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-S347-FA-18
Time Frame:	July - August 2018

LOCALITY

State(s):	Alaska
General Locality:	Lisburne Peninsula, Alaska

2018

CHIEF OF PARTY
CDR Marc Moser, NOAA

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Date:

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NOAAS Fairweather S-220
Chief of Party: CDR Marc Moser, NOAA
Year: 2018
Version: 1
Publish Date: 2018-08-23

A System Equipment and Software

A.1 Survey Vessels

A.1.1 NOAAS Fairweather

Vessel Name	NOAAS Fairweather	
Hull Number	S-220	
Description	NOAAS Fairweather (FA) is a 70.4 meter oceanographic research vessel owned and operated by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). It has a welded steel and ice strengthened hull for an ABS classification of #A1, #AMS.	
Dimensions	*LOA*	70.4 meters
	Beam	12.8 meters
	Max Draft	4.8 meters
Most Recent Full Static Survey	*Date*	2014-11-23
	Performed By	The IMTEC Group, Ltd.

Figure 1: NOAA Ship Fairweather S-220

A.1.2 FA 2805

Vessel Name	FA 2805	
Hull Number	2805	
Description	FA 2805 is a Jenson “Type 1” aluminum hydrographic survey launch (HSL) aboard S-220. It has an 8.64 meter aluminum hull, a 13 passenger capacity, and a weight of 15,500 lbs. A 490 HP Cummins Diesel engine with a 2' diameter fixed pitch propeller powers the HSL to reach a 20 knot (kt) cruising speed.	
Dimensions	*LOA*	8.6 meters
	Beam	3.5 meters
	Max Draft	1.1 meters
Most Recent Full Static Survey	*Date*	2006-01-25
	Performed By	National Geodetic Survey, Geodetic Services Division
Most Recent Partial Offset Verification	*Date*	2018-04-02
	Method	Direct measurement from benchmarks by the field unit.

Figure 2: FA 2805

A.1.3 FA 2806

Vessel Name	FA 2806	
Hull Number	2806	
Description	FA 2806 is a Jenson “Type 1” aluminum hydrographic survey launch (HSL) aboard S-220. It has an 8.64 meter aluminum hull, a 13 passenger capacity, and a weight of 15,500 lbs. A 490 HP Cummins Diesel engine with a 2' diameter fixed pitch propeller powers the HSL to reach a 20 knot (kt) cruising speed.	
Dimensions	*LOA*	8.6 meters
	Beam	3.5 meters
	Max Draft	1.1 meters

Most Recent Full Static Survey	*Date*	2010-01-24
	Performed By	National Geodetic Survey, Geodetic Services Division
Most Recent Partial Offset Verification	*Date*	2018-04-05
	Method	Direct measurement from benchmarks by the field unit.

Figure 3: FA 2806

A.1.4 FA 2807

Vessel Name	FA 2807
Hull Number	2807
Description	FA 2807 is a Jenson "Type 1" aluminum hydrographic survey launch (HSL) aboard S-220. It has an 8.64 meter aluminum hull, a 13 passenger capacity, and a weight

	of 15,500 lbs. A 490 HP Cummins Diesel engine with a 2' diameter fixed pitch propeller powers the HSL to reach a 20 knot (kt) cruising speed.	
Dimensions	*LOA*	8.6 meters
	Beam	3.5 meters
	Max Draft	1.1 meters
Most Recent Full Static Survey	*Date*	2010-01-25
	Performed By	National Geodetic Survey, Geodetic Services Division
Most Recent Partial Offset Verification	*Date*	2018-04-02
	Method	Direct measurement from benchmarks by the field unit.

Figure 4: FA 2807

A.1.5 FA 2808

Vessel Name	FA 2808
Hull Number	2808
Description	FA 2808 is a Jenson "Type 1" aluminum hydrographic survey launch (HSL) aboard S-220. It has an 8.64 meter aluminum hull, a 13 passenger capacity, and a weight of 15,500 lbs. A 490 HP Cummins Diesel engine with a 2' diameter fixed pitch propeller powers the HSL to reach a 20 knot (kt) cruising speed.
Dimensions	*LOA*: 8.6 meters *Beam*: 3.5 meters *Max Draft*: 1.1 meters
Most Recent Full Static Survey	*Date*: 2010-01-25 *Performed By*: National Geodetic Survey, Geodetic Services Division
Most Recent Partial Offset Verification	*Date*: 2018-04-02 *Method*: Direct measurement from benchmarks by the field unit.

Figure 5: FA 2808

A.1.6 CCOM-UNH Autonomous Surface Mapping Vehicle

<table>
<tr><td>Vessel Name</td><td colspan="2">CCOM-UNH Autonomous Surface Mapping Vehicle</td></tr>
<tr><td>Hull Number</td><td colspan="2">BEN</td></tr>
<tr><td>Description</td><td colspan="2">BEN is a C-Worker 4 autonomous surface vehicle (ASV) manufactured by ASV Global Ltd. It has a total length of 3.95 meters, a weight of approximately 1900 pounds, and is powered by a 30 HP Yanmar 3YM30 diesel engine. BEN was managed and operated entirely by a team of research engineers from the Center for Coastal Ocean Mapping (CCOM) at the University of New Hampshire.</td></tr>
<tr><td rowspan="3">Dimensions</td><td>LOA</td><td>3.95 meters</td></tr>
<tr><td>Beam</td><td>1.58 meters</td></tr>
<tr><td>Max Draft</td><td>0.66 meters</td></tr>
</table>

Most Recent Full Offset Verification	*Date*	2018-08-01
	Method	BEN's configuration establishes the IMU target as the vessel reference point. Offsets were determined by the team at CCOM through the following methods: post-processed POS/MV calibrations, mechanical drawings provided by ASV Global, direct physical measurements, or mathmatically derived constraints provided by the other measurements. See the offset diagram below for information on how each individual offset was derived.

Figure 6: BEN ASV

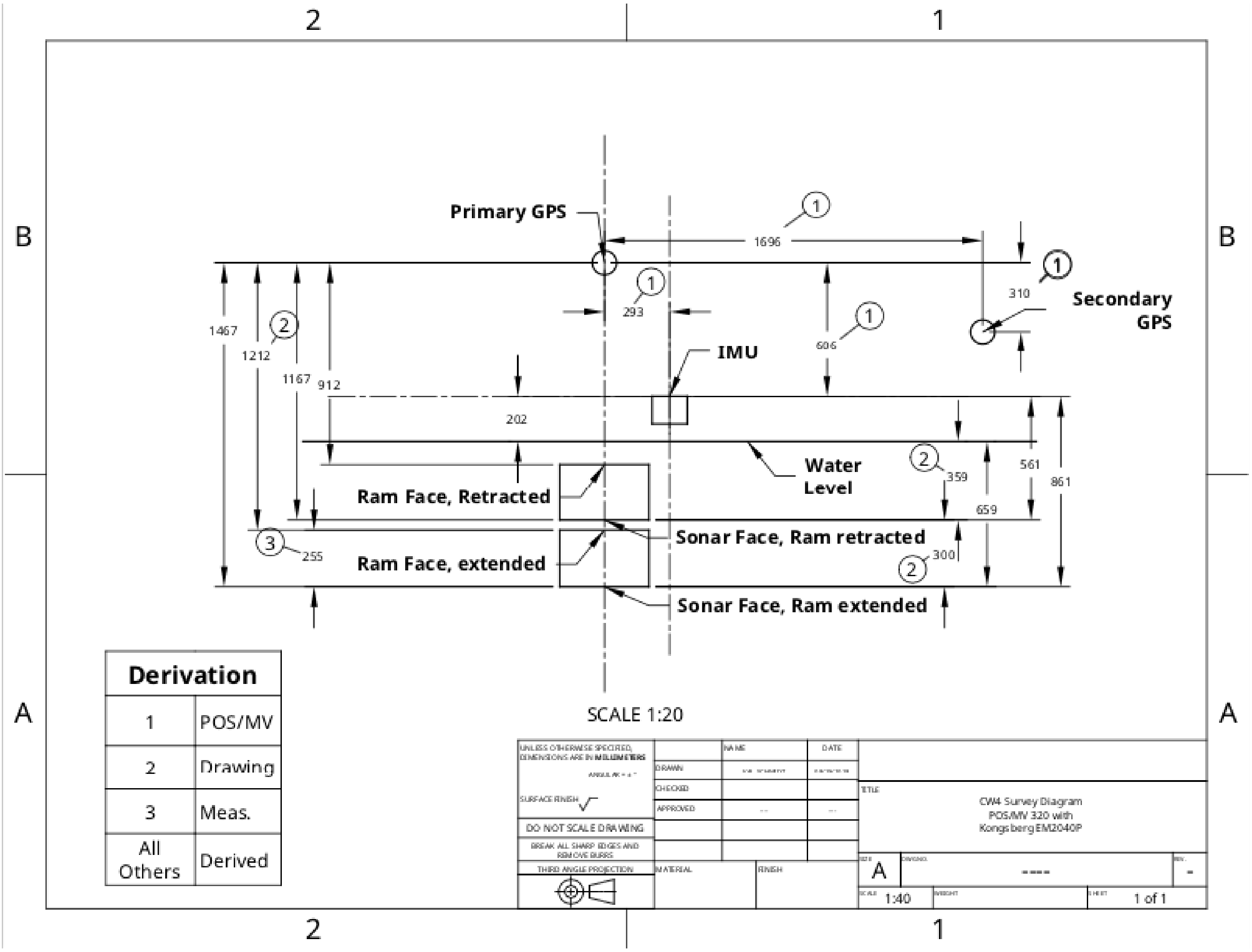

Figure 7: BEN offset diagram

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM 710

<table>
<tr><td>Manufacturer</td><td colspan="4">Kongsberg</td></tr>
<tr><td>Model</td><td colspan="4">EM 710</td></tr>
<tr><td>Description</td><td colspan="4">S-220 has a hull-mounted Kongsberg EM 710 multibeam echosounder (MBES), which operates at sonar frequencies in the 70 to 100 kHz range. The across-track swath coverage is up to 140° with a published maximum depth of >2500 meters (m). The along track beam width configuration is ½° with a receive beam width of 1°. The system forms 256 beams, with dynamic focusing employed in the near field. A high density beam processing mode provides up to 400 soundings per swath. The beam spacing may be set to be either equiangular or equidistant. S-220 typically collects 400 beams per ping in equidistant mode. The transmit beams are divided into three sectors to maximize range capability and to suppress interference from multiples of strong bottom echoes. The sectors transmit sequentially within each ping, and use distinct frequencies or waveforms.</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">S-220</td><td>Component</td><td>HWS</td><td>Transceiver (TRU)</td></tr>
<tr><td>Model Number</td><td>MP8300</td><td>EM 710</td></tr>
<tr><td>Serial Number</td><td>CZC34076Z9</td><td>232</td></tr>
<tr><td>Frequency</td><td>70-100kHz</td><td>70-100kHz</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2018-04-20</td></tr>
<tr><td>Accuracy Check</td><td>2018-04-21</td><td>2018-04-21</td></tr>
</table>

Figure 8: EM 710 gondola during transducer installation

A.2.1.2 Kongsberg EM 2040

Manufacturer	Kongsberg
Model	EM 2040
Description	FA 2805, 2806, 2807, and 2808 each has a Kongsberg EM 2040 MBES. The EM 2040 is capable of operating at low frequency (200 kHz), intermediate frequency (300 kHz), and high frequency (400 kHz), with maximum swath coverage of 140°. At the common usage frequency of 300kHz, the beam width is 1° for both TX and RX. The system forms 256 beams, with dynamic focusing employed in the near field. A high density beam processing mode provides up to 400 soundings per swath. The beam spacing may be set to be either equiangular or equidistant. All HSLs typically collect 400 beams per ping in equidistant mode. The transmit beams are divided into three sectors to maximize range capability and to suppress interference from multiples of strong bottom echoes. The sectors transmit sequentially within each ping, and use distinct frequencies or waveforms.The typical operational depth range for the EM 2040 is 0.5 to 600 m. Each HSL has a hull mounted system along the centerline, a topside processing unit, and hydrographic workstation for control and monitoring.

Inventory	*2805*	*Component*	HWS	Processing Unit (PU)
		Model Number	MP8300	Slim PU
		Serial Number	CZC5502TD	40122
		Frequency		
		Calibration	2018-04-18	2018-04-18
		Accuracy Check	2018-04-20	2018-04-20
	2806	*Component*	HWS	Processing Unit (PU)
		Model Number	MP8300	Slim PU
		Serial Number	CZC3410KPV	40111
		Frequency		
		Calibration	2018-04-19	2018-04-19
		Accuracy Check	2018-04-20	2018-04-20
	2807	*Component*	HWS	Processing Unit (PU)
		Model Number	MP8300	Slim PU
		Serial Number	CZC3410KMV	40109
		Frequency		
		Calibration	2018-04-19	2018-04-19
		Accuracy Check	2018-04-20	2018-04-20
	2808	*Component*	HWS	Processing Unit (PU)
		Model Number	MP8300	Slim PU
		Serial Number	CZC3410KN0	40117
		Frequency		
		Calibration	2018-04-19	2018-04-19
		Accuracy Check	2018-04-20	2018-04-20

Figure 9: EM 2040 topside processing unit

Figure 10: EM 2040 transceiver array

A.2.1.3 Kongsberg EM2040p

<table>
<tr><td>Manufacturer</td><td colspan="4">Kongsberg</td></tr>
<tr><td>Model</td><td colspan="4">EM2040p</td></tr>
<tr><td>Description</td><td colspan="4">BEN has a Kongsberg EM 2040p MBES. The EM 2040p is capable of operating at frequencies of 200, 300, and 400kHz with maximum swath coverage of 140°. At the common usage frequency of 300kHz, the beam width is 1° for both TX and RX. The system forms 256 beams, with dynamic focusing employed in the near field. A high density beam processing mode provides up to 400 soundings per swath in single swath, and 800 soundings in dual swath. The beam spacing may be set to be either equiangular or equidistant. BEN typically collects 400 beams per ping in equidistant mode. The transmit beams are divided into three sectors to maximize range capability and to suppress interference from multiples of strong bottom echoes. The sectors transmit sequentially within each ping, and use distinct frequencies or waveforms.The typical operational depth range for the EM 2040p is 0.5 to 600 m. BEN has a hull mounted system along the centerline, a topside processing unit, and hydrographic workstation for control and monitoring.</td></tr>
<tr><td rowspan="6">Inventory</td><td rowspan="6">BEN</td><td>Component</td><td>HWS</td><td>Processing Unit</td></tr>
<tr><td>Model Number</td><td>Intel NUC</td><td>Slim PU</td></tr>
<tr><td>Serial Number</td><td>N/A</td><td>50003</td></tr>
<tr><td>Frequency</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2018-08-01</td><td>2018-08-01</td></tr>
<tr><td>Accuracy Check</td><td>2018-08-01</td><td>2018-08-01</td></tr>
</table>

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

<table>
<tr><td>Manufacturer</td><td colspan="4">FA Personnel</td></tr>
<tr><td>Model</td><td colspan="4">Traditional</td></tr>
<tr><td>Description</td><td colspan="4">Field units Field units maintain calibrated lead lines for use in occasional direct water measurements, particularly during shoreline investigation. Fairweather maintains two calibrated lead lines on board.</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S-220</td><td>Component</td><td>Lead Line</td><td>Lead Line</td></tr>
<tr><td>Model Number</td><td>Traditional</td><td>Traditional</td></tr>
<tr><td>Serial Number</td><td>30_01_05</td><td>10_05_09</td></tr>
<tr><td>Calibration</td><td>2018-05-29</td><td>2018-05-31</td></tr>
</table>

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

A.4.1.1 GNSS Differential Control Base Station

Manufacturer	GNSS Differential Control
Model	Base Station
Description	FA may maintain GPS base stations within hydrographic project areas in the absence of a Continuously Operating Reference Station (CORS) network. Base station sites must be within 40 kilometers (km) of the project area's data, in accordance with the 2018 Hydrographic Survey Specifications and Deliverables (HSSD). Each station has a Trimble NetR5 or NetR9 Global Navigation Satellite System (GNSS) reference receiver with a FreeWave HTP-900RE 900 MHz Ethernet radio interface contained within a watertight plastic case. A Zephyr Geodetic 2 GNSS antenna is secured atop a Seco fixed-height GNSS antenna tripod. This connects to the Trimble receiver through a watertight connection fitted in the side of the case. A standard survey tripod supports a UHF antenna on an extension pole which connects to the FreeWave Ethernet radio and provides remote Trimble data downloads. External 12V marine sealed lead acid batteries and solar panels provide power.

Inventory

Component	GPS Receiver	GPS Receiver	GPS Receiver	GPS Receiver	GPS Antenna	GPS Antenna	GPS Antenna	GPS Antenna
Model Number	Trimble NetR9	Trimble NetR9	Trimble NetR9	Trimble NetR5	Zephyr Geodetic 2	Zephyr Geodetic 2	Zephyr Geodetic 2	Zephyr Geodetic 2
Serial Number	5439R49375	5034K69677	5034K69698	4910K61054	1441031361	1441027807	6127560651	30767996
Calibration	2018-02-20	2018-02-20	2018-02-20	2018-02-20	2018-02-20	2018-02-20	2018-02-20	2018-02-20

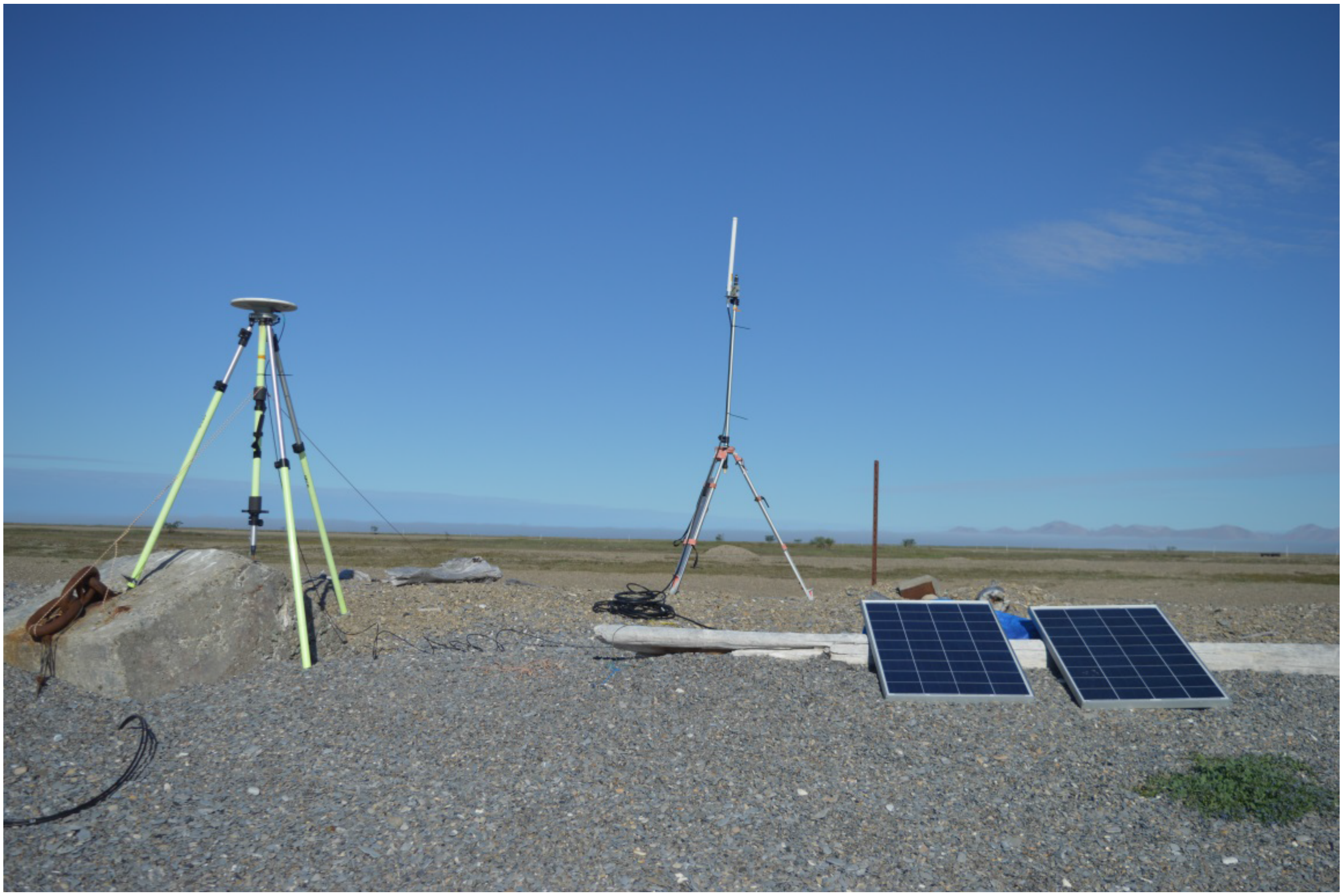

Figure 11: GNSS differential control base station set up

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

Manufacturer	Applanix
Model	POS MV 320 V5
Description	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.

Inventory

2805	*Component*	PCS	IMU	GNSS Antenna	GNSS Antenna
	Model Number	320 V5	LN200	GA830	GA830
	Serial Number	8198	294	9961	9962
	Calibration	2018-04-09	2018-04-09	2018-04-09	2018-04-09
2806	*Component*	PCS	IMU	GNSS Antenna	GNSS Antenna
	Model Number	320 V5	LN200	GA830	GA830
	Serial Number	8197	991	9963	9964
	Calibration	2018-04-09	2018-04-09	2018-04-09	2018-04-09
2807	*Component*	PCS	IMU	GNSS Antenna	GNSS Antenna
	Model Number	320 V5	LN200	GA830	GA830
	Serial Number	8195	37	9965	9966
	Calibration	2018-04-19	2018-04-19	2018-04-19	2018-04-19
2808	*Component*	PCS	IMU	GNSS Antenna	GNSS Antenna
	Model Number	320 V5	LN200	GA830	GA830
	Serial Number	8196	324	9967	9968
	Calibration	2018-04-09	2018-04-09	2018-04-09	2018-04-09
S-220	*Component*	PCS	IMU	GNSS Antenna	GNSS Antenna
	Model Number	320 V5	LN200	GA830	GA830
	Serial Number	8194	292	9959	9960
	Calibration	2017-05-19	2017-05-19	2018-04-21	2018-04-21
BEN	*Component*	PCS		IMU	
	Model Number	320 V5		LN200	
	Serial Number	5512		36	
	Calibration	2018-08-01		2018-08-01	

Figure 12: POS MV 320 V5 System

A.5.2 DGPS

A.5.2.1 Hemisphere MBX-4

Manufacturer	Hemisphere
Model	MBX-4
Description	S-220 and its HSLs each have differential GPS beacon receivers. FA personnel tune these receivers to the closest available U.S. Coast Guard (USCG) beacon transmitters with reliable signals. The selected beacon will change throughout acquisition, based on the signal reception and survey platform position. The GPS correctors feed to the Applanix POS-MVs to produce real time differentially corrected positions.

Inventory	*2805*	*Component*	DGPS Receiver	DGPS Antenna
		Model Number	MBX-4	MA40
		Serial Number	0927-9567-0001	0924-9488-0046
		Calibration	N/A	N/A
	2806	*Component*	DGPS Receiver	DGPS Antenna
		Model Number	MBX-4	MA40
		Serial Number	0923-9416-0005	0919-9231-0193
		Calibration	N/A	N/A
	2807	*Component*	DGPS Receiver	DGPS Antenna
		Model Number	MBX-4	MA40
		Serial Number	0923-9416-0007	0919-9231-0191
		Calibration	N/A	N/A
	2808	*Component*	DGPS Receiver	DGPS Antenna
		Model Number	MBX-4	MA40
		Serial Number	0924-9498-000	0924-9488-0040
		Calibration	N/A	N/A
	S220	*Component*	DGPS Receiver	DGPS Antenna
		Model Number	MBX-3	MGL3
		Serial Number	0328-12362-0001	9824-1779-0002
		Calibration	N/A	N/A

A.5.3 GPS

GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

A.5.4.1 Laser Tech TruPulse 200

Manufacturer	Laser Tech
Model	TruPulse 200
Description	The TruPulse laser range finders are used to measure the static draft of S220.

<table>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S-220</td><td>Component</td><td>Laser Range Finder</td><td>Laser Range Finder</td><td>Laser Range Finder</td><td>Laser Range Finder</td></tr>
<tr><td>Model Number</td><td>TruPulse 200 Laser Rangefinder</td><td>TruPulse 200 Laser Rangefinder</td><td>TruPulse 200 Laser Rangefinder</td><td>TruPulse 200 Laser Rangefinder</td></tr>
<tr><td>Serial Number</td><td>000676</td><td>041169</td><td>041156</td><td>001481</td></tr>
<tr><td>Calibration</td><td>2018-03-01</td><td>2018-03-01</td><td>2018-03-01</td><td>2018-03-01</td></tr>
</table>

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 AML Oceanographic MVP-200

<table>
<tr><td>Manufacturer</td><td colspan="4">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="4">MVP-200</td></tr>
<tr><td>Description</td><td colspan="4">The MVP-200 system is a self-contained system capable of sampling water column profiles to 200m depth from a vessel moving at up to 12 knots, and deeper depths at slower speeds. During towed operation, the MVP-200 is completely autonomous and 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 controller with user interface computer. Fairweather's MVP fish is equipped with an AML Oceanographic Micro-CTD sensor capable of acquiring a conductivity, temperature, and depth (CTD) profile to determine the speed of sound and absorption in the water column, primarily to correct bathymetry data acquired with the EM 710 MBES. A MVPX-SVPT sensor was loaned to Fairweather by AML, and utilized briefly while troubleshooting connectivity to the Micro-CTD sensor.</td></tr>
<tr><td rowspan="4">Inventory</td><td rowspan="4">S-220</td><td>Component</td><td>CTD Sensor</td><td>SV Sensor</td></tr>
<tr><td>Model Number</td><td>Micro-CTD</td><td>MVPX-SVPT</td></tr>
<tr><td>Serial Number</td><td>8808</td><td>N/A</td></tr>
<tr><td>Calibration</td><td>2017-12-28</td><td>N/A</td></tr>
</table>

Figure 13: MVP 200 system

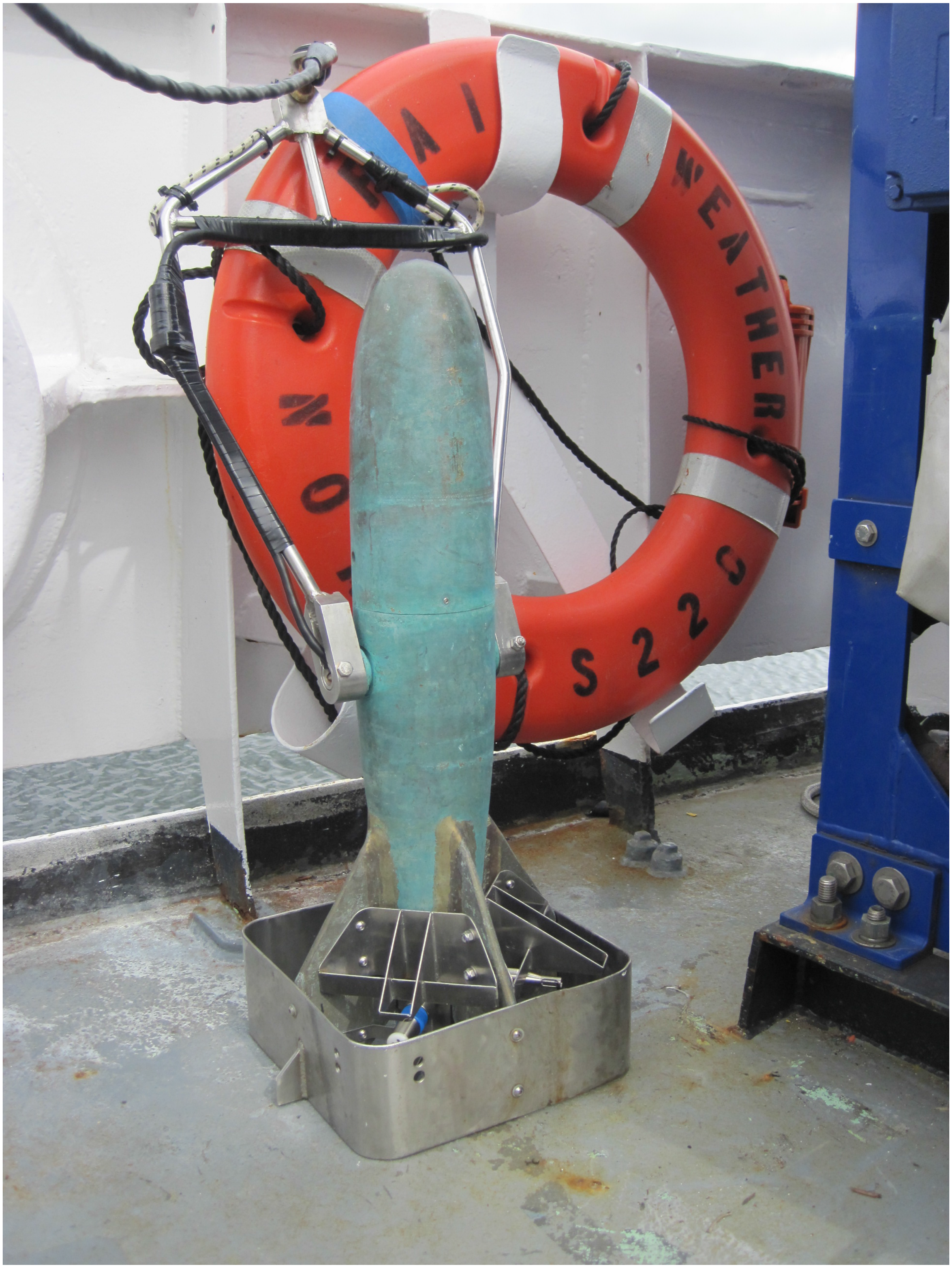

Figure 14: Single sensor free fall fish

A.6.2 CTD Profilers

A.6.2.1 Sea-Bird Electronics SBE CTD

Manufacturer	Sea-Bird Electronics
Model	SBE CTD
Description	Fairweather is equipped with one SBE 19plus and four SBE 19plusV2 SeaCAT sound speed profilers used to acquire conductivity, temperature, and depth (CTD) data throughout the water column. The titanium-cased SBE 19plus has a pressure sensor rated to 3,500m, while the four SBE 19plusV2 have pressure sensors rated to 600m. All SeaCAT sound speed profilers were calibrated by the manufacturer during the 2017-2018 winter repair period. The survey department performs quality checks and comparison casts on any instruments suspect of being out of calibration.

Inventory

Component	CTD
Model Number	SBE 19plus
Serial Number	19P36026-4585
Calibration	2018-02-09
Component	CTD
Model Number	SBE 19plus V2
Serial Number	19P75469-7370
Calibration	2018-02-09
Component	CTD
Model Number	SBE 19plus V2
Serial Number	19P50959-6122
Calibration	2018-02-09
Component	CTD
Model Number	SBE 19plus V2
Serial Number	19P50959-6121
Calibration	2018-02-09
Component	CTD
Model Number	SBE 19plus V2
Serial Number	19-7634
Calibration	2018-02-09

Figure 15: SBE 19plus V2

A.6.3 Sound Speed Sensors

A.6.3.1 Teledyne RESON SVP-71

<table>
<tr><td>Manufacturer</td><td colspan="3">Teledyne RESON</td></tr>
<tr><td>Model</td><td colspan="3">SVP-71</td></tr>
<tr><td>Description</td><td colspan="3">The SVP-71 is a direct-reading sound speed probe with a 125mm sound transmission path. The unit’s housing composition is a hard, anodized, and sea water resistant aluminum. This sensor is mounted in close proximity to the multibeam transceiver on each HSL, providing real-time surface sound speed values for refraction corrections.</td></tr>
<tr><td rowspan="16">Inventory</td><td rowspan="4">2805</td><td>Component</td><td>Surface Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>SVP-71</td></tr>
<tr><td>Serial Number</td><td>1713034</td></tr>
<tr><td>Calibration</td><td>2015-01-26</td></tr>
<tr><td rowspan="4">2806</td><td>Component</td><td>Surface Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>SVP-71</td></tr>
<tr><td>Serial Number</td><td>1213046</td></tr>
<tr><td>Calibration</td><td>2015-01-26</td></tr>
<tr><td rowspan="4">2807</td><td>Component</td><td>Surface Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>SVP-71</td></tr>
<tr><td>Serial Number</td><td>1213046</td></tr>
<tr><td>Calibration</td><td>2015-01-26</td></tr>
<tr><td rowspan="4">2808</td><td>Component</td><td>Surface Sound Speed Sensor</td></tr>
<tr><td>Model Number</td><td>SVP-71</td></tr>
<tr><td>Serial Number</td><td>3511352</td></tr>
<tr><td>Calibration</td><td>2015-01-26</td></tr>
</table>

A.6.3.2 Teledyne RESON SVP-70

Manufacturer	Teledyne RESON
Model	SVP-70
Description	The SVP-70 is a direct-reading sound speed probe with a 125mm sound transmission path. The unit’s housing is composed of robust titanium, which reduces marine growth on these continually submerged sensors. S-220 has two sensors in close proximity to the ship’s multibeam transducer.

Inventory	*S-220*	*Component*	Surface Sound Speed Sensor	Surface Sound Speed Sensor
Inventory	*S-220*	*Model Number*	SVP-70	SVP-70
Inventory	*S-220*	*Serial Number*	0614171	0614172
Inventory	*S-220*	*Calibration*	2015-01-26	2015-01-26

A.6.3.3 AML Oceanographic SV-Xchange Micro-X SV

Manufacturer	AML Oceanographic
Model	SV-Xchange Micro-X SV
Description	The Micro-X is a direct-reading sound speed probe. The unit’s housing is composed of robust titanium, which reduces marine growth on these continually submerged sensors. BEN has one SV sensor in close proximity to the ASV's multibeam transducer.

Inventory	*BEN*	*Component*	Surface Sound Speed Sensor
Inventory	*BEN*	*Model Number*	Micro-X SV
Inventory	*BEN*	*Serial Number*	204937
Inventory	*BEN*	*Calibration*	2018-03-16

A.6.4 TSG Sensors

A.6.4.1 Sea-Bird Scientific Thermosalinograph

Manufacturer	Sea-Bird Scientific
Model	Thermosalinograph
Description	The SBE 45 shipboard thermosalinograph (TSG) continuously pumps water through the sensors to determine the sea surface temperature and conductivity, from which the surface sound speed is derived. Additionally, the TSG has an auxiliary SBE 38 temperature probe for immediate measurement upon entering the hull.

Inventory	*S220*	*Component*	MicroTSG	Digital Oceanographic Thermometer
Inventory	*S220*	*Model Number*	SBE 45	SBE 38
Inventory	*S220*	*Serial Number*	0117	0702
Inventory	*S220*	*Calibration*	2018-02-16	2018-03-01

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*
Teledyne CARIS	HIPS and SIPS	10.4.x and 10.3.3	Processing
Teledyne CARIS	BASE Editor	4.4	Processing
Applanix	MV POSView	9.21	Acquisition
Applanix	POSPac MMS	8.2	Processing
HYPACK, Inc.	HYPACK 2017a	2017a	Acquisition
Quality Positioning Services BV (QPS)	Fledermaus Geocoder Toolbox	7.8.1	Processing
Kongsberg Maritime AS	Seafloor Information System (SIS)	4.3.1 - 4.3.2	Acquisition
NOAA Hydrographic Systems and Technology Branch (HSTB)	Pydro Explorer	18.4	Acquisition and Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 NOAA Hydrographic Survey Division (HSD) Image Grab Sampler

Manufacturer	NOAA Hydrographic Survey Division (HSD)
Model	Image Grab Sampler
Description	The Fairweather's bottom sampler is a “Wildlife Supply Company: Petite Ponar Grab.” The sampler is attached to a frame which includes a GoPro camera within a waterproof housing, and two flashlights. The GoPro records video during deployment, from which still images of the habitat can be extracted.

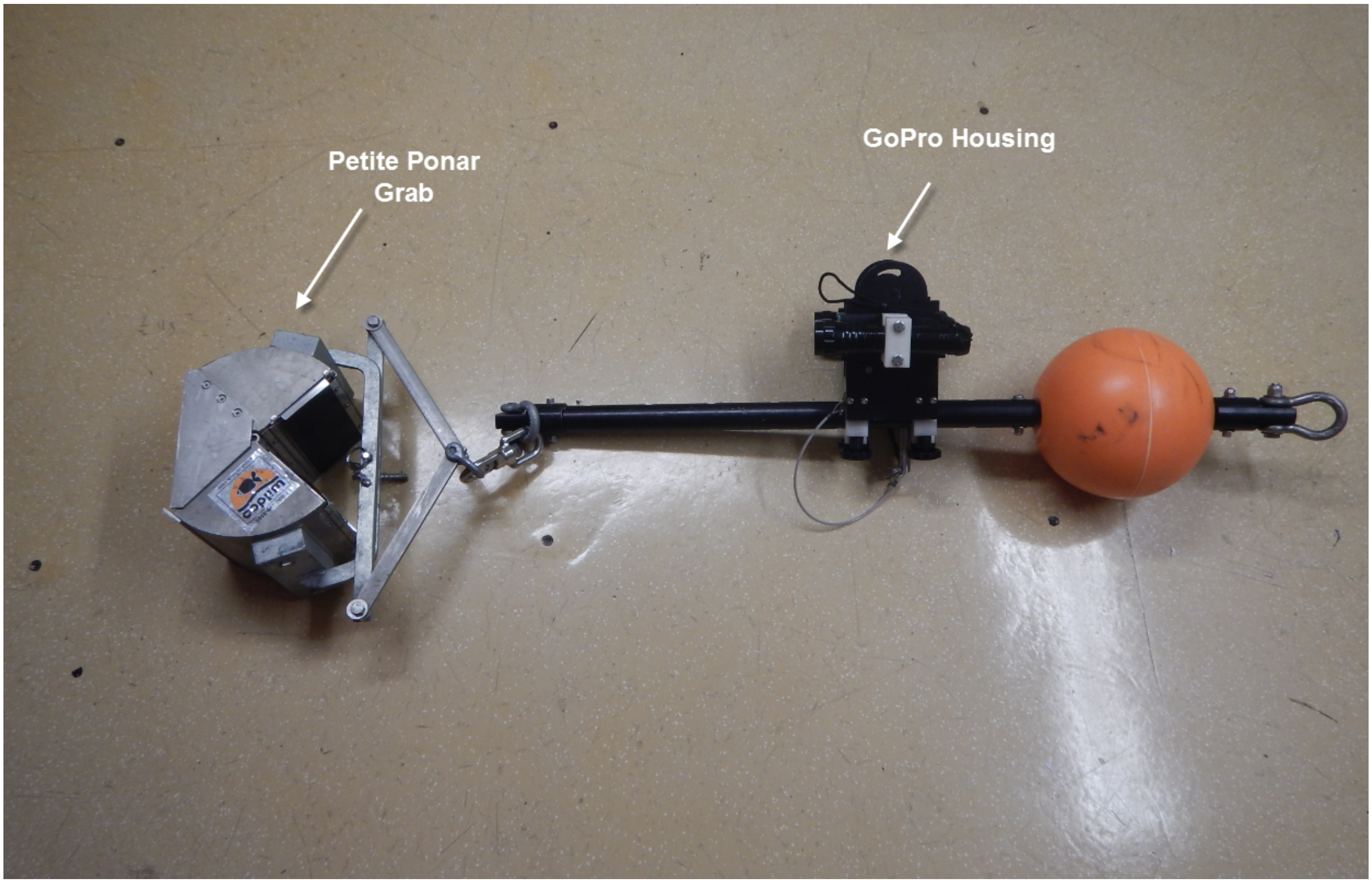

Figure 16: Image Grab Sampler Assembly

B System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

The reference point for all positioning, attitude, and sonar systems maintained by Fairweather is co-located at the phase center of the sonar transmitter and rotated to the face of the transducer for both the EM2040 installations on HSLs and the EM710 installed on Fairweather. A single reference point simplifies downstream processing and eliminates errors due to incorrect offset application in CARIS HIPS. This was achieved for position and attitude by entering the surveyed translational and rotational offsets of the IMU and antennae into the POS configuration. Thus the position and attitude reported by the POS, including heave and delayed heave, are valid at the transmit array. Furthermore, this reference point is the center of rotation in POS for the purposes of applying the heave filter (the reference to center of rotation field is zero).

The reference point for the positioning, attitude, and sonar systems for the ASV "BEN" is the IMU target, and therefore the POSMV configuration for Vessel Reference to IMU target is zero.

Rotational and translational offsets for the EM710 system on Fairweather were determined by IMTEC Group during drydock in 2014, and a reference frame was delivered which centered on the EM710 transmit array and aligned with the array in heading, pitch, and roll. This allows direct entry of these values since they were already in the desired reference frame. For the HSL EM2040 systems, offsets were derived from a combination of the 2010 NGS survey of control points permanently installed on the launch hull and engineering drawings of the sonar mount rather than being directly surveyed. Due to the relatively short baselines between HSL systems, this is not expected to introduce significant error.

Transducer and navigation offsets and alignments were entered in SIS according to the EM710 or EM2040 transmitter reference frame. The translational and angular offsets of the receiver array (labeled “RX Transducer”) relative to the transmit array were entered into SIS. Since the transmit array is at the reference point and was aligned with the reference frame by definition, the translational and angular offsets of the transmit array (labeled “TX Transducer”) are all zero. Since the reference point of the POS was configured to be located at and aligned with the transmit array centered frame, the offsets for the position and attitude data from the POS are also zero in SIS. With this approach, any residual misalignment between the EM710 or EM2040 and the IMU discovered in a patch test (see Section B.3.1) was added to the IMU alignment with respect to the reference frame in the POS configuration, maintaining the transmit array as aligned with the reference frame.

Entries in the CARIS HVF account for the offset between the transmitters and receivers for the EM710 and EM2040 systems, but this is entered only under the SVP 2 section so that processing of raw range-angle data is correct after sound speed profile corrections are applied. All other vessel offset values have been set to zero and apply to “No” to avoid double-correction. The only exceptions to this are the SVP 2 offset values, dynamic draft correctors (Section B.2.2), and waterline (Section B.2.1). Offsets to the IMU and primary GNSS antenna are also entered under the TPU section, but this is only used for estimates of uncertainty and not positioning of soundings.

B.1.1.1 Vessel Offset Correctors

<table>
<tr><td>Vessel</td><td colspan="4">FA_2805_EM2040</td></tr>
<tr><td>Echosounder</td><td colspan="4">Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode</td></tr>
<tr><td>Date</td><td colspan="4">2018-04-14</td></tr>
<tr><td rowspan="19">Offsets</td><td rowspan="7">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>0.195 meters</td><td>0.006 meters</td></tr>
<tr><td>y</td><td>0.148 meters</td><td>0.006 meters</td></tr>
<tr><td>z</td><td>0.534 meters</td><td>0.006 meters</td></tr>
<tr><td>x2</td><td>-0.110 meters</td><td>N/A</td></tr>
<tr><td>y2</td><td>0.048 meters</td><td>N/A</td></tr>
<tr><td>z2</td><td>0.518 meters</td><td>N/A</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.877 meters</td><td>0.006 meters</td></tr>
<tr><td>y</td><td>0.954 meters</td><td>0.006 meters</td></tr>
<tr><td>z</td><td>3.712 meters</td><td>0.006 meters</td></tr>
<tr><td>x2</td><td>0.572 meters</td><td>N/A</td></tr>
<tr><td>y2</td><td>0.854 meters</td><td>N/A</td></tr>
<tr><td>z2</td><td>3.696 meters</td><td>N/A</td></tr>
<tr><td rowspan="5">Transducer Roll</td><td>Roll</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
</table>

<table>
<tr><td>Vessel</td><td colspan="5">FA_2806_EM2040</td></tr>
<tr><td>Echosounder</td><td colspan="5">Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode</td></tr>
<tr><td>Date</td><td colspan="5">2018-04-14</td></tr>
<tr><td rowspan="17">Offsets</td><td rowspan="7">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>0.205 meters</td><td>0.006 meters</td></tr>
<tr><td>y</td><td>0.134 meters</td><td>0.006 meters</td></tr>
<tr><td>z</td><td>0.532 meters</td><td>0.006 meters</td></tr>
<tr><td>x2</td><td>-0.100 meters</td><td>N/A</td></tr>
<tr><td>y2</td><td>0.034 meters</td><td>N/A</td></tr>
<tr><td>z2</td><td>0.516 meters</td><td>N/A</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.842 meters</td><td>0.006 meters</td></tr>
<tr><td>y</td><td>0.966 meters</td><td>0.006 meters</td></tr>
<tr><td>z</td><td>3.697 meters</td><td>0.006 meters</td></tr>
<tr><td>x2</td><td>0.537 meters</td><td>N/A</td></tr>
<tr><td>y2</td><td>0.866 meters</td><td>N/A</td></tr>
<tr><td>z2</td><td>3.681 meters</td><td>N/A</td></tr>
<tr><td rowspan="4">Transducer Roll</td><td>Roll</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
</table>

<table>
<tr><td>Vessel</td><td colspan="4">FA_2807_EM2040</td></tr>
<tr><td>Echosounder</td><td colspan="4">Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode</td></tr>
<tr><td>Date</td><td colspan="4">2018-04-14</td></tr>
<tr><td rowspan="17">Offsets</td><td rowspan="7">MRU to Transducer</td><td></td><td>Measurement</td><td>Uncertainty</td></tr>
<tr><td>x</td><td>0.207 meters</td><td>0.006 meters</td></tr>
<tr><td>y</td><td>0.130 meters</td><td>0.006 meters</td></tr>
<tr><td>z</td><td>0.540 meters</td><td>0.006 meters</td></tr>
<tr><td>x2</td><td>-0.098 meters</td><td>N/A</td></tr>
<tr><td>y2</td><td>0.030 meters</td><td>N/A</td></tr>
<tr><td>z2</td><td>0.523 meters</td><td>N/A</td></tr>
<tr><td rowspan="6">Nav to Transducer</td><td>x</td><td>0.992 meters</td><td>0.006 meters</td></tr>
<tr><td>y</td><td>0.941 meters</td><td>0.006 meters</td></tr>
<tr><td>z</td><td>3.691 meters</td><td>0.006 meters</td></tr>
<tr><td>x2</td><td>0.688 meters</td><td>N/A</td></tr>
<tr><td>y2</td><td>0.841 meters</td><td>N/A</td></tr>
<tr><td>z2</td><td>3.674 meters</td><td>N/A</td></tr>
<tr><td rowspan="4">Transducer Roll</td><td>Roll</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
<tr><td>Roll2</td><td>0.00 degrees</td><td></td></tr>
</table>

Vessel	FA_2808_EM2040			
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode			
Date	2018-04-14			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	0.205 meters	0.006 meters
		y	0.140 meters	0.006 meters
		z	0.534 meters	0.006 meters
		x2	-0.100 meters	N/A
		y2	0.040 meters	N/A
		z2	0.518 meters	N/A
	Nav to Transducer	*x*	0.886 meters	0.006 meters
		y	0.977 meters	0.006 meters
		z	3.698 meters	0.006 meters
		x2	0.582 meters	N/A
		y2	0.877 meters	N/A
		z2	3.682 meters	N/A
	Transducer Roll	*Roll*	0.00 degrees	
		Roll2	0.00 degrees	
		Roll2	0.00 degrees	
		Roll2	0.00 degrees	

Vessel	FA_S220_EM710			
Echosounder	Kongsberg Simrad EM710			
Date	2015-02-06			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	1.728 meters	0.002 meters
		y	8.427 meters	0.002 meters
		z	4.677 meters	0.002 meters
		x2	1.839 meters	N/A
		y2	7.204 meters	N/A
		z2	4.675 meters	N/A
	Nav to Transducer	*x*	1.728 meters	0.002 meters
		y	8.427 meters	0.002 meters
		z	4.677 meters	0.002 meters
		x2	1.839 meters	N/A
		y2	7.204 meters	N/A
		z2	4.675 meters	N/A
	Transducer Roll	*Roll*	0.00 degrees	
		Roll2	0.00 degrees	
		Roll2	0.00 degrees	
		Roll2	0.00 degrees	
		Roll2	0.00 degrees	

Vessel	UNH_ASV_Ben_EM2040P			
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode			
Date	2018-05-01			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.000 meters	0.006 meters
		y	-0.267 meters	0.006 meters
		z	1.575 meters	0.006 meters
		x2	0.000 meters	N/A
		y2	-0.267 meters	N/A
		z2	1.575 meters	N/A
	Nav to Transducer	*x*	0.000 meters	0.006 meters
		y	0.000 meters	0.006 meters
		z	2.683 meters	0.006 meters
		x2	0.000 meters	N/A
		y2	0.000 meters	N/A
		z2	2.683 meters	N/A
	Transducer Roll	*Roll*	0.00 degrees	
		Roll2	0.00 degrees	

B.1.2 Layback

No towed arrays were utilized for this project.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

The static drafts (Waterline Height in the HVF) for HSLs 2805, 2806, 2807, and 2808 were calculated based on steel tape and plumb bob measurements of the distance from benchmarks on the port and starboard quarter of the vessel to the waterline. These measurements were combined with the offset from these benchmarks to the sonar transducer to determine the waterline relative to the reference frame. Measurements were conducted in March of 2018 in Yaquina Bay, Newport, OR. The values and calculations for static draft of the HSLs are listed in the respective Waterline Measurement spreadsheets included within this report.

Static draft for Fairweather is determined by using a laser rangefinder to measure the vertical distance to the water from benchmarks on the port and starboard E-Deck breezeway below the bridge wings. The measurements are translated to the transmitter reference frame using surveyed offsets to the benchmarks. The loading condition of the ship, particularly fuel and launches, has a more significant influence on static draft than for the launches. To compensate for static draft changes, static draft values are measured on S220 after any changes in fuel levels, and at the start of survey operations for each leg throughout the season. These measurements are taken while the vessel is at anchor or hove to.

For both the S-220 and HSL sonar systems, static draft corrector values are entered in the Kongsberg SIS Installation Parameters window. In addition, waterline values are entered in the CARIS HVF. For S-220, only the HVF is updated with the measurements taken throughout the field season, as this will override the SIS waterline during processing. The waterline value in CARIS will only be used during Sound Speed Correction. The Apply switch is set to “No” to avoid double application of the waterline value during HIPS merge.

The static draft value for ASV BEN is estimated per the offset diagram above in section A.1.6 (Figure 7). This value matches with intercomparison to other vessels, as verified via crossline comparisons.

2805 Waterline Measurements

Background Info

Date:	**4/11/2018**	Notes:	
Launch Fuel Level:	**62.2 gal**	**rainy, cloudy, calm seas**	
Persons Onboard:	**Johnson, Swart, Shapiro**		

Raw Measurements

Name:	Swart			Johnson/Shapiro		
	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.968)	(0.961)	(0.964)	(0.972)	(0.959)	(0.971)
Stbd Benchmark to Waterline	(0.951)	(0.959)	(0.952)	(0.955)	(0.956)	(0.940)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	**STBD**	**Port**	**STBD**
Avg (m)	(0.964)	(0.954)	(0.967)	(0.950)
Stdev (m)	0.004	0.004	0.007	0.009

	Measurer A			Measurer B		
	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	0.032	(0.010)	0.042	0.032	(0.017)	0.049

Waterline Value

	Measurer A		Measurer B	
	Port	**STBD**	**Port**	**STBD**
BM Z-Value (m)*	1.075	1.043	1.075	1.043
RP to WL (m)	0.111	0.089	0.108	0.093

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.100**	*This value is used in the 2805 vessel offset workbook*
Global STDEV (m)	**0.009**	*This value is used in the 2805 vessel TPU workbook*

Value for HVF (m) -0.619

Figure 17: 2805 Waterline Measurements

2806 Waterline Measurements

Background Info

		Notes:
Date:	16/03/2018	
Launch Fuel Level:	77.3	
Persons Onboard:	2	Partly cloudy, slight drizzle, mild winds

Raw Measurements

Name:	Shawn			Ali		
	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.970)	(0.955)	(0.954)	(0.958)	(0.945)	(0.961)
Stbd Benchmark to Waterline	(0.969)	(0.970)	(0.976)	(0.972)	(0.981)	(0.974)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
Avg (m)	(0.960)	(0.972)	(0.955)	(0.976)
Stdev (m)	0.009	0.004	0.009	0.005

	Measurer A			Measurer B		
	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	0.078	0.012	0.066	0.078	0.021	0.057

Waterline Value

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
BM Z-Value (m)*	1.096	1.018	1.096	1.018
RP to WL (m)	0.136	0.046	0.141	0.042

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.092**	*This value is used in the 2806 vessel offset workbook*
Global STDEV (m)	**0.011**	*This value is used in the 2806 vessel TPU workbook*

Value for HVF (m) -0.624

Figure 18: 2806 Waterline Measurements

2807 Waterline Measurements

Background Info

Date:	16/03/2018
Launch Fuel Level:	70.1
Persons Onboard:	2

Notes:
Partly cloudy, slight drizzle, mild winds

Raw Measurements

Name:	Shawn			Ali		
	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.970)	(0.971)	(0.969)	(0.952)	(0.969)	(0.953)
Stbd Benchmark to Waterline	(0.973)	(0.966)	(0.954)	(0.942)	(0.984)	(0.972)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	**STBD**	**Port**	**STBD**
Avg (m)	(0.970)	(0.964)	(0.958)	(0.966)
Stdev (m)	0.001	0.010	0.010	0.022

	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	(0.055)	(0.006)	0.049	(0.055)	0.008	0.063

Waterline Value

	Measurer A		Measurer B	
	Port	**STBD**	**Port**	**STBD**
BM Z-Value (m)*	1.033	1.088	1.033	1.088
RP to WL (m)	0.063	0.124	0.075	0.122

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.096**	*This value is used in the 2807 vessel offset workbook*
Global STDEV (m)	**0.012**	*This value is used in the 2807 vessel TPU workbook*

Value for HVF (m) **-0.636**

Figure 19: 2807 Waterline Measurements

2808 Waterline Measurements

Background Info

Date:	14/03/2018
Launch Fuel Level:	71.9 gal
Persons Onboard:	2

Notes:
Sunny, mild winds with variable chop

Raw Measurements

Name:	Shawn			Ali		
	Measurer A			Measurer B		
	Measure 1	Measure 2	Measure 3	Measure 1	Measure 2	Measure 3
Port Benchmark to Waterline	(0.960)	(0.962)	(0.971)	(0.949)	(0.956)	(0.969)
Stbd Benchmark to Waterline	(0.959)	(0.956)	(0.949)	(0.961)	(0.965)	(0.976)

Waterline measurements should be negative and in meters!

Calculations

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
Avg (m)	(0.964)	(0.955)	(0.958)	(0.967)
Stdev (m)	0.006	0.005	0.010	0.008

	Measurer A			Measurer B		
	Theoretical	Actual	Error	Theoretical	Actual	Error
Port to STBD Z-Difference	0.032	(0.010)	0.042	0.032	0.009	0.023

Waterline Value

	Measurer A		Measurer B	
	Port	STBD	Port	STBD
BM Z-Value (m)*	1.076	1.044	1.076	1.044
RP to WL (m)	0.112	0.089	0.118	0.077

**Values come from 2010 NGS survey*

Average RP to WL Value (m)	**0.099**	*This value is used in the 2808 vessel offset workbook*
Global STDEV (m)	**0.008**	*This value is used in the 2808 vessel TPU workbook*

Value for HVF	**-0.633**

Figure 20: 2808 Waterline Measurements

B.2.1.1 Static Draft Correctors

Vessel		FA_2805_EM2040	FA_2806_EM2040	FA_2807_EM2040	FA_2808_EM2040	FA_S220_EM710	UNH_ASV_Ben_EM2040P
Date		2018-04-14	2018-04-14	2018-04-14	2018-04-14	2018-07-14	2018-05-01
Loading		0.018 meters	0.018 meters	0.018 meters	0.018 meters	0.116000 meters	0.018000 meters
Static Draft	*Measurement*	-0.634 meters	-0.624 meters	-0.636 meters	-0.633 meters	-4.730000 meters	0.202000 meters
	Uncertainty	0.009 meters	0.011 meters	0.012 meters	0.008 meters	0.128000 meters	0.009000 meters

B.2.2 Dynamic Draft

Dynamic draft data were acquired for launches 2805, 2806, and 2807 in April of 2018 in Puget Sound, Washington. The method employed calculates the ellipsoid height change while the vessels transit at different speeds in a straight line. The ellipsoid heights were determined using a Post Processed Kinematic (PPK) trajectory for each vessel by processing the recorded POS MV data with RTX correctors in Applanix POSPac MMS software. A third order polynomial curve was fit to the speed versus ellipsoid height data using a least squares fit through a script implemented in the POSPac AutoQC tool.

Since all launches are of essentially identical construction, a historical average for all launches using data from 2011-2018 was used to populate the CARIS HVF in order to reduce uncertainty introduced by wave action noise. Outlier vessel measurements with multiple delta draft values more than two standard deviations from the mean were removed from the average. The standard deviation of the residuals was used to determine the associated uncertainty in the measurement.

For the ship, the 2016 polynomial curve was used to derive the table used in the CARIS HVF as this value has historically remained consistent, and the 2016 data was collected in an environment free from currents and swell.

No dynamic draft values were measured for ASV BEN.

B.2.2.1 Dynamic Draft Correctors

Vessel	280x		S220		UNH_ASV_Ben_EM2040P	
Date	2018-04-27		2016-05-02		2018-05-01	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*	*Speed (m/s)*	*Draft (m)*	*Speed (m/s)*	*Draft (m)*
	0.00	0.00	0.00	0.00	0.00	0.00
	0.50	-0.01	1.50	0.01	0.50	0.00
	1.00	0.00	2.00	0.03	1.00	0.00
	1.50	0.02	2.50	0.06	1.50	0.00
	2.00	0.03	3.00	0.08	2.00	0.00
	2.50	0.05	3.50	0.11	2.50	0.00
	3.00	0.06	4.00	0.14	3.00	0.00
	3.50	0.06	4.50	0.17	3.50	0.00
	4.00	0.05	5.00	0.20	4.00	0.00
	4.50	0.04	5.50	0.23	4.50	0.00
	5.00	0.01	6.00	0.25	5.00	0.00
	5.50	-0.03	6.50	0.27	5.50	0.00
	6.00	-0.08			6.00	0.00
	6.50	-0.13			6.50	0.00
	7.00	-0.18			7.00	0.00
	7.50	-0.23			7.50	0.00
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*	*Vessel Speed (m/s)*	*Delta Draft (m)*	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.03	0.04	0.03	0.10	0.03	0.04

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

Patch test data were collected along a slope with two parallel lines surveyed in both directions at two speeds for determination of pitch, timing and yaw correctors. An additional line was surveyed in a flat area in reciprocal directions for determination of the roll corrector.

Data were converted in CARIS HIPS using an HVF file with heave, pitch, roll, and timing values set to zero. Delayed heave, SBETs, SBET RMS, GPS tides via a VDATUM separation model, the most recent dynamic draft, and sound speed were applied and the data and merged before cleaning via Subset Editor. Bias values were determined in the following order; timing, pitch, roll, and yaw. At least three individual testers determined alignment test result biases in CARIS. Additionally, a reviewer examined these results for outlier elimination, after which the other results were averaged. The averaged values were entered as opposite sign rotations into the POS MV angular offsets in “IMU Frame w.r.t. Ref Frame" within the Lever Arms & Mounting Angles setup. The values for roll, pitch, and yaw correctors were entered as X, Y, and Z, respectively. These rotations are therefore applied to all raw orientation data output from the POS.

An additional examination of the correlation between a bathymetric roll artifact and the motion time series is used to solve for timing errors that are difficult to detect in the traditional patch test methodology. From these results, a constant timing delay is applied to all motion data in Kongsberg SIS. A value of 7 milliseconds is used for all HSLs and 14 milliseconds for S-220.

The values listed below are those entered into the POS MV, as the alignment values in the HVF are all set to zero.

B.3.1.1 System Alignment Correctors

Vessel	FA_2805_EM2040		
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode		
Date	2018-04-14		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	-0.15 degrees	0.07 degrees
	Roll	0.12 degrees	0.07 degrees
	Yaw	0.24 degrees	0.10 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

Vessel	FA_2806_EM2040		
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode		
Date	2018-04-14		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	0.57 degrees	0.07 degrees
	Roll	0.12 degrees	0.07 degrees
	Yaw	-0.66 degrees	0.10 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

Vessel	FA_2807_EM2040		
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode		
Date	2018-04-14		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.000 seconds	0.001 seconds
	Navigation Time Correction	0.000 seconds	0.001 seconds
	Pitch	0.03 degrees	0.07 degrees
	Roll	0.13 degrees	0.07 degrees
	Yaw	-0.79 degrees	0.10 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

Vessel	FA_2808_EM2040
Echosounder	Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode
Date	2018-04-14
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.001 seconds
Navigation Time Correction	0.000 seconds	0.001 seconds
Pitch	0.59 degrees	0.07 degrees
Roll	0.02 degrees	0.07 degrees
Yaw	-0.23 degrees	0.10 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

Vessel	FA_S220_EM710
Echosounder	Kongsberg Simrad EM710
Date	2018-04-15
Patch Test Values	

	Corrector	*Uncertainty*
Transducer Time Correction	0.000 seconds	0.005 seconds
Navigation Time Correction	0.000 seconds	0.005 seconds
Pitch	-0.00 degrees	0.04 degrees
Roll	0.08 degrees	0.04 degrees
Yaw	0.09 degrees	0.06 degrees
Pitch Time Correction	0.000 seconds	0.005 seconds
Roll Time Correction	0.000 seconds	0.005 seconds
Yaw Time Correction	0.000 seconds	0.005 seconds
Heave Time Correction	0.000 seconds	0.005 seconds

<table>
<tr><td>Vessel</td><td colspan="3">UNH_ASV_Ben_EM2040P</td></tr>
<tr><td>Echosounder</td><td colspan="3">Kongsberg Simrad EM2040 300kHz 0.5x1_Normal Mode</td></tr>
<tr><td>Date</td><td colspan="3">2018-05-01</td></tr>
<tr><td rowspan="10">Patch Test Values</td><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Pitch</td><td>0.00 degrees</td><td>0.07 degrees</td></tr>
<tr><td>Roll</td><td>0.00 degrees</td><td>0.07 degrees</td></tr>
<tr><td>Yaw</td><td>0.00 degrees</td><td>0.10 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Date</td><td colspan="3">2018-05-01</td></tr>
<tr><td rowspan="10">Patch Test Values (Transducer 2)</td><td></td><td>Corrector</td><td>Uncertainty</td></tr>
<tr><td>Transducer Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Navigation Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Pitch</td><td>0.00 degrees</td><td>0.07 degrees</td></tr>
<tr><td>Roll</td><td>0.00 degrees</td><td>0.07 degrees</td></tr>
<tr><td>Yaw</td><td>0.00 degrees</td><td>0.10 degrees</td></tr>
<tr><td>Pitch Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Roll Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Yaw Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td>Heave Time Correction</td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
</table>

C Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

Acquisition methods employed are determined based on consideration of sonar system specifications, seafloor topography, water depth, and the capability of the acquisition platforms. They are also dictated by the coverage method specified in the Project Instructions for a survey area. For the Kongsberg EM 710 and EM 2040, all multibeam data were acquired in the .all format within the SIS (Seafloor Information System) software. Data were monitored in 2D, 3D and backscatter real-time display windows. A survey template defined the storage location of raw and gridded (survey) data and the file naming convention for mainscheme (Filename_M.all) and crossline (Filename_X.all) data. During acquisition, the hydrographers often adjusted parameters of the Kongsberg systems to improve data quality. The following are parameters that are 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.

During both launch and ship acquisition, mainscheme MBES lines are generally run parallel to depth contours with appropriate overlap to ensure the data density requirements for the proper finalized BASE surfaces are met. For discrete item developments, 200 percent coverage is acquired to ensure least-depth determination by multibeam near-nadir beams. For complete coverage surveys, Hypack Hysweep realtime coverage display is used in lieu of pre-planned line files. Hysweep displays the acquired multibeam swath during acquisition and is monitored to ensure overlap and full bottom coverage.

For set line spacing surveys, pre-planned lines are run perpendicular to contours to best define them. In general, lines are planned in multiple directions to offer contingencies in the event of prohibitive weather conditions. Bathymetric splits and shoal developments are run in accordance to section 5.2.2.1 of the HSSD.

For areas where shoreline verification is not conducted before multibeam acquisition and hazards are suspected to exist, extra caution is taken by “half stepping” shoreward when operating near shore. Half stepping is executed by driving along the edge of real time coverage to prevent the survey vessel from working in un-surveyed waters. Survey launch crews in the field survey to the Navigable Area Limit Line (NALL) line as defined by section 1.3.2 of the HSSD.

Seafloor backscatter data were acquired for all lines during the 2018 field season, logged in the .all files. The Kongsberg EM710 system has an internal file, BsCorr, used to correct for beam pattern and other effects to equalize backscatter between swaths, sectors, and modes. A default file is populated at the factory. A modified BsCorr file was provided by HSTB following the sonar acceptance, to optimize the quality of the backscatter data. This HSTB version was used for all backscatter acquisition for the EM710.

Navigation and motion data are acquired and monitored in POSView and logged into a POS MV file with a .### extension, starting with .000. Data is logged on a USB flash drive inserted into the PCS and automatically split into 12 MB files. Various position and heading accuracies, as well as satellite constellations, are monitored real-time both in POSView and Hypack Hysweep. It is standard procedure not to log the POS/MV data through UTC midnight on Saturdays. At this time the GPS seconds of the week reset.

Data Processing Methods and Procedures

Following acquisition, all data are loaded to an external hard drive connected to the launch acquisition computer. This drive contains a standard file structure created by Charlene, an automated data transfer and batch processing software developed by HSTB and distributed within the PydroXL software suite.

Initial processing is typically completed the same day as acquisition, and employs Charlene to transfer the external hard drive data to the S-220 network and process it to a daily QC product, which is typically a bathymetric surface with data from that acquisition platform. Charlene automates the following tasks between raw data collection and the final daily product:

1. Perform verification of raw data
2. Build a deliverable directory structure
3. Transfer and verify raw data
4. Convert the Kongsberg .all file to CARIS HIPS HDCS format
5. Apply delayed heave from the POS files
6. Apply a water level corrector (Zoned Tides or TCARI tides)
7. Optionally generate and apply SBET and SBET RMS files (this is not done for all projects)
8. Apply sound speed correctors
9. Merge the data
10. Compute the Total Propagated Uncertainty
11. Generate a CARIS CSAR bathymetric surface from the data

Once Charlene has completed, night processors inspect the data in CARIS HIPS to ensure all correctors have been properly applied, and that the final products reflect observed conditions to the standards set by the relevant OCS guidance. Bathymetric surfaces are reviewed to ensure that all data quality problems are identified and resolved if possible, and all submerged features are 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 field unit’s final deliverable bathymetric surface is a single resolution Combined Uncertainty Best Estimator (CUBE) surface. The CUBE surface’s resolution, depth range, and parameters follow HSSD specifications 5.2.2. The bathymetric surfaces are generated following the application of all correctors highlighted above in Section C.1.1.

C.1.4.2 Depth Derivation

Multibeam data were reviewed and analyzed in CARIS HIPS subset mode and in swath editor as necessary. The CUBE surfaces were used for directed data editing in subset editor, rejecting data that lead to fliers in the surface. The surfaces 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 in HIPS navigation editor and attitude editor if deemed necessary upon review of surfaces. Where necessary, data spikes (fliers) or gaps 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.

Hydrographers may designate soundings if the bathymetric surface fails to represent navigationally significant depths and features. Designated soundings were selected following the criteria in section 5.2.1.2.3 of the HSSD.

C.1.4.3 Surface Computation Algorithm

For each survey within OPR-S347-FA-18, a four meter single resolution CUBE surface was generated to comply with the set line spacing requirements set in section 5.2.2.4 of the HSSD. The following settings were utilized in the generation of each surface:

Bounding Polygon Type: Buffered

IHO Order: S44 Order 1a

Disambiguation Method: Density and Locale

Cube Configuration: NOAA_4m

The CUBE Configuration utilized comes from the CUBE_Parameters_NOAA_2018.xml file included within the Caris_Support_Files_5_7. This file contains the parameters necessary to create CUBE surfaces meeting the requirements as stated in the HSSD.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

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

The Kongsberg EM 710 and EM 2040 systems log backscatter to the .all file concurrently with all MB data. The HIC monitors the “Seabed Image” tear-off to ensure adequate backscatter imagery is obtained during survey acquisition. The HIC also documents all Kongsberg system frequency changes to aid in the file segregation prior to processing.

Data Processing Methods and Procedures

Backscatter data are processed with the FM Geocoder Toolkit (FMGT) using the subsequent steps:

- A new project was created for each frequency used by each vessel within the sheet. For example, if Launch 2806 acquired data in 200kHz and 300kHz, two separate projects must be created.

- The vessel pulse mode correction parameters of each frequency for each vessel were set to create a smoother appearance of the imagery between mosaics created for each project within the sheet. These parameters were based on an analysis performed by HSTB of data collected over a calibration line during HSRR.

- Lines were imported into FMGT, combining the .all files with the HDCS files created in CARIS, resulting in the generation of GSF files.

- A mosaic in floating point GeoTIFF format was created for each project from the imported GSF files. The backscatter mosaic's minimum resolution depends on the acquisition frequency, using the equation provided in HTD 2018-3. The minimum resolutions for all systems utilized by the field unit were as follows: 6 meters for 100kHz, 3 meters for 200kHz, 2 meters for 300kHz, and 1.5 meters for 400kHz.

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

Data Acquisition Methods and Procedures

No water level data were acquired for this project.

Data Processing Methods and Procedures

A Tidal Constituent and Residual Interpolation (TCARI) grid provided by CO-OPs was initially utilized to reduce all data to MLLW, using the observed water levels available immediately following daily acquisition. Upon receipt of a Tide Note from CO-OPs after the completion of acquisition for the project, the verified water levels were applied to all data via the TCARI grid.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

Vessel attitude is measured by the Applanix POS MV and recorded in both SIS .all files (for real-time correctors) and POS MV .000 files (for delayed heave data). The POS MV continuously logs data to a USB drive throughout the survey day. A five minute buffer period of POS MV data is acquired preceding and following any sonar data acquisition to permit proper initialization of filters for delayed heave and PPK solutions.

Data Processing Methods and Procedures

Attitude correctors applied after initial CARIS HIPS conversion use the raw POS MV attitude data recorded in the Kongsberg data files (.all). The .000 delayed heave file logged by the POS MV is separately loaded into HIPS, replacing the real-time heave values recorded in the raw data.

This .000 file is then post processed in Applanix POSPac to generate a Smoothed Best Estimate of Trajectory (SBET), adjusting the integrated positioning and inertial measurements with Trimble Centerpoint Real-Time Extended (RTX) differential correctors. Trimble RTX uses a network of globally distributed high-performance GNSS receivers that generate the precise orbit, clock, and observation biases for any location on Earth, eliminating the need to establish local reference stations. Post processed RTX corrections are available an hour after data acquisition. The SBET file is exported from WGS84 to NAD83, and then run through the POSPac AutoQC tool in Pydro to evaluate the quality of the ERS vessel positioning. Any short-term unresolvable errors in the GNSS height and uncertainty time series data are manually replaced with an interpolated signal derived from differential heave, dynamic draft, and water level data. Once this quality assessment has been completed, the SBET and corresponding RMS uncertainty file containing the recomputed vessel navigation and ellipsoidal height are applied to the data in CARIS HIPS.

Once SBETs have been applied to the data an Ellipsoidally Referenced Zoned Tides (ERZT) model is generated, providing a separation model from MLLW to the ellipse based on the tidal correctors applied to the data. This model is then inspected for consistency, checking for any anomalies that may require reexamination of the SBET and further interpolation of the GNSS height. Once the ERZT model is deemed to be adequate, it is subsequently differenced with the Poor Man's VDATUM (PMVD) model provided by HSTB. The mean difference value is then used to debias the PMVD through a vertical shift using the mean difference value between the ERZT and PMVD. This debiased PMVD is then applied to the data to reference it to the chart datum.

To determine the uncertainty value of the composite PMVD model, the variance sum law was used between the independent variables of the ERZT model and the PMVD model. As the ERZT model's uncertainty is driven primarily from tidal uncertainties, the uncertainty in the TCARI grid was used as the starting point for ERZT uncertainty. This is then adjusted based on the average number of survey lines for the given nodes which represent individual "samples" and serves to tighten (make smaller) the ERZT uncertainty. Other ERZT factors such as SBET and waterline are small enough to be absorbed by the gridding resolution (1,000m). The PMVD uncertainty value was then calculated using this value and the standard deviations of the PMVD-ERZT difference surfaces.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

HSL sound speed profiles are captured with the SeaBird Electronics SBE19plus V2 CTD. All HSLs have small swing-arm davits with 24- volt electric winches for deploying and recovering the CTD profilers. Sound speed profiles are collected while the launch is at rest.

For acquisition with S-220, sound speed profiles are taken with the Rolls Royce MVP200. The Moving Vessel Profiler (MVP) is an automated winch system that deploys a fish containing a CTD sensor. The fish is typically towed behind the survey vessel in a "docked" position that is marked by messengers attached to the tow cable. Ideally at survey speeds the fish is towed just above the depth of the sonar transducers. The deployment depth is selected by specifying a distance off the bottom (typically 10 meters). Once at the depth limit, the winch free fall is automatically stopped and the drag forces on the fish cause it to rise toward the surface due to the ship's forward motion. The cable slack is then pulled in by the winch to the docked position.

In the event of a particularly deep survey area or when there are risks to towing the MVP fish, the MVP fish can be manually deployed while the ship is stationary using the hand-operated control box located on the winch. This method ensures that the maximum possible depth is obtained since the cable is deployed vertically. If necessary, the deep end of such a stationary cast can be added to the end of shallower casts obtained while the ship is underway. Static casts for S-220 were taken using an SBE19plus during periods where the MVP200 was non-operational.

Sound speed casts were taken at least once every four hours during multibeam survey operations in accordance with section 5.2.3.3 of the HSSD. All platforms collected sound speed casts according to changes in the water column and any changes in survey location that would influence sound speed differences in excess of the accepted 2 m/s range. Changes are monitored through the real-time surface sound speed view in Sound Speed Manager and the data view in SIS. Sound speed manager provides a geographic view of changes to surface sound speed which assists in placement of casts for zoning water masses. The CastTime algorithm is also employed in SSM to guide cast frequency. In SIS, the user is warned for the need of a new cast by highlighting both the “SV Profile” and “SV Used” numerical displays in yellow with a difference greater than 3 m/s and red for a difference greater than 5 m/s.

Data Processing Methods and Procedures

Sound speed cast processing was performed via HydrOffice Sound Speed Manager (SSM). HSL casts from SBE 19 plus CTDs were downloaded from the CTD and converted from their raw binary sensor measurements (.hex) to standard units (.cnv) using a manufacturer supplied calibration file (.xmlcon). These files were then smoothed using 1 meter cosine averaged depth bins and saved to the SSM database. The smoothing eliminates errors near the surface resulting from wave action and engine cooling water outflow. S-220 casts were loaded over the network from the MVP computer as .m1 files to gain the highest resolution available. Since these profiles start deeper, they are less prone to erroneous values and were therefore manually checked for outlier values in the SSM interface. Any outliers were removed and the profile was saved to the SSM database to retain the greater depth resolution. Once the profiles have been loaded and filtered or inspected, they were transmitted by SSM over the network to the Kongsberg HWS for application in SIS. SSM confirms reception, or the hydrographer may inspect the updated file name in the “Runtime Parameters” tear-off upon network errors.

At least one cast was compared daily to the SVP 71 surface sound speed sensors on the HSLs to verify their accuracy in lieu of annual SVP 71 calibration. The results of the daily SSP sensor comparisons are logged in the Microsoft Excel acquisition log to track instrument health. Deviations from this procedure are outlined in the Descriptive Report for the affected survey.

All sound speed casts saved to the SSM database are exported into a .svp file that is readable in CARIS HIPS. Casts are progressively concatenated per sheet, including all casts taken within the sheet limits. This concatenated file is applied to all HDCS data using the “Nearest in distance within time” algorithm, using the time interval suggested by the Hydrographer in Charge during acquisition. This time interval is generally four hours, but may be reduced if necessitated by environmental conditions.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

S-220 measures surface sound speed (SSP) values with a SBE 45 Thermosalinograph, while all HSLs use SVP 71 probes. The surface sound speed sensors supply the MBES with real-time values, which correct the flat-faced transducer's refraction. SIS also applies a median filter to the SSP values. During acquisition, the HIC adjusts this filter's length to capture variability while suppressing bubble sweep-down errors. Typical values for the filter length are 1-10 seconds. HICs monitor the SSP for a > 2 m/s change, which requires a new cast using the methods described in C.5.1. SIS also prompts the user for a cast with a > 3 m/s SSP change.

Data Processing Methods and Procedures

Surface sound speed data are not post-processed.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

Final uncertainty for soundings was calculated within CARIS HIPS using the Compute TPU tool. CARIS HIPS computes the TPU based on: the vessel's static and dynamic measurements; project specific tidal referencing; ERS positioning; and sound speed values. The TPU section of the HVF captures fixed estimates of uncertainty. Uncertainty values for the multibeam and positioning systems were compiled from manufacturer specification sheets for each sensor, and from those set forth in Section 4.2.3.8 of the 2014 FPM. CARIS HIPS also applies a sonar device model for uncertainty values associated with the sounding detections.

Tidal uncertainty is captured in the TCARI grid supplied with the project. Sound speed uncertainty is estimated based on cast frequency and distribution, with a typical value of 2 m/s employed unless otherwise specified in the DR. Real-time sonar uncertainties are provided via EM2040 or EM710 MBES data, and positioning errors via Applanix Delayed Heave RMS. Following post-processing of the real-time vessel motion, recomputed uncertainties of navigation and ellipsoidal height were applied in CARIS HIPS via a Smoothed Best Estimate of Trajectory (SBET) RMS file generated in Applanix POSPac.

C.6.2 Uncertainty Components

A Priori Uncertainty

Vessel		FA_2805_EM2040	FA_2806_EM2040	FA_2807_EM2040	FA_2808_EM2040	FA_S220_EM710	UNH_ASV_Ben_EM20
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees	0.02 degrees	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	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	0.02 degrees	0.02 degrees	0.02 degrees
	Pitch	0.02 degrees	0.02 degrees	0.02 degrees	0.02 degrees	0.02 degrees	0.02 degrees
Navigation Sensor		0.50 meters	0.50 meters	0.50 meters	0.50 meters	0.50 meters	0.50 meters

Real-Time Uncertainty

Vessel	*Description*
All Platforms	Real-time sonar uncertainties are provided via EM2040 or EM710 MBES data, and positioning errors via Applanix Delayed Heave RMS.

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>

HSD-OPS recommends bottom sample sites in the project reference file (PRF). The field unit examines these proposed sample sites and potentially eliminates some based on the actual depths found during survey operations (if deeper than 80 m), or supplements them with good anchorage positions located by the ship. Bottom sample locations may also be adjusted by the field unit to investigate areas of interest as determined through analysis of the backscatter data in an effort to ground truth returns of different intensities.

Field units acquire bottom samples with the image grab sampler, as described in Section A.8.1. This method utilizes a GoPro camera and lights to capture sea floor imagery. After starting the video recording, the sampler is lowered rapidly to the bottom until the line goes slack, then lifted slowly to approximately 0.5 m above the seafloor. This elevation is maintained for a few seconds to capture the environment before retrieving the sampler to the surface. The physical sample from the Petite Ponar is released into a bucket for visual and textural analysis. A picture is taken of the sample on deck. The physical sample analysis further verifies the sediment type for S57 attribution classification, with the most prevalent type listed first. Attribution is recorded in the field on a bottom sample form and may also be entered into a CARIS feature layer. The sample site's "Nature of Surface" (NATSUR) is characterized as “unknown” upon the field unit’s failure to obtain a sample after three attempts. Field units discard samples after completing analysis.

Data Processing Methods and Procedures

All bottom samples are entered or imported into the Final Feature File as Seabed Area (SBDARE) point features and attributed to match the recorded characteristics. A minimum of three images were selected from each GoPro video to satisfy the requirements as described in HTD 2018-4. Sheet managers link the sample images to the corresponding S-57 SBDARE attributed feature within the Final Feature File.

D Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

Preliminary data cleaning is performed daily during night processing following acquisition, addressing the most blatant fliers and blowouts. Cleaning is primarily done in Subset Editor, rejecting data that cause fliers in the CUBE grid. Following this gross cleaning, Flier Finder, part of the QC Tools package of HydrOffice, is used to assist the search for spurious soundings. Flier Finder is run iteratively until all remaining flagged fliers are deemed to be valid aspects of the steep slopes and dynamic nature of the seafloor. Additionally, the uncertainty, hypothesis count, hypothesis strength, and node standard deviation child layers of the surface in CARIS HIPS are utilized to identify potential problem areas.

D.1.2 Designated Sounding Selection

In depths less than 20 meters and in areas of navigational significance where the bathymetric surface does not depict the desired depth for the given area, a designated sounding may be selected. Designated soundings are selected in accordance with section 5.2.1.2.3 of the HSSD. Detailed designated sounding searches in subset editor are only performed in regions expected to contain variation not captured in the standard grid, or when searching for known features. Generation of higher resolution grids than required for the depth range may be used to guide the search for designated soundings.

D.1.3 Holiday Identification

To verify that all surfaces meet the uncertainty specifications as described in the HSSD, each surface is run through the Grid QA tool within the HydrOffice QC Tools suite. This tool plots histograms of the percentage of nodes that pass uncertainty standards, allowing for a quick method to determine uncertainty compliance.

D.1.4 Uncertainty Assessment

Pydro's "Grid QA v.5" function verifies that all surfaces meet HSSD's uncertainty specifications. This tool plots node percentage histograms, which demonstrates if the surface complies with HSSD's uncertainty standards.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

As a quality control measure, approximately 4% of the linear nautical mile total of mainscheme multibeam lines were run on each survey as crosslines. Crosslines were run in accordance with Section 5.2.4.2 of the HSSD. Following acquisition, a surface containing strictly data from mainscheme lines, and a surface containing strictly data from crosslines were generated and analyzed with the Compare Grids tool in Pydro. 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/distribution summary plots of the difference surface and the allowable error fraction are generated to provide easily interpretable analyses of the differences between the surfaces.

D.1.5.2 Junctions

Survey managers perform junction analyses between the current survey and all adjacent contemporary surveys. To ensure proper overlap between surveys, approximately one bathymetric swath of overlap was acquired at each junction. 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

Agreement and continuity of data collected between platforms was visually investigated by the survey manager to ensure consistency and highlight any potential biases in the data. To aid in the determination of potential biases, the depth child layer of the surfaces was inspected with an increased vertical exaggeration, generally between five and ten times greater. The ERZT model (see Section C.4) also reveals differences between platforms and acquisition days, and can be used to locate problematic data.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Processed backscatter mosaics were inspected in CARIS HIPS to ensure that no data were omitted during processing, and that no errors occurred in mosaic generation.

D.2.2 Contact Selection Methodology

Not applicable.

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	280x Wiring Diagram.pdf S220 Wiring Diagram.pdf
Sound Speed Sensor Calibration	MVP_Calibration.pdf Seabird_Calibration.pdf SVP71_Calibration_Report.pdf 205937 999999 205937 160317 112326_Calibration Certificate_Sound Velocity_16.3.2017.pdf SBE 45 C0117 28Feb18.pdf SBE 45 T0117 28Feb18.pdf ASV_BEN_Sound Velocity_Calibration.pdf
Vessel Offset	HSRR_2018_ERDDM.pdf HSRR_2018_Waterline.pdf BEN_Offset_verification.png
Position and Attitude Sensor Calibration	2805_POS_GAMS_Report_2018_Dn100.pdf 2806_POS_GAMS_Report_2018_Dn099.pdf 2807_POS_GAMS_Report_2018_Dn109.pdf 2808_POS_GAMS_Report_2018_Dn099.pdf
Echosounder Confidence Check	HSRR_2018_Patch_Tests.pdf HSRR_2018_Reference_Surfaces.pdf
Echosounder Acceptance Trial Results	N/A

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 Specifications and Deliverables, 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 herein.

Approver Name	Approver Title	Date	Signature
CDR Marc Moser, NOAA	Chief of Party	11/09/2018	
LT Damian Manda	Operations Officer	11/09/2018	
HCST Sam Candio	Chief Survey Technician	11/09/2018	