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

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-C319-FH-21
Time Frame:	July - October 2021

LOCALITY

State(s):	New Jersey
General Locality:	Approaches to New York

2021

CHIEF OF PARTY
Michael Gonsalves, CDR/NOAA

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Date:

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NOAA Ship *Ferdinand R. Hassler*
Chief of Party: Michael Gonsalves, CDR/NOAA
Year: 2021
Version: 1.0
Publish Date: 2022-02-28

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*	2011-09-04
	Performed By	Raymond C. Impastato, Professional Land Surveyor
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

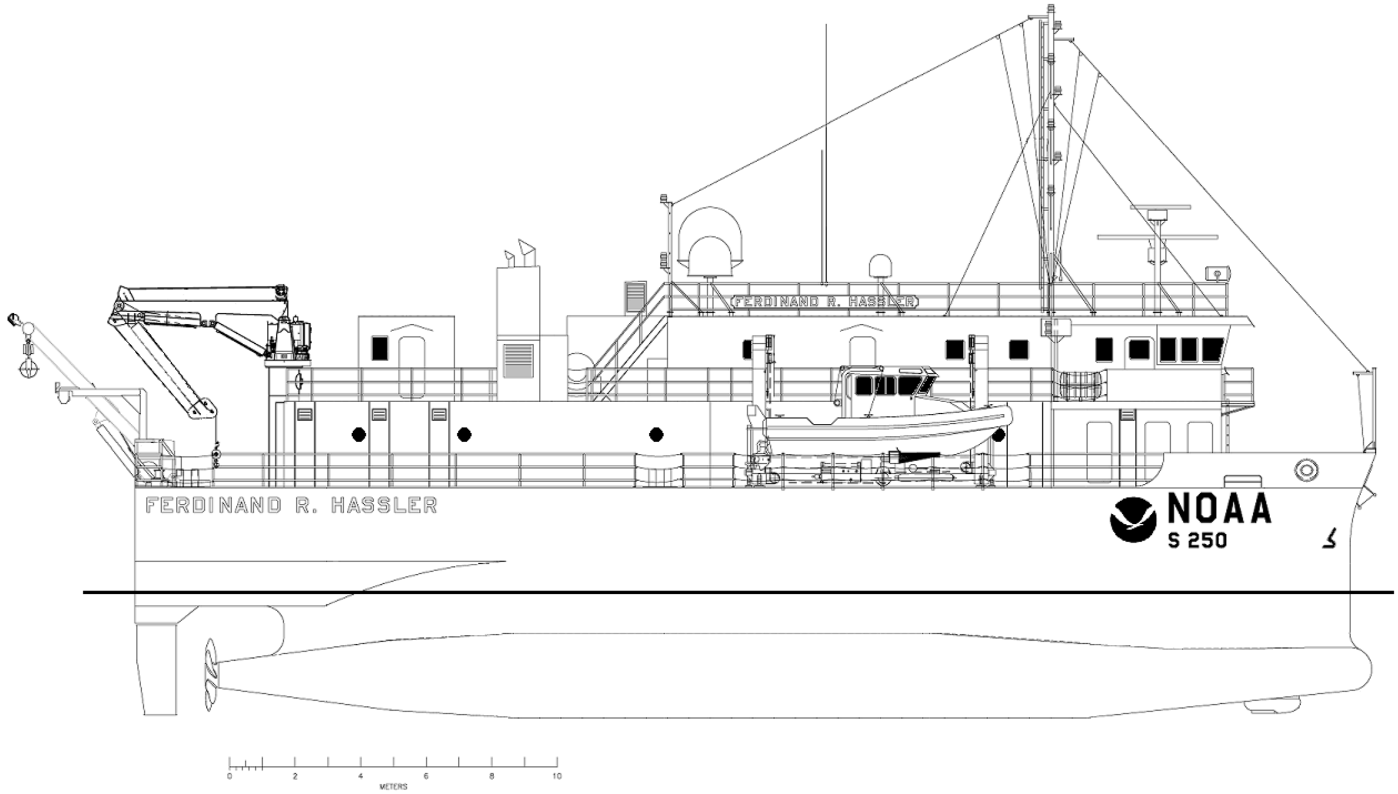


Figure 2: NOAA Ship FERDINAND R. HASSLER, starboard view

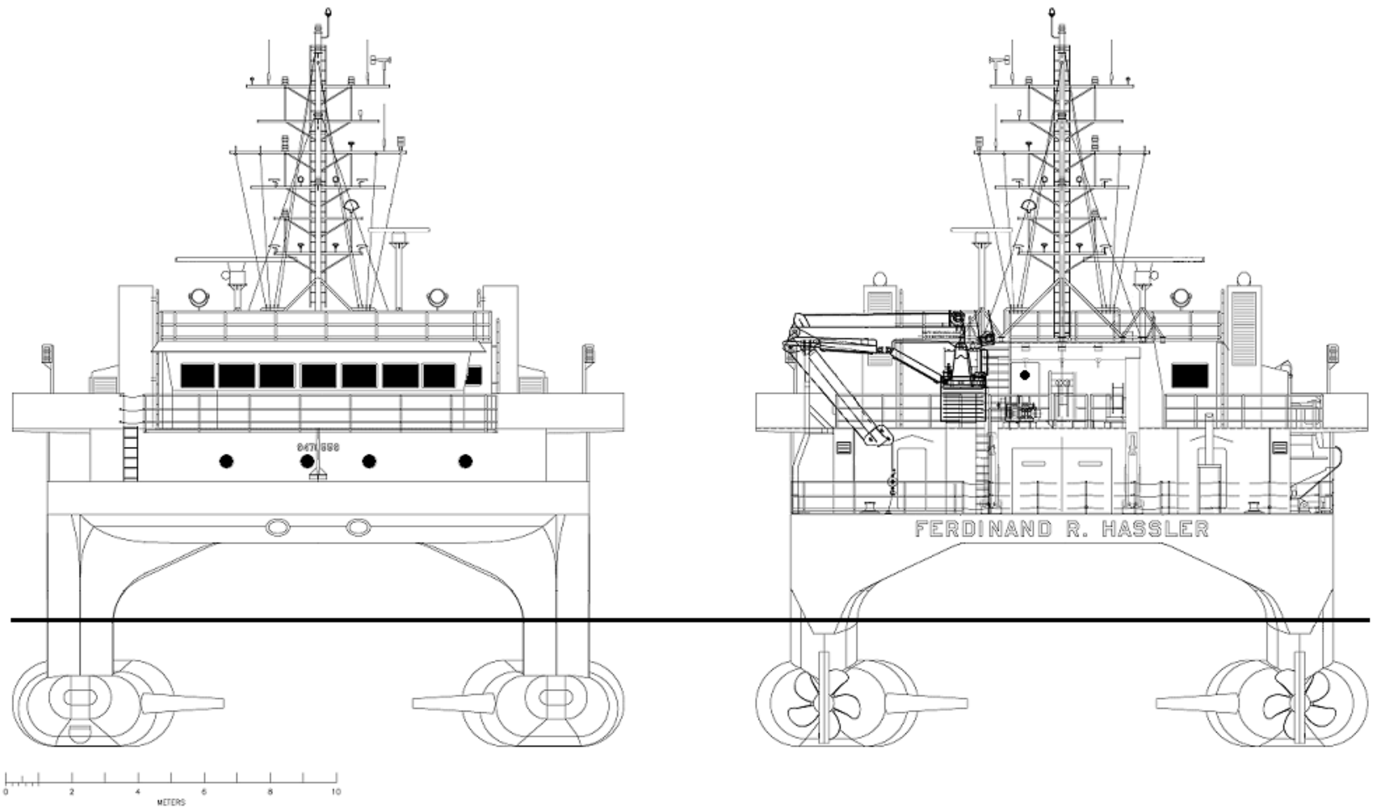


Figure 3: NOAA Ship FERDINAND R. HASSLER, bow and stern view

A.1.2 FH2702

Vessel Name	FH2702	
Hull Number	2702	
Description	Launch 2702 is a North River S.A.F.E. boat aluminum hull with a Yanmar 8LV Diesel powerhouse jet drive propulsion.	
Dimensions	*LOA*	8.4 meters
	Beam	3.3 meters
	Max Draft	0.76 meters
Most Recent Full Static Survey	*Date*	2015-06-16
	Performed By	Kevin Jordan, NGS

Figure 4: Launch 2702

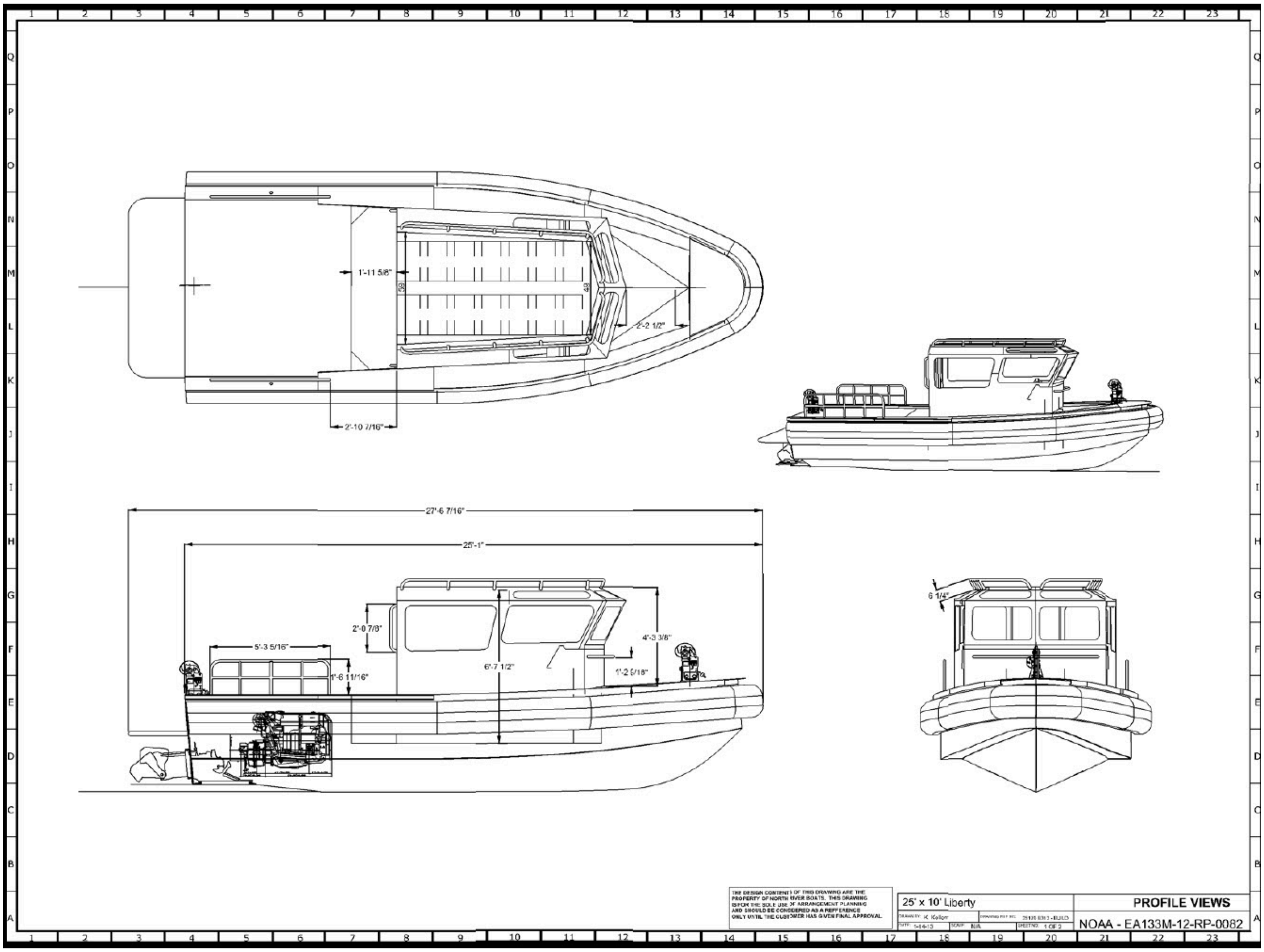


Figure 5: Line drawing of launch 2702

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 compromised of two EM 2040 systems in a Master/Slave configuration, with one installed on each of the FERDINAND R. HASSLER's hulls. The systems are angled slightly 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 the 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 and dynamic focusing employed in the near field. 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.

<table>
<tr><td>Manufacturer</td><td colspan="5">Kongsberg</td></tr>
<tr><td>Model</td><td colspan="5">EM 2040</td></tr>
<tr><td rowspan="12">Inventory</td><td rowspan="6">S250 Starboard</td><td>Component</td><td>Processing Unit</td><td>Receiver</td><td>Transducer</td></tr>
<tr><td>Model Number</td><td>n/a</td><td>EM 2040</td><td>EM 2040</td></tr>
<tr><td>Serial Number</td><td>40156</td><td>394</td><td>297</td></tr>
<tr><td>Frequency</td><td>n/a</td><td>200-400kHz</td><td>200-400kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2019-07-16</td><td>2019-07-16</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>2019-07-13</td><td>2019-07-13</td></tr>
<tr><td rowspan="6">S250 Port</td><td>Component</td><td>Processing Unit</td><td>Receiver</td><td>Transducer</td></tr>
<tr><td>Model Number</td><td>n/a</td><td>EM2040</td><td>EM2040</td></tr>
<tr><td>Serial Number</td><td>40144</td><td>389</td><td>285</td></tr>
<tr><td>Frequency</td><td>n/a</td><td>200-400kHz</td><td>200-400kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2019-07-16</td><td>2019-07-16</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>2019-07-13</td><td>2019-07-13</td></tr>
</table>

Figure 6: EM 2040 gondola installed in one hull of S250.

A.2.1.2 R2Sonic SONIC 2022

The Sonic 2022 is a compact wideband shallow water multibeam echo sounder. The Sonic 2022 provides over 20 selectable operating frequencies to chose from within the 200 to 400 kHz band. In addition to selectable operating frequencies, the Sonic 2022 provides variable swath coverage selections from 10° to 160°.

The system is hull mounted at a 30° angle off the starboard side.

Patch Tests -
A patch test was conducted for each sonar head in the 400kHz mode on March 9, 2021 in the vicinity of Norfolk, VA.

Reference Surfaces -
In conjunction with the patch test noted above, a reference surface in 400kHz mode was conducted on May 6, 2021 in the vicinity of Cape Charles, VA.

<table>
<tr><td>Manufacturer</td><td colspan="5">R2Sonic</td></tr>
<tr><td>Model</td><td colspan="5">SONIC 2022</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">2702</td><td>Component</td><td>Transducer(projector/receiver combo)</td><td>Processor</td></tr>
<tr><td>Model Number</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>800148</td><td>103297</td></tr>
<tr><td>Frequency</td><td>200-400 kHz</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>N/A</td><td>N/A</td></tr>
</table>

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 Klein 5000 V2

The Klein 5000 V2 side scan sonar, using frequency modulated Chirp, yields consistent cross track resolution at all range settings and speeds. The tow fish operates on a 455 kHz frequency. The Klein sonar is on board and was utilized on this project. A Klein representative was on board to groom and troubleshoot on 2020-02-18. A new system (V2) was procured and subsequently installed and tested on 2020-07-09. It was discovered in May 2021 during troubleshooting that the cable counter is not functioning. To account for this, colored tape markings were placed along the side scan cable and marked at 5m intervals. such that anyone could read the amount of cable paid out directly from the side scan cable. Towfish height was adjusted for the changing seafloor depth or oceanographic conditions. When changes were made to length of cable paid out, the SonarPro acquisition software was updated to account for layback error.

<table>
<tr><td>Manufacturer</td><td colspan="5">Klein</td></tr>
<tr><td>Model</td><td colspan="5">5000 V2</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">S250</td><td>Component</td><td>Side Scan Tow Fish</td><td>Side Scan TPU</td></tr>
<tr><td>Model Number</td><td>5000</td><td>5000</td></tr>
<tr><td>Serial Number</td><td>386</td><td>N/A</td></tr>
<tr><td>Frequency</td><td>455 kHz</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2016-03-08</td><td>N/A</td></tr>
<tr><td>Accuracy Check</td><td>2016-03-08</td><td>N/A</td></tr>
</table>

Figure 7: Klein 5000 V2 on the deck

Figure 8: TPU for the Klein in server rack 5 on board

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-200 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 for both hulls. 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. Both sonars reference the starboard V5 system described below.

All data are referenced to the starboard POS MV V5 system. FH 2702 launch additionally has a POS MV V5 system on board. The two antennas are Zephyr II's. There is no previous record of the antennas in HASSLER's hydrographic survey inventory, and the serial numbers on the bottom of the antennas have faded away.

<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="16">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>
<tr><td rowspan="4">2702</td><td>Component</td><td>PCS</td><td>IMU</td><td>Antenna</td><td>Antenna</td></tr>
<tr><td>Model Number</td><td>POS/MV 320</td><td>V4- Type 2</td><td>382AP</td><td>382AP</td></tr>
<tr><td>Serial Number</td><td>3189</td><td>803</td><td>N/A</td><td>60243047</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 Spares- Port sonar void</td><td>Component</td><td colspan="2">Antenna</td><td colspan="2">Antenna</td></tr>
<tr><td>Model Number</td><td colspan="2">GA830 GNSS/MSS</td><td colspan="2">GA830 GNSS/MSS</td></tr>
<tr><td>Serial Number</td><td colspan="2">16041</td><td colspan="2">16246</td></tr>
<tr><td>Calibration</td><td colspan="2">N/A</td><td colspan="2">N/A</td></tr>
</table>

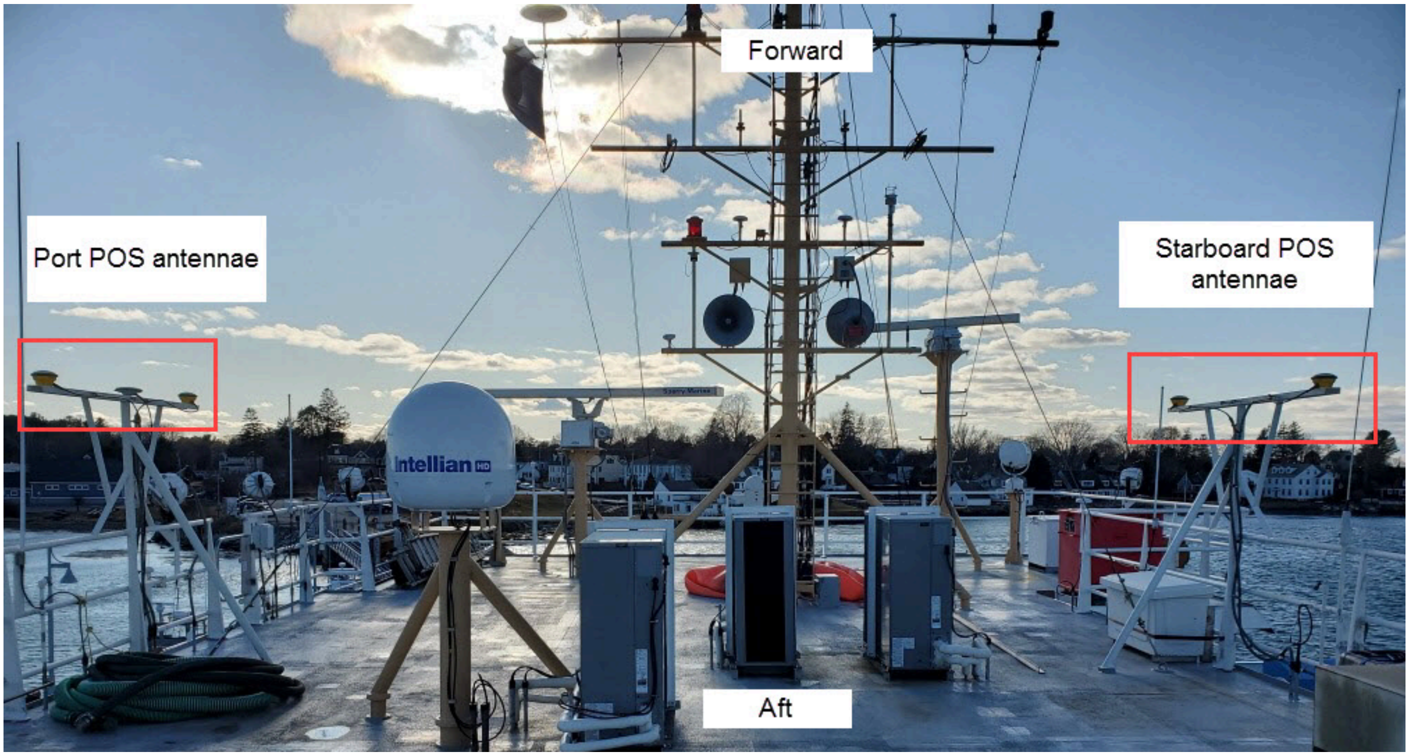


Figure 9: Antennae location on the flying bridge

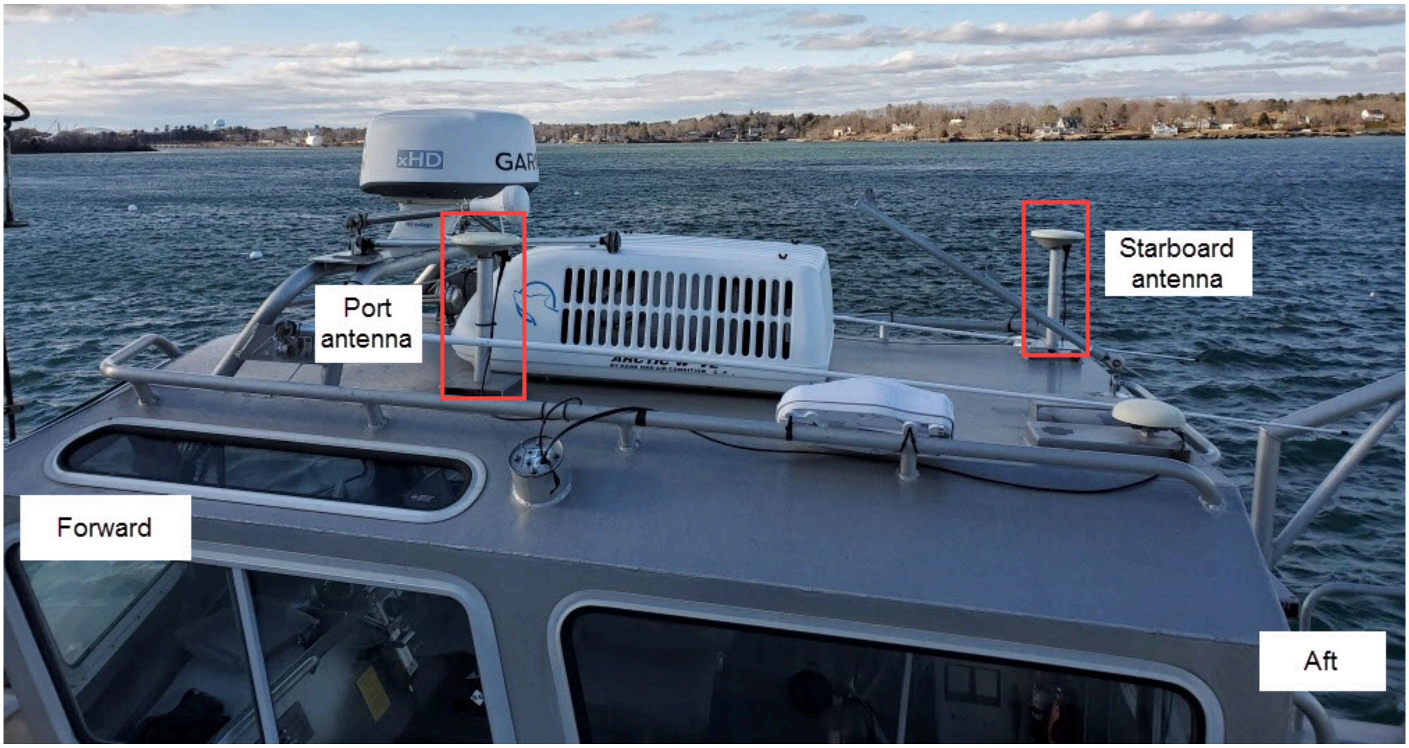


Figure 10: Antennae location on board 2702 launch

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

A.5.4.1 Laser Technology. Inc. LTI TruPulse 360R

The LTI TruPulse 360R laser range finder measures distance, angles and azimuth calculating Horizontal Distance (HD), Vertical Distance (VD), Height (HT), 3D Missing Line (ML). This system can solve 3D missing line calculations between any two remote points, and can integrate GPS for data capture.

This equipment is primarily used during HSRR to determine the the waterline of the vessel.

<table>
<tr><td>Manufacturer</td><td colspan="3">Laser Technology. Inc.</td></tr>
<tr><td>Model</td><td colspan="3">LTI TruPulse 360R</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S250</td><td>Component</td><td>TruPulse</td></tr>
<tr><td>Model Number</td><td>360R</td></tr>
<tr><td>Serial Number</td><td>002557</td></tr>
<tr><td>Calibration</td><td>N/A</td></tr>
</table>

Figure 11: Laser range finder on board

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 FERDINAND R. HASSLER's MVP fish 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="4">Rolls-Royce Brooke-Ocean</td></tr>
<tr><td>Model</td><td colspan="4">MVP 200</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S250</td><td>Component</td><td>Winch</td><td>Towfish</td></tr>
<tr><td>Model Number</td><td>N/A</td><td>MVP200 Single Sensor Free Fall Fish</td></tr>
<tr><td>Serial Number</td><td>10794</td><td>11406</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>N/A</td></tr>
</table>

Figure 12: Moving Vessel Profiler on the starboard water of the ship

A.6.2 CTD Profilers

A.6.2.1 Sea-Bird Electronics (SBE) SeaCat 19plus 350 meter

The SBE SeaCat 19plus is an internal logging conductivity, temperature, and depth measuring device. Serial Number 6918 and 4642 are board. The SBE SeaCat 19plus is used during launch surveys and when the MVP is inoperable.

Manufacturer	Sea-Bird Electronics (SBE)		
Model	SeaCat 19plus 350 meter		
Inventory	*Component*	CTD	CTD
	Model Number	SBE 19plus	SBE 19plus
	Serial Number	6918	4642
	Calibration	2020-12-22	2020-12-22

Figure 13: SBE SeaCat 19plus on board

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic micro-CTD

AML micro-CTD SN 8615 was installed on the Rolls-Royce Brooke-Ocean MVP towfish on 31 March 2021. AML micro-CTD is a realtime, single sensor probe designed for hull / pole mounted and vehicle integration applications.

Manufacturer	AML Oceanographic			
Model	micro-CTD			
Inventory	*S250*	*Component*	MVP Sound Speed Sensor	MVP Sound Speed Sensor
		Model Number	Micro CTD	200 Micro CTD 1000dBa
		Serial Number	8660	8615
		Calibration	2021-02-07	2021-02-07

A.6.3.2 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.

Manufacturer	RESON			
Model	SVP-70			
Inventory	*S250*	*Component*	Surface Sound Speed Sensor	Surface Sound Speed Sensor
		Model Number	SVP 70	SVP 70
		Serial Number	2718066	2718067
		Calibration	2019-12-09	2019-12-09

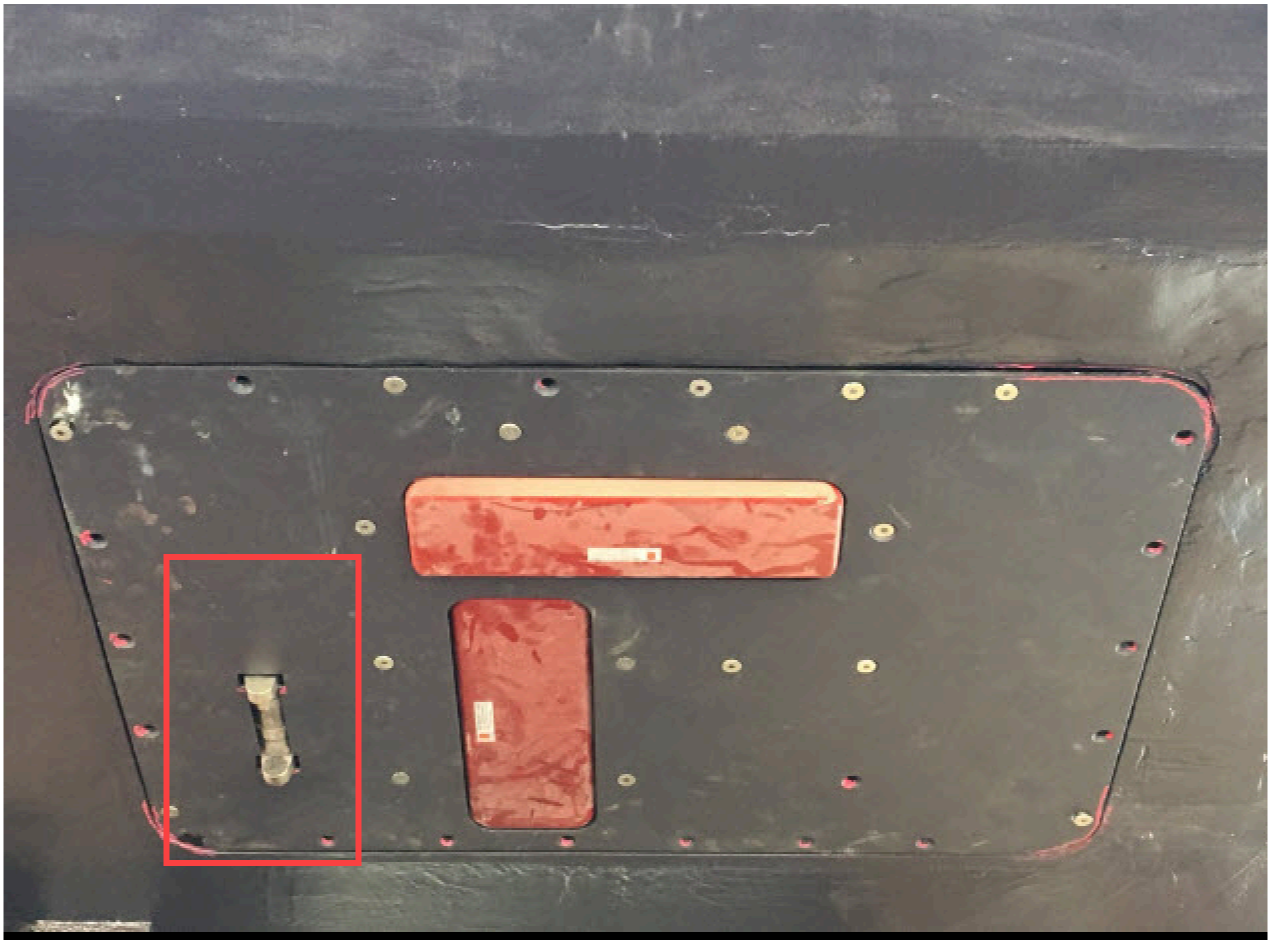


Figure 14: SVP-70 mounted locally at the 2040 transducer and reciever.

A.6.3.3 Valeport Mini Surface Sound Speed Sensor Mini SVP

The miniSVS consists of a single circuit board controlling all sampling, processing and communications functions, and a sensor comprising a ceramic transducer, a signal reflector, and spacer rods to control the path length. The two are connected by a single coaxial cable. A titanium housing may be fitted, which provides waterproof protection to a depth in excess of 6000m. The house is made of titanium, with spacer rods composed of carbon composite. The signal cable is a 3mm co-ax cable, nominally 25cm in length with push fit connector. The pressure transducer is a stainless steel diaphragm with an acetal protective cover, and the temperature sensor is composed of PRT in titanium housing with polyurethane backing.

<table>
<tr><td>Manufacturer</td><td colspan="2">Valeport Mini Surface Sound Speed Sensor</td></tr>
<tr><td>Model</td><td colspan="2">Mini SVP</td></tr>
<tr><td>Inventory</td><td>2702</td><td><table>
<tr><td>Component</td><td>Valeport mini SVP</td></tr>
<tr><td>Model Number</td><td>N/A</td></tr>
<tr><td>Serial Number</td><td>48002</td></tr>
<tr><td>Calibration</td><td>2019-02-13</td></tr>
</table></td></tr>
</table>

Figure 15: Valeport Mini SVP sensor mounted locally near R2 Sonic transducer and reciever on board launch 2702

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	11.3.6	Processing
CARIS	Bathy BASE Editor	5.3.0	Processing
CARIS	Plot Composer	5.3	Processing
Applanix	POSPac MMS	8.5sp1	Acquisition and Processing
NOAA	Pydro Explorer	19.4+	Processing
QPS	FMGT	7.9.6	Processing
Hypack	Hypack/Hysweep	2018, 2020	Acquisition and Processing
Applanix	MVPOS View Controller	10.5	Acquisition
QPS	Qimera	2.3.5	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco 1728

The Ponar Wildco grab sampler is desgined to trigger when contact is made with the seafloor. A custom mount equipped with camera and light was designed for the acquisition of video of the seafloor.

A GoPro HERO3 camera was rigged as a drop camera to function along with grab sampler. The camera contained a 12 MP sensor capable of 1440p at 48fps. This camera supplemented the data gathered with the grab sampler, and allowed for data collection fom null samples from the Ponar grab sampler.

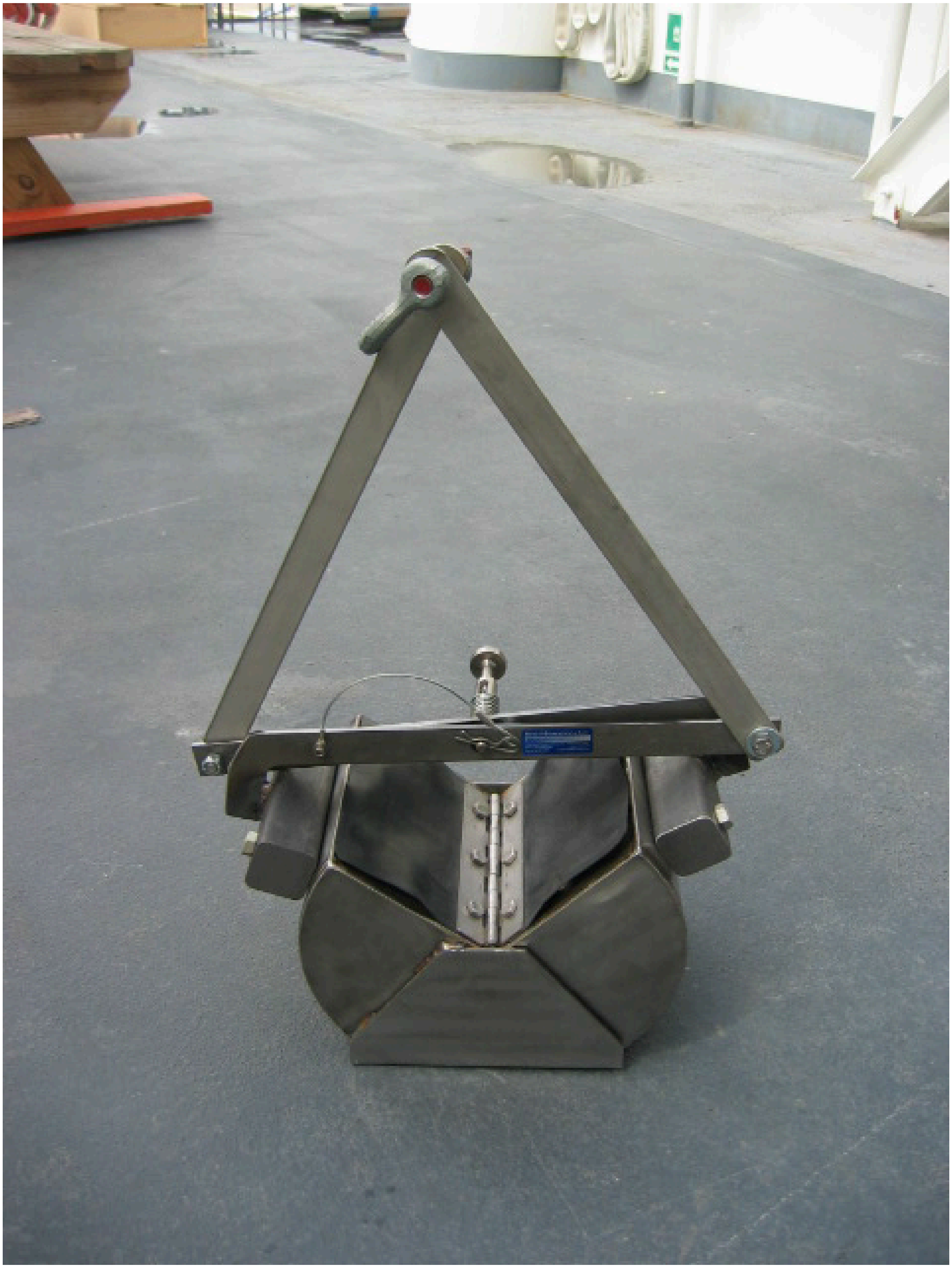


Figure 16: Ponar grab sampler.

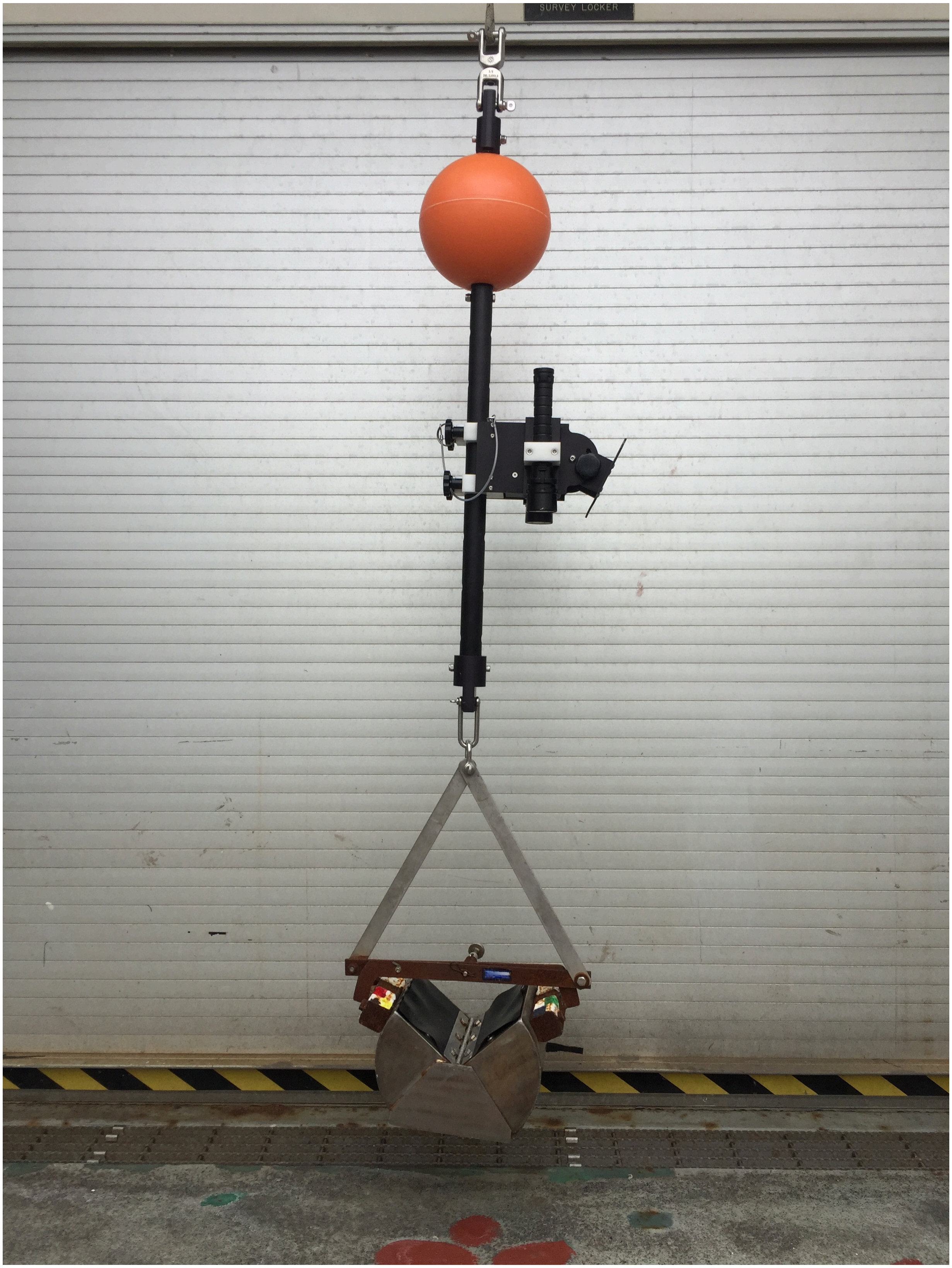


Figure 17: Camera with custom mount allowing for high quality video of the seafloor.

Figure 18: GoPro video camera

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, a partial survey performed by NOAA National Geodetic Survey (NGS) personnel, 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, altitude, and sonar systems on the Hassler is co-located at the starboard IMU.

A thorough examination of bathymetric surfaces derived from survey launch 2702, which were created prior to the beginning of this project, revealed an approximate 15cm vertical offset compared to S250 surfaces. After consultation with R2 Sonic and HSD, it was determined that the non-standard installation of the R2 Sonic 2022 multibeam was not accounted for in the 2702 .hvf file. The correct acoustic center of the R2 Sonic, adjusted to its current configuration, was provided by the manufacturer. Then navigation data from 2702 was post processed in PosPAC and compared to the lever arm offsets entered in the .hvf. After an iterative process of making adjustments to GNSS lever arms and then reprocessing navigation data in PosPAC, updates were made to the .hvf file for 2702. All 2702 data for this project was processed using the updated .hvf.

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*	4.274 degrees	
		Roll2	-3.448 degrees	

Vessel	FH_2702_R2Sonic			
Echosounder	R2 Sonic 2022 400kHz			
Date	2021-07-01			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.231 meters	0.006 meters
		y	-0.633 meters	0.006 meters
		z	0.403 meters	0.006 meters
	Nav to Transducer	*x*	0.753 meters	0.006 meters
		y	-0.109 meters	0.006 meters
		z	2.928 meters	0.006 meters
	Transducer Roll	*Roll*	-23.500 degrees	

B.1.2 Layback

Layback correctors are applied in the HVF. Due to the lack of a cable counter, realtime towfish layback was entered into SonarPro during acquisition, based off the Sidescan cable which was labled every 5 meters.

B.1.2.1 Layback Correctors

Vessel	S250_2021_Klien5000_V2_100		
Echosounder	Klien 5000V2		
Frequency	400 kHz		
Date	2021-06-05		
Layback	*Towpoint*	*x*	-5.085 meters
		y	-26.056 meters
		z	-9.515 meters
	Layback Error	0.000 meters	

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. While underway, the ballast is actively managed to maintain the draft at the design draft of 3.77 meters.

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. Ballast is adjusted daily to account for fuel burn and the levels in other tanks. Uncertainty is estimated at 0.05 meters. 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.

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
FH_2702_R2Sonic	2016-03-03	0.020 meters	-0.660 meters	0.050 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 2020 Field Procedures Manual (FPM) on May 4, 2021 (DN 124) for vessel S250. The ship conducted a comprehensive ERDDM in that, in addition to the traditional ERDDM, utilized the ship's canards at a 15°up and 15°down position.

An area was selected off the coast of Cape Charles, VA in the Chesapeake Bay where the slope of the geoid was minimal. 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 were entered into the HVF; because there has been significant weight redistribution throughout the ship, these values were not averaged with ERDDM results from past years. The 2019 results and comparisons between 2011 - 2019 can be found included in the attached appendices.

The results from the canard up and canard down tests were not entered into the HVF but were retained for future reference.

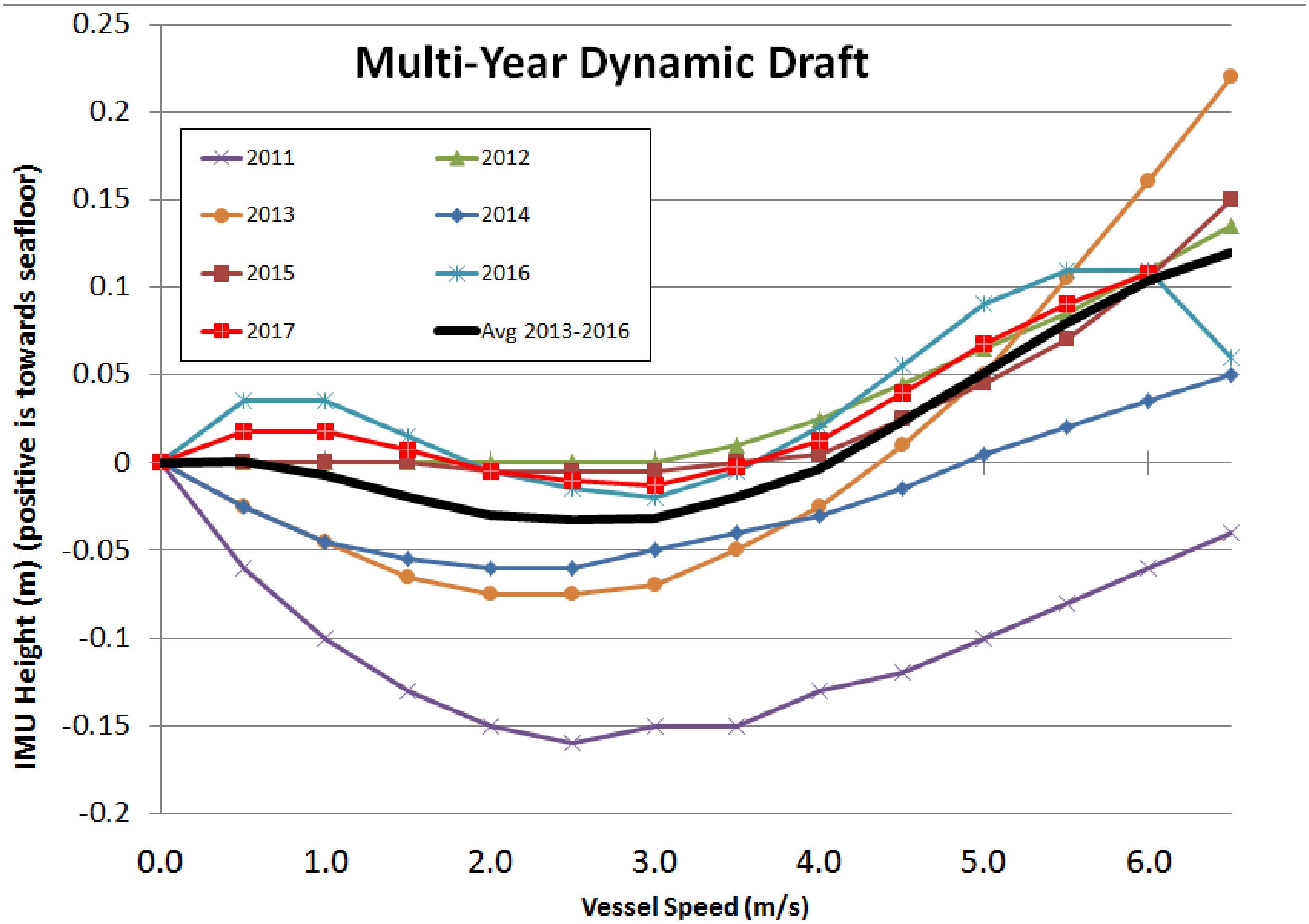
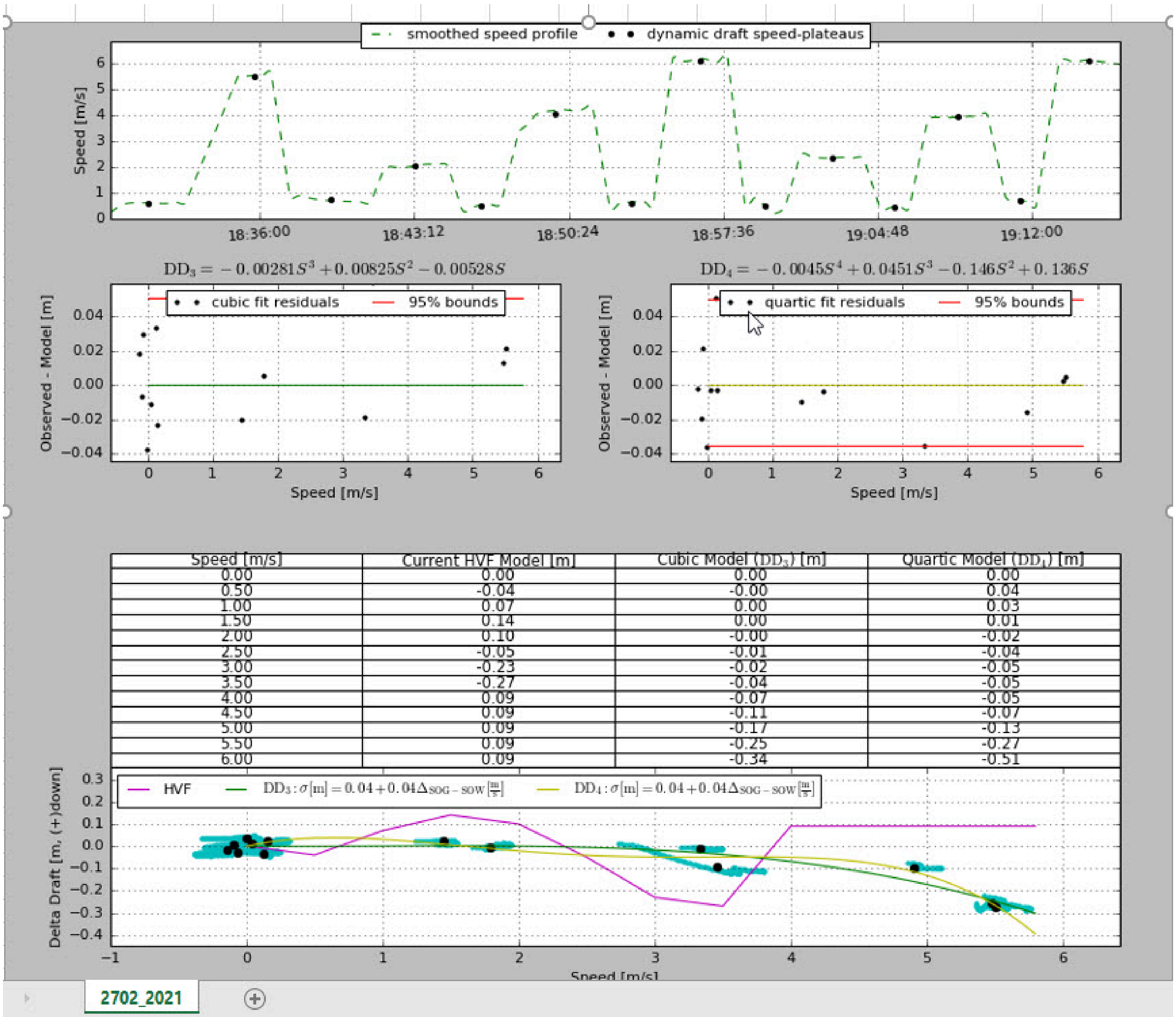
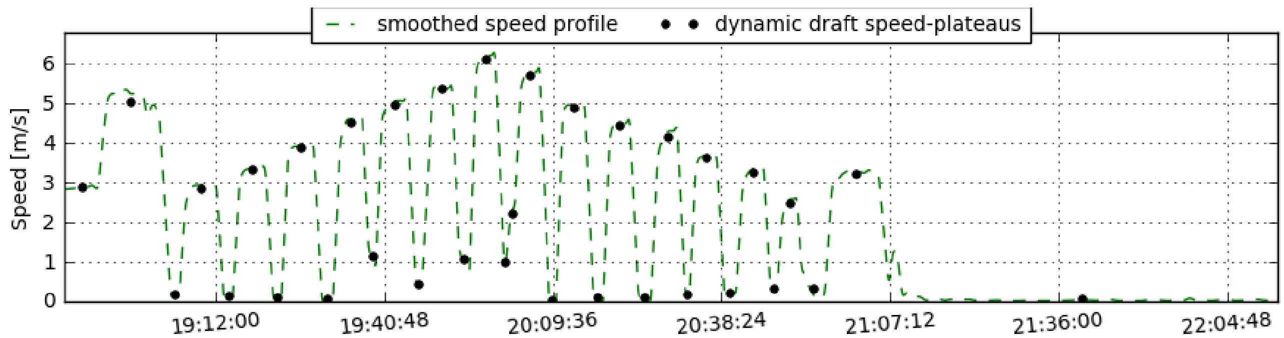


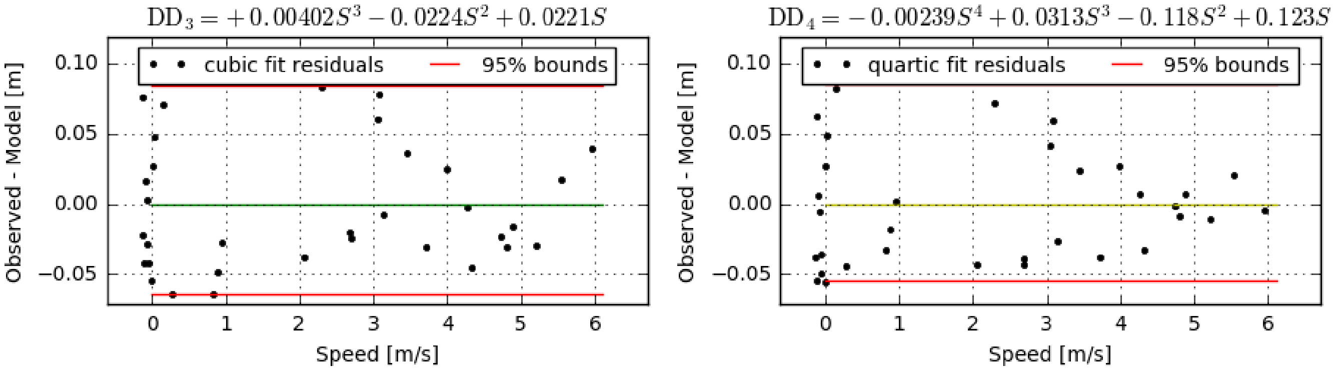
Figure 19: S250 dynamic draft derived from ERDDM methods comparison from 2011-2017.



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	-0.04	-0.00	0.04
1.00	0.07	0.00	0.03
1.50	0.14	0.00	0.01
2.00	0.10	-0.00	-0.02
2.50	-0.05	-0.01	-0.04
3.00	-0.23	-0.02	-0.05
3.50	-0.27	-0.04	-0.05
4.00	0.09	-0.07	-0.05
4.50	0.09	-0.11	-0.07
5.00	0.09	-0.17	-0.13
5.50	0.09	-0.25	-0.27
6.00	0.09	-0.34	-0.51

Figure 20: 2702 dynamic draft results derived from ERDDM.





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	0.10	0.01	0.04
1.00	0.12	0.00	0.03
1.50	0.08	-0.00	0.01
2.00	0.01	-0.01	-0.02
2.50	-0.07	-0.02	-0.04
3.00	-0.13	-0.03	-0.04
3.50	-0.14	-0.02	-0.04
4.00	-0.09	-0.01	-0.01
4.50	0.05	0.01	0.03
5.00	0.31	0.05	0.08
5.50	0.70	0.11	0.12
6.00	0.70	0.20	0.15
6.50	0.70	0.30	0.13

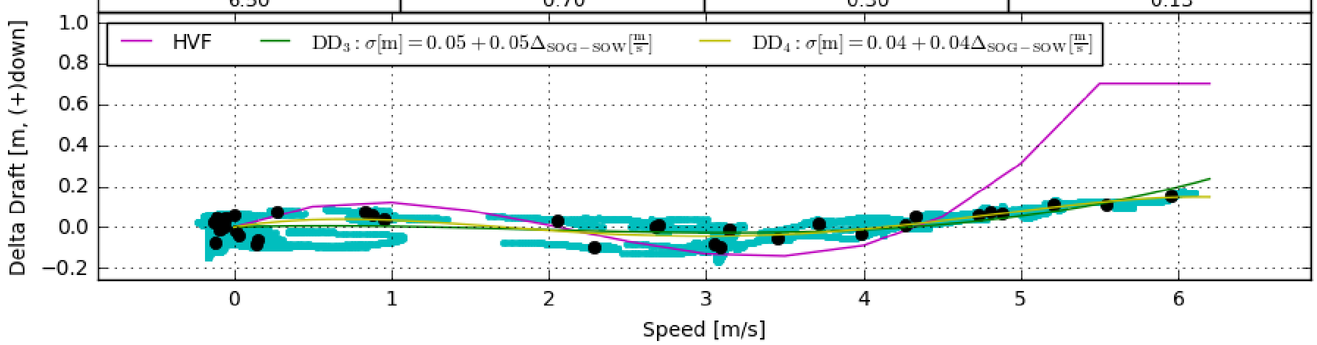
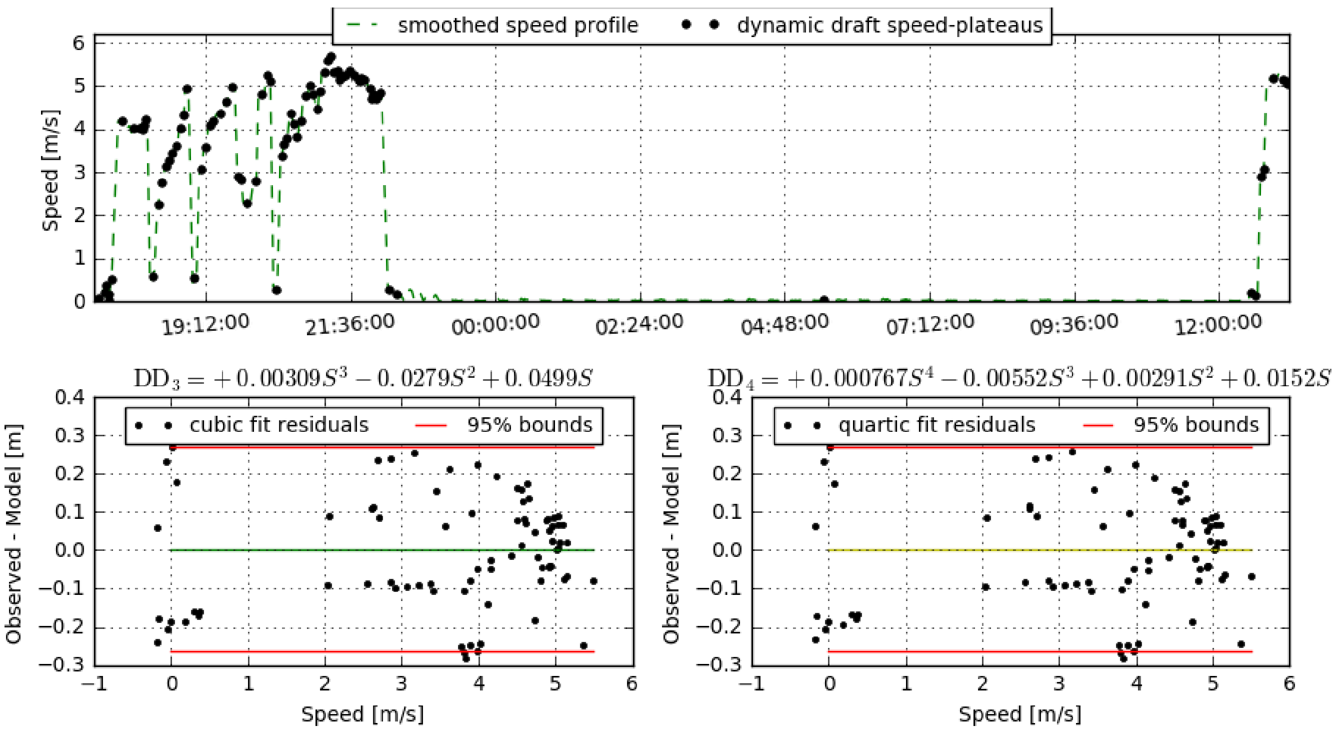


Figure 21: 2021 ERDDM



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	0.06	0.02	0.01
1.00	0.06	0.03	0.01
1.50	0.04	0.02	0.01
2.00	0.00	0.01	0.01
2.50	-0.05	-0.00	-0.00
3.00	-0.08	-0.02	-0.02
3.50	-0.08	-0.03	-0.03
4.00	-0.05	-0.05	-0.05
4.50	0.03	-0.06	-0.06
5.00	0.18	-0.06	-0.06
5.50	0.40	-0.06	-0.05

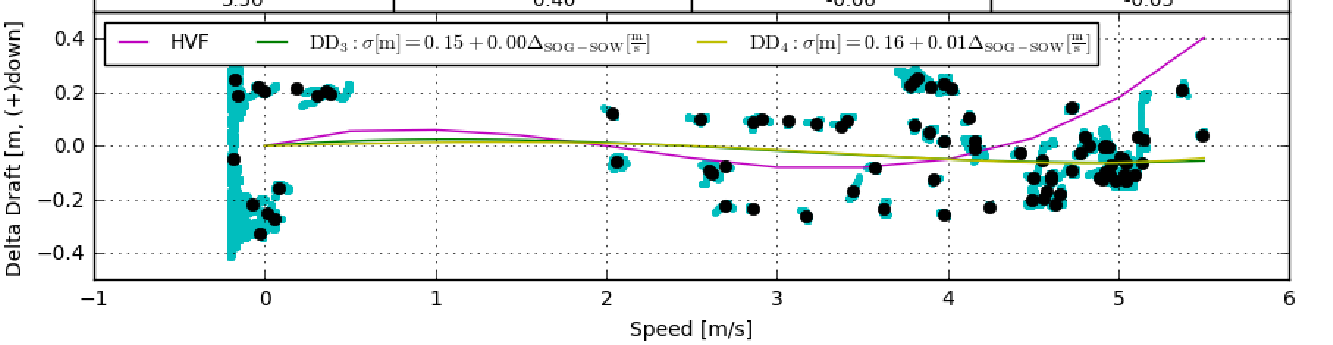
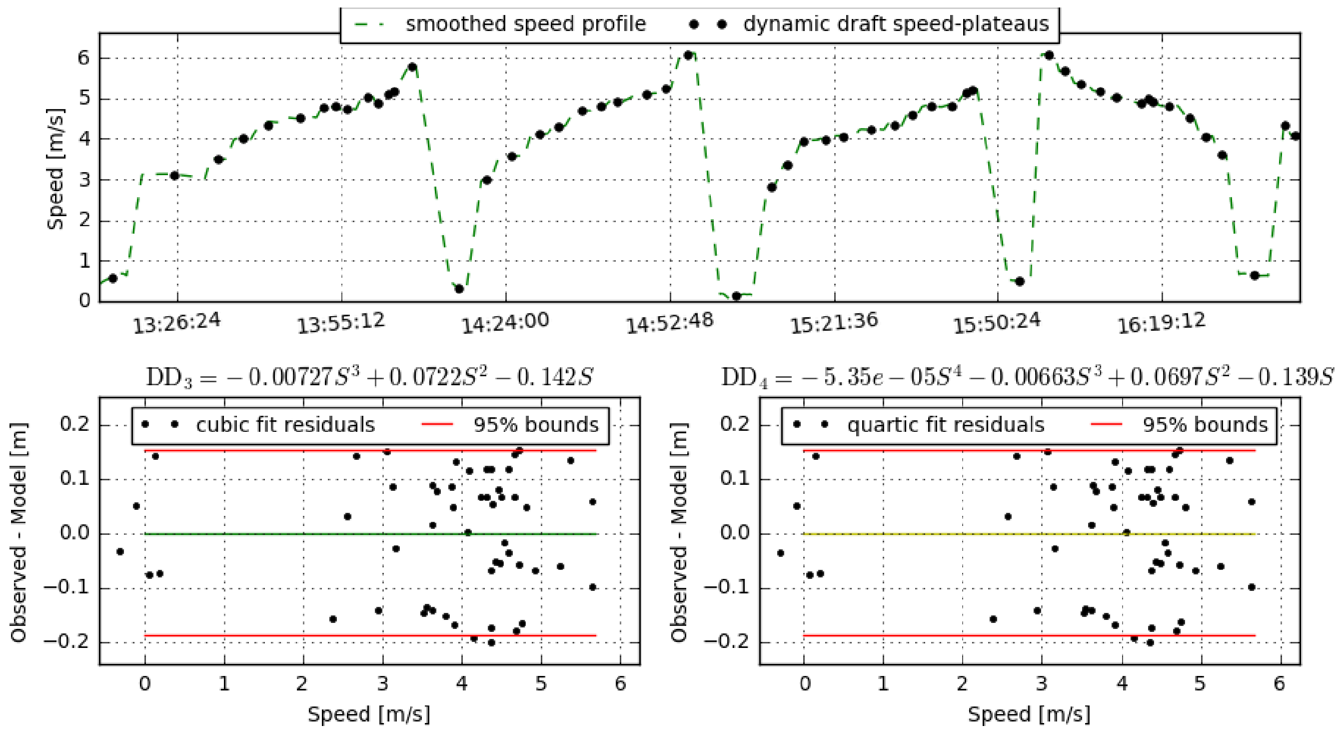


Figure 22: 2021 ERDDM Canard 15° up



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	0.10	-0.05	-0.05
1.00	0.12	-0.08	-0.08
1.50	0.08	-0.07	-0.07
2.00	0.01	-0.05	-0.05
2.50	-0.07	-0.02	-0.02
3.00	-0.13	0.03	0.03
3.50	-0.14	0.08	0.08
4.00	-0.09	0.12	0.12
4.50	0.05	0.16	0.16
5.00	0.31	0.19	0.19
5.50	0.70	0.19	0.19
6.00	0.70	0.18	0.18

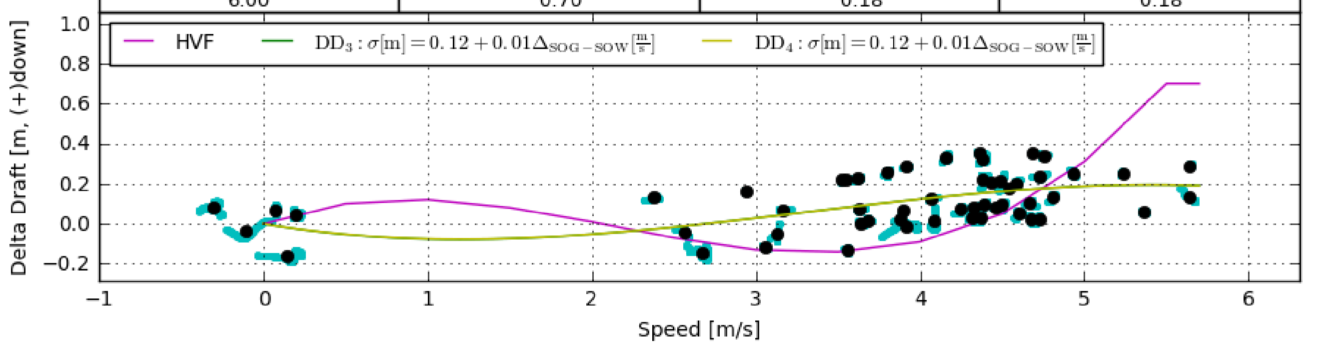


Figure 23: 2021 ERDDM Canard 15° down

B.2.2.1 Dynamic Draft Correctors

Vessel	Hassler_2040_Dual		FH_2702_R2Sonic	
Date	2021-05-04		2021-03-09	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*	*Speed (m/s)*	*Draft (m)*
	0.00	0.00	0.00	0.00
	0.50	0.03	0.50	0.04
	1.00	0.02	1.00	0.03
	1.50	0.00	1.50	0.01
	2.00	-0.02	2.00	-0.02
	2.50	-0.04	2.50	-0.04
	3.00	-0.05	3.00	-0.05
	3.50	-0.04	3.50	-0.05
	4.00	-0.02	4.00	-0.05
	4.50	0.02	4.50	-0.07
	5.00	0.06	5.00	-0.13
	5.50	0.10	5.50	-0.27
	6.00	0.13	6.00	-0.51
	6.50	0.12		
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.50	0.03	0.05	0.04

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 May 4-6, (DN124-126). The values used for the ship's angular offsets were determined by way of a statistical mean using values from 2021. Any values outside the standard deviation were removed and values were re-averaged.

B.3.1.1 System Alignment Correctors

Vessel	Hassler_2040_Dual		
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode		
Date	2019-06-08		
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	2019-06-08		
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

<table>
<tr><td>Vessel</td><td>FH_2702_R2Sonic</td></tr>
<tr><td>Echosounder</td><td>R2 Sonic R2 Sonics 2022 400kHz</td></tr>
<tr><td>Date</td><td>2021-07-01</td></tr>
<tr><td>Patch Test Values</td><td>
<table>
<tr><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Pitch</td><td>1.840 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Roll</td><td>-1.250 degrees</td><td>0.020 degrees</td></tr>
<tr><td>Yaw</td><td>0.570 degrees</td><td>0.090 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.005 seconds</td></tr>
</table>
</td></tr>
</table>

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

The acquisition methods employed were determined based on considerations of sonar system specifications, sea floor topography, water depth, and the capabilities of the acquisition platforms. They were also dictated by the coverage method specified in the Project Instructions for a 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. During acquisition, the hydrographers adjusted the parameters of the Kongsberg systems to improve data quality. 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 2021 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 was 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 2021 field season, logged in the .all file format.

Navigation and motion data were acquired and monitored in MV POSView and logged to a POS MV file with a .### 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 MV 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 on Saturdays, the end of the UTC week. At this time the GPS seconds of the week would reset.

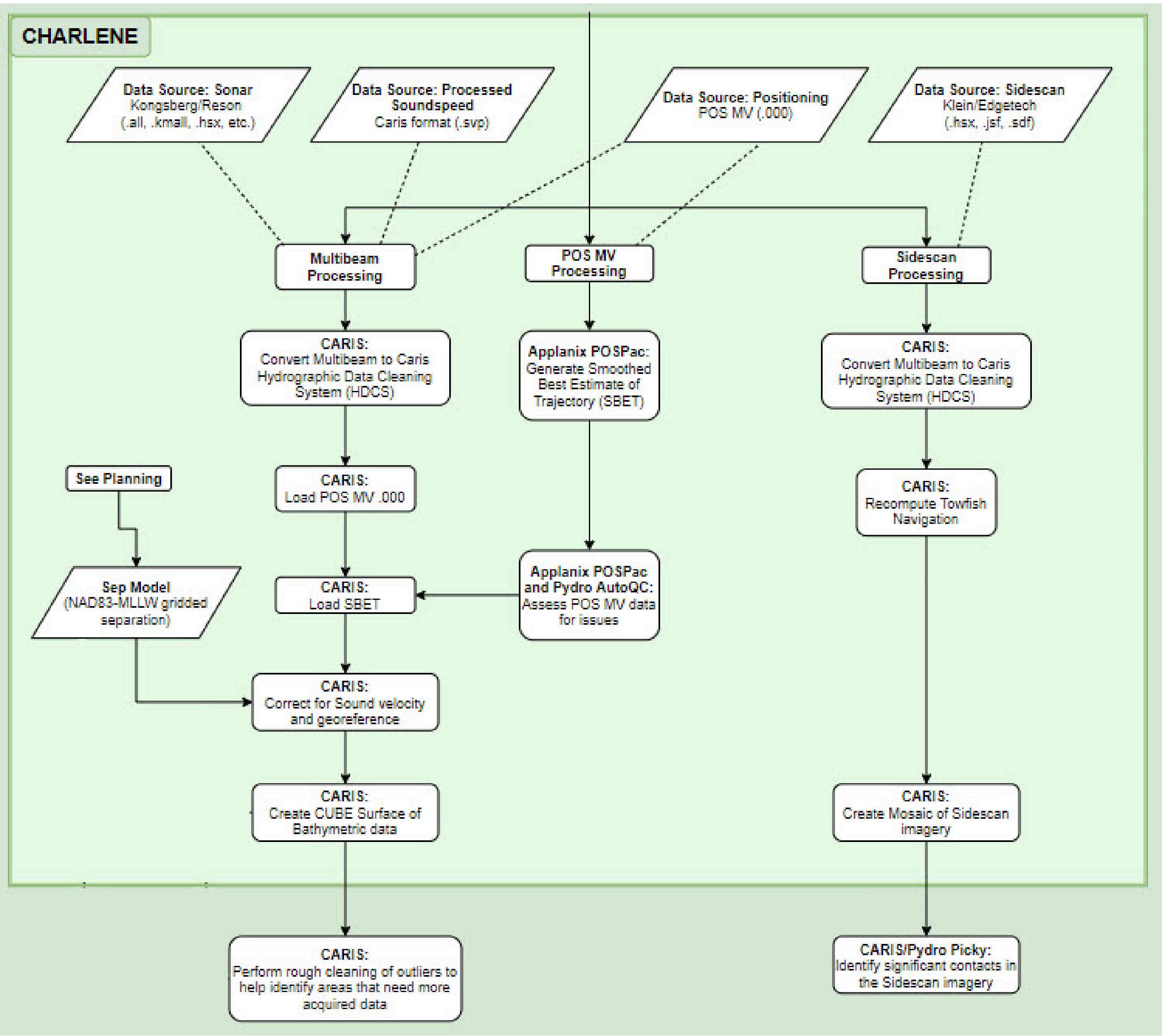


Figure 24: Charlene and raw data processing work flow

Data Processing Methods and Procedures

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 2021 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.

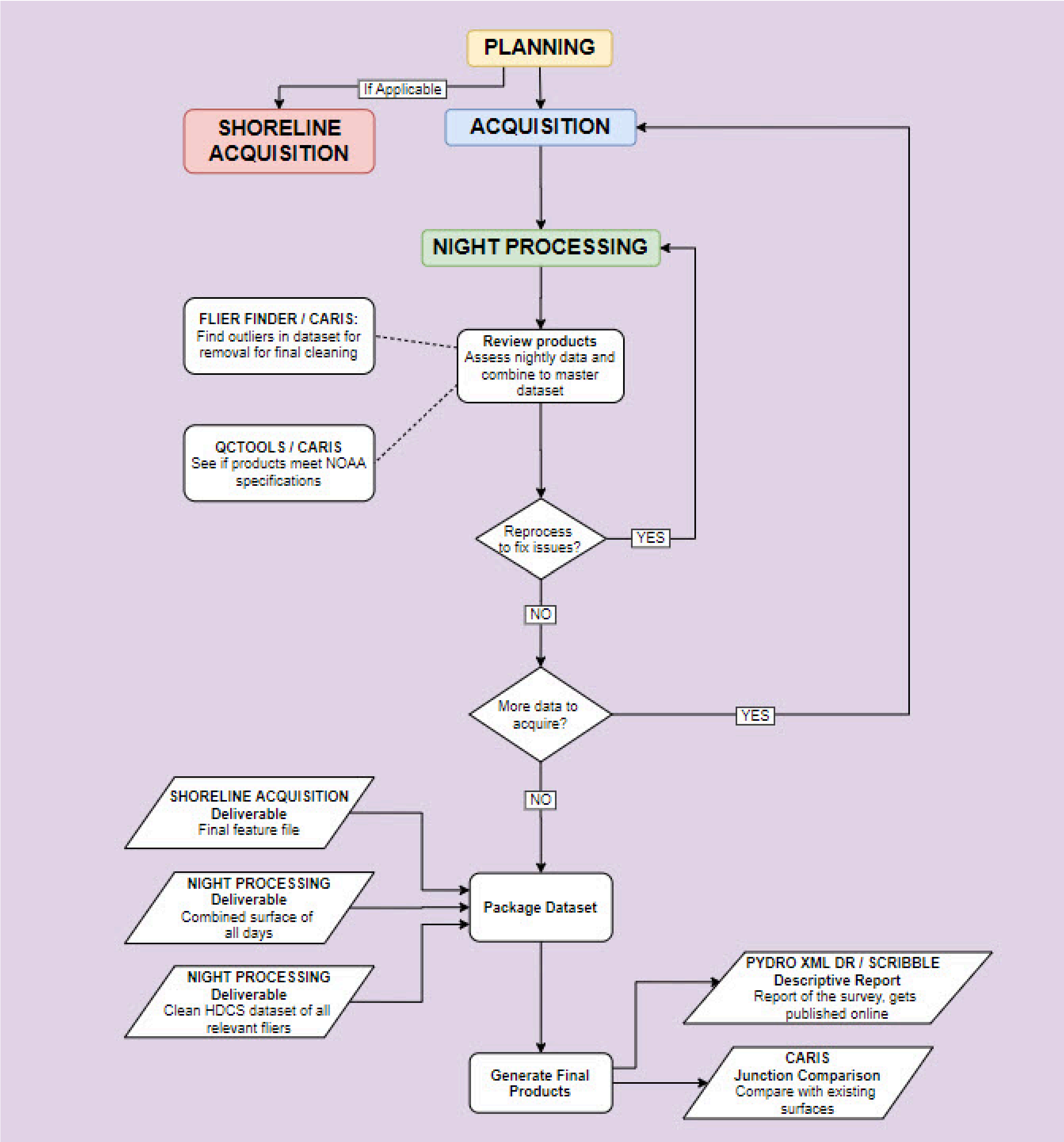


Figure 25: Overview of the life cycle of a survey on the HASSLER

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 2021 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 required adjustment for analysis and submission of individual surveys, a waiver from NOAA HSD Operations Branch was requested. A detailed listing of the resolutions and the actual depth ranges used during the processing of each survey is provided in the 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_2021v2.xml file as provided by NOAA HSD Hydrographic Systems and Technologies Branch (HSTB). The CUBEParams_NOAA_2021v2.xml file is included with the HIPS Vessel Files in the submission files for each individual survey data. The NOAA parameter configurations for variable resolution 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. 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.

MBES backscatter data are logged via SIS and are included in the MBES files (.all format) by default. 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.

Backscatter can be logged via the R2 Sonic 2022. Due to the manual variation of the gain, frequency, and power, the backscatter proccesing technique differs from that of EM 2040. The surveyor should be aware of this condition and, if need be, change the operating parameters of the Sonic 2022. When discussing the changing of the operating parameters, it is generally a matter of increasing transmit power or pulse length to get more total power into the water. In some circumstances, increasing the Absorption value will allow the system to rapidly increase gain to capture the reflected energy that has been dissipated by seafloor absorption or scattering in the water column. Adjusment of the frequency it typically done through trial and error to optimize the data collection. The adjustment of these paramters typically favors the MBES collection rather than the backscatter.

Data Processing Methods and Procedures

Backscatter processing complied with guidance provided in the 2021 HSSD and HTD 2018-3. All backscatter processing done aboard the vessel uses the program FM Geocoder Toolbox (FMGT)[a module of the QPS Fledermaus package] and following the subsequent steps:

- A new project is created for each sheet and each vessel and each sonar frequency. 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 FM GT. One mosaic is created per boat and frequency. Typically the Kongsberg EM 2040 is collected with 300 kHz and the R2 Sonic is collected with 200 kHz & 400 kHz.
-Create a mosaic. All crosslines are deslected 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

Data Acquisition Methods and Procedures

Side scan sonar data is acquired with the Klein 5000V2 SSS and is logged using Klein Sonar Pro software in a .SDF format. During acquisition the hydrographer ensures that the SSS is operated in a manner consistent with the HSSD, and manually updates the layback estimate based on changes to cable in/out. Potential contacts placed in the SSS imagery by a hydrographer may have alongtrack errors which are the result of the amount of cable out being entered in manually (as the ship does not have a cable counter at this time). This potential alongtrack error is addressed during SSS contact investigation by acquiring 3 neighboring parallel lines of MBES in a direction perpendicular to the mainscheme acquisition directly over the potential SSS contact.

Data Processing Methods and Procedures

Raw SSS data (.SDF), is processed using the Charlene automated data processing tool for consistency among processors. This automated tool converts the raw .SDF file, and computes towfish navigation utilizing the navigation data from the ship's POS .000 file. A Beam Pattern file (.BBP) is then created which averages the intensities and angles across the data set to produce a consistent mosaic image. Every resulting Side Scan image is independently reviewed by two hydrographers, who identify seafloor features to include in the .000 "side scan sonar contact file". Each contact identified in the review of side scan imagery is then further examined by the ship by acquiring additional MBES data over the potential contact, in a direction perpindicular to the diretion of mainscheme acquisition.

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 DGPS correctors via WAAS and recording in both SIS .all files (for real-time correctors) and the POS MV .000 files (for delayed heave data). The POS MV 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.

Hassler utilizes Post Processed Kinematic (PPK) 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.

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/Axillary Data/Applanix POS M/V" function. TrueHeave was 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 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/Axillary Data/Applanix SBET" and "Import/Axillary 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 had been 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 was 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 regularly 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.

On the HSL 2702 the only method for sound speed profiling is the use of the Seabird SBE 19plus. The Seabird SBE 19plus is deployed and recovered by hand.

Casts were taken at least every four hours, but typically far more frequently. The interval between casts was typically between ten and sixty minutes based on the observed variability between casts. The Survey Data Monitoring tab within Sound Speed Manager was used to run CastTime which assisted the hydrographer in determining an appropriate frequency to conduct sound speed casts.

Data Processing Methods and Procedures

Data were downloaded from the Seabird CTDs with a serial connection to a processing computer in the form of .HEX and .cnv files. Data were instantly transmitted from the MVP 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 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 transmited 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.

Surface sound speed for the R2 Sonic is measured by the Valeport mini SVX sound velocity sensor mounted near the 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 or miniSVS 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	Hassler_2040_Dual	FH_2702_R2Sonic
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees	0.02 degrees
	Heave	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters
	Roll	0.02 degrees	0.02 degrees	0.02 degrees
	Pitch	0.02 degrees	0.02 degrees	0.02 degrees
Navigation Sensor		0.50 meters	0.50 meters	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 Hassler 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:
With the advent of custom CARIS support files supplied by OCS, Bathy DataBASE now supports feature flags previously available only in Pydro. All feature flagging can now be accomplished in BDB while Pydro is used for generating reports and performing QC. Features are selected for investigation by the 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."

The 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 features 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 confirm to direction located within both the 2021 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 end up surveying 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.
• S3006 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 will remain "leveling" (aka eyeballing) during traditional shoreline, 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 2021 submission structure.

C.8 Bottom Sample Data

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

Bottom Sampling followed guidelines set forth in HTD 2018-4 and sections 7.1 of the 2021 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. Images and video are collected via the attached bottom sample set up with the HERO 3 GOPRO aboard. Samples are brought on board to be analyzed for color, sediment size, and description.

Data Processing Methods and Procedures

The ship is provided with a number of recommended bottom sample locations included 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". Observations are recorded into a Google drive spreadsheet, that is then referenced in the office to update the .hob file. Bottom sample images are named in accordance with HTD 2018-4 HXXXXX_SBDARE_YYYMMDDThhmmss.jpg

Drop camera video files were processed using VLC Media Player to clip the video starting just before the bottom sampler lands on the sea floor and ending just after recovery was initiated. 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. 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.

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 VR grid that are flagged according to the 2021 HSSD. The results of the Holiday Finder are outputted 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 VR grids, a histogram with the percentage of nodes at a prescribed resolution is created. This histogram can be used to evaluate whether "95% of all surface nodes have a resolution equal to or smaller than the coarsest allowable resolution for the node depth" as required by the HSSD. These plots are analyzed for compliance with the applicable specifications and are included in the sheet's Descriptive Report as proof of compliance.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Crossline to mainscheme comparison was conducted as outlined in section 5.2.4.3 of the 2021 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 2021 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

Imagery data integrity and quality management were not conducted for this survey.

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
Michael O. Gonsalves, CDR/NOAA	Chief of Party	07/23/2021	GONSALVES.MICHAEL .OLIVER.1275635126 Digitally signed by GONSALVES.MICHAEL.OLIVER.12 75635126 Date: 2022.02.23 06:25:02 -08'00'
Jeffrey J. Douglas, LT/NOAA	Operations Officer	07/23/2021	DOUGLAS.JEFFREY. JAMES.1365482353 Digitally signed by DOUGLAS.JEFFREY.JAMES.136548 2353 Date: 2022.02.23 04:45:57 -08'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	Visio-FH_2021_wiring_diagram.pdf Visio-2702_2021_Wiring_Diagram.pdf
Sound Speed Sensor Calibration	6918_22DEC20_CAL.pdf 4642_22DEC20_CAL.pdf 8615 2021 cal.pdf SV70 2021.pdf
Vessel Offset	Hassler Launch 2702 2015 NGS Survey.pdf
Position and Attitude Sensor Calibration	S250_2702_2020 HSRR Spreadsheet.pdf
Echosounder Confidence Check	S250_2702_2020 HSRR Spreadsheet.pdf
Echosounder Acceptance Trial Results	FH SAT 10-13JUL2019.pdf FH_2702_R2S_2022_Acceptance.pdf

Additional Report	***File***
09APR2019 Gondola and EM2040 Installation Orthogonal Coordinate Survey Rev 1	S250 Survey 18MAR2019 Rev-1.pdf
2020 Survey Inventory	FH_Survey_nventory_2021.xlsx