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National Oceanic and Atmospheric Administration
National Ocean Service

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-A366-FH-19
Time Frame:	October - October 2019

LOCALITY

State(s):	Maine
General Locality:	Gulf of Maine

2019

CHIEF OF PARTY
CDR Mark Blankenship, NOAA

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NOAA Ship *Ferdinand R. Hassler*
Chief of Party: CDR Mark Blankenship, NOAA
Year: 2019
Version: 1.0
Publish Date: 2019-11-01

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 EM2040 install 15-18March, 2019 and is included in the Appendix.

Figure 1: NOAA Ship FERDINAND R. HASSLER

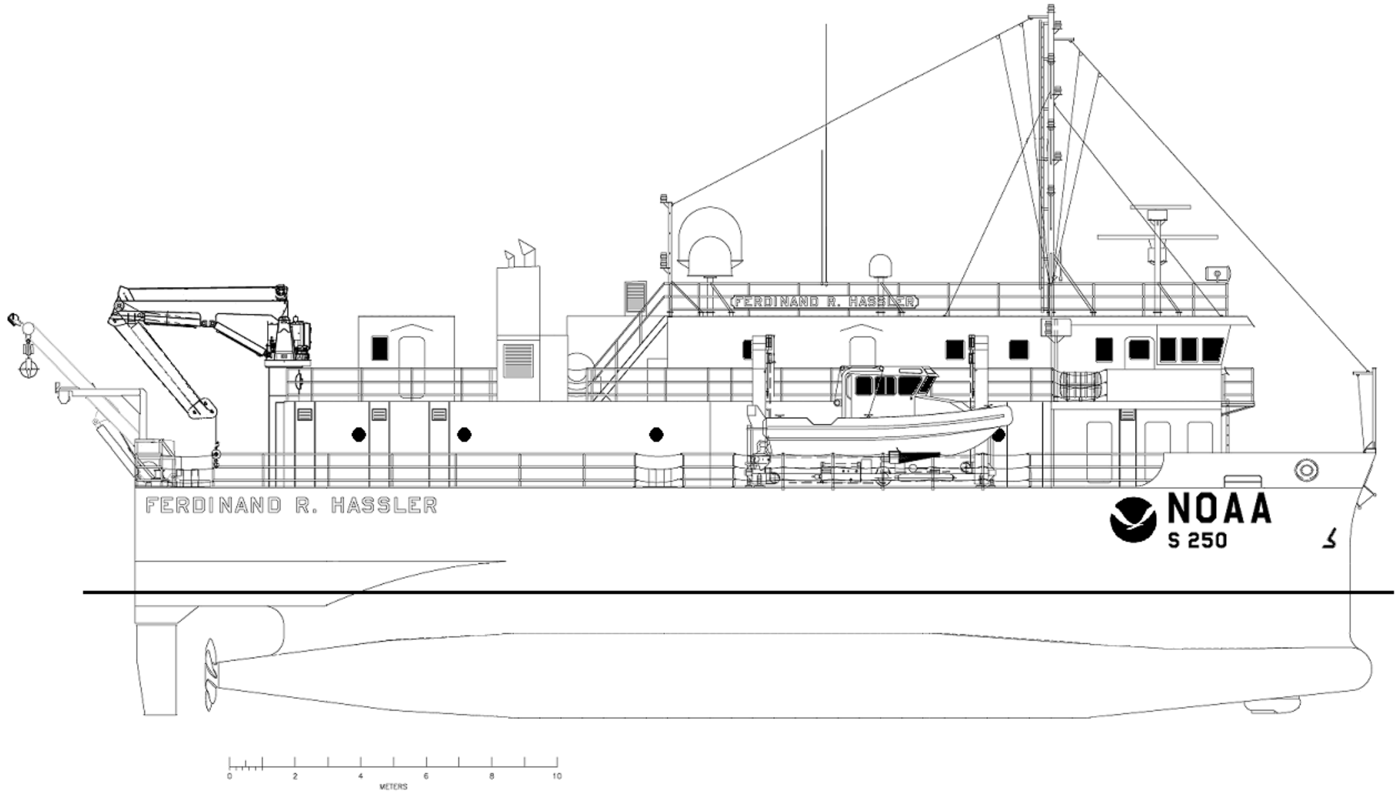

Figure 2: NOAA Ship FERDINAND R. HASSLER, starboard view

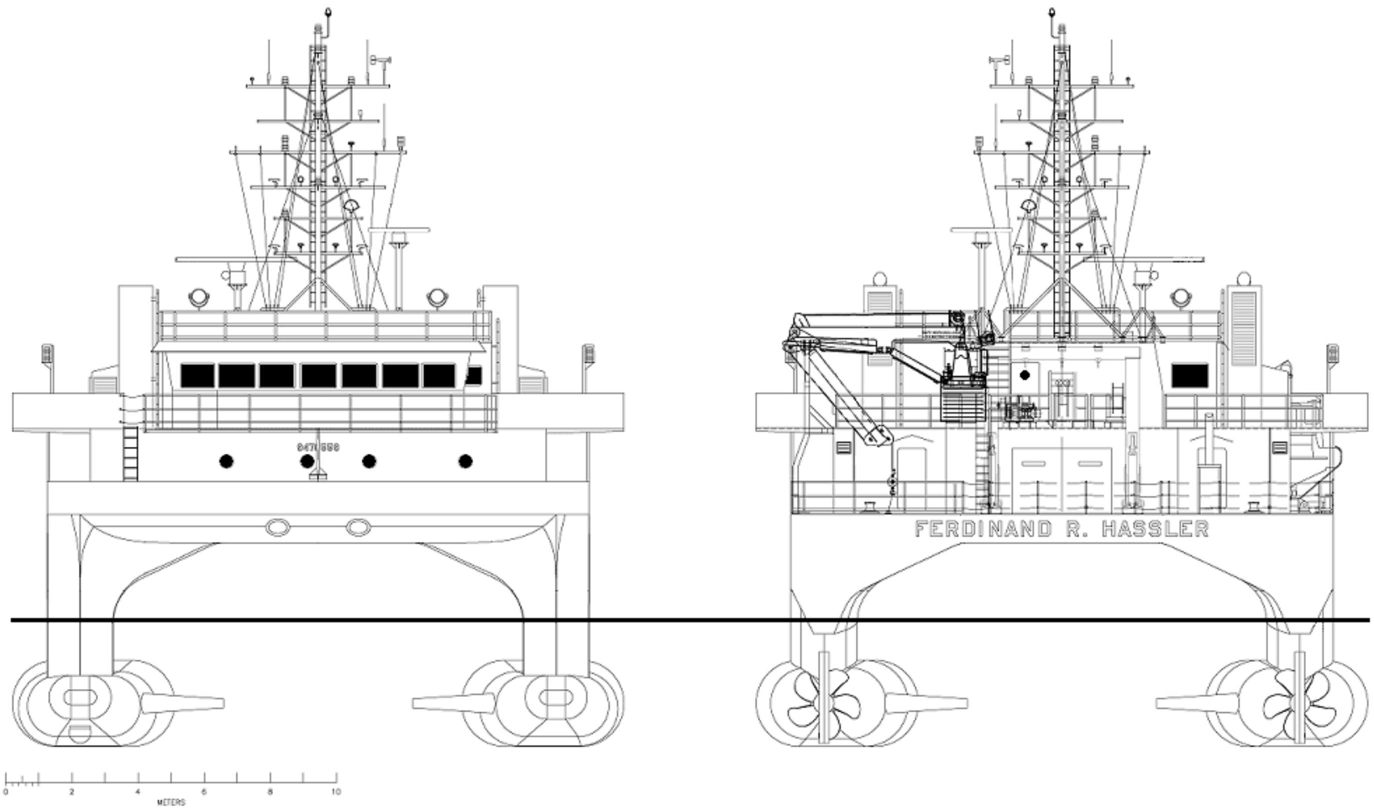

Figure 3: NOAA Ship FERDINAND R. HASSLER, bow and stern view

A.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 degrees, 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 with 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 600 meters.

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

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 displacements (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 antenna 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.

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

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

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 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>N/A</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>

A.6.2 CTD Profilers

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

Internal logging conductivity, temperature, and depth measuring device.

<table>
<tr><td>Manufacturer</td><td colspan="3">Sea-Bird Electronics</td></tr>
<tr><td>Model</td><td colspan="3">SeaCat 19plus 350 meter</td></tr>
<tr><td rowspan="4">Inventory</td><td>Component</td><td>CTD</td><td>CTD</td></tr>
<tr><td>Model Number</td><td>SBE 19plus</td><td>SBE 19plus</td></tr>
<tr><td>Serial Number</td><td>6918</td><td>4642</td></tr>
<tr><td>Calibration</td><td>2019-03-02</td><td>2019-02-28</td></tr>
</table>

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic micro-CTD

AML micro-CTD SN 8660 was installed on the Rolls-Royce Brooke-Ocean MVP towfish on 30 March, 2018.

Manufacturer	AML Oceanographic		
Model	micro-CTD		
Inventory	*S250*	*Component*	MVP Sound Speed Sensor
		Model Number	Micro CTD
		Serial Number	8660
		Calibration	2017-09-18

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	N/A	N/A

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
CARIS	HIPS/SIPS	10.4.16	Processing
CARIS	Bathy BASE Editor	5.3.0	Processing
CARIS	Plot Composer	5.3	Processing
Applanix	POSPac MMS	8.3	Acquisition and Processing
NOAA	Pydro Explorer	19.4	Processing
QPS	FMGT	7.8.6	Processing
Hypack	Hypack/Hysweep	2018	Acquisition and Processing
Applanix	POS View	9.91	Acquisition

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco 1728

The grab 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.

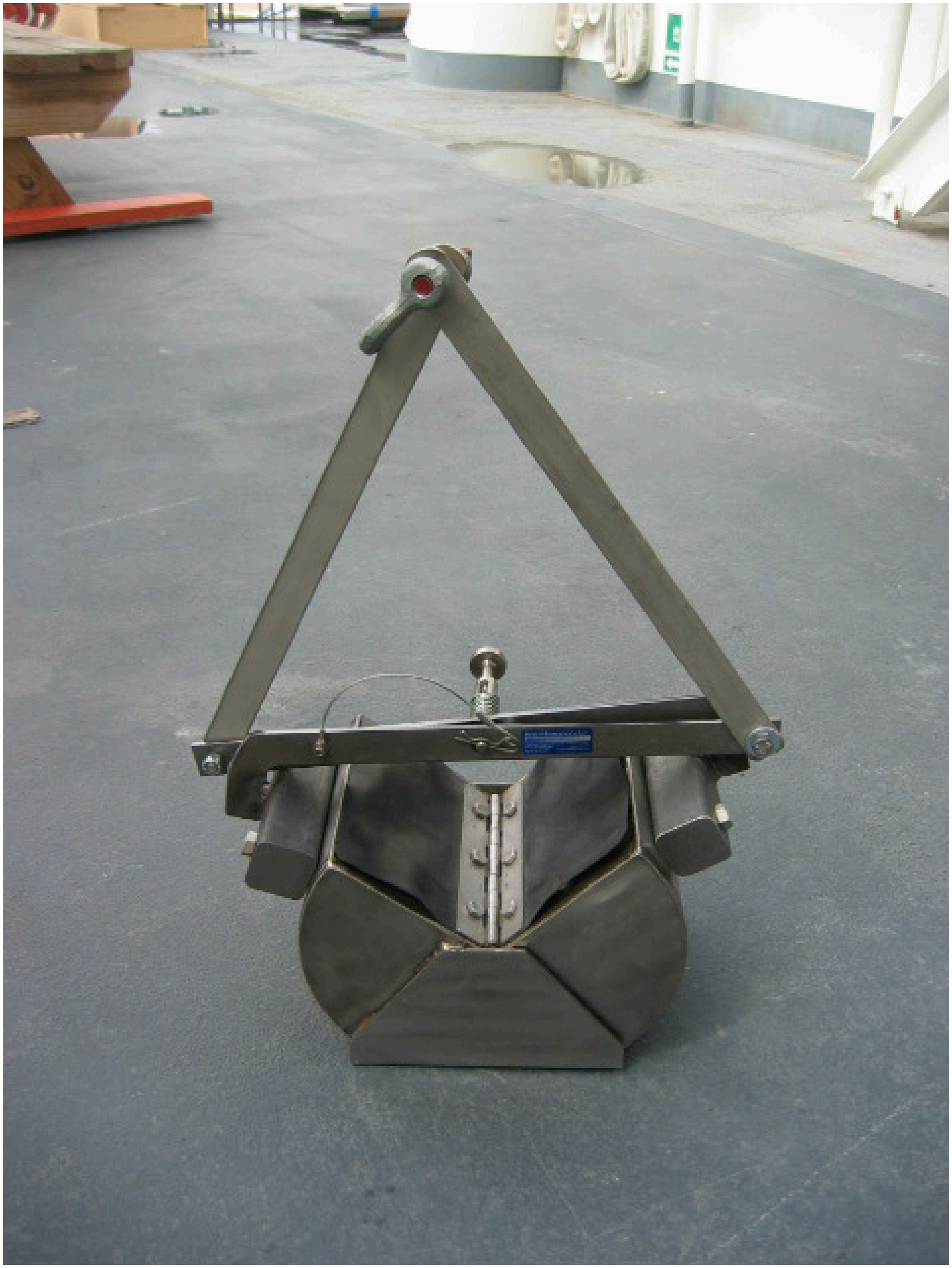

Figure 5: Ponar grab sampler.

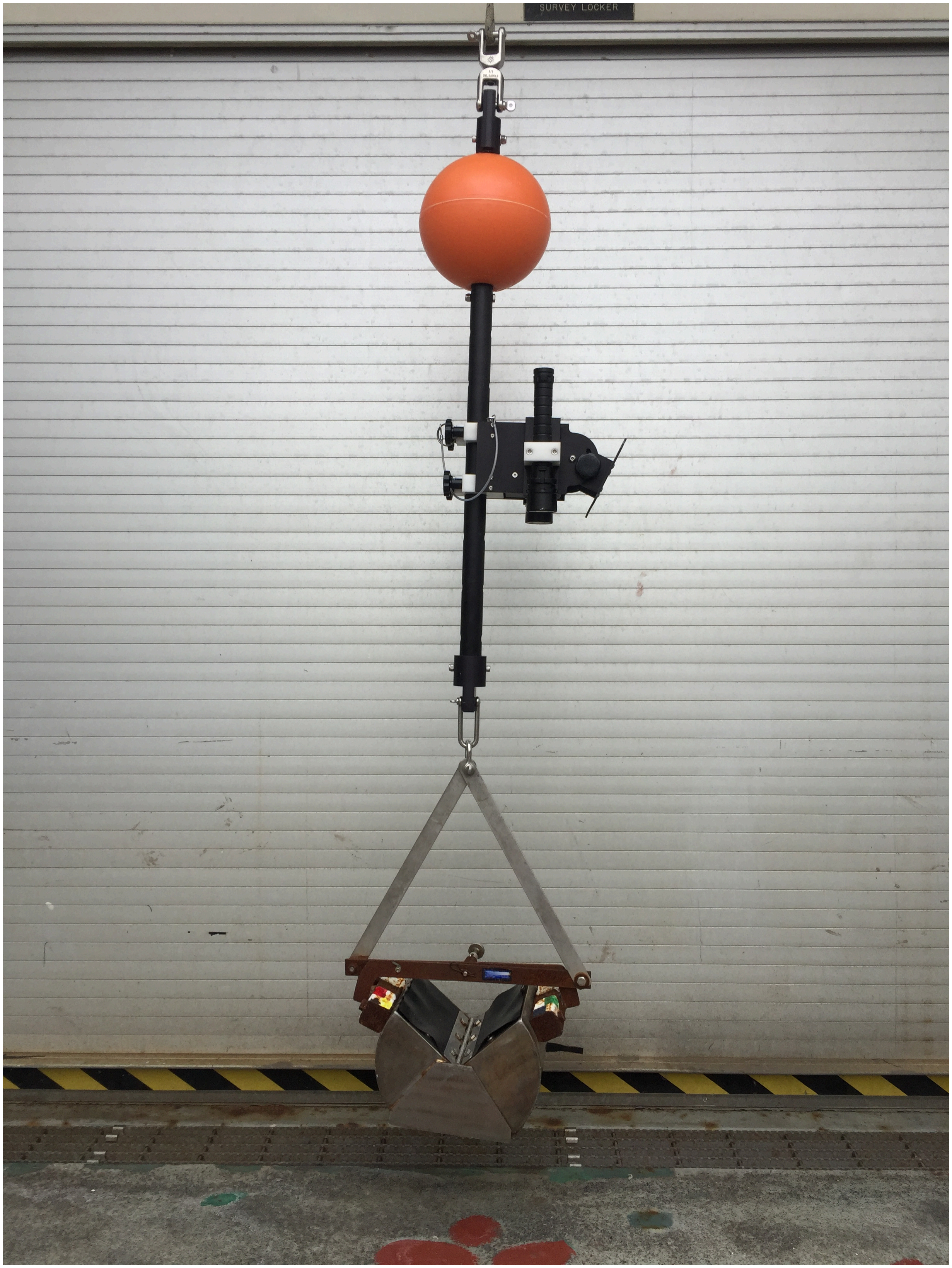

Figure 6: Camera with custom mount allowing for high quality video of the seafloor.

Figure 7: 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.

B.1.1.1 Vessel Offset Correctors

Vessel	S250			
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	

B.1.2 Layback

Side Scan Sonar was not used for this project.

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. 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 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 measured offsets to IMU were used to determine the static draft of the reference point.

B.2.1.1 Static Draft Correctors

Vessel		S250
Date		2019-06-08
Loading		0.050000 meters
Static Draft	*Measurement*	-2.383000 meters
	Uncertainty	0.030000 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 on following guidelines in the 2014 Field Procedures Manual (FPM) on September 3rd, 2018 (DN246) for vessel S250. An area was selected approximately 5NM off the Virginia coast near the Chesapeake Bay entrance 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 6 to 10 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 6 to 10 knots were run in the opposite direction. The fourth order polynomial results for the dynamic draft curves from the port and starboard side were averaged. Averages are being calculated from all ERDDM tests since the installation of the buoyancy appendages in 2013. The 2019 results and comparisons between 2011 - 2019 can be found included in the attached appendices. Results from 2011-2017 were averaged for use as the dynamic draft corrector values for 2018. An ERDDM was performed for the ship on a transit with temporal and spatial limitations (ie: on a transit well offshore). The results indicated a bad test that was likely the result of sea state miles offshore. The distribution at dead in water, at speed, and between runs is spread out. A decision was made that the averages from 2017 would be used for 2019 since S250 dynamic draft did not likely change and the ship submits ellipoidally referenced (ERS) surfaces.

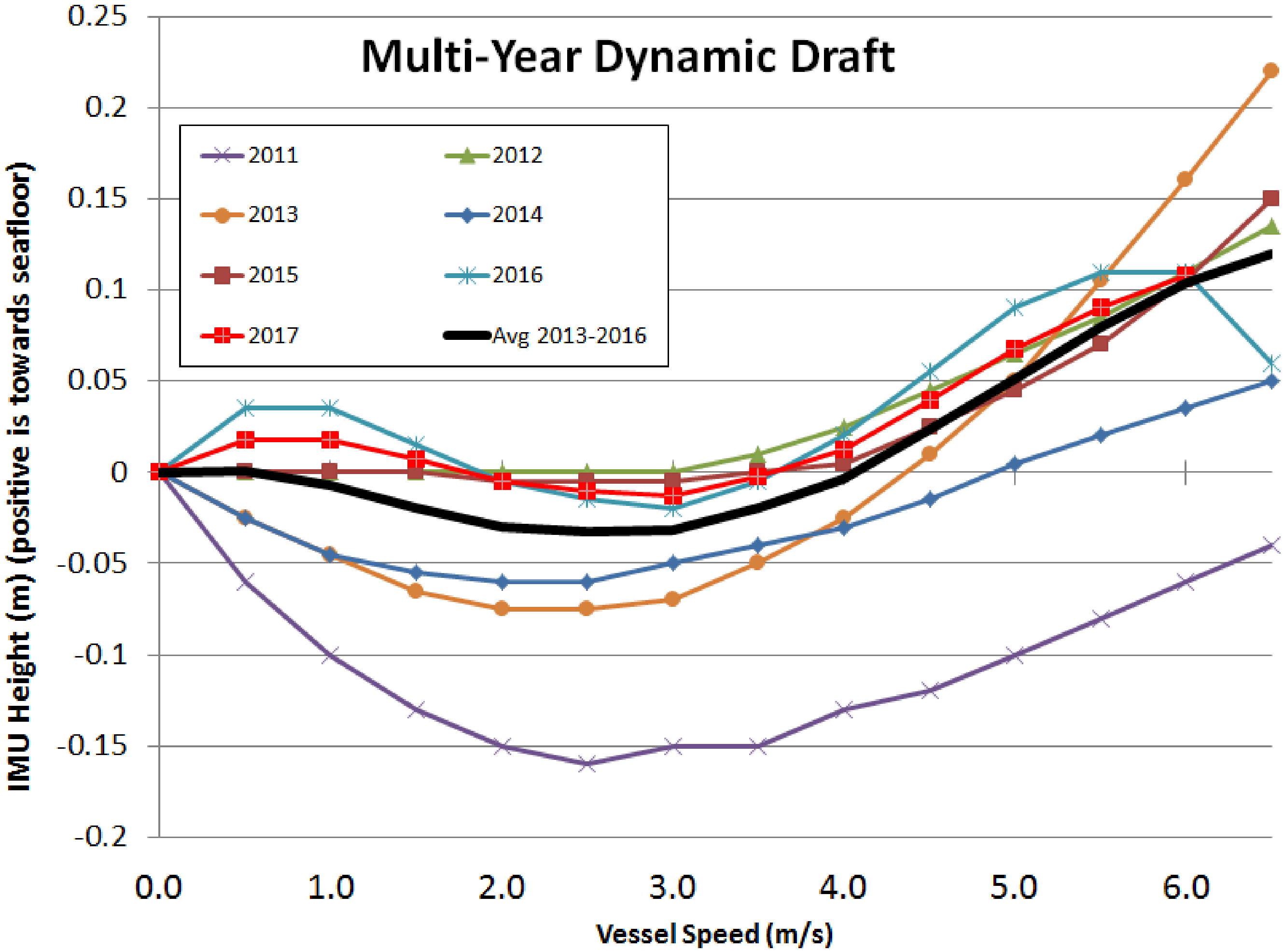

Figure 8: S250 dynamic draft derived from ERDDM methods comparison from 2011-2017.

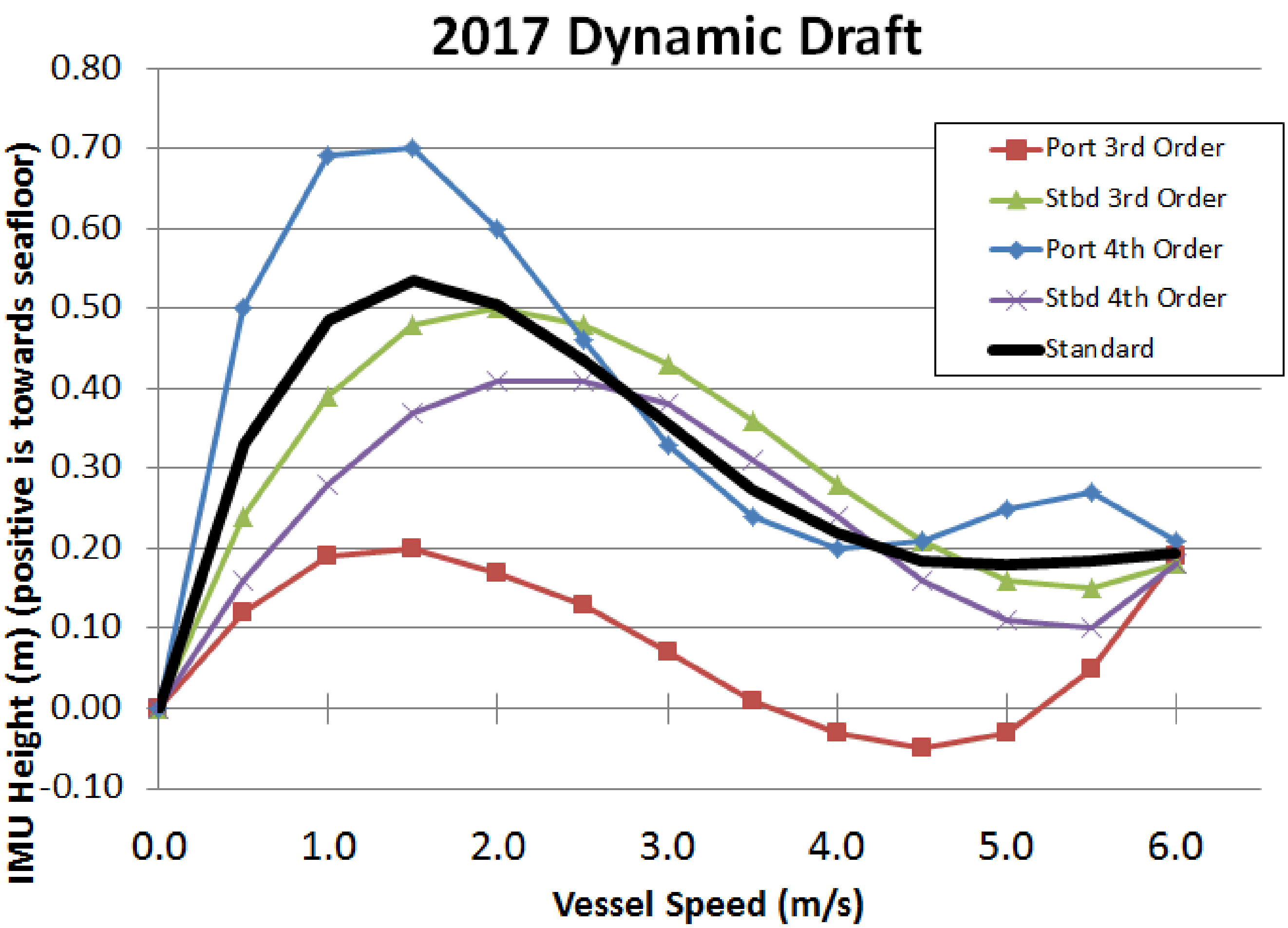

Figure 9: S250 dynamic draft derived from ERDDM methods.

B.2.2.1 Dynamic Draft Correctors

Vessel	S250	
Date	2019-06-08	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*
	0.00	0.00
	0.50	0.00
	1.00	-0.01
	1.50	-0.03
	2.00	-0.04
	2.50	-0.04
	3.00	-0.04
	3.50	-0.02
	4.00	-0.01
	4.50	0.02
	5.00	0.05
	5.50	0.08
	6.00	0.10
	6.50	0.12
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 Jacksonville, FL on July 15-16, 2019 (DN196-197). The values used for the ship's angular offsets were determined by way of a statistical mean using values from 2019. Any values outside the standard deviation were removed and values were re-averaged.

B.3.1.1 System Alignment Correctors

Vessel	S250		
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

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Acquisition methods employed were determined based on consideration 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 often 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 2019 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 overlap and full bottom coverage.

Seafloor backscatter data were acquired for all lines during the 2019 field season, logged in the .all file format.

Navigation and motion data were acquired and monitored in POSView and logged to a POS MV file with a .### extension. Data were logged on a USB flash drive inserted into the POS computer, and automatically split into 12 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 on Saturdays, the end of the UTC week. At this time the GPS seconds of the week would reset.

<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 was 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 2019 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.

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 2019 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_2019.xml file as provided by NOAA HSD Hydrographic Systems and Technologies Branch (HSTB). The CUBEParams_NOAA_2019.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 layers properties and can be modified if desired.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

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.

Data Processing Methods and Procedures

All processing of backscatter was done using the FM Geocoder Toolbox (FMGT) module of the QPS Fledermaus package. Backscatter processing complied with guidance provided in the HSSD and HTD 2018-3.

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 two POS/MV systems 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 data to a USB drive 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.

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 buy 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.

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.

Casts were taken at least every four hours, but typically far more frequently. The interval between casts was typically between ten and forty 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.

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 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
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

Shoreline and feature data was not acquired.

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 2019 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 individual DR for additional information.

Data Processing Methods and Procedures

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 were reviewed and edited in HIPS Subset Editor as necessary. Pydro Explorer's QC Tools Flier Finder guided directed data editing. 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.

Vessel heading, attitude, and navigation data were reviewed with the HIPS navigation editor and attitude editor as deemed necessary upon review of surfaces. 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.

D.1.3 Holiday Identification

The identification of holidays was accomplished by visual inspection of surfaces in addition to using QC Tools' Holiday Finder. Holidays were identified as outlined in section 5.2 of the 2019 HSSD.

D.1.4 Uncertainty Assessment

QC Tools' Grid QA functions to verify that all surfaces meet the HSSD's uncertainty specifications. This tool plots node percentage histograms, which demonstrates 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.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

A crossline to mainscheme comparison was conducted as outlined in section 5.2.4.3 of the 2019 HSSD. Following acquisition, a surface containing strictly data from mainscheme lines and a surface containing strictly data from crosslines are generated and analyzed with the Compare Grids tool in Pydro Explorer. This tool analyzes the difference between the two grids and outputs a difference surface between the depths, as well as a second surface that contains the fraction of NOAA allowable error represented by that depth difference for each node. Additionally, statistics and distribution summary plots of the difference surface and the fraction of allowable error are generated to provide easily interpretable analyses of the differences between the surfaces.

D.1.5.2 Junctions

Junction comparisons were conducted as outlined in section 7.2.2 of the 2019 HSSD. Surface based and statistical analysis of the junctions is performed through the Compare Grids tool as described in D.1.5.1.

D.1.5.3 Platform to Platform

n/a

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
Mark Blankenship, CDR/NOAA	Chief of Party	12/31/2019	2020.01.18 13:23:03 -05'00'
Steven Wall, LT/NOAA	Operations Officer	12/31/2019	WALL.STEVEN.JAMES.1459978298 Digitally signed by WALL.STEVEN.JAMES.1459978298 Date: 2020.01.18 13:52:37 -05'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	Visio-FH_2019_Wiring_Diagram.pdf
Sound Speed Sensor Calibration	8660.pdf SBE 19plus C4642 28Feb19 Final Cal.pdf SBE 19plus P4642 25Feb19 Final Cal.pdf SBE 19plus T4642 28Feb19 Final Cal.pdf SBE 19plus V2 C6918 02Mar19 Final Cal.pdf SBE 19plus V2 P6918 25Feb19 Final Cal.pdf SBE 19plus V2 T6918 02Mar19 Final Cal.pdf AML Micro CTD 8661 04APR2019 Final Cal.pdf
Vessel Offset	Hassler_2040_VesselOffsets_2019.pdf
Position and Attitude Sensor Calibration	N/A
Echosounder Confidence Check	N/A
Echosounder Acceptance Trial Results	FH SAT 10-13JUL2019.pdf

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