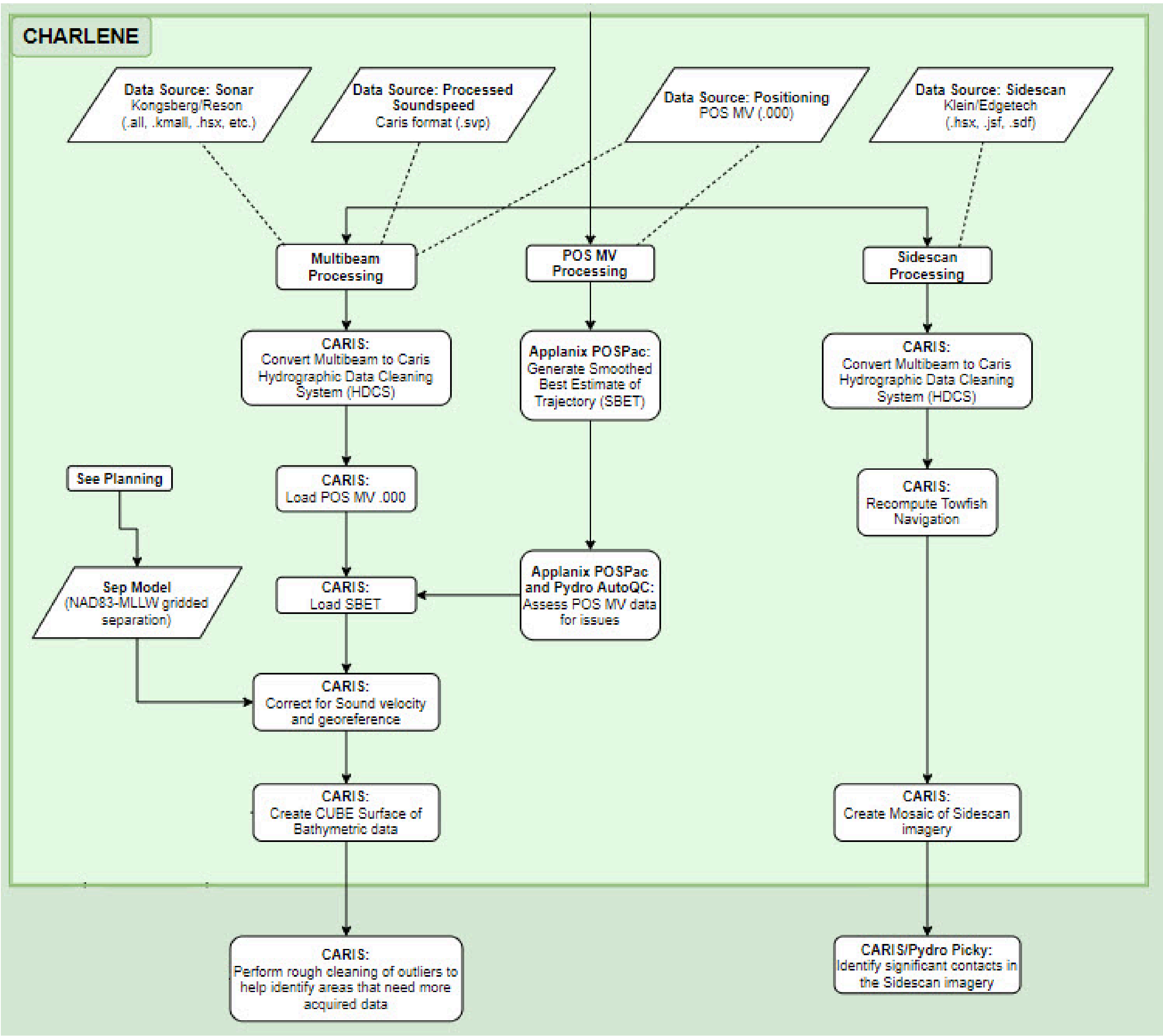


Figure 12: Pydro Charlene and raw data processing work flow

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

Bathymetry processing followed section 4.2 of the FPM unless otherwise noted. Raw .all (Kongsberg) multibeam data were converted to CARIS HIPS HDCS format using established and internally documented settings. After TrueHeave, Smoothed Best Estimate of Trajectory (SBET) attitude/navigation, and SBET RMS data were applied, GPS Tides were calculated using the HSD Operations Branch provided VDatum separation model. Sound speed correctors were then applied and finally the lines were merged. Once lines were merged, Total Propagated Uncertainty (TPU) was computed using settings documented for each survey in the Descriptive Report (DR). Default CARIS device models (devicemodels.xml) were used during processing. The standard option to accomplish this workflow in an automated fashion was to use Charlene, a data conversion and processing tool available in Office of Coast Survey's Pydro Explorer.

Data were then inspected in CARIS HIPS to ensure all correctors had been properly applied, and that final products reflected the observed conditions to the standards in the 2022 HSSD. Bathymetric surfaces were reviewed to ensure that all data quality problems were identified and resolved if possible, and all submerged features were accurately represented.

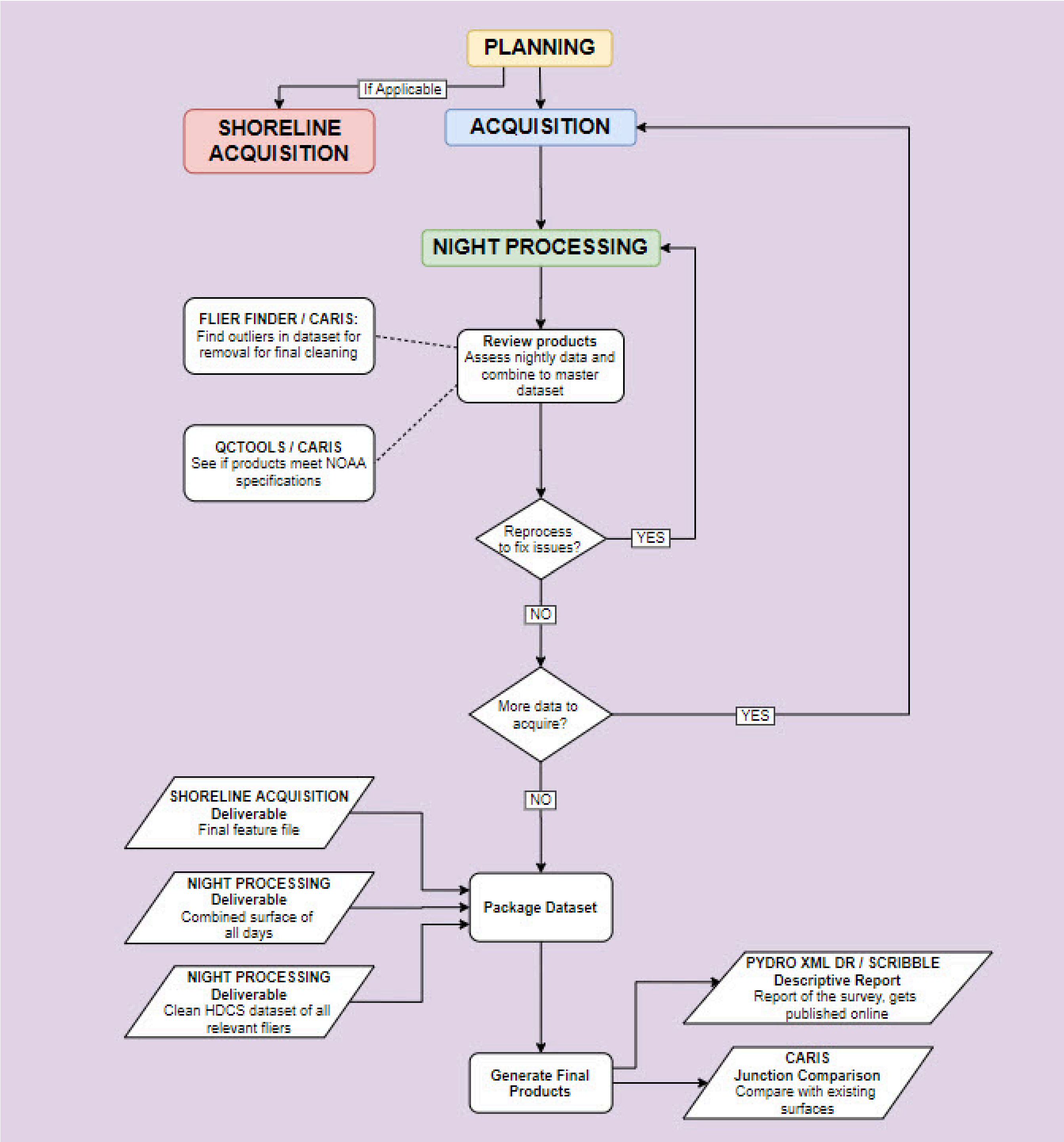


Figure 13: Overview of the life cycle of a survey on the HASSLER

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

The general resolution, depth ranges, and Combined Uncertainty and Bathymetric Estimator (CUBE) parameter settings outlined in section 5.2.2 of the 2022 HSSD and section 4.2.1.1.1.1 of the FPM were used for surface creation and analysis. If these depth range values for specific resolutions require adjustment for analysis and submission of individual surveys, a waiver from NOAA HSD Operations Branch is requested. A detailed listing of the resolutions and the actual depth ranges used during the processing of each survey is provided in the Descriptive Report (DR) that accompanies each survey.

C.1.4.2 Depth Derivation

The surface filtering function in CARIS HIPS was not utilized routinely. If utilized, the individual DR lists the confidence level settings for standard deviation used and discusses the particular way the surface filter was applied.

C.1.4.3 Surface Computation Algorithm

BASE surfaces were created using the CUBE algorithm and parameters contained in the NOAA CUBEParams_NOAA_2023.xml file as provided by NOAA HSD Hydrographic Systems and Technologies Branch (HSTB). The CUBEParams_NOAA_2023.xml file is included with the HIPS Vessel Files in the submission files for each individual survey data. If variable resolution surfaces were created, the NOAA parameter configurations for variable resolutions were used.

The Density & Locale method for hypothesis disambiguation is used. This follows section 4.2.1.1.1 of the FPM as available disambiguation methods. The disambiguation method can be seen in each individual layer's properties and can be modified if desired.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

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

The Kongsberg EM 2040 systems logged backscatter to the .all file concurrently with multibeam data by default. The hydrographer monitored the "Seabed Image" tear-off to ensure adequate backscatter imagery was obtained during acquisition. The hydrographer also documented all Kongsberg system frequency changes to aid in file segregation prior to backscatter processing.

The acoustic backscatter strength of the bottom is calibrated in the factory, and have a typical accuracy of ±1 dB. However, this value may be offset from zero to serve as a correction factor, for example if there is a change with the age of the system, or if data from two different systems are merged and there is a systematic offset between the two systems. These offset values are kept at zero unless otherwise documented. The absorption coefficient depends upon depth, water temperature, salinity and frequency. A correct value is important with respect to the validity of the bottom backscatter data measured by the system. Users may also adjust the normal incidence sector [angle from nadir (deg)] which defines the angle at which the bottom backscatter can be assumed not to be affected by the strong increase at normal incidence. For seabed imaging, it is important to adjust this angle so that a minimum of angle dependent amplitude variation is seen. The value for this parameter is kept at 15 degrees unless otherwise documented.

Data Processing Methods and Procedures

Backscatter processing complied with guidance provided in the 2022 HSSD and HTD 2018-3. All backscatter processing done aboard FERDINAND R HASSLER uses the program FM Geocoder Toolbox (FMGT)[a module of the QPS Fledermaus package] following these steps:

- A new project is created for each sheet, each vessel, and each sonar frequency used during acquisition. Metadata within the .all files ensures that sonar-specific characteristics are captured during mosaic processing.
-Vessel parameters are set, and allow the hydrographer to set configuration for each frequency and pulse length in order to calibrate slight differences in decibel levels. This produces a smoother, less patchwork appearance of backscatter mosaics between each frequency and pulse length. Parameter values may be determined by running a calibration line in the same direction with each possible combination of vessel, frequency, and pulse length.
-Lines are imported into FMGT. One mosaic is created per boat and frequency. Unless documented otherwise, the Kongsberg EM 2040 is collected with 300 kHz .
-Create a mosaic. All crosslines are deselected when creating the mosaic. Mosaic gridding resolution is set to ensure resulting TIF backscatter mosaic files do not exceed 200MB to keep the program from crashing. The product is exported as gray scale GeoTIFF.

C.2.2 Side Scan Sonar

Side scan sonar imagery was not acquired.

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.3.2 Vertical Control

C.3.2.1 Water Level Data

Water level data was not acquired.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

Realtime vessel navigation and attitude was measured by the starboard POS/MV system by receiving correctors via the Wide Area Augmentation System (WAAS) and recording in both the SIS .all files (for real-time correctors) and the POS MV .000 files (for delayed heave data). The POS/MV data is continuously logged via Ethernet logging throughout the survey day. A five minute buffer period of POS MV data was collected preceding and following any sonar data acquisition to permit proper initialization of filters for delayed heave and PPK solutions.

FERDINAND R HASSLER utilizes Post Processed Kinematic (PPK) or Trimble PP-RTX methods for the horizontal positioning of bathymetric data. The exact method selected is based upon the availability, or lack thereof, of Continually Operating Reference Stations (CORS) near the project area and current program licensing.

Data Processing Methods and Procedures

The POS/MV TrueHeave data were logged within the POS/MV .000 files and were applied in CARIS HIPS during post processing using the "Import/Auxiliary Data/Applanix POS M/V" function. TrueHeave is a forward-backward filtered heave corrector as opposed to the real time heave corrector, and is fully described in section 6 of the POS/MV V5 User Guide 2011.

The POS files produced during acquisition were processed through the POSPac MMS software to produce an SBET via PP-RTX or PPK in the NAD83 reference frame and an RMS file containing the realtime uncertainty estimates of the position and attitude data. The resulting SBET and RMS files were then applied in CARIS HIPS during post processing using the "Import/Auxiliary Data/Applanix SBET" and "Import/Auxiliary Data/Applanix RMS" functions, respectively.

Applanix's unique PP-RTX GNSS aided-inertial module provides centimeter-level post-processed positioning accuracies by using a network of approximately 100 stations that track GPS, GLONASS, BDS, QZSS, and Galileo satellites. These correctors are made available via the internet within minutes of real-time which prevents any delays in the data processing timeline.

Once SBETs were applied to the data, a GPS vertical adjustment was computed in CARIS HIPS, utilizing a VDatum model provided by HSD Operations Branch to reduce the data from the ellipsoid to MLLW. The data were then reviewed for consistency, ensuring that no vertical offsets due to artifacts in the SBET or improper application existed.

The standard option to accomplish this workflow in an automated fashion is to use Charlene, a data conversion and processing tool available in Office of Coast Survey's Pydro Explorer.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

Seabird SBE 19plus and MVP sound speed profilers were used to collect sound speed data for ray tracing corrections for the multibeam sonar systems. Due to the time saving potential, the MVP was the primary means of collecting sound speed data. If necessary, the SBE 19plus was hand deployed from the stern of the ship.

Casts were taken at least every four hours, but typically far more frequently. The interval between casts based on the observed variability between casts and changes in the surface sound speed as monitored in SIS 4 by the hydrographer.

Data Processing Methods and Procedures

If used, data were downloaded from the Seabird CTDs with a serial connection to a processing computer in the form of .HEX and .cnv files. For the MVP, data were instantly transmitted from the towfish to a processing computer once a dynamic cast is completed in the form of .s12, .calc, .eng, .raw, and .log files. Data from both the Seabird and MVP were then processed through Sound Speed Manager to produce CARIS .svp and NODC .nc formatted sound velocity profiles. All .svp profiles for a survey sheet were then concatenated to one master file for a survey. The sound speed profiles are transmitted from the Seabird CTD and the MVP to the Kongserg EM 2040 through Sound Speed Manager.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

Surface sound speed for both Kongsberg EM 2040 sonars was measured by the SVP-70 sound velocity sensors mounted near the starboard transducer.

Data Processing Methods and Procedures

The data collected by the SVP-70 were used for realtime beam steering. Sound speed DQAs were conducted by using Pydro Explorer's Sound Speed Manager to compare the measured sound speed from the SVP-70 to the measured sound speed from the MVP or CTD at the same depth.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

TPU was calculated in CARIS HIPS using the Compute TPU tool. Project specific values for tide and sound speed were used over the duration of each project. Error values for the multibeam and positioning systems were compiled from manufacturer specifications sheets for each sensor and from values set forth in section 4.2.3.8 of the FPM.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		S250_2040_Dual
Motion Sensor	*Gyro*	0.02 degrees
	Heave	5.00% 0.05 meters
	Roll	0.02 degrees
	Pitch	0.02 degrees
Navigation Sensor		0.50 meters

C.6.2.2 Real-Time Uncertainty

Real-time uncertainty was not applied.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

Source shoreline data is typically supplied by the Project Manager in a single Composite Source File (CSF) in S-57 format. The CSF is delivered with the Project Instructions and is used as the shoreline data for the field. The CSF is compiled from available source shoreline files (i.e. ENC, geographic cells, LIDAR, RNC, and Prior Surveys) into a single file in an S-57 .000 format. Additionally, a Project Reference File (PRF) is supplied containing sheet limits, maritime boundary points, and recommended bottom sample locations.

Shoreline verification is performed using several different methods depending on the nature of the feature. Under water features are verified or disproved using MBES and/or SSS. All features with the custom attribute “asgnmt” populated with 'Assigned' and offshore of the Navigational Area Limit Line (NALL) are fully investigated. 'Assigned' features inshore of the NALL are verified or DP’d for height if exposed but survey vessels do not navigate inshore of the NALL to either disprove or investigate potential submerged 'Assigned' features. Above water features such as piers and pilings are verified using Hypack detached positions during daylight periods near predicted MLLW tides. A line is run along the shore approximating the position of the NALL.

The definition of the NALL is subject to modification by the Project Instructions, Chief of Party, and the team as a whole. The NALL is typically defined as the sheet limits.

Data Processing Methods and Procedures

Features are generally documented and given S-57 attribution in real time. To increase efficiency, the boat crew may forgo S-57 attribution in the field and take thorough notes, either digitally using screen shots or on paper for later attribution. In the following days of shoreline verification, the HXXXXX_Final_Feature_File.hob used on the vessel, any digital photos taken, and the boat's trackline are then used to place and attribute features properly in the working project directory.

S-57 Attribution:
Features are selected for investigation by the FERDINAND R HASSLER OPS based on distance from MHW. Project Instructions require that "All features with attribute asgnmt populated with 'Assigned' shall be verified even if they are inshore of NALL."

FERDINAND R HASSLER will not venture inshore of the NALL for investigation of assigned items if there is a question of safety or potential equipment damage. If the feature in question is exposed, time and height attributes are assigned while it is visible. If the feature is not evident while investigating the NALL during shoreline verification, a remark of "inshore of NALL not investigated" is made with a recommendation of "Retain as charted."

Feature attribution is completed for all "Assigned" and any newly discovered items. Unassigned features are left untouched. Submerged features, such as wrecks and submerged piles designated in CARIS HIPS and SIPS are also brought into BDB for attribution.
All features marked as "primary" are edited to have their object/attribute instances describe each feature as completely as possible. Object attributes assigned to each feature conform to direction located within both the 2022 HSSD and the CARIS "IHO S-57/ENC Object and Attribute Catalogue". S-57 attribution is not required for those features flagged as "Secondary" nor for unassigned features.

NOAA specific attribution in BDB includes "descp" with a drop-down menu which is edited to reflect the hydrographer recommendations as follows:
• descrp - new -- A new feature is identified during survey operations. The hydrographer recommends adding the feature to the chart. Also, in cases in which the geographic position of an existing point feature is modified; the newly proposed feature is characterized as "new", while the original feature is flagged as "delete".
• descrp - update -- The feature was found to be portrayed incorrectly on the chart. Update is also used in the case where the feature was found to be attributed incorrectly or insufficiently and is modified to reflect the additional or corrected attribution. Also, for cases in which the geographic extents/position of an existing line feature are modified; the newly proposed feature is characterized as "update".
• descrp - delete -- The feature is disproved using approved search methods and guidelines. The hydrographer recommends removing it from the chart. Also, for cases in which the geographic position of an existing point object is modified; the newly proposed feature is characterized as "new", while the original feature was flagged as "delete".
• descrp - retain -- The feature is found during survey operations to be positioned correctly and no additional attribution was required. The hydrographer recommends retaining the feature as charted.
• descrp – not addressed -- The feature is not investigated during shoreline acquisition, typically because it is either inshore of the NALL or unsafe to approach. The hydrographer recommends retaining the feature as charted.

Features described as "new" and "update" are updated with the SORIND/SORDAT attribution of the current survey.
Features described as "delete", "retain" and "not addressed" have their SORIND/SORDAT attribution remain unchanged.

On occasions when the conditions are right, a MBES launch may survey close to the inshore survey limits and end up collecting a significant number of soundings inshore of the NALL. Any additional soundings collected inshore of the NALL were processed as follows:
• “Good” sea floor is not rejected anywhere. Any bad soundings are cleaned out to make the surface represent the sea floor, but there is no cut-off of soundings shoaler than the 4-meter or 0-meter curves. Negative soundings are fine so long as they accurately represent the bottom.
• 2702 will not go inside the NALL line trying for the 0-meter curve, or developing items that are found outside the survey limits (i.e. NALL line)
• For cultural features (pilings, piers, buoy's and buoy chains, etc.) that are above MLLW (i.e. negative sounding) AND on the CSF HOB layer, all soundings on the cultural item are deleted. This technique will prevent the BASE surface from being pulled up on features already charted above MLLW in the HOB file.
•For cultural features that are below MLLW, the shoalest sounding is designated (which the BASE surface will honor) AND the feature is included on the field verified HOB file.
•For cultural features that are above MLLW and are not on the field verified HOB file, the least depth is flagged as "outstanding," but not included in the BASE surface and all other data on the object is rejected. In this case, the "outstanding" sounding is used as a basis for creating a new feature in the field verified HOB, but it will not affect the BASE surface. This is accomplished by using the option in BASE surface creation to not include outstanding soundings. Alternatively, in the case of area-type cultural features, all depths may be temporarily retained and the resultant DTM used to digitize the feature. Once digitization is complete, all soundings on the cultural item are deleted.
• Rocks and reefs are treated as "sea floor." No data is rejected on rocks, reefs, or ledges, even above MLLW. The primary method of getting heights on rocks is "leveling" during traditional shoreline acquisition, but if a least depth of a rock is obtained with MBES, it will be designated and the height/depth will be used as the VALSOU in the CSF HOB. As previously stated, launches will not go inshore of the NALL line trying to get these data, but they will not be discarded if they are obtained. In cases where the echosounder data does not get the least depth, the soundings obtained will be left in the surface and a DP (or previously acquired comp source data) will be used for the feature.
Following acquisition, digital photos are named utilizing the "Rename FFF Images per HTD" tool in Pydro explorer HTD 2018-4 and are located in the "multimedia" folder in the 2023 submission structure.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Bottom Sampling followed guidelines set forth in HTD 2018-4 and sections 7.1 of the 2022 HSSD and 2.5.4.2.1 of the FPM. Unless specified otherwise in the DR, bottom sample locations were guided by analysis of the backscatter and bathymetry of the survey area. Refer to the individual DR for additional information.

The clam shell style bottom sampler is set for deployment by placing the attached pin between the hinge. The device is allowed to free fall to the bottom and upon contact the line is jerked up sharply to snap the jaws shut. Bottom material is transferred from the clam shell into a plastic bucket and examined for type, color, and texture before it is photographed. To determine size and color, the bottom sample is then compared with the color card and sediment grid referred to in HTD 2018-1. Samples are brought on board to be analyzed for color, sediment size, and description. Images of the bottom sample are supplied with the Final Feature File.

Data Processing Methods and Procedures

The ship is provided with a number of recommended bottom sample locations in the Project Reference File (PRF), encoded as S-57 SPRINGS. In the event that no sample is obtained after three attempts, the sample site's NATSUR is characterized as "unknown". Bottom sample images are named in accordance with HTD 2018-4 HXXXXX_SBDARE_YYYMMDDThhmmss.jpg

Bottom sample attribution was conducted as prescribed in section 7.2.3 of the HSSD and HTD 2018-4.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

Multibeam data is created and viewed as a CUBE surface in Caris HIPS and SIPS, and includes a number of viewable child layers (uncertainty, hypothesis count, hypothesis strength, standard deviation, etc.). The depth layer was reviewed and edited in HIPS Subset Editor to view or edit problematic data. The surfaces and subset editor views were also used to demonstrate coverage and to check for errors due to tides, sound speed, attitude, and timing. Pydro Explorer's QC Tools features a Flier Finder, which guides the hydrographer to areas of the surface that may have erroneous data. This tool was used after each day's acquisition and as part of the final on board quality control steps. Where necessary, fliers or holidays in heading, attitude, or navigation data were manually rejected or interpolated for small periods of time. Any editing of this nature is outlined in the Descriptive Report for the particular survey.

D.1.2 Designated Sounding Selection

Designated soundings were selected as outlined in section 5.2.1.2.3 of the HSSD as necessary.

On occasion, the resolution of the CUBE surface may not be sufficient to capture the high point of a feature. In less than 20m of water, any feature where the most probable accurate sounding is shoaler than the CUBE surface by greater than one half the allowable error under IHO S-44 Order 1 is considered inadequately captured by the CUBE surface. In greater than 20m of water, this allowable error is expanded to the full Order 1 error allowance at that depth. By the criteria above, if a sounding is eligible for designation it is not necessarily implied that a sounding must be designated. In general, sounding designation solely to adjust the surface is frowned upon and rarely used. Rather, sounding designation is used only when those soundings are of critical importance. The hydrographer reviews significant feature least depths to ensure the features or highs are accurately portrayed by the surface. If a specific least depth is preferred over the weighted mean-depth calculations, the sounding may be flagged as designated.

For features derived from multibeam coverage a designated sounding of the least depth is identified. The associated S-57 feature attribution is then imported onto the designated sounding to best represent the least depth of the identified feature. Hydrographers utilize discretion in designating soundings with regard to features, and should refer to the outlined section in 5.2.1.2.3 of the HSSD.

D.1.3 Holiday Identification

A holiday plan is developed mid-way or at completion of a survey area. Holidays are identified and provided to the bridge team.

Holidays are identified through hydrographer investigation and Pydro Explorer's QC Tools' Holiday Finder to scan and flag the areas of the grid where gaps occur according to the 2022 HSSD. The results of the Holiday Finder are output in various different files for analysis. Files are opened and investigated in Caris HIPS and SIPS for analysis and planning purposes.

D.1.4 Uncertainty Assessment

Pydro Explorer's QC Tools' Grid QA automates the computation of grid statistics to ensure compliance to uncertainty and density requirements. The depth, uncertainty, density, and total vertical uncertainty (TVU) are used to compute particular statistics, producing a variety of plots. The plots produced show node percentage histograms, which demonstrate surface compliance with the uncertainty standards set forth in the HSSD.

Additionally, IHO child layers may be created using the following two formulas for IHO_1 and IHO_2, respectively: -Uncertainty/((0.5^2 +((Depth*0.013)^2))^0.5) and -Uncertainty/((1.0^2 +((Depth*0.023)^2))^0.5). IHO_1 is created for all soundings less than 100 meters while IHO_2 is for 100 meters and deeper. This layer helps the hydrographer identify possible trends or regions where surfaces are failing uncertainty specifications.

For finalized grids, the uncertainty value for nodes was the computed uncertainty derived from a mix of a priori and resl-time uncertainty estimates as outlined in the 2022 HSSD section 5.2.1.2.4.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Crossline to mainscheme comparison was conducted as outlined in section 5.2.4.2 of the 2022 HSSD. As a quality control (QC) measure, crosslines with a linear nautical mile total of at least 4% of mainscheme multibeam lines were run on each survey. Following acquisition, a CUBE surface containing strictly data from mainscheme lines and CUBE surface containing strictly data from crosslines are each generated and analyzed with the Compare Grids tool in Pydro Explorer. This tool generates statistics and distribution summary plots of the mainscheme-crossline difference surface and the fraction of allowable error to provide easily interpretable analyses of the differences between the surfaces. These output graphics are also added to the Descriptive Report for each sheet. When using Compare Grids, the input CSARs and/or BAGs may be any combination of variable resolution or raster grids. The output consists of two CSAR grids and three plot files containing summary statistics. One of the CSAR output files contains the simple depth differences in a Diff layer. The other CSAR grid contains the layer fracAllowError, the fraction of the IHO-allowable error.

D.1.5.2 Junctions

Junction comparisons were conducted as outlined in section 7.2.2 of the 2022 HSSD. Surface based and statistical analysis of the junctions is performed through Pydro's Compare Grids tool in a similar manner to crossline and mainscheme analysis described above.

D.1.5.3 Platform to Platform

No platform to platform comparison is typically conducted as part of the standard processing work flow.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Coverage is assessed in accordance with the 2022 HSSD.

Backscatter data is assessed for quality and coverage visually by the hydrographer. During data acquisition, the hydrographer monitors the "waterfall" tear off for data quality including data gaps and swath width. If adjustments of speed are needed, the bridge is alerted and a change in speed or direction is requested. Once created in FMGT, each mosaic is visually assessed in CARIS HIPS for data gaps and over all quality by inspecting the surface against a brightly colored background. Additionally, any holidays in the bathymetric surface may also correspond to data gaps in the backscatter mosaic. By assessing the bathymetric grid using holiday finder, these bathymetric data gaps are assessed and acquired.

D.2.2 Contact Selection Methodology

MBES backscatter is not used for contact selection, but can be used to find objects or confirm the existence of an object in the bathymetric grid. As the mosaic is assessed visually by the hydrographer, any objects of interest are noted and confirmed in the bathymetric grid. The mosaic may also be used to assess the need to change the location or number of bottom samples based on the assessment of the various bottom intensity returns seen in the backscatter.

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 survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys and Specifications Deliverables Manual, 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
CDR William Winner	Commanding Officer	10/21/2023	Digitally signed by WINNER.WILLIAM.GORDON.1284010430 Date: 2023.10.24 14:20:18 -04'00'
LT Patrick Debroisse, CMH CAT-A	Operations Officer	10/21/2023	Digitally signed by DEBROISSE.PATRICK.JOSEPH.1501248670 Date: 2023.10.24 14:45:29 -04'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	FH_S250_Survey_Wire_Diagram_2023.pdf
Sound Speed Sensor Calibration	2023_MVP_8615_Cal.pdf 2023_MVP_8660_Cal.pdf 2023_SVP70_Cal.pdf SBE_19plus_SN4480_2023.pdf SBE_19plus_SN4642_2023.pdf
Vessel Offset	Hassler_2040_Dual_offset_report.xlsx
Position and Attitude Sensor Calibration	S250_POS_GAMS_Report_2023.xls
Echosounder Confidence Check	N/A
Echosounder Acceptance Trial Results	FH SAT 10-13JUL2019.pdf

Additional Report	***File***
ERDDM Report	FH_2023_ERDDM_Report.docx S250_ERDDM_Results_2023.xlsx
DQA Report	FH_HSRR_DQA_Report_2023.docx
Patch Test Report	FH_2023_Patch_Report.docx